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Improvement of resilience of urban areas by integrating social perception in flash-flood risk management

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SUMMARY

In urban areas prone to flash floods, characterization of social resilience is critical to guarantee the success of emergency management plans. In this study, we present the methodological approach that led to the submission and subsequent approval of the Civil Protection Plan of Navaluenga (Central Spain), in which the first phase was to analyse flood hazard by combining the Hydrological Modelling System (HEC-HMS) and the Iber 2D hydrodynamic model. We then analysed social vulnerability and designed measures to put into practice within the framework of the Civil Protection Plan. At a later phase, we assessed citizens' flash-flood risk perception and level of awareness regarding some key variables of the Civil Protection Plan. To this end, 254 adults representing roughly 12% of the population census were interviewed. Responses were analysed descriptively, comparing awareness regarding preparedness and response actions with the corresponding information and behaviours previously defined in the Civil Protection Plan. In addition, we carried out a latent class cluster analysis aimed at identifying the different groups present among the interviewees. Our results showed that risk perception is low. Specifically, 60.8% of the interviewees showed low risk perception and low awareness (cluster 1); 24.4% had high risk perception and low awareness (cluster 2), while the remaining 14.8% presented high long-term risk perception and high awareness (cluster 3). These findings suggest the need for integrating these key variables of social risk perception and local tailored information in emergency management plans, especially in urban areas prone to flash-floods where response times are limited.

1. Introduction

Small and medium size catchments, i.e., catchments with a drainage area up to a few hundred square kilometres (Kelsch, 2001), often respond rapidly to intense rainfall events and/or orographic forcing of precipitation because of the strong connectivity between their high slopes and quasi-circular morphology (Ruiz-Villanueva et al., 2010). Additional physical properties, such as the fraction of impervious area, land uses and soil types, together with time-varying states like soil moisture, will also help to modulate the flash flood potential of heavy rainfall (Hapuarachchi et al., 2011).

The context described above is highly prone to extreme precipitation events, in terms of both total volume and intensity. The resulting floods have a rapid hydrological response, characterized by "peaky" hydrographs (i.e., short lag time). The flow peaks are reached within a few hours, thus giving little or no advance warning to mitigate flood damage (Borga et al., 2007, 2008). This hydrological response leads to the occurrence of a typology of floods known as flash floods because of their rapid onset, i.e., within six hours of rainfall (Ogden et al., 2000; Delrieu et al., 2005; Marchi et al., 2010; Hapuarachchi et al., 2011; Naulin et al., 2013; Ballesteros-Canovas et al., 2015).

Because of the rapidity and suddenness of their onset and their high intensity over a relatively small geographic area, flash floods pose a significant threat to human systems world-wide. Compared to river flooding, flash floods provoke a higher average mortality as they are usually unexpected events which evolve rapidly and affect relatively small areas. In contrast, river flooding affects

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considerably larger areas and many more people, but results in lower casualties per event (Jonkman, 2005; Jonkman and Vrijling, 2008). Therefore, the characteristic hydrological response in flash floods may result in high social risk, as occurred, for instance, in northern Venezuela in December 1999, where a high-magnitude storm triggered debris flows and flash floods that killed about 15,000 people (Larsen and Wieczorek, 2006), or in the 1997 Biescas disaster in the Central Pyrenees, Spain, in which a flash-flood caused the loss of 87 lives at a camp site located on an active alluvial fan (Benito et al., 1998). In fact, according to Barredo (2007), 40% of flood-related casualties in Europe between 1950 and 2005 were caused by flash-floods.

The main difficulty in flash-flood risk management is related to their rapid occurrence and the spatial dispersion of the urban areas that may be affected by this typology of water-related hazard. As a result, the socio-economic environment is impacted on a spatio-temporal scale that implies short warning lead times (Creutin et al., 2009). In this respect, the short time available for minimizing risks requires preparedness and response actions to be put into practice (Faulkner and Ball, 2007). This management strategy is mainly focused on emergency management or civil protection actions involving the implementation of coordinated actions, both to prevent flash-floods from happening and to minimize their effects once a given event has occurred (Alexander, 2002; Zerger and Smith, 2003). Within this framework, three levels of action can be identified: (i) monitoring and forecasting, aimed at detecting threats by determining threshold runoff estimates (Verkade and Werner, 2011), (ii) prevention measures comprising either structural or non-structural actions; and (iii) the development of emergency response plans to evacuate and rescue people in the context of a flash-flood hazard (Wilhelmi and Morss, 2013).

