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MAPPING INFECTED AREA AFTER A FLASH-FLOODING STORM USING MULTI CRITERIA ANALYSIS AND SPECTRAL INDICES

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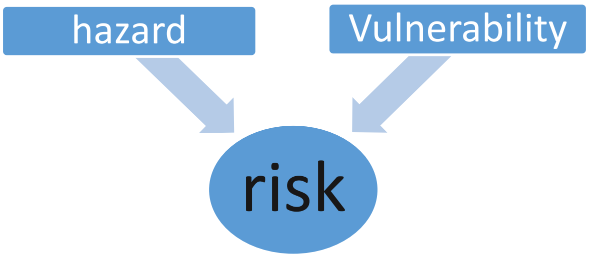
ABSTRACT:

This research article is summarize the applications of remote sensing and GIS to study the urban floods risk in Al Mukalla. Satellite acquisition of a flood event on October 2015 in Al Mukalla (Yemen) by using flood risk mapping techniques illustrate the potential risk present in this city. Satellite images (The Landsat and DEM images data were atmospherically corrected, radiometric corrected, and geometric and topographic distortions rectified.) are used for flood risk mapping to afford a hazard (vulnerability) map. This map is provided by applying image-processing techniques and using geographic information system (GIS) environment also the application of NDVI, NDWI index, and a method to estimate the flood-hazard areas. Four factors were considered in order to estimate the spatial distribution of the hazardous areas: flow accumulation, slope, land use, geology and elevation. The multi-criteria analysis, allowing to deal with vulnerability to flooding, as well as mapping areas at the risk of flooding of the city Al Mukalla. The main object of this research is to provide a simple and rapid method to reduce and manage the risks caused by flood in Yemen by take as example the city of Al Mukalla.

1. INTRODUCTION

Natural disasters have their greatest impact at local level, especially on the lives of ordinary people. Current disasters are becoming more complex and climate change poses a greater potential for adverse impacts (Aalst and Burton, 2002). The damage caused by natural disasters at Community level in Yemen is increasing exponentially due to the lack of infrastructure and studies carried out in this field.

The risk of flooding is now the most widespread natural hazard, causing the greatest damage in the world. Flooding is the most costly natural hazard that results in injuries and deaths. It can now be understood that interest is paramount to improve flood risk management by addressing its two components, hazard and vulnerability. The hazard represents the natural phenomenon which is for us the risk of flooding which is an overflow of the water course and the extension of the water in the flooded place. Vulnerability, which presents as the sensibility of the issues (land use and the human factor).



The biggest causes of flood risk are climatic changes, changes in land use and other anthropogenic factors. The most common anthropogenic factors (Human activities) effects are: urban growth, watercourse alignment, deforestation and the consequent erosion, the construction of roads across the watercourse. Observe two Landsat-8 satellite images acquired one weeks before and three days after the floods. It can be observed that the rains turned them into a powerful torrents (meaning the amount of rainfall ten years in 72 hours), causing floods of houses and cultivated fields in the zone. And DEM (digital elevation model) has become the fundamental solution for flood monitoring [1] and its impact assessment.

November 2015, violent storms have caused in AL Mukalla city. According to journals, this natural catastrophe caused the death of persons and a significant damage to the infrastructure; urban areas were inundated (Figure 1) causing thousands of houses to collapse, many agricultural fields were destructed (Figure 2), power and telephone networks and several roads and bridges were damaged.

Figure 1. Destruction of road and infrastructure in the Al Mukalla city region (Photos from the web)

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Figure 2. Destruction of road and infrastructure in the Al Mukalla city (Photos from the web).

2. OBJECTIVE

The purpose of this study is to identify areas at risk of flooding and areas already affected by the of 2015'Th flood in Al Mukalla, the multi-criteria analysis method was used. Indeed, the development of flood risk maps is an excellent decision-making tool that will contribute to the development of strategies for mitigation and adaptation of populations to natural hazards due to the effects of variability Climate change.

