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Collaborative decision making in selection of risk management strategies through an interactive web-GIS based platform

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Extended Abstract:
This paper presents a collaborative decision making tool through the design and prototype implementation of an interactive and participatory web-GIS based platform. The platform aims at supporting the engagement of different stakeholders and collaborative group decision making in the selection of risk management strategies and concrete measures. The conceptual framework of the prototype platform was initially based on the observations obtained from field visits and stakeholder meetings carried out in the case study areas of the CHANGES project: Buzău County in Romania, the Friuli-Venezia-Giulia region of Italy and the Małopolska region of Poland. The needs and viewpoints of different stakeholders in implementing measures realized through findings from case study field observations are taken into consideration and integrated in this conceptual framework and overall development of the prototype tool. Based on those needs, this paper presents a prototype web tool to potentially assist and enhance the interactions between risk management stakeholders in proposing and selecting alternatives particularly for targeting preventative measures for flood and landslide management based on interactive web-GIS and multi-criteria evaluation (MCE) tools. As a final part of the prototype development process, additional stakeholder feedback and suggestions to the prototype are discussed to understand the stakeholders' perspectives of whether the proposed platform is useful and applicable for their activities.

INTRODUCTION

Collaborative decision-making is among the most participatory levels of stakeholders' involvement (Neuvel and Van Der knaap, 2010) and it generally takes place in decision-making processes with 'active' involvement of stakeholders. This 'active' involvement draws from the concept of 'active participation' in policy and literature often focused on public participation (EC, 2003; Arnstein, 1969; Rowe and Frewer, 2000). The research expands this term and is understood within this research to reflect the need for ownership in a given decision making process in which stakeholders contribute ideas, influence decision making criteria, and assist in selecting a final action (including non-action). Multi-stakeholder engagement is a catalyst for proactive commitment in disaster issues. However, one of the main problems in risk management is the lack of good communication, efficient and effective coordination and collaboration between the agencies, services and organizations in charge of risk prevention, mitigation and management (De Marchi and Scolobig, 2011). In this matter, web-GIS based decision support tools could support the engagement of relevant stakeholders to propose and select risk management solutions bound to a certain risk prone location. In complement to the attention drawn on collaborative participation, the research also addresses the widely recognized need for adaptive risk management strategies under changing environments. Particularly European mountain regions, there is a need to widen the range of appropriate and innovative cost-effective and sustainable risk management alternatives (Holub et al, 2012).

In the case study areas of the CHANGES project, effectiveness and sustainability is particularly relevant due to 1) the limited financial funds; 2) the (in several but not all cases) outmigration problem more in the mountainous areas[1] and 3) the lack of coordination activities between authorities dealing with risk management. There is a need to make efficient use of the resources and to identify the most efficient alternative option in a long-term perspective by taking into account the existing socio-economic and environmental objectives and cost-benefits of each alternative option during the decision making process. This in turn highlights the importance of collaborative decision making and coordination between different stakeholders to achieve the common goal within existing constraints (Prenger-Berninghoff et al, 2014).

Therefore, in this research, we present an online collaborative prototype platform to assist the stakeholders in creating and selecting risk mitigation alternatives interactively through the use of web-GIS tools and Multi-Criteria Decision Making (MCDM) approaches. This enables a more transparent and better informed decision making process with the use of provided risk information. The decision making process can benefit from the use of such techniques as they can be used to facilitate the process by making it more explicit, rational, and efficient (Hobbs et al. 1992). According to observations and informal interviews carried out in the study areas, there is no such existing collaborative decision support platform with involvement of stakeholders from different sectors. There are several information platforms and inventory databases that exist mainly for emergency preparedness and response activities as well as some hazard information inventories. Therefore, developing such kind of platform would be beneficial to the community and could help facilitate coordination across sectors, supporting also the kind of coordination called for under the Hyogo Framework for Action (United Nations, 2005).

FRAMEWORK OF THE PROTOTYPE

The proposed prototype platform (Figure 1) is composed of a two-phase workflow in which the experts propose the preliminary risk mitigation options (i.e. Step 1: Identification of possible risk reduction options) followed by a group decision making process in selection of alternatives using the objectives and preferences of the involved decision makers (i.e. Step 2 to 4: from the formulation of criteria to the comparison of different ranking outcomes). The three types of users are involved in the platform: administrative users, expert users and decision makers. The administrative users of the platform can adjust the involvement of the other users depending on their respective roles and responsibilities in a certain study area.

[1] For example, in Italian study area, large-scale and high cost structural mitigation works have been implemented due to the desire to reverse outmigration in the area and in order to protect the existing small settlements. This shows the needs to consider other important criteria and weigh the benefits of alternatives against long-term maintenance and residual risk consequences for the future development.

They act as ‘gatekeepers’ with the ability to control accessibility of the platform for different users. The expert users include, for example, geologists and spatial planners while, decision makers are composed of, for example, the mayor of a municipality, civil protection, a water board, public representatives, including expert users. The combination of an interactive web-GIS interface with a MCE approach allows the expert users not only to share risk information and propose alternatives interactively but also to assist the decision makers in decision making processes under a collaborative framework.

