LANDSLIDE SUSCEPTIBILITY MAPPING OF THE AITOLOAKARNANIA AND EVRYTANIA REGIONAL UNITS, WESTERN GREECE, UPDATED WITH THE EXTENSIVE CATASTROPHIC OF WINTER 2015.

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ABSTRACT

A great number of landslides has been repeatedly reported in Aitoloakarnania and Evrytania Regionals Units of Western Greece; causing serious damages to villages' infrastructure due to prolonged precipitations events. These phenomena have caused severe damages to provincial roads, which triggered several landslides between 2015-01-23 and 2015-02-08. Under this frame, this study has focused: a) on the screening and reporting of the landslide phenomena in the wider study area through engineering geological survey, b) on the design of updated landslide susceptibility maps of the region by the implementation and on the comparison of two expert based geospatial techniques; Analytical Hierarchy Process (AHP) and Rock Engineering System (RES) in a specific area. The validation results presented that RES methodology is more adaptive and better in prediction than AHP with 51.98% and 44.89% respectively in the highest-class zone of landslide susceptibility. The outcome of this work aims to produce a useful and sustainable tool, which will serve to the mitigation of the impact of landslide occurrences on humans, structures and settlements' infrastructure.

KEYWORDS

AHP; geological survey; landslide susceptibility; RES; Western Greece

1. INTRODUCTION

Landslides globally cause major socio-economic and environmental impact annually. Climate crisis and occasional extreme weather events combined with human activities have increased the number of observed landslides in global scale. According to the Emergency Disasters Data Base (EM-DAT), taking into consideration all the landslide induced phenomena per continent (between 1903 and 2016) an estimation of over 61,000 casualties and over 3,500 million US$ in damage has been reported (Fig. 1).

The main objectives of the present study were: a) the identification and thorough analysis of landslide phenomena during an engineering geological survey in Aitoloakarnania (Aetolia-Acarnania) and Evrytania Regional Units (Western Greece), b) the production of updated landslide susceptibility maps for this particular high interest region and c) the validation and comparison between two expert-based geospatial techniques applied for the development of landslide susceptibility maps.

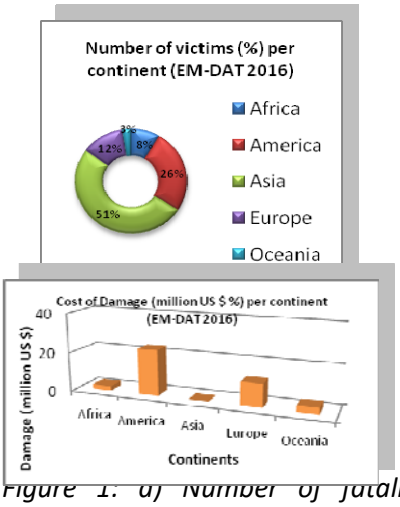

Figure 1: a) Number of fatalities and b) cost damage induced from landslides between 1903 and 2016, sorted by continents (Source: EM-DAT: The OFDA/CRED International Disaster database)

Multiple landslide events have been reported in the study area due to its complex tectonic and geological setting (East Pindos flysch, argillites and siltstones). The major triggering factor in the examined area is the high intensity and long lasting rainfall episodes. Various researches have investigated the dominant landslide causal factors utilizing the production of a Landslide Susceptibility Map (Yalcin 2008; Kouli et.al., 2010; Rozos et al 2011).

The RES approach is a multi-objective system and it has been established and developed by J.A. Hudson (1992), as a response to the need for a semi- quantitative technique to approach increasingly complex rock engineering problems. The AHP is also a semi- quantitative, multi- objective and multi- criteria decision-making methodology (Saaty 1980, 2008), which has been widely applied for the solution of decision problems. The selection of the factors is a very important process for AHP and RES techniques, in order to rate the influence of a parameter as a landslide causal factor based on expert's justice.

2. METHODOLOGY

The developed methodology could be divided into a four phase procedure: a) producing the landslide inventory map and selecting the landslide related variables, b) classifying each variable, c) applying Analytical Hierarchy Process (AHP) and Rock Engineering System (RES), and d) validation and comparison of the two models. Both techniques were adopted in a GIS environment in adjacent areas with similar geological setting. Tsangaratos & Rozos (2013), Tavoularis et al. (2017), Krassakis & Loupasakis (2018) have applied application of RES and AHP in an attempt to assess landslide susceptibility.

A detailed field survey took place during winter 2015, right after the manifestation of the landslide events (Fig. 2). It is worth to be mentioned that 92 failures were recorded and imported in the created geodatabase. The majority of those events were classified as rotational slides, transitional, flows or complex.

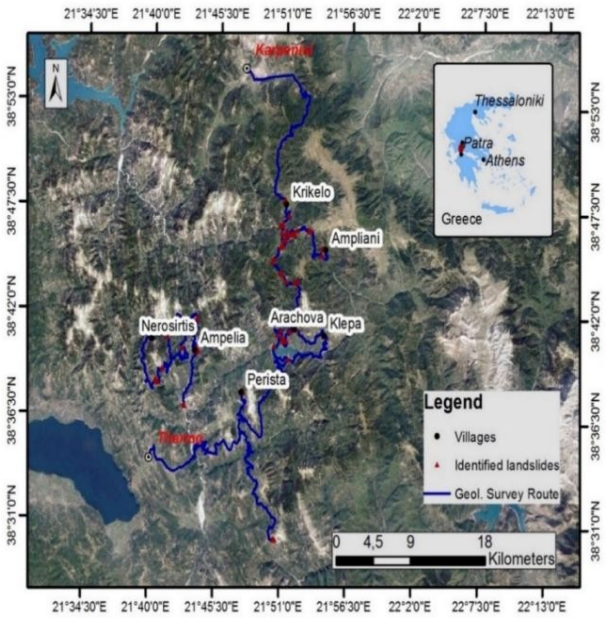

Figure 2: Route of engineering geological survey for the identification of landslide occurrences.