3. STUDY AREA

Al Mukalla is the capital of Hadramout province in Yemen, with more than half a million people, according to 2005 statistics. Geography It is located in the eastern part of the coast of the Republic of Yemen along a length of 49.10 degrees and a latitude of 14.33 degrees and about 620 kilometres from the capital Sana'a and surrounded by a group of mountains in the medium height in the form of a circle.

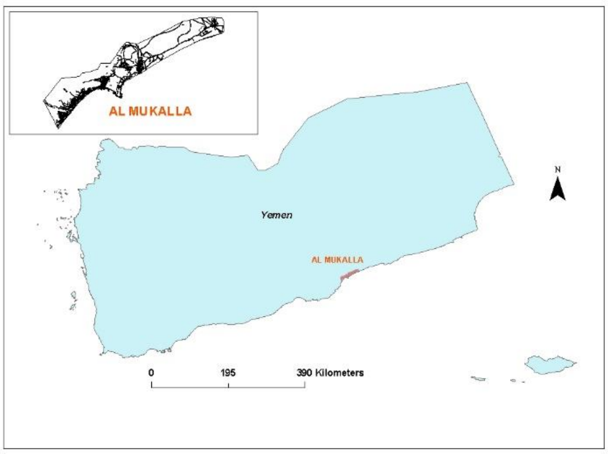


Figure 3. Location of the study area.

4. DATA AND METHODOLOGIES

The availability of Landsat data since 1972, from the oldest Earth observation program until the last polar-orbiting landsat-8 (Landsat scientific collaboration program between the NASA and USGS), makes it an exceptional documentary source, indeed, the Landsat data provide a global coverage of the Earth. The analysis of the Landsat archive images makes it possible to identify the phenomenon of flooding, as well as the extracting of essential information concerning the cartography of the flooded areas. Finally, Landsat data can be used to monitor the overall evolution of land use. In this research, two landsat-8 images were used, the first image was acquired in October 26 2015 (fifteen days before the inundation) and the second image was collected in November 11 2015, eight days after the flood. Take into consideration that the bands 1, 8 and 9 were not considered in this study.

The ASTER (Advanced Space borne Thermal Emission and Reflection Radiometer) instrument, Industry (METI) of Japan and the United States National Aeronautics and Space Administration (NASA), it was built in December 1999 with, along-track stereoscopic capability, providing GDEM (Global Digital Elevation Model) product. Since 2001, these stereo pairs have been used to produce single-scene (60 km × 60 km) DEM based on a stereo-correlation matching technique using WGS84 geodetic reference data [2].

In this study, the ASTER DEM of the Al Mukalla city was downloaded from the USGS data explorer gate and was retro-projected, then the global height surfaces was calculated. The derived DEM was used for the extraction of topographic attributes derivation, and analysis.

4.1 Methods

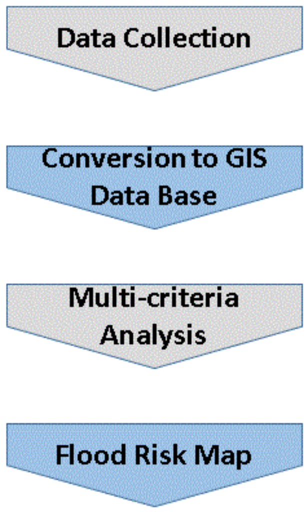


Figure 4. General procedure undertaken to develop flood risk map in GIS for the study area by using multi-criteria analysis.

Multi criteria analysis is applied and integrates with the spatial data in order to describe the causative factors of a phenomenon under concern. In this study, the risk areas were first produced by numerically overlaying soil, drainage network, and slope. The selection of these criteria was based on the expert's opinion and availability of data. This overlay was carried out as a Boolean overlay. All criteria are combined by logical operators such as intersection (AND) and union (OR) [3].

