RECONSTRUCTION OF THE 1909 HYDRO-GEOMORPHOLOGIC EVENTS IN NORTH OF PORTUGAL: THE IMPORTANCE OF GIS DATABASES.

Reconstrucción de los eventos hidro-geomorfológicos de 1909 en el Norte de Portugal: importancia de las bases de datos en SIG.

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Resumen: Se presenta una reconstrucción de los eventos hidro-geomorfológicos que tuvieron lugar en el norte de Portugal en 1909, considerando el desarrollo de una base de datos construida a partir de la prensa diaria. El año 1909 fue elegido por la asociación entre un gran número de desastres naturales y una crisis político-institucional, logrando estos eventos, por exploración de vulnerabilidades preexistentes, haber contribuido a un creciente descontento con la monarquía, derribada al año siguiente. La metodología se basa en la intersección de los eventos, en SIG, con la cartografía de peligrosidad a inundaciones y movimientos de ladera, registros meteorológicos/hidrológicos y los datos de reanálisis de NCEP/NCAR. Los resultados muestran la validez de la consulta sistemática de los medios de comunicación para la reconstrucción del número, localización y magnitud de eventos extremos, justificando también la importancia de las bases de datos como apoyo a la ordenación del territorio y protección civil.

Key words: Slope movements, floods, database, reanalysis, risk management
Palabras clave: Movimientos de ladera, inundaciones, base de datos, reanálisis, gestión de riesgos

INTRODUCTION

The *Disaster* research project, oriented to the study of hydro-geomorphological disasters, is preparing a GIS database (DB) on floods and slope movements occurred in Portugal during the XX and XXI centuries, with direct consequences over the population. This database aims, above all, to support studies related to risk management, analyzing its spatial distribution, the susceptibility of territories and the vulnerability of exposed elements, constituting a tool for decision support in territory management and civil protection.

Nevertheless, considering its structure and sources of information, *Disaster* DB can be used as a proxy-data for various purposes, including those of socio-economic, political and cultural domains. Indeed, it enables to obtain data on the frequency and magnitude of the events in question, but can also be applied, for example, to studies on social perception of risk (Llasat et al., 2009). From another perspective, this database also allows to analyze the consequences of past events, framing them in its socio-political context and assess the extent to which they may enhance its modification. However, there are still very few studies that address how natural disasters affect political regimes or the outbreak of conflicts, although they may incite or aggravate already instable situations (Abney and Hill, 1966; Nel and Righarts, 2008; Adler, 2009).

Finally, we highlight the potential of *Disaster* DB in the reconstitution of specific extreme events, allowing to step back in time and define evolutionary trends in greater detail, with the advantage that they can be classified and compared, in the case of the events that we are dealing, with secular meteorological records in order to obtain more objective data.

1. OBJECTIVES AND METHODOLOGY

This study integrates the last perspective: it presents a reconstruction of hydro-geomorphological events that took place in northern Portugal in 1909, one of the emblematic years that emerges from the *Disaster* DB by the number and combination of damaging occurrences. With a strong socio-economic and environmental impact, these events happened on the eve of the establishment of the Republic, after the assassination of King Carlos I and his son, heir to the throne. At that time, when Portugal was living a constitutional crisis undermining the monarchy and its values, the occurrence of several natural disasters probably contributed to aggravate the latent conflict. Not only the North of Portugal has recorded great magnitude events: there were major floods in Mondego and Tejo rivers affecting large areas (Azevedo et al., 2006), and earthquakes like the one of Benavente, that is considered the most destructive of the last century in Portugal (Senos e Carilho, 2003). If the political-institutional crisis had historical, socio-economic and cultural roots, no doubt that natural events, exploring pre-existing vulnerabilities, may have contributed to increase popular discontent. However, we do not approach these issues, leaving them as a clue to future work.

The methodology followed in the reconstruction process and analysis of 1909 floods and slope movements, was based on records of *Disaster* DB, but involves all the events reported in the a selected newspaper - *Jornal de Notícias* (JN) - regardless of whether they involved deaths, wounded, missing or displaced people. These events were projected, in a GIS environment, over the hazard maps developed under the PROT-Norte issue. To assess the information source relevance, we proceeded comparing the number, location and date of the reported events with meteorological and hydrological available records. We've also used the reanalysis data of NCEP/NCAR to visualize the precipitation anomalies in some of the most problematic dates, in part to address the lack of weather stations with long enough series to cover the period and study area (Compo *et al*, 2011).

