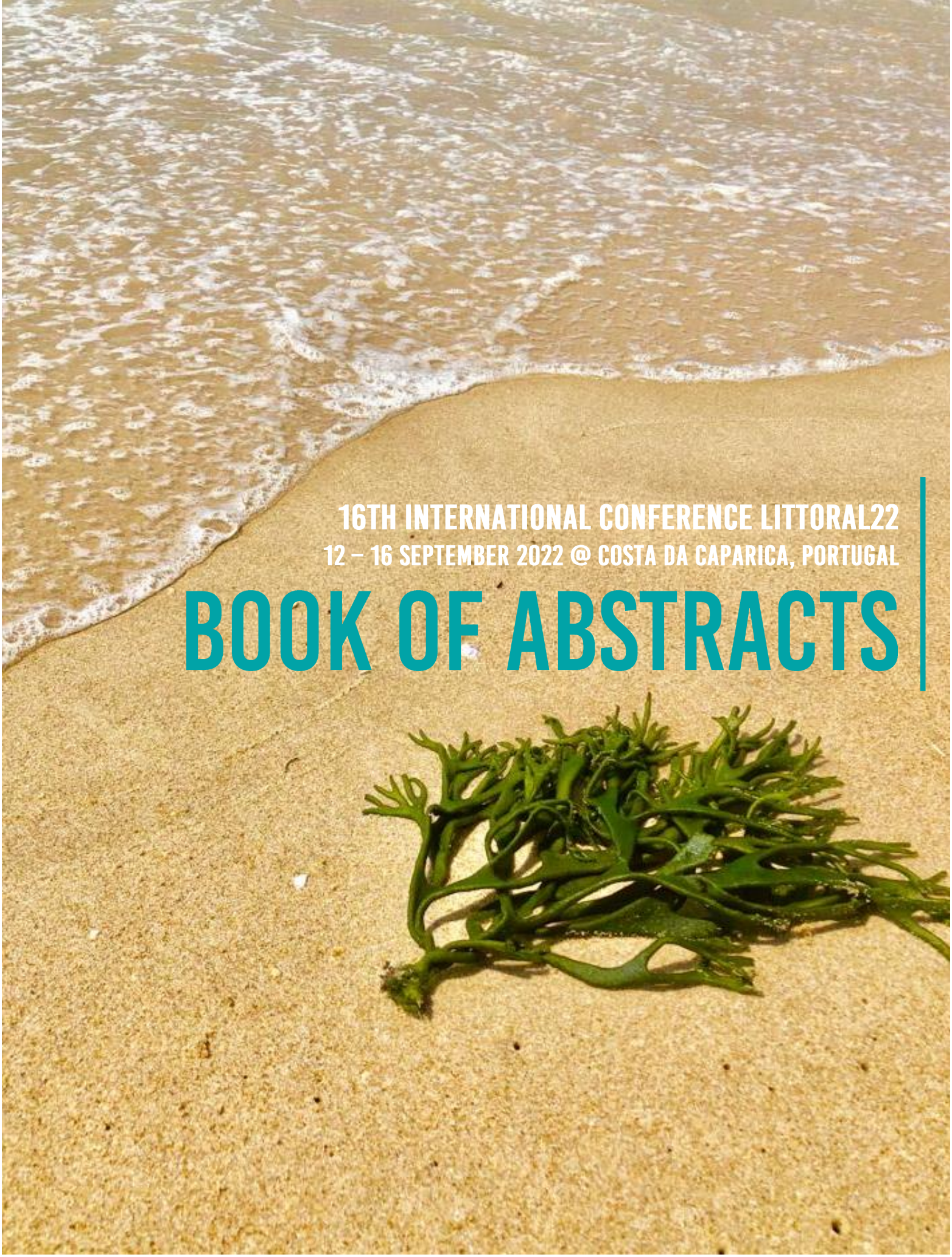

16TH INTERNATIONAL CONFERENCE LITTORAL22

12 – 16 SEPTEMBER 2022 @ COSTA DA CAPARICA, PORTUGAL

BOOK OF ABSTRACTS

16TH INTERNATIONAL CONFERENCE LITTORAL 22
12 - 16 SEPTEMBER| COSTA DA CAPARICA, PORTUGAL
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Abstracts are organized by chronological order of presentation.

December 2022

Machine learning evaluation and statistical prediction techniques for landslide susceptibility assessment in Essaouira coastal area

Tuesday, 13th September - 15:40: (Caparica B Room) - Accept for Oral

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1. INTRODUCTION

Landslides are a common hazard in the coastal area of Essaouira province, West Atlantic Morocco. They occur with different frequencies and magnitudes, under different conditioning and triggering factors, and could lead to significant consequences at both social and economic levels. Landslide susceptibility mapping is an important tool for land use planning and environmental management (Schuster et al 1996, Pham et al 2015). The study and management of unstable landscapes is useful to deal not only with the existing instability hotspots but also with possible new ones. Therefore, research on the existing unstable areas is the key to predict their behavior in the future, regarding the volume and severity prior to their occurrence (Nadim et al., 2006, Marjanović et al 2011).

