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# A collaborative (web-GIS) framework based on empirical data collected from three case studies in Europe for risk management of hydro-meteorological hazards

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ABSTRACT

This paper presents a collaborative framework of an interactive web-GIS platform integrated with a multi-criteria evaluation tool. The platform aims to support the engagement of different stakeholders and the encouragement of a collaborative, decision-making process for flood and landslide management. The conceptual framework is based on initial data collected from field visits and stakeholder meetings carried out in the case study areas of the CHANGES[3] project: the Małopolska Voivodeship of Poland, Buzău County of Romania and the Friuli-Venezia-Giulia region of Italy. Based on the needs and issues identified in each case study, this paper also presents how such a platform could potentially assist and enhance the interactions between risk management stakeholders in formulating and selecting risk management measures. The developed prototype was presented to the local and regional stakeholders of the study areas and feedback was collected to understand the stakeholders' perspectives in determining whether the platform is useful and applicable for their activities in risk management. Feedback from stakeholder responses indicate that stakeholders found the prototype not only useful, but innovative and supportive in potentially assisting their activities. However, feedback also highlighted several aspects of the platform that can be improved for the development of a full-scale system to apply in practice. This includes the engagement of stakeholders toward higher levels of participation and a more extensive evaluation of the platform by carrying out concrete group exercises in the study areas.



## 1. Introduction

In broad terms, collaborative decision-making within the context of disaster risk management can be defined as the "combination and utilization of resources and management tools by several entities to achieve a common goal" ([27], p. 366). Collaborative interactions are increasingly required under complex decision-making processes to facilitate knowledge and contributions of different stakeholders and actors towards better-informed decisions [12,15]. These interactions may evolve throughout the different stages of a decision-making process [26,35,7]. In practice, decision-making processes for risk management vary depending on a variety of factors including which stakeholders and actors are involved in the process, what are the mechanisms of deliberation, what are the values and interests of the involved parties, and the spatial distribution of risks. In the case of widespread spatial distribution of risk, for example, multiple municipal jurisdictions and higher (whether it be regional or even national) levels of authority will be involved in the management process. The degree to which different actors are involved depends also on the legal and regulatory structure in place which can prescribe both formally and informally the roles and responsibilities of the different actors.

The term "actor" is understood as apart from the term "stakeholder" as it describes the agents of action in decision making, referring quite literally to who can take actions and have power in

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the decision-making process. Borrowing from Scharpf ([41], p. 43), actors are identified as individuals or entities "…that are actually involved in the policy process and whose choices will ultimately determine the outcome". In a broader sense, the term "stakeholder" means any individual, group, or organization which has an interest in the issue at hand, as well as those who are potentially affected by decisions, actions, and plans ([5], p. 87), including individuals who are not aware that they will be affected. There are overlaps between the two terms where, for example, a mayor has both an interest and power in decision making for reducing risk in his or her community. In contrast, a member of the general public may have an interest in the outcome of a risk reduction measure decision but might not have any power in the decision-making process.

It is important to establish an understanding of the key actors and stakeholders as they often determine priorities for risk reduction goals and influence the formulation and selection of risk reduction measures. The outcome of the selection of measures varies depending upon the perceived benefits of these measures given the available information. Risk management measures targeting flood and landslide risks must also account for information including both the temporal and spatial dynamics of the hazard itself and the distribution and vulnerability of elements at risk [16]. Regardless of either a temporary or permanent period of implementation, measures can be categorized into structural and non-structural as well as passive and active measures [22,25]. According to [22], structural measures distinguish physical engineering from more organizational and institutional measures. Active measures attempt to alter hazard characteristics to reduce consequences. In contrast, passive measures are based on the separation of elements at risk from the hazard itself. Uncertainties in the spatial-temporal distribution of risks often require a combination of measures, grouped into management alternatives. Hence, the identification of potential alternatives is a continuous iterative process to achieve a specific combination of measures towards implementing risk management strategies [24]. In addition, the complexity of the decision-making process increases due to the different and competing objectives which should be considered in the evaluation of alternatives (for example, immediate vs. sustainable benefits in the long term). According to Balbi et al. [6], decision criteria are related not only to direct costs or benefits from the implementation, but also to other indirect and non-tangible aspects such as socio-economic development and environmental protection. Consideration of these many aspects supports the use of multi-criteria evaluation (MCE) tools that can facilitate the evaluation of the variety of consequences in a risk management problem without measuring them only at the monetary scale [30]. These tools can be used in combination with GIS and spatial information technologies through online platforms to reach and involve a wide range of stakeholders and actors in the decision-making process.

