Landslides on São Miguel Island (Azores-Portugal) in the period 1900-2020: Analysis of the spatio-temporal distribution, triggering factors and impact based on newspapers press articles

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1. GENERAL SETTING

The São Miguel Island (Azores) has an area of 744.6 km² and 133,390 inhabitants, divided into six municipalities: Ponta Delgada, Lagoa, Ribeira Grande, Vila Franca do Campo, Povoação and Nordeste (Fig. 1). The island has three active central volcanoes with summit calderas: Furnas Volcano, Fogo Volcano and Sete Cidades Volcano. These volcanos are linked by two Fissural Volcanic Systems: Picos Fissural Volcanic System and Congro Fissural Volcanic System. The oldest and extinct part of the island corresponds to the Povoação Volcano and Nordeste Volcanic Complex.

The climate of São Miguel Island is Cfb according to the Koppen-Geiger classification. The rainfall occurs throughout the year, although with maximum during the winter. The precipitation is also controlled by the orography: the average annual rainfall ranges from 1,200-2,000 mm near the coast up to 4,800 mm in the highest altitude volcanos in the island.

Since the settlement of São Miguel Island, in the mid-fifteenth century, there was reported the occurrence of landslides, some with high socio-economic impact (Fig. 2). Landslides have been occurred mostly along steepest slopes, such as: interior walls of calderas, fault scarps, coastal cliffs and valley slopes.



Examples of damaging landslide occurrences on São Miguel Island.

2. METHODOLOGY

This work presents the spatial, temporal and impact analysis of landslide events contained in the NATHA (Natural Hazards in Azores) database, registered on São Miguel Island in the period 1900-2020. Data collection was based on the analysis of more than 55,500 newspapers.

Acoriano Oriental and Correio dos Acores were selected as the main press archives (Fig. 3). Both newspapers have a regional coverage. Açoriano Oriental is the oldest newspaper in Portugal, and is still published today. It has been published as a weekly newspaper since April 18, 1835 and as a daily newspaper since January 1, 1979. Correio dos Açores has been published as a daily newspaper since May 1, 1920.



Figure 1

1 - Sete Cidades Volcano; 2 - Picos Fissural Volcanic System; 3 - Fogo Volcano; 4 - Congro Fissural Volcanic System; 5 - Furnas Volcano; 6 – Povoação Volcano and 7 - Nordeste Volcanic Complex.





Figure 3

Examples of newspaper news: (a) newspaper cover of Acoriano Oriental reporting a landslide that caused 29 fatalities in 31 October 1997 (the most damaging landslide event since the beginning of the 20th century) and (b) newspaper cover of Correio dos Açores reporting a landslide that caused 3 fatalities in 13 Mach 2013 (the last landslide event with victims).



3. TEMPORAL TRENDS OF LANDSLIDE OCCURRENCE

1989 show a higher concentration of events.



4. LANDSLIDES TRIGGERING FACTORS

The landslide events were classified according to their triggering factor: rainfall, earthquake, sea erosion and anthropic action. Those cases for which it was not possible to discriminate the triggering factor were classified as unknown. On São Miguel Island, rainfall was the triggering factor responsible for 70% of the landslide events, followed by sea erosion (8%), anthropic factors (4%) and earthquakes (2%) (Fig. 5). In addition, 16% of landslide events were classified as unknown. The landslide events occurred throughout the rainiest months of the year, mainly between November and March (78% of events) (Fig. 6).





7. CONCLUDING REMARKS

A total of 236 landslide events were catalogued on the São Miguel Island in the period 1900-2020 (1.9 events per year, on average). On São Miguel Island, rainfall was the triggering factor responsible for 70% of the catalogued landslide events, followed by sea erosion (8%), anthropic factors (4%) and earthquakes (2%). The landslide events occurred throughout the rainiest months of the year, mainly between November and March, representing 78% of the recorded events. The spatial distribution of landslide events shows that some municipalities are more prone to landslide occurrence: Povoação, Ponta Delgada and Ribeira Grande have the highest number of events, whereas Vila Franca do Campo, Nordeste and Lagoa have a smaller number of catalogued events.

Although the similar number of events in the municipalities of Povoação, Ribeira Grande and Ponta Delgada, the same is not true regarding the impact caused. The Povoação municipality stands out for the high number of events that caused fatalities and high damage, registering 48 fatalities (59% of the total). On São Miguel Island, the mortality was highest in the period 1920-1950, decreasing in the period 1951-1990, increasing again from 1991 onwards. The compilation of data about natural hazards is a key step towards risk analysis. The development of a database represents a fundamental source of information for assessing the spatial distribution, temporal trends, and the impact of natural hazards. In addition it is an important contribution to land-use planning and risk mitigation.



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