In the last decade, a great amount and variety of spatial data has become accessible, including data on the relevant known drivers of landslides. Moreover, the use of new data-driven methods for the assessment of landslide susceptibility had recently a big evolution based on computer processing tasks enhancement such as classification, prediction or clustering, learning from the available data, This process is called machine learning (Mitchell, 1997, Marjanović et al 2011).

Machine learning (ML) models proved to be a useful tool for dealing with multiple variables, big geodatabases and model comparison and testing, which have been increasingly applied for landslide modeling and susceptibility mapping. These susceptibility maps are considered the first important step in landslide risk assessments and are widely accepted for land use planning and disaster prevention (Pham and Prakash 2018).

The main objective of this work is to model landslide susceptibility in coastal slopes using the best model results between traditional statistical approaches and ML models. In this work, we test the performance of traditional statistical methods and ML algorithms to predict the spatial distribution of landslide susceptibility using the most popular statistical models, namely logistic regression (LR), Support Vector Machines (SVM), k-Nearest Neighbor (kNN), Random Forest (RF) and Information Value (IV). Analysis are supported by an inventory-based landslide geodatabase.

The Essaouira coastal area is located along the middle section of the Atlantic coast of Morocco, which extends over 134 km. It has high coastal systems diversity including cliffs and rock shore platforms (Weisrock, 1980; Lharti et al., 2006), with diverse geological settings that include sedimentary successions of marls, clays, and limestones, which makes it highly susceptible to slope instability.

2. METHODS

ML techniques provide an automated solution for complex systems and studies such as landslide susceptibility. Since ML algorithms consider all data points in a dataset without any human bias attributable to previous experience, they are more well-grounded than human-created rules (Rebala et al. 2019).

After checking and selecting landslide drivers based on collinearity values, coastal slope landslide susceptibility was independently assessed using LR (e.g., Atkinson and Massari 1998; Ohlmacher and Davis 2003), kNN (Cover and Hart 1967), SVM (Belousov et al., 2002), RF (Calle and Urrea 2010; Micheletti et al. 2014; Pham et al. 2019; Rebala et al. 2019 and Abu El-Magd et al 2021). Modeling results were compared with traditional statistical approaches such as IV (Yin and Yan 1988; Zêzere, 2002).

The landslide inventory shows 588 landslide records, obtained from the observation and interpretation of different data sources, namely high-resolution satellite images, aerial photographs, topographic maps, and extensive field surveys. In which rockfalls are the most frequent slope instability, with 149 records, followed by rotational slides, while the least frequent landslide type is the debris fall (6 records). Most of the study area is occupied by translational slides (68%), followed by rotational slides (17%).

Landslide and drivers geodatabase was build based on 142769 pixels with a resolution of 12.5m. Each pixel have information on the type of landslide and the different drivers (22 landslide conditioning factors), selected based on the available cartography, geomorphological characteristics, bibliography and field surveys. From where 7 conditioning factors were excluded based on successive collinearity checks.

The methodological steps considered for training and validation the coastal landslide susceptibility models have followed these steps: i) elaborate the landslide inventory, classifying the landslides by type and depth of the rupture surface (shallow and deep); ii) prepare a set of 22 conditioning factors grouped in seven categories (topographical, geomorphological, lithological, geotechnical, hydrological, climatic and tectonic); iii) model coastal landslides susceptibility for the Essaouira coastal area using a pixel based approach; iv) and independently validate the predictive susceptibility models using spatial k-fold cross-validation, confusion matrix and ROC curves, after splitting the landslide inventory into two independent sets, 70% of the landslides for the training set and the remaining 30%. In term of validation, the machine learning approaches (LR, SVM, KNN and RF) were compared with the traditional method (IV).

3. RESULTS

Landslides are distributed along the entire study area, with more concentration in the southern sector (Sidi M'bark, Sidi Ahmed Essayeh, Tafedna and Timzguida Oufettas), mainly because it's topographic characteristics, while the less susceptible areas are more located in the middle and northern part of Essaouira coastal area.

For example, comparing LR and IV for all instability types in Essaouira coastal area, the ROC curves validation shows a value of 0.798 for IV model, while the LR model presents a higher value of 0.911.

For IV model, the most important explaining drivers are; slope factor, especially >45 ° and solar radiation factor class 400-600 kWh/m2, those factors are already highlighted by many authors as important conditioning factors of many landslides types. Most of the landslide susceptibility models presented a strong interdependence with lithological factor or factors extracted from lithology as grain size and organic matter, which means that the different landslides types occurrence is highly impacted by lithology variations.

For LR, in term of driver importance, the minimum score was -2.743 for the elevation factor, and the maximum score was 6.630 for the slope factor, which mean that this factor is highly contributed for the occurrences of all instabilities in Essaouira coastal cliffs.

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