As mentioned before many rainfall- induced landslide events have been recognized worldwide. In a specific region of our study area several landslide events were recorded at the wider area of the Perista village (Naupaktia Municipality) (Fig. 3). The selected region is occupied by Pindos flysh and moreover by its weathering mantle. The first landslide event (PE1) occurred inside the village. This phenomenon is the reactivation of a former rotational landslide of the weathering mantle. A house and its frontal road suffered serious damages. Ruptures were also recorded at two

houses which were located at the toe slope of the road (Fig. 3b). A second landslide event (PE2) is located in the cliff above the village (1000m asl) (Fig. 3c)

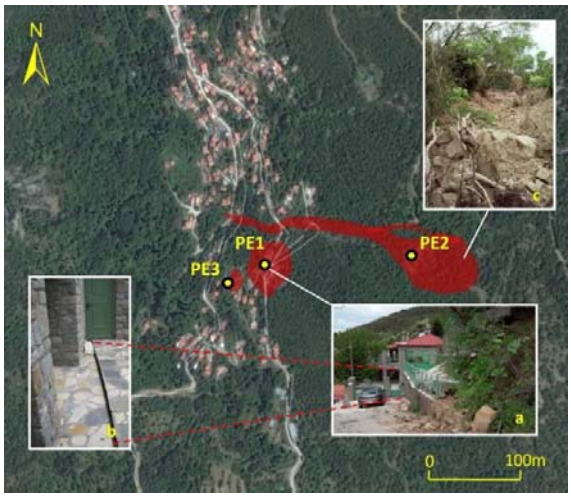

Figure 3: *General View of the Perista village and the identified landslides : a) rotational landslide affecting a residence (PE1), b) Detail of the differential movement that was observed in the house in PE1 position, c) Complex landslide which took place outside of the village (PE2).*

In addition, excessive mud flows were depicted at the Ampliani settlement (Karpenision Municipality) at the hill above the village. The landslide deposits moved approximately 150m causing serious damages at the Ampliani village. The investigated landslide (Fig. 4) is classified as complex, as the rotational slide which occurred at the crown of the slope progressed to earth flow. Creep markings were identified at the parameter of the landslide's borders.

Figure 4: Perspective views of the a) mud flow that caused extensive damages to b) Ampliani's village buildings.

3. RESULTS AND DISCUSSION

In the total of the 92 landslide events in the common area (Fig.5) the Very Low susceptibility zone from AHP and RES covers 16.09% and 15.09% respectively. The low susceptibility area from AHP and RES covers the 26.37% and 26.10%, the moderate class covers the 27.30% and 27.72%, the total percentage of the High and the Very High class covers 30.25% and 31.09% respectively. According to the final landslide susceptibility map (Fig. 5) the extent within the common region (black polygon) is classified as 30% including High and Very High (orange and red colour) classes. Moreover, the vast majority of landslide events occurred in cherts and flysch formations. Evaluating the results of the comparison between AHP and RES techniques the lithology and slope inclination, were calculated as the dominant factors in landslide manifestation.

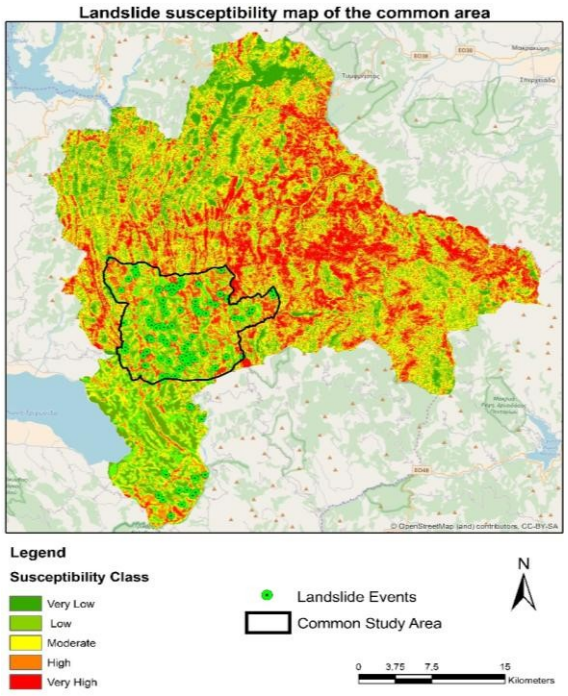

Figure 5: This map represents the landslide susceptibility map in the common area of the two applied geospatial techniques (black polygon).

4. CONCLUSIONS

Regarding the infield findings, the most important landslide causal factors were the ground settings such as mechanical properties, discontinuities and slope's orientation. According to the final map, lithology and slope inclination, were the dominant factors in landslide manifestation. The validation results showed that RES methodology is better and more adaptive in prediction than AHP with 51.98% and 44.89% respectively in the highest-class zone of landslide susceptibility. This work also aims to create a useful and sustainable geospatial application, in order to reduce the impact of landslide occurrences on humans and manmade environment in the future.

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