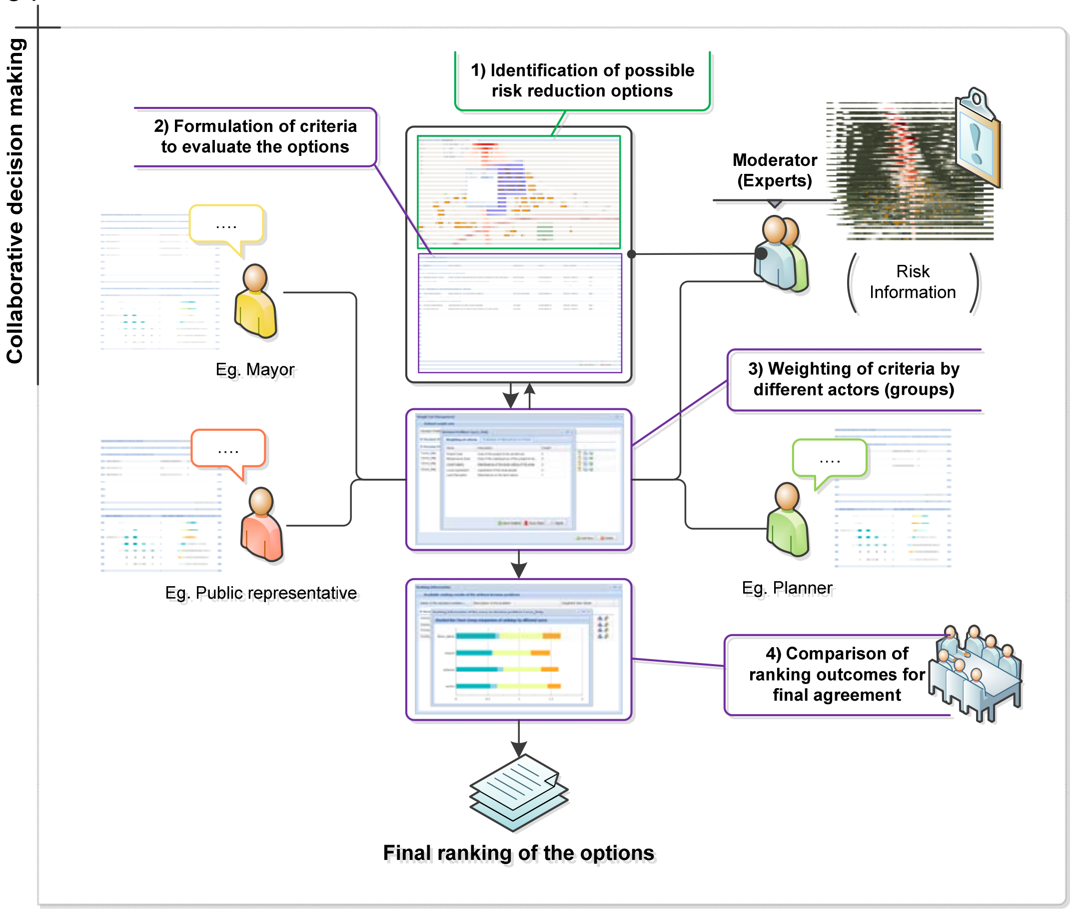

Figure 1. Illustration of collaborative decision making framework with different stakeholders.

In the first phase (i.e. step 1), the *expert users* can formulate their own preliminary draft (sketches) of different risk mitigation measures (structural and non-structural) using the interactive web-GIS interface based on the available risk information. Regardless of the type of measures, adaptation planning and development of management options can be grouped into four management strategies: protection, accommodation of infrastructure, strategic retreat, and the action of ‘doing nothing’. Table 1 illustrates a list of optional measures.

Table 1. Example of potential measures according to the management strategy (based on de Bruin et al, 2009; Holub and Hubl, 2008; Niven and Bardsley, 2013).

Management strategies	**Structural**	**Non-Structural**
Protection	Technical protection measures implemented along the catchment, channel track or deposition area	Soil bio-engineering, forest measures, spatial planning and land-use, private insurances

Accommodation of infrastructure	Local structural measures, adapted building design, maintenance and planning of hydraulic structures	Adjustment of forest management
Strategic Retreat	Exclusion zones	Establishment and management of protected areas
Do Nothing	No specific action is carried out.	

This phase, therefore, allows expert users (i.e. geologists and planners in this case) to interactively propose and categorise the preliminary risk reduction alternatives based on their expertise and local knowledge of the territory. This is a preliminary but essential step towards combined management strategies for a risk prone area. Moreover, providing planners access to such kind of platforms would be useful for information exchange and the development of spatial plans and regulations in the hazard prone area (Prenger-Berninghoff et al, 2014).

