



Using causal loop diagrams for the initialization of stakeholder engagement in flood risk management in a river delta area of Basilicata Region, Italy

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Human activities such as modification of waterways, deforestation of catchments, and development on floodplains interact with the natural environment and may cause adverse environmental effects. Therefore, the multiple causes and consequences of flooding resulting from human environment interactions, require a holistic understanding of complex social-economical-environmental systems. Moreover, floods as compared to other environmental policy and governance issues (e.g., waste management, pollution control, water management) represent a direct threat to property, economic activity, and human life. Hence, flood risk management implies a need for concerted engagement and participation by different stakeholders; this can support the improvement of communities' social awareness and adaptability to confront flood hazards, and to develop locally accepted flood risk management plans and mitigation interventions. Past studies indicate that management strategies may fail if a participatory (modeling) risk approach that incorporates opinions and preferred policy options of stakeholders and local authorities, is not considered.

Problems in stakeholder engagement processes related to flood risk management include a lack of institutional support, as well as clear and effective guidelines of stakeholder engagement processes, and lack of communication, information sharing, and resources with special reference to large participation processes. In this context, an innovative methodology to initialize the involvement of key stakeholders in the development of qualitative system dynamic models, i.e. causal loop diagrams (CLDs), has been used. CLDs are based on the development of mental models for the "co-construction" of participatory modeling and allow for the direct involvement of stakeholders with limited technical skills, even in situations with limited financial resources and time availability. The main advantage of CLDs is to provide a holistic picture of the complete system by representing interactions between different variables and helping to understand the feedbacks between different system components.

The proposed methodology consists of five main stages: (i) definition of the problem; (ii) stakeholder analysis and identification of key groups; (iii) interviews with key stakeholders for the construction of the individual causal loop diagrams, (iv) merging of individual CLDs into an overall group CLD of the entire system to form a holistic qualitative model of the system; and finally, (v) an innovative methodology is proposed to reduce the complexity of the final merged causal loop diagram, making CLDs understandable for all kinds of stakeholders.

In order to test the participatory modeling approach proposed in this study, a case study on a coastal area, historically affected by flood events, in the South of Italy was chosen. The case study demonstrates the usefulness of the proposed approach because stakeholders were able to think about various flood risk management policies and the results indicated socio-economic aspects that have not been considered by other technical and research studies conducted in the past. Participation emerged as an appropriate approach for enhancing flood risk management and all participating stakeholders indicated their satisfaction with the transparency of the modeling process and the overall group CLD model that depicts the aspects of a complex system in a clear, simple and understandable way.