However, risk management based solely on the technocratic approach described above may give people a false sense of security (Adams, 1995), since the social dimension of flash-flooding is not integrated in the management process (Lara et al., 2010). Therefore, understanding the characteristics of local communities should be a priority in order to enhance community resilience during a flash-flood. In this regard, the extent to which a community can demonstrate resilience after a flood largely depends on human perception, which in turn is related to the social context in which a given event occurs (Wickes et al., 2015). Moreover, the social perception of flash-flood risk depends on different psychological variables, including intuitive evaluation of risk and qualitative reflections such as fear and trust in decision makers (Figueiredo et al., 2009).

This paper aims to assess the flash-flood risk perception of the inhabitants of the village of Navaluenga (Central Spain), as well as the level of awareness of civil protection and emergency management strategies developed with the main objective of safeguarding people and assets exposed to particular threats derived from flash-flood occurrence.

2. Materials and methods

2.1. The study area and its problems with relation to flash-floods

The municipality of Navaluenga is located in Central Spain on the banks of the Alberche River, between the Sierra del Valle

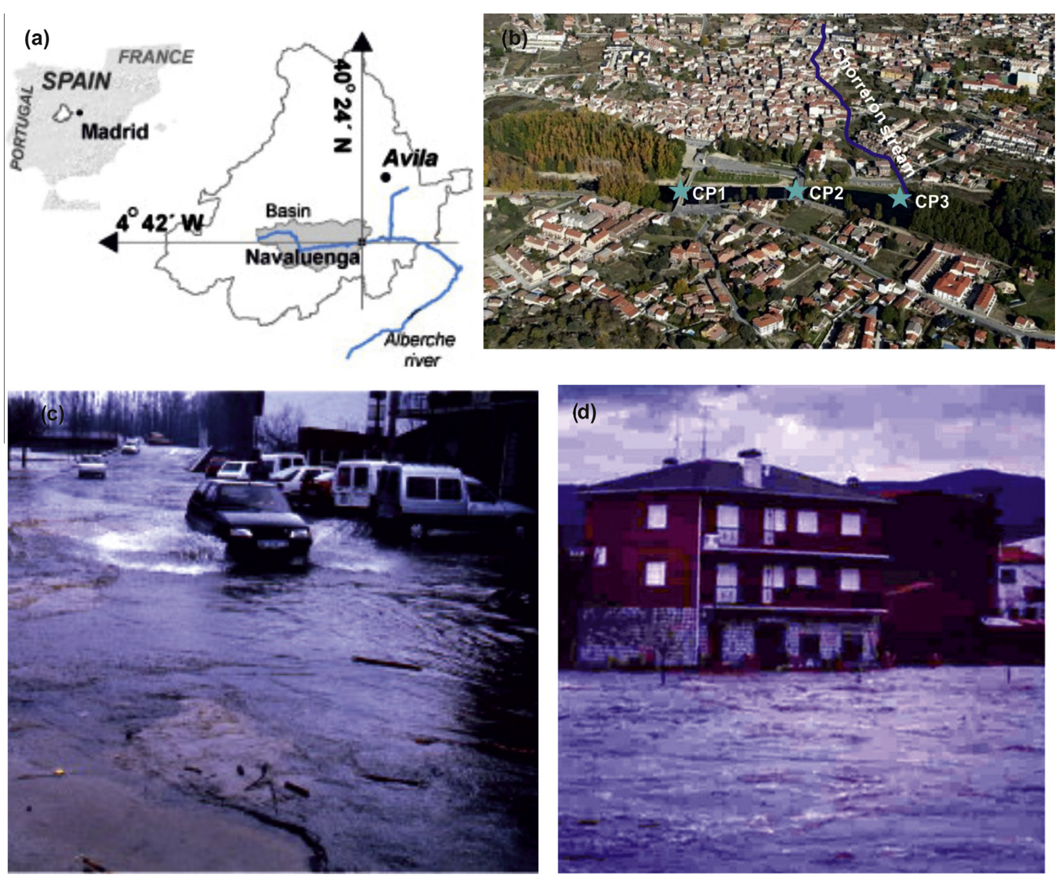

Fig. 1. (a) Location of the study site; (b) aerial view of Navaluenga showing the course followed by the Chorrerón Stream. CP1, CP2 and CP3 are conflicting points, which increase flood hazardousness. The first two are associated with bridges. The third is located at the confluence of the Chorrerón Stream and the Alberche River. Pictures (c) and (d) show floods that occurred in Navaluenga.