In the second phase, Ranking Method was used, where every criterion under consideration was ranked in the order of the decision maker's preference. Each factor was weighted according to the estimated significance for causing flooding. The inverse ranking was applied to these factors. Factor of rank 1 is the least important and 8 is the most important factor. In the third phase, Pairwise Comparison Method which was developed by Saaty [4] was used to determine the weight of each criterion. Figure 3 illustrates the general procedure used to create flood risk map for the study area.

4.1.1 Pairwise Comparison Method

This method involved the comparison of the criteria and allows the comparison of two criteria at a time. It can convert subjective assessments of relative importance into a linear set of weights. This method could estimate the weight of the following criteria:
C1 = Slope of the basin.
C2 = land cover.
C3 = Drainage network.
C4= topography.

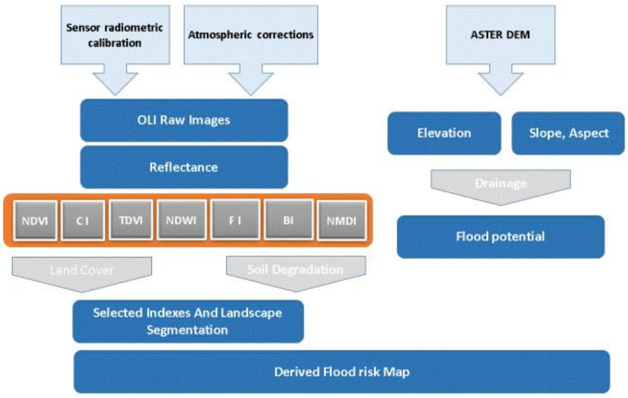
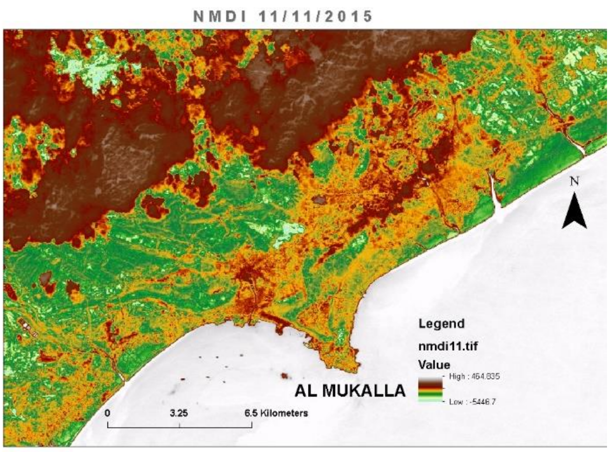


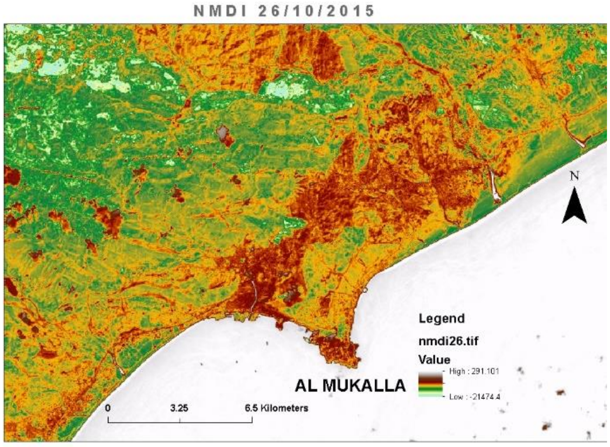
Figure 5. Methodology flowchart.

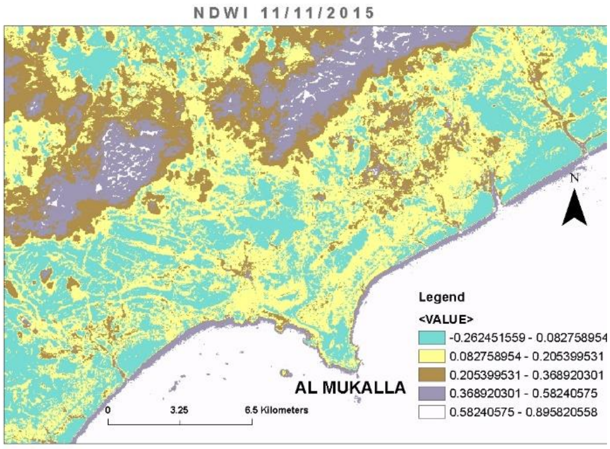
The used methodology for identification of flood risk map using spectral indices is summarized in Figure 4. It involves four fundamental steps:

