Landslide Susceptibility in Macedonia

Comparison of Global and Regional Models with Landslide Inventory

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Introduction

Considerable efforts have been made by researchers to develop reliable landslide inventories in order to better understand and therefore reduce landslide risk. By applying both Geographical Information Systems (GIS) and Remote Sensing (RS) technology, these inventories can be combined with other geospatial datasets to build landslide susceptibility maps in which geographical zones are assigned levels of risk. Improved visualization helps to provide hazard insight allowing for preemptive decision making on land use practices and human development in order to minimize environmental, economic, and social damages.

Macedonia has particularly heightened susceptibility to frequent landslides as a result of significant soil erosion from weak regional geology and soil, scarce vegetation resulting from a semi-arid climate, and steep slopes given the dominant mountainous terrain.

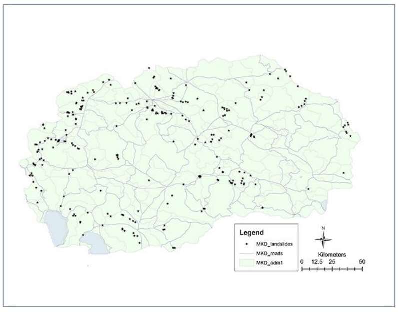


Figure 1. Landslides inventory map of the Republic of Macedonia, Peševski, Jovanovski, & Nedelkovska 2018.

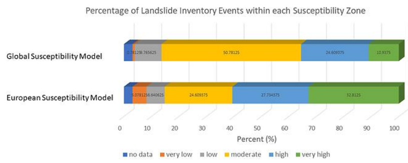


Table 1 Number of landslide inventory events within risk zones.

Method

This study examines the differences in global and regional susceptibility mapping by comparing the predictive factors used in the susceptibility models' raster functions as well as the distribution of actual inventoried landslide event data into risk zones.

A recent Macedonian Landslide Inventory (Peshevski 2018, Fig. 1) containing 256 events provided the baseline for a geospatial analysis incorporating a series of dataset layers to examine patterns of model similarities and differences. Excluding 8 landslides that occurred on or outside of the administrative border, 248 recorded events were assigned risk values of 1-5 (very low to very high) susceptibility, corresponding to spatially overlapping susceptibility raster layers. This was completed for both the Global Landslide Susceptibility Map (Stanley & Kirschbaum 2017) and the European Landslide Susceptibility Map (ELSUS Version 2, Wilde *et al*. 2018). Variables considered in the assessment included thematic predictors of slope angle (Fig.2) , elevation (Fig. 3), land cover and land use (Fig 4), and topography (Fig 5).

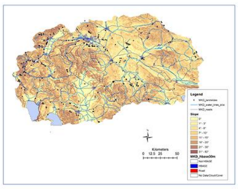


Figure 2. Slope angle and human development (Wilde etal.2018)

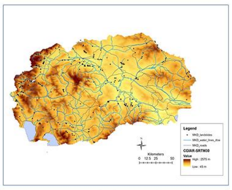


Figure 3. Digital Elevation (SRTM30 Elevation Model)

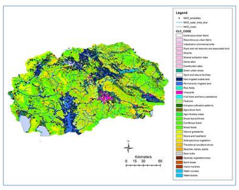


Figure 4. Land cover and land use (CLC2012 100m, Copernicus 2018).

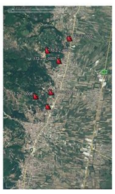


Figure 5. Google Earth Topography

Results

According to the distribution of landslide events within the five risk values, the European Susceptibility Model suggests a higher degree of accuracy compared to the Global Susceptibility Model. Using the Global Susceptibility Map about 51% of events occurred in zones of moderate risk, 24% in high risk, and 11% in very high risk. It is expected that most events would occur in areas of high to very high risk, yet this is not the case. The European Susceptibility Model however shows a much stronger correlation as the number of landslides increase for each bin of greater risk; 5% in very low, about 7% in low, about 25 % in moderate, about 28 % in high, and about 33% in vary high.

A large portion of the landslides occurred at mountain foots, mid-elevation slopes, the edge of lacustrine valley basins, and depressions between plains and mountain hillslopes. These landslide prone settings are visualized in the model as the steep color gradient indicating change from very high to very low risk (6a, 7a). A large cluster of events can be seen along the northwestern side of the country (6b, 7b). In this region the Global Susceptibility Map considers the area to be mainly of moderate risk, while the European Susceptibility Map classifies the region as very high risk. This likely explains why the low to moderate risk is overestimated and high to very high risk is underestimated in the Global Susceptibility Map.

Figure 6. Global Landslide Susceptibility Map

Fig 6a.

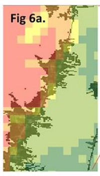


Fig 6b.

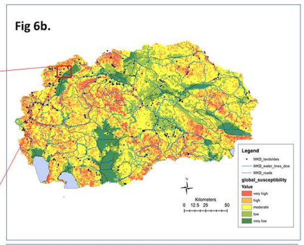


Figure 7. European Landslide Susceptibility Map

Fig 7a.

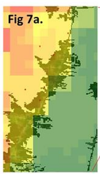
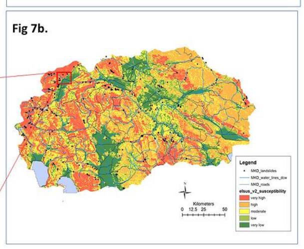


Fig 7b.



Discussion

The significant difference in susceptibility distribution (Table 1) seen in the 248 landslide inventory events across the two models is likely a result of the different parameters used in the raster generating function, and their relative weighting.

The Global Landslide Susceptibility Model incorporates four factors: slope, distance to fault zones and geological regions, presence of roads, and forest loss. The European Landslide Susceptibility Model used three predictive factors: relief, lithology, and land cover.

It is noteworthy that neither of these models explicitly take into consideration soil erosion, which is a significant factor on the sub-regional scale (Milevski *et al*. 2015, 2018). It is possible that erosion plays a less dominant role in modeling landslide risk on a global or continental scale, however erosion is one of the prominent predictive factors in Macedonian landslides.

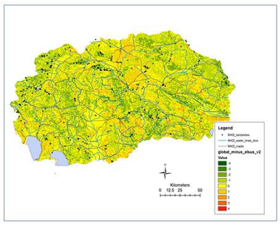


Fig 8. European Map Subtracted from the Global Map

Conclusions

Initial qualitative analysis incorporating landslide event inventory, susceptibility models and GIS approaches reveals significant model differences and dependencies on environmental and socio-economic changes.

Further studies of global to sub-regional downscaling should focus on the sensitivity to a broader range of predictive variables.

References

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