Due to the rapid development in modern web, GIS, and spatial information technologies, it has become possible to deliver and communicate risk information to a wider range of communities, facilitating the participation of different stakeholders in collaborative decision-making. Rapid exchange of spatial information can be enabled through web-GIS platforms shared by several entities allowing access to risk related information at various spatial and temporal scales. These platforms can feature decision support systems (DSS), which are widely recognized as computer-based systems developed to assist decision makers through interactive tools to enhance understanding of a management problem [39]. DSSs generally go beyond the need of centralizing all necessary information while assisting in the interpretation of available knowledge, formulation, and evaluation of choices [37]. Such systems can thereby assist problem analysis without taking over the decision maker's responsibility for their choices and actions [21]. The main goal and expected outputs of the decision support applications should be discussed and agreed with those who are involved in the use of these applications. Prototypes of these decision support applications provide a form of user requirement analysis [14] and can facilitate the contribution and integration of the needs of potential users, evaluation and potential improvement of the support system itself [31].

In this study, we proposed a collaborative decision support framework for the management of hydro-meteorological risks, integrating an interactive web-GIS interface with a MCE tool. The aim was to assist stakeholders in the formulation of potential risk reduction measures and the elucidation of criteria preferences for the selection of those measures. The preliminary empirical inputs of the framework were based on initial data collection methods in the form of semi-structured interviews and observations obtained from field visits and stakeholder meetings carried out in three case study areas of the CHANGES project: the Małopolska Voivodeship of Poland, Buzău County of Romania and the Friuli-Venezia-Giulia region of Italy (as shown in Fig. 1). These cases were chosen primarily based on their physical characteristics. All are located in mountainous areas prone to hazards including; flash floods, river floods, landslides, and debris flows. A prototype platform was developed based on these preliminary empirical inputs and then presented to the stakeholders for feedback during the dissemination meetings of the CHANGES project.

The structure of this paper is organized as follows. Section 2 introduces the need for collaborative decision-making and interactions. Section 3 discusses important considerations in the development of a collaborative decision-making tool based on initial data collection from the case study areas, including for establishing an understanding of the key actors and about the potential for application of a web-based collaborative decision support platform. Section 4 describes the proposed collaborative decision-making framework. Section 5 presents the feedback collected for the prototype in the different study areas and discusses how it could support and enhance collaboration and exchange activities between the participating actors. Finally, we conclude this paper by discussing the presented framework and its potential for in-practice implementation along with relevant aspects for platform improvement.

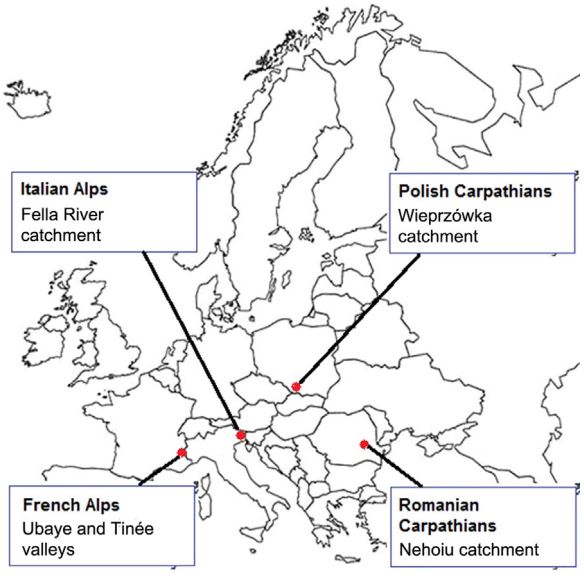


**Fig. 1.** All case study sites of the CHANGES project (Source: [34]).