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A rainfall risk analysis thanks to an GIS based estimation of urban vulnerability

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The urban community of