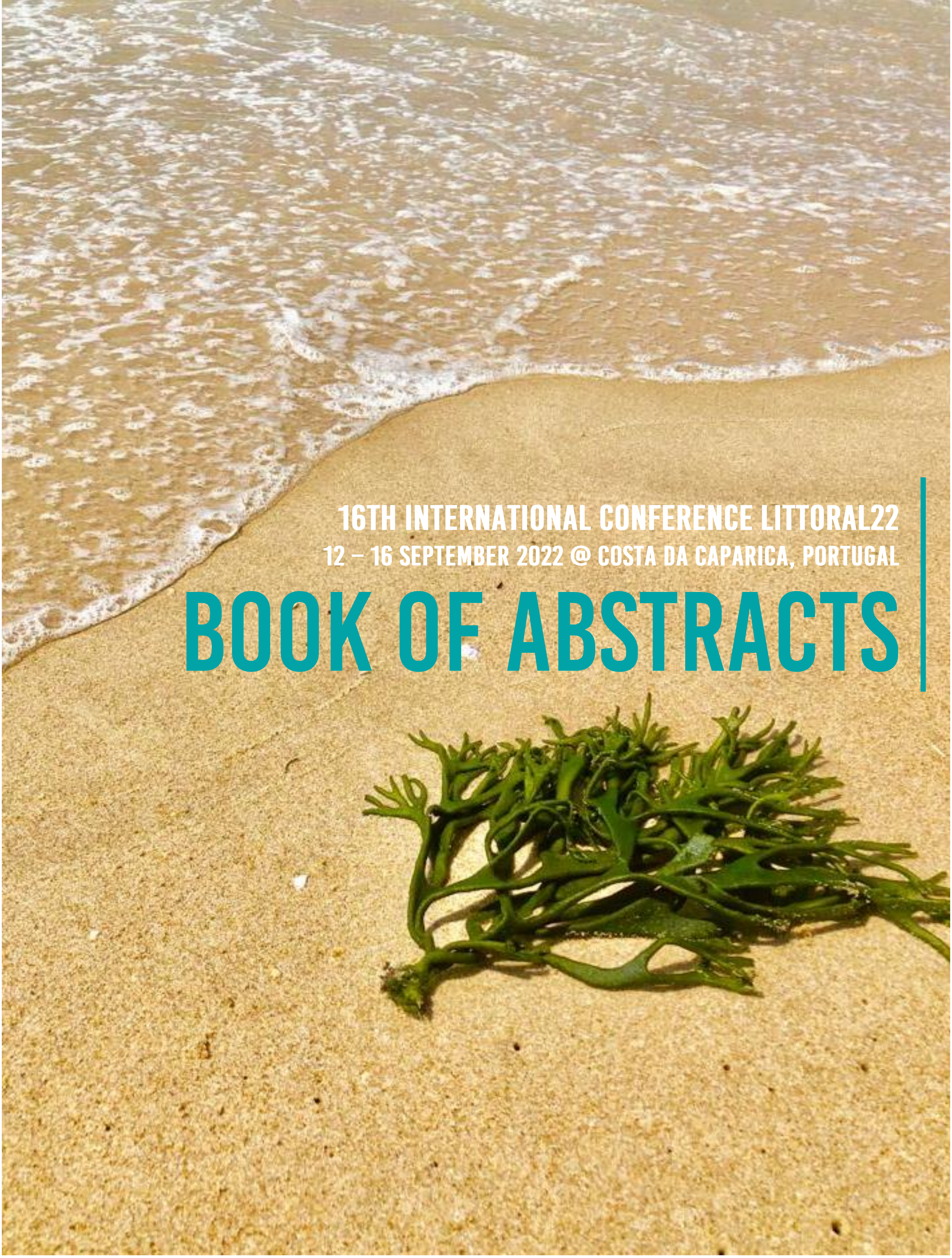

16TH INTERNATIONAL CONFERENCE LITTORAL22

12 – 16 SEPTEMBER 2022 @ COSTA DA CAPARICA, PORTUGAL

BOOK OF ABSTRACTS

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ADAPT OUR COAST FOR A SUSTAINABLE FUTURE

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December 2022

Geospatial modelling for sinkholes hazard in the coastal area of Abda-Doukkala, Morocco

Tuesday, 13th September - 16:20: (Caparica B Room) - Accept for Oral

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1. INTRODUCTION

Karst landscape forms as groundwater interacts with soluble rocks (carbonate or evaporites), during which subsurface drainage causes unique solutional patterns, forming cavities and triggering land subsidence if topsoil subsides into the voids (Kaufmann, 2007). Land subsidence surface morphology usually includes the formation of dolines, also called sinkholes (Hubbard, Jr, 1988). Karst morphology is well developed in the coastal area of Safi in West Morocco, and include the presence of dolines, rounded depressions, caves, and karst aquifers. However, despite this karst diversity few research has been carried out so far related to the karst environment (Gigout, 1951; Ferré and et Ruhard 1975; Barbara et al. 2014).

The main objective of this study to assess the sinkhole collapse susceptibility in the coastal area of Safi (Morocco) to support regional land use management.

2. METHODOLOGY

The information source for sinkhole inventory includes topographical maps, aerial photographs, satellite imagery, borhole data, and detailed fieldwork. The inventory aimed to identify location, size, shape, depth of sinkhole and sinkhole geological formation.104 sinkholes locations were identified, described, mapped and validate by the field work.