2. RESULTS AND DISCUSSION

2.1. The 1909 floods.

The 1909 year can be considered exceptional in terms of the number of recorded floods in northern Portugal. Projecting the DB occurrences on the hazard map, there is an obvious correlation with the areas identified as medium and high hazard, even considering the emphasis given to the events registered in the main rivers and those of greatest impact on the exposed elements, given their incidence in the areas having, at the time, a higher population density (fig.1).

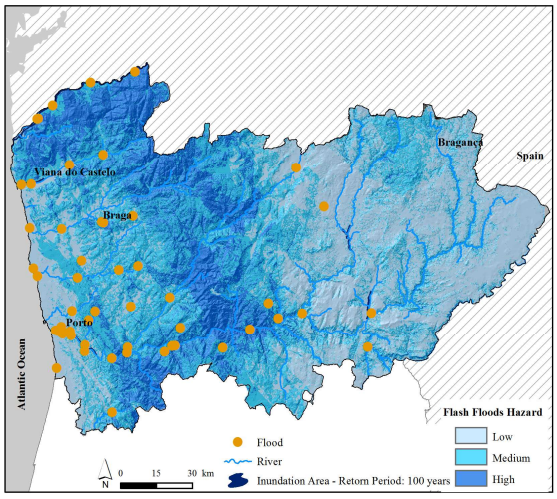


Fig.1.Distribution of 1909 floods in northern Portugal.

But the flood that has assumed greater prominence was developed in the Douro river at the end of the year. The JN of 21 December refers the *(...) endured harsh winter that has been as rigorous as for many years not felt* [which] *resulted in a flood of our Douro river.* Facing that, in Miragaia waters started *(...) to break and spread to that location, making it a picturesque Venetian canal.* The next day it was written that *(...) the waters reached up almost to the middle of Ribeira square,*

whose establishments were flooded [and in Miragaia] *there are two boats...leading people to their homes or from these to the street.* At December 24, was notorious the *(...) fear and desolation...the waters rising even above the height of the 1860 flood, that in memory of old people, until now, was appointed as being the largest that had been in Oporto*. In the event aftermath, between December 27 and 30, there were news about the *(...) large number of deaths, the great economic loss, shattered buildings, lost crops, shipwrecks…poverty and hunger* [such that Douro flood was reported] *in Paris newspapers.*

These transcripts reflect the information revealed by the available data and literature: the 1909 Douro flood was the largest during the twentieth century (fig. 2), reaching in Régua a discharge of 16700m^3/s, value that exceeds the threshold of 10000m^3/s defined by Rodrigues, Brandão & Costa (2003) for exceptional floods in this river, and overcoming the height of +6.00m measured near D. Luiz bridge. This height implies the flooding of Ribeira docks, since it is situated at +5.90m, but when this happen Miragaia (+4.19m) is already 'submerged' (Aires Pereira & Azevedo, 2000).

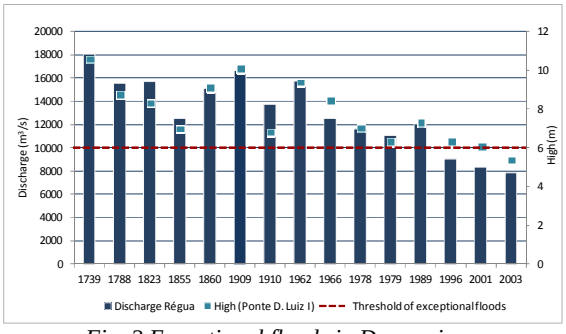


Fig. 2.Exceptional floods in Douro river.

The registers of Serra do Pilar meteorological station, shows a prolonged sequence of days with precipitation since late November, particularly important from December 17, when are notice the early reports and flood warnings. At December 22 were attained 63mm of rainfall, and the accumulated precipitation approached 700mm (fig. 3).

