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Human-induced Landslides in Northern Euboea Island, Central Greece

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Introduction

Landslides can be triggered by a variety of physical factors (Bathrellos *et al.*, 2017). Additionally, human activities such as deforestation of slopes, removal of slope support in road cuts, alteration of surface runoff paths, have become important triggers for landslide manifestation (Skilodimou *et al.*, 2018).

The scope of the present study is to identify the influence of human activities on landslide occurrences. To accomplish this scope, the existing landslides along with anthropogenic factors such as road network and land use were used. Statistical analysis and GIS were applied to process and evaluate the landslides and factors. Thus, the spatial distribution landslides and their relation to roads and land use were determined.

Study area

The study area is located in the northern part of Euboea Island, in central Greece. The island is separated from the continental Greece through Euboean Gulf (Figure 1a). The region covers an area of about 93 km^2 and its altitude varies from 0 to 960m. The morphology of the area comprises a northern mountainous land with very steep slopes reaching an altitude of 960 m asl; an intermediate semi-mountainous land with lower altitudes and steep slopes; and a southern coastal area of limited extent with low altitudes and gentle slopes. The drainage networks of the area flow with a main direction from N to S and discharge into the North Euboean Gulf (Figure 1b).

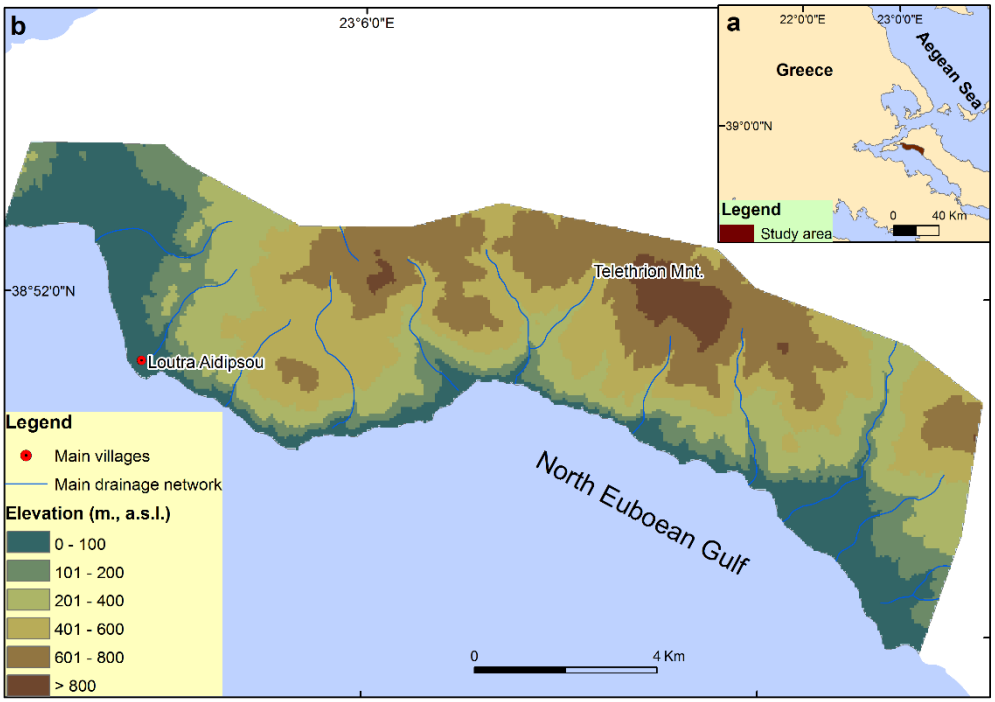

Figure 1. a) Location map of the study area; b) the elevations of the study area, the drainage network, and the main settlements.

Data and Methods

The existing landslides, provincial and rural road network along with land use of the study area are taken into consideration. To accomplish the scopes of the study nine buffer zones of increasing length measured around to each type the road network and five categories of land use were created. The number of landslide events, which were located in each class of each factor was determined. The relative frequency of landslides and the frequency ratio were calculated. The relative frequency of landslides is the ratio between the number of landslide that located in each category of factor and the total landslide events of the study area. To determine the frequency ratio, the area ratio for each category to the total area was computed. Finally, the frequency ratio for each category was calculated by dividing the relative frequency of landslide events to the area ratio.

Results

Table 1 shows the results of the statistical analysis. The relative frequency of landslides reaches its maximum value within

the first 50m of distance from any given provincial and rural road and decreases in distances beyond 50 m from roads. Table 1 presents the computed frequency ratio of landslide events for each buffer zone of both types of road network. According to Lee and Pradhan (2006), the frequency ratio values > 1, indicate strong relationship between landslides and the given buffer zone. The frequency ratio values show that buffer zones with distances smaller than / or equal to 50 m from provincial and rural roads is strongly related to landslide manifestation. In the case of land use, the majority of landslides are located in cultivated areas. The frequency ratio values are > 1 in cultivated land and in bare area, showing a strong relation to slope failures**.**

Table 1. Frequency and frequency ratio values of landslide occurrences into each category of each type of road network and land use.

Provincial roads network buffer zone (m)	**Area (m^2)**	**Area %, (a)**	**Landslides**	**Landslides %, (b)**	**Frequency ratio (b/a)**
10	3,918,733	4	3	12	2,7
25	5,587,498	6	5	19	3,2
50	8,414,607	9	8	31	3,4
75	7,447,923	8	2	8	0,9
100	6,590,960	7	1	4	0,5
150	10,955,038	12	0	0	0,0
200	8,858,134	10	0	0	0,0
300	13,252,325	14	0	0	0,0
>300	27,698,912	30	7	27	0,9
Total	92,736,734	100	26	100	1,0
Rural roads network buffer zone (m)					
10	2757475	3	1	4	1,3
25	3996804	4	2	8	1,8
50	6188115	7	3	12	1,7
75	5630217	6	1	4	0,6
100	5089316	5	0	0	0,0
150	8878116	10	0	0	0,0
200	7472717	8	0	0	0,0
300	12013350	13	0	0	0,0
>300	40710624	44	19	73	1,7
Total	92736734	100	26	100	1,0
Land use					
Urban area	1605997	5	3	12	2,2
Cultivated area	25478977	46	13	50	1,1
Forest	31084154	6	1	4	0,7
Shrubby area	34216126	42	2	8	0,2
Bare area	365310	1	7	27	24,6
Total	92736734	100	26	100	2,2

Conclusions

The frequency of landslides increases in close proximity to roads. A 100m wide zone along with any type of road corridors is strongly correlated with landslide events. The extensive cultivated land and the bare area of the study area are strongly related to landslide activity.

References

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