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MAPPING IT OUT: A USER-CENTRED DESIGN FRAMEWORK FOR WEBGIS PUBLIC WARNINGS

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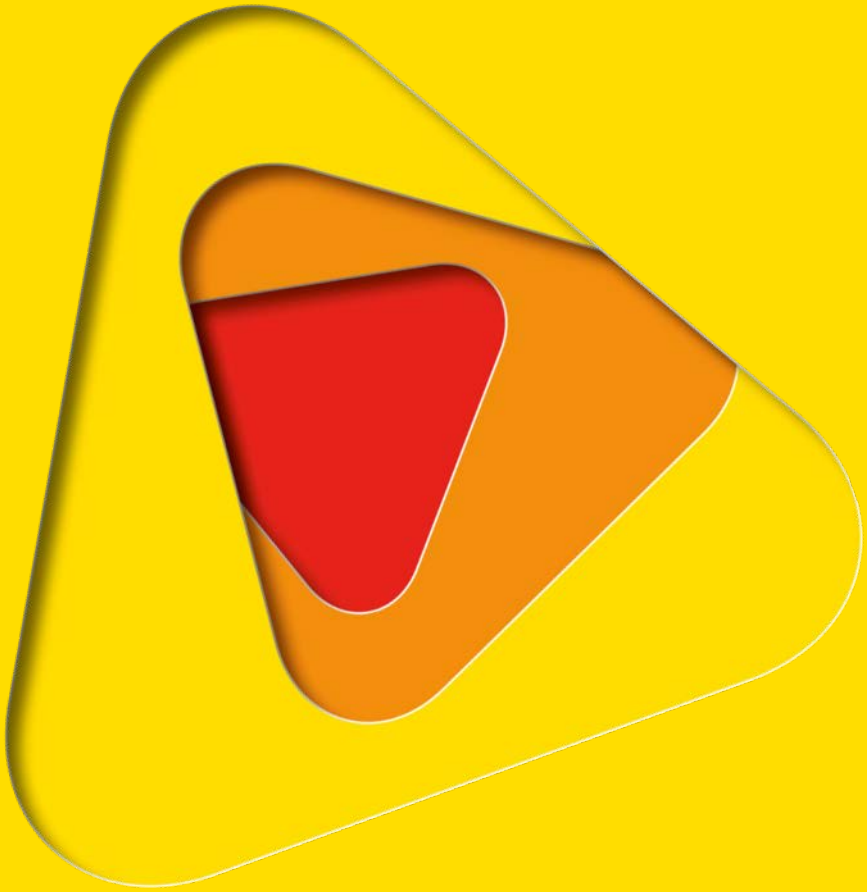

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ABSTRACT

Hazard early warnings play a critical role in protecting lives and reducing property loss by providing information to citizens in a timely manner (Quarantelli, 1984). In recent decades, the way in which hazard related information is collected, managed and analysed has been revolutionised by geospatial technologies, such as Geographic Information Systems (GIS), Remote Sensing (RS) and Global Positioning Systems (GPS). Used in all phases of the disaster management cycle, GIS technologies allow for the integration and visualisation of a diverse range of spatial information (in the form of maps) during response and recovery as well as in the planning for and mitigation of hazards.

The effectiveness of maps has long been recognised for conveying the spatial and temporal dimensions of hazard conditions (Dymon, 1990, Hodgson and Cutter, 2001). In general, maps are demonstrated as essential tools for facilitating spatial cognition and aiding spatial reasoning (MacEachren, 1995). The contemporary interactive maps supported by either desktop- or web-based GIS technologies have experienced increasing attention for the ability to integrate a multitude of information whilst maintaining a suitable degree of complexity with ease of understanding (Dransch et al., 2010). The use of maps for decision support and communication however, occurs primarily within and between emergency management agencies. When it comes to communication with the public, hazard warning messages are still predominantly transmitted in textual or verbal forms and apply generically to large geographic regions. Recently, researchers have highlighted a need for map-mediated delivery of risk information to the public through WebGIS supported applications (Dransch et al., 2010). In addition to the inherent nature of maps for delineating spatial related risk information, WebGIS technologies also allow for location-based personalisation of maps, providing for a higher degree of contextualisation whilst overcoming the complex cognitive challenges of risk communication (Dransch et al., 2010). The applicability of such instruments is further supported by the advent of smart phones and wireless data communication technologies, which conjointly promise geographical targeting of at-risk population (Bennett et al., 2013) as well as real-time online dissemination of enriched content (e.g. images, videos, and mapping applications, etc.) (Dransch et al., 2010).