In the second phase (i.e. from step 2 to 4), the proposed alternatives identified by the experts in the first phase are used as inputs for evaluation and ranking of the potential alternative options with all involved decision makers. During the *step 2*, expert users can propose criteria to evaluate the preliminary alternatives. Each criterion can be assigned as qualitative or quantitative indicator, for example, number of people and buildings at risk, agreement of local population on alternatives, etc. Then, in *step 3*, each decision makers can assign the weights on each criterion depending on their own preferences and valuations, and can also propose additional criteria and alternatives to the expert users by commenting in the platform. Finally, in *step 4*, based on each outcomes of the weighting and evaluation process, the decision makers can compare and visualize their ranking of alternatives in order to reach the final agreement. The ranking of alternatives is calculated based on Compromise Programming method[2] in this prototype platform. This method is applied to identify alternative solutions which are closest to the ideal one by distance values. This ideal solution is based on the extreme (best or worst) value of each criterion considered depending on the types of the criteria (cost or benefit). The distance value of each alternative is “a function of the criteria values themselves, the relative importance of the various criteria to the decision makers, and the importance of the maximal deviation from the ideal solution” (Simonovic, 2010, p. 274). In the platform, the decision makers can not only assign weights and rank the alternatives but also visualize the proposed alternatives and related risk information as provided by the expert users, facilitating the sharing of risk information in an appropriate format to the decision makers. Through the use of the applied Compromise Programming approach, different alternatives can be evaluated against each other in a collaborative manner based on the socio-economic and environmental objectives of different stakeholders. This would greatly support making decisions towards better allocation of available financial resources in risk prevention policies (Prenger-Berninghoff et al, 2014). Different views and valuations amongst experts and authorities in implementing risk mitigation strategies can also be better reflected with their weighting preferences on different objectives.

FEEDBACK DISCUSSION

This prototype platform was presented to the local and regional stakeholders in the case study regions (Poland, Romania and Italy) to collect their feedback and suggestions on particular aspects. One-page preliminary feedback forms provided in the stakeholders’ native

[2] Compromise Programming (CP) is a mathematical programming method introduced by Zeleny (1973) to apply in Multi-Criteria Decision Making (MCDM) problems and used to identify the best compromise solution from a set of potential alternatives (Zeleny, 1973; Zeleny, 1974; Nirupama and Simonovic, 2002).

languages were given to the participants to fill out. The form was composed of three different sections. The first section consisted of establishing an understanding (gathering opinions) of the platform followed by five rating questions with a scale of 1 to 5 (Very poor to Excellent) including: usefulness, innovativeness, user-friendliness, practice and supporting collaborative ability of the prototype. The second section asked participants about what aspects of the platform could be improved, while the third section provided an open space for additional comments and suggestions on the platform.

In **Poland**, out of 17 responses obtained, the *innovativeness* of the platform achieved the best score while the rest of the category rated more than or equal to 4 (meaning more than Good or Good in terms of the 1-5 scale used for the analysis). In general, stakeholders had a good impression of the platform and found it useful and interesting though there may be several aspects which need to be improved in order to apply the platform in practice. There was also a relevant concern regarding the participation of experts in the platform and that there should be a way to motivate experts to engage in the process. In **Romanian**, out of 19 responses obtained, the *usefulness* and *innovativeness* of the platform achieved the best score around 4.3 (meaning more than Good) while the rest of the category rated around 3.8 (meaning Good enough). To summarize their feedback, stakeholders found the platform highly useful and mentioned their interests in implementing the platform. It has also been suggested to develop concrete exercises with different stakeholders to validate its functionality and to determine whether the stakeholders can interact amongst each other through its use. It was also suggested to introduce a manual and to organize instructional training courses to apply the prototype platform in practice. In **Italy**, out of 13 responses, the *usefulness* and *supporting ability* of the platform achieved the best score out of the five categories rated as 3.8 (can be interpreted as Good Enough). During the discussion, it has been highlighted to integrate cost-benefit and interactive spatial query tools to analyse the risk consequences of hazard events in a certain area of interest.

CONCLUSIONS

We presented a prototype of the web-based participative decision support platform applied in the field of natural hazards and risk management mainly for floods and landslides. The purpose of this is to assist the experts and decision makers in the formulation and selection of risk management strategies using an interactive web-GIS drawing interface and Compromise Programming approach. This extended abstract has demonstrated how the potential use of the platform could be beneficial to the coordination and collaborative of activities between the involved stakeholders through a two-phase collaborative decision making framework. The development of the platform has been strengthened by case study observations as well as the preliminary feedback carried out with local and regional stakeholders. The feedback has been briefly discussed to highlight the strengths and weaknesses of the prototype: that the stakeholders found it useful, innovative and supportive while addressing several aspects of the platform that need to be improved for the development of a full-scale system to apply in practice. This included the active engagement of stakeholders in the process, validation of the platform through the interactive real-time exercises with different stakeholders and integration of additional supportive tools and is a topic of current and continued research.

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