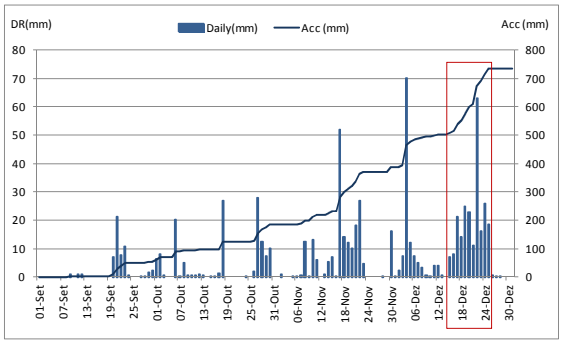
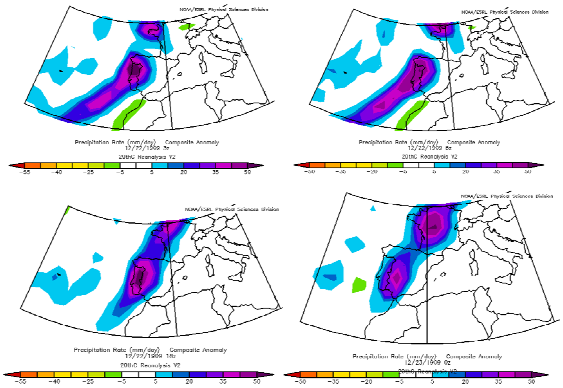


Fig.3. Values of daily and accumulated rainfall between September and December of 1909.

The reanalysis data of NCEP/NCAR, illustrates precisely the important precipitation values that occurred in that day, reaching higher quantitative



overnight, with an estimated anomaly greater than 50 mm at 3 pm of December 22 (fig. 4).

Fig.4.Precipitation reanalysis for December 22, 1909.

2.2. The slope movements.

During 1909, there were accounted 52 slope movements, 86% of which in December, and particularly on day 22 (fig. 5).

From the descriptions of the newspaper, they mostly correspond to rock and debris falls, as suggests the extract we transcribe: *(...) several trenches fall at various points of Douro railway...yesterday morning…an extensive trench collapsed...Finished the transshipment, the train left to Régua, but when passing among Chancelleiros and*

Ferrão stations, was collected by stones and trees that fell from a trench causing heavy damage. Remedied the accident, the train followed again to Régua, where he was detained four hours and a half, due to line interruption…given the landslides that happened during the night (JN, December 21).

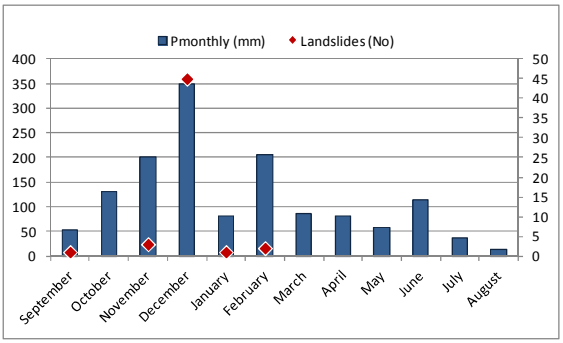


Fig.5. Precipitation and slope movements values, 1909.

Most of the movements registered in 1909 were in fact observed in the middle section of Douro Valley and nearby the railway, verifying that, such it happens with floods, a significant correlation with the areas of middle and high hazard to slope movements previously defined (fig. 6).

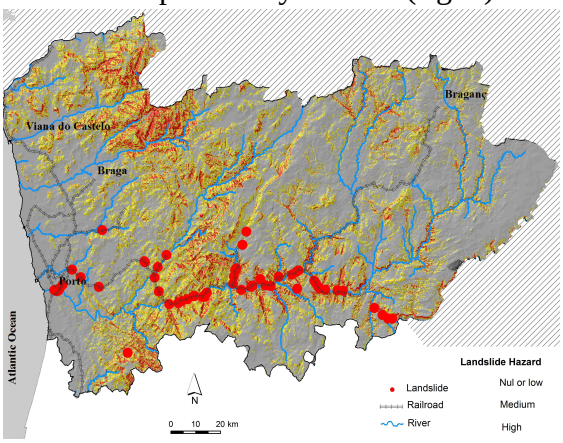


Fig 6. Spatial distribution of slope movements.

3. CONCLUSIONS

The natural disasters inventories, aiming the development of databases and their manipulation in a GIS environment, is a key initial step for the application of temporal/spatial predictive models, with direct applications in territory management. This study demonstrates that press news can be used as *proxy-data* to estimate flood and slope movements evolution, trough a systematic consultation that allows the reconstitution of number, location and magnitude of extreme events. Indeed, there is a positive correlation between the news about floods and landslides reported to northern Portugal in 1909 (duly organized in a GIS database), the meteorological/hydrological records, and the hazard cartography previously prepared for the same territory.

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