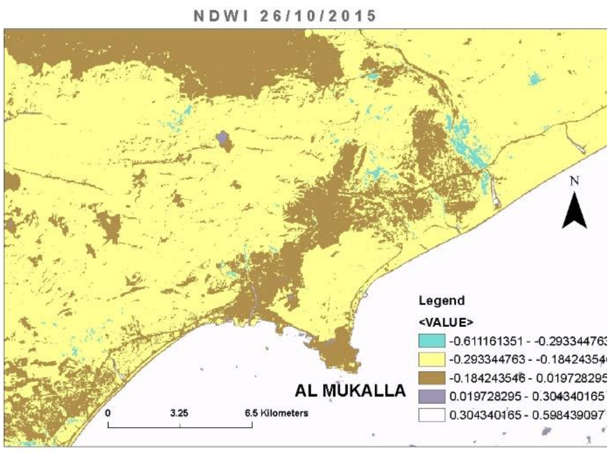
1) Data pre-processing.
2) Topographic profile retrieval.
3) Soil, vegetation and moisture spectral indices processing.
4) Information integration.

5. RESULTS

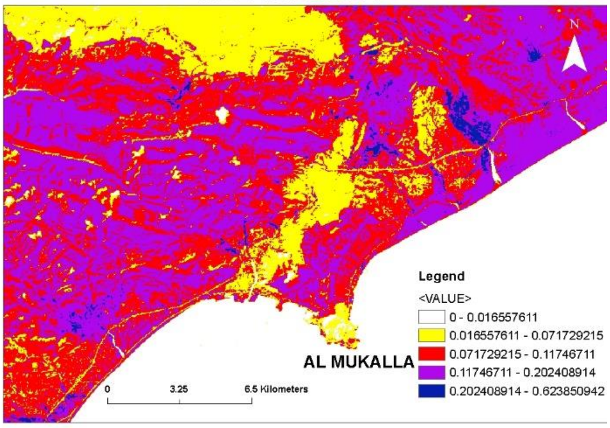








NDVI 26/10/2015



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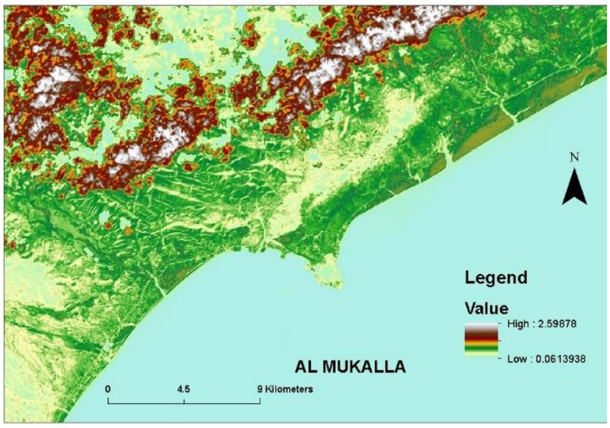