In addition to a clear need to increase the development of risk communication maps, researchers have stressed a growing necessity and importance of user-centred evaluation for designing usable and effective maps (Haynes et al., 2007, Dransch et al., 2010). This means that, rather than simple data fusion, effective hazard/risk mapping tools should be designed by assessing what is needed by the end-users (i.e. the public) to achieve the communication goals (Dransch et al., 2010, Lieske, 2012). It is underscored that such assessment is distinctive from the usability test in the sense of designing ordinary visual communication systems due to the profound psychological component of human perception and response to hazard/risk maps (Handmer, 1985, Lieske, 2012). However, a thorough search of literature only uncovered several general 'frames' for the development of user-centred risk maps, especially focusing on communicating *long-term* probabilistic risk (e.g. risk of climate change) (Haynes et al., 2007, Dransch et al., 2010, Lieske, 2012). There exists no precedent for the design of map-mediated *early warning* instruments to inform impending threats. In fact, the limited number of public warning maps that have been developed to date has generally been designed based on the subjective judgment of those creating the messages (i.e. cartographer, technician or emergency management personnel). For example, local authorities have recently started to release static or simplistic interactive maps over the Internet vaguely depicting incident locations to supplement the text warnings. The intention of such a mapping approach, although unsubstantiated, is potentially driven by a series of common emergency management myths, such as the public are not fluent map readers and may be overwhelmed with large amounts of highly accurate information (Sorensen,

2000). In addition, online mapping portals (e.g. Liu and Palen, 2010, USGS 2012) often focus on integrating and presenting an assortment of hazard and risk information (e.g. wind, topography) neglecting critical warning elements such as response guidance. What remains unknown is whether, and exactly how, the heterogeneous mapped information is understood and used by the recipients to understand risk and undertake appropriate actions (Haynes et al., 2007).

To address this void, this paper describes a user-centred framework utilised as the methodological foundation for designing an innovative WebGIS based bushfire early waring tool. The overall methodology draws upon the rich body of literature that investigates and illustrates user-centred design approaches for developing map-based visualisation tools in other domains (e.g. Robinson, 2005). Measurement of *effectiveness* of the bushfire mapping tool is defined based upon the cognitive objectives of public early warnings in general, which concerns three major aspects: 1) whether the (mapped) information is comprehended; 2) whether risk perception is facilitated; and 3) whether adaptive behaviours are stimulated (Mileti and Sorensen, 1990). The adapted research workflow is shown in figure 1. Initially, a conceptual model was conceived to facilitate individuals' risk perception and decision-making through location-based map presentation, and personal risk assessment and decision support. The following two critical design questions were then addressed: i) what information should be communicated, and ii) how can maps be designed to effectively present the information.

A two-phase user assessment approach was established to answer the design questions. First, a collection of hazard/risk information elements and associated cartographic representations were collated based on existing bushfire warnings and mapping schemes across Australia. A *users' needs assessment* was then conducted via an online survey with residents from bushfire prone areas, seeking to investigate the extent to which maps are more or less effective than texts in terms of understandability and promotion of risk perception. The survey also identified the most effective cartographic methods for representing and communicating a diverse range of hazard/risk related information elements. The survey findings showed a corroborated efficiency and effectiveness of maps (in contrast with texts) for communicating a majority of bushfire information. Based on the findings, a web-based bushfire information mapping tool was prototyped to integrate and deliver a range of information through texts, maps, or a combination of both. The second assessment phase, *usability and effectiveness evaluation*, was subsequently conducted using the prototyped web-based bushfire information mapping tool through 'think aloud' interviews with individual residents, to examine the ease-of-use of the tool and investigate how each bushfire information element is interpreted and used by residents in their cognitive procedure of perceiving risk and making decisions. In addition to illustrating a first user-centred approach to the development of a bushfire warning tool, the presented research framework can provide a general structure to guide user-centred design of map-mediated risk communication tools for a range of other hazards. More specifically, it demonstrates how design questions, evaluation attributes and assessment methods can be defined and formulated in a way that gives the user a central role.

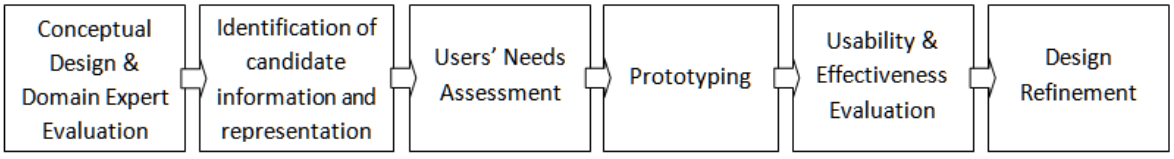

Figure 1. The user-centred research workflow for designing map-mediated public warning tools, adapted from Robinson (2005).

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