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Vulnerability Assessment of Buildings and Roads to Shallow Translational Landslides in Santa Marta de Penaguião, Vila Real, Portugal

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Landslides are among the most frequent geomorphologic processes in the planet and every year is considerable the number of human lives lost and the economic consequences related to this phenomenon.
According to the expression proposed by Varnes (1984), risk analysis and cartography combines three major components – the probability of occurrence of a certain phenomenon with a given magnitude, the identification and valuation of the elements exposed to the process and, at last, the degree of loss that those elements are expected to suffer (vulnerability).
Following this idea, the concept of vulnerability can be defined as the degree of loss that the elements in risk are able to experience as consequence of a phenomenon with a particular magnitude (Glade et al., 2005). Essentially, vulnerability refers to the potential loss, damage or destruction of an element (Alexander, 2000).
However, although landslide susceptibility and hazard studies are frequent and the identification of exposed elements can be reasonably easy to achieve, internationally few works have contemplated the spatial assessment of vulnerability (Bell & Glade, 2004). Once the term vulnerability is defined and comprehended in many manners, the quantity of methods and variables selected to its analysis is equally extensive (Hufschmid et al., 2005).
In fact, the difficulties inherent to data collection and the collaboration needed between different sciences experts make studies about vulnerability very expensive, time-consuming and hard to realize (Parise, 2001). This impasse becomes even more serious when it is assumed that quantitative risk assessments make possible the identification of areas where are expected the most important losses and where the mitigation efforts should take place in order to obtain the best harmony possible between cost and benefits (Remondo et al., 2008) in the occupation of territories.
In this context, the present study, integrant part of the research project named "MapRisk", focuses in the contribution to the development of fixed elements vulnerability assessment to landslides, namely buildings and roads.
Taking as work field the council of Santa Marta de Penaguião (70 km^2), localized in the Portuguese district of Vila Real, the main objectives that have structured this study were the identification of the different exposed elements and the estimation of their vulnerability face to shallow translacional landslides.
Considering the concept of vulnerability as the degree of loss of a certain element exposed, expressed in a scale between 0 (no loss) and 1 (total loss), resultant of the occurrence of a process with a certain degree of intensity, this assessment of buildings and roads vulnerability contemplated two vectors – the destructive capacity of the phenomenon and the constructive consistence of the exposed element. Based on these two components we have developed the following formula which results in the classification of vulnerability for different structures: V = DC x (1 - CC)

V – Vulnerability
DC – Destructive Capacity of the landslide
CC – Constructive Consistence

To the area of Santa Marta de Penaguião is available the cartography of susceptibility to shallow translacional landslides conceived by Pereira (2009), equally during the "MapRisk" project. For the identification of the exposed elements and assessment of vulnerability we have mapped more than 8100 buildings and over 301 km of roads, based in ortophotomaps dated from the year 2006.
In this study we also resort to an intensive field research, creating a functional evaluation of almost every structure built, considering its own characteristics (typology, building technique, major building materials, number of floors, state of conservation, . . .); identifying the structures that are affected to civil protection services and distinguishing the different types of roads existing in the study area.

The main results of this study are the identification of the different elements placed in areas of high and very high susceptibility to shallow translacional landslides and the assessment of their vulnerability, in function of the intensity expected for this kind of processes and the construction characteristics of the elements in study. The final cartography produced with this work constitutes a contribute to the analysis of Santa Marta de Penaguião council, allowing to determine the structures that present the highest vulnerability levels face to shallow translational landslides and providing an important instrument to the study and mitigation of the possible consequences resultant of this risk.

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