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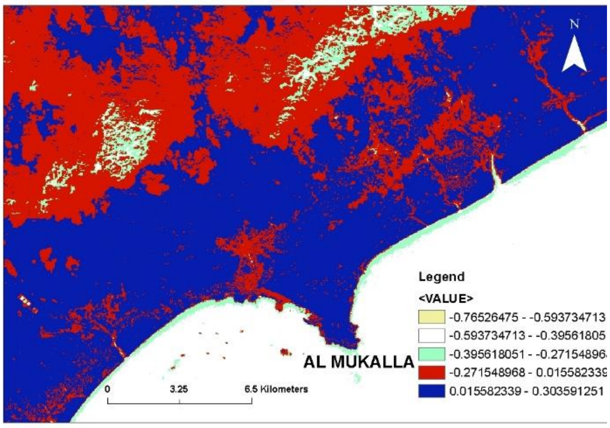
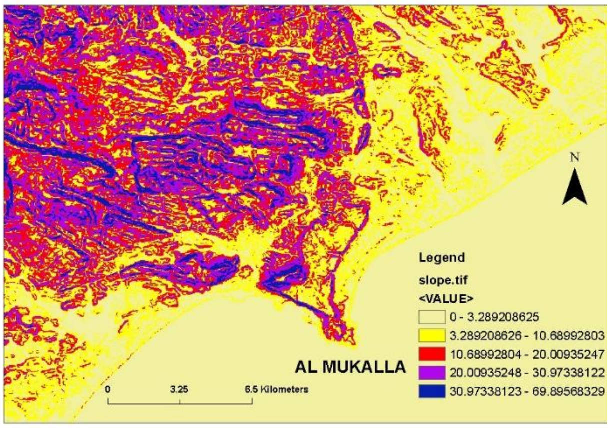


Slope



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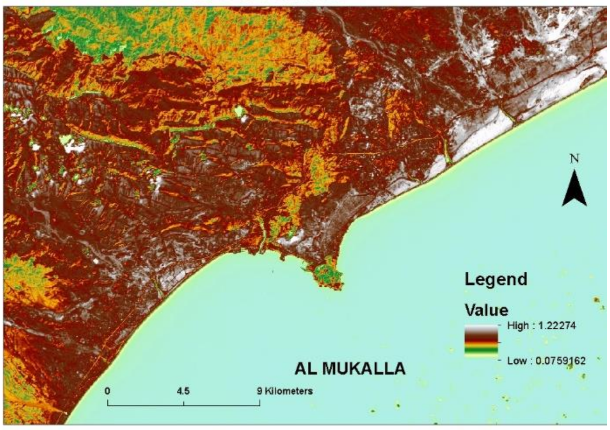
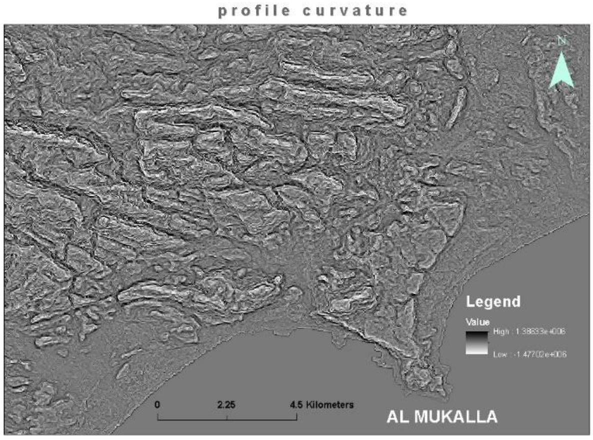


profile curvature



6. CONCLUSIONS

This research could be a valuable tool for assessing flood risk. The study also reviewed the role of GIS in decision-making and then outlined the evaluation approach for many criteria in decision process by using the Multi criteria analysis. It also deal with the characterization of areas associated with flash floods caused by severe rainfall storm using topographic profiles and spectral indices. Topographic attributes and profiles were retrieved from ASTER-V2.1 DEM. the remote sensing approach integrates spectral indices, such as the FI, and the BI, which describes the soil reflectance curve. Vegetation indices, such as the TDVI, was also used. In addition to this characterization process, soil moisture conditions and vegetation water content were integrated, exploiting the NDWI and the NMDI. All these indices were derived from two Landsat-OLI images acquired before and after the flood-storm. The OLI images data were atmospherically corrected, sensor radiometric drift calibrated. The results show that the NDWI characterizes correctly soil and vegetation moisture content before and after flooding than NMDI. TDVI describes correctly the scattered vegetation along the riverbed, on the top of mountains and in oases.

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