Sinkhole susceptibility analysis may include several drivers such as lithology, fault lineaments, streams, roads, water table, rain, slope, aspect or land use/land cover. However, sinkhole susceptibility model has also to account for data availability not disregarding model effectiveness, and independence. In this study, some drivers data isn't available. Nevertheless, to pursue the main aim of this research we used from different sources (SRTM-DEM , geology maps, field work, topographic maps, Landat 8 and Sentinel satellite images). So the geodataset mapping of sinkhole controlling factors were rasterized, and harmonized to a cell size of 30 m × 30 m, including the following variables: elevation, slope, aspect, curvature, drainage density, lineament density, topographic witness index (TWI), lithology and landuse/landcover (LU/LC).

On the last few decades, many researchers have produced sinkhole susceptibility maps using different techniques including the probability methods as frequency ratio, analytical hierarchy processes (AHP), bivariate and multivariate analysis, logistic regressions, fuzzy logic and artificial neural network modelling (Saaty, 1977, Dogan & Yilmaz,2011, Aurit et al., 2013, Lamelas et al., 2008).

The sinkhole susceptibility mapping is based on frequency ratio (FR) and analytical Hierarchy process (AHP) methods. Model validation was concentrated in the receiver operating characteristics area under the (AUC-ROC) approach. The models included nine predisposing factors and an inventory of 104 sinkhole locations in coastal area of Safi.

Analytic Hierarchy Process (AHP) is an effective, systematic, and hierarchical multi-target decision method combining qualitative analysis with quantitative analysis. AHP can efficiently combine data, expertise, and objective judgments of analyzer (Wang et al. 2017), that would meet the need for evaluation of the sinkhole collapse susceptibility. In this study, sinkhole susceptibility is assessed considering the relative weights assigned to nine controlling factors and calculated through a weighted linear combination.

Frequency Ratio (FR) is a bivariate statistical model that can be applied to measure the level of contribution to sinkhole occurrence based on the spatial association between the sinkhole inventory and controlling factors (Demir et al 2014, Lee and Pradhan, 2007). A relationship between the sinkhole inventory and controlling factors can be established in a GIS environment. The frequency ratio is the ratio between the percent areas where sinkhole collapse has occurred in a class to the percent area of the influencing class relative to the whole study area. In this study, the FR model was used for sinkhole analysis using nine factors and 104 sinkhole locations divided in training (70%) and validation (30%) datasets. The sinkhole susceptibility map was created using the weighted overlay function in GIS environment, which were used to merge different factors that were assigned to the ratio (Oh et al., 2011). The sinkhole susceptibility values were then divided into four classes of equivalent interval range, to represent four susceptibility classes in the final model: very high, high, moderate and low. The natural break classification method, commonly used in landslide susceptibility mapping, was used to categorize the susceptibility classes .

3. RESULTS AND DISCUSSION

Sinkhole collapse is one of the geo-hazard events which can have a disastrous impact on the various regions, regardless of the land use. In the Study area, Sinkholes occur mainly in South of Safi (Jorf Lihoudi region), and the northeast in Moul Bergui region along of the NE-SW lineament direction. The sinkholes are usually circular in their shape and have between 10 and 400 meters in diameter. Smaller ones, with diameters ranging between 15 to 50 m have usually depths from a few meters to 40 meters.

This localization is related to the controlling factors, such as lithological factor (Upper Jurassic evaporitic-limestone, and Plio-Quaternary biodetritic limestone). In the south of the study area, the outcrop of the evaporitic limestone explains the number of sinkholes that occurred in this area.

The distribution of collapse sinkholes follows the NE-SW direction which is the same as flexures and faults observed in the study area. One may conclude that the presence of such tectonic structures guiding the distribution of these sinkholes. In addition, the topographic factors such as elevation and slope play a key role.

A sinkhole susceptibility mapping was based on two methods: Analytical Hierarchy Process (AHP) and Frequency Ratio (FR), shows that the high and very high susceptibility levels are spatially concentrated in the South and the Northeast of the study area. This susceptibility reflects the predisposing factors in this part of study area such as the presence of the karst formations of the Upper Jurassic and Plio-Quaternary which is formed by the gypsum and the biodetritic limestone, respectively. In addition, the topographic factors and structural factors through the control of NE-SW lineaments.

Validation using the ROC method revealed success rates of 73.5 % and 90.5 % for AHP and FR, respectively. The results revealed that both models have a good prediction capability. Also, AHP model has less prediction accuracy than the FR model.

The models were also evaluated by comparing the maps with the known sinkhole locations. The all 104 sinkhole locations were overlaid on to susceptibility maps produced by the AHP and FR analyses.By overlaying the sinkhole susceptibility map produced by FR method with the total , training and validation sinkholes, the results indicated that 78.85%, 76.71% and 83.87% of the observed sinkholes were concentrated in the very high potential class, respectively. The sinkhole susceptibility map obtained from FR method shows that 44.3% of the total area is no sinkhole or low potential area, moderate, high and very high sinkhole susceptibility zones constitute 32%,16.1% and 7.6% of the total area, respectively.

4. CONCLUSION

The present study presents a novel methodology in which AHP and FR models were used for classifying related variables in order to produce sinkhole susceptibility maps. The methodology was based on the analysis of nine (9) conditional variables, namely, lithology, altitude, slope, aspect, topographic wetness index, curvature, LuLc, lineament density and stream density. According to the results of the research, each model had satisfactory performance, though the FR model had a slightly higher performance in terms of AUC predictive values (0.905) against the ones estimated for the AHP model (0.735). From the produced sinkholes susceptibility maps, the most susceptible areas are located at the South and Northeast areas, while the central area is characterized by moderate to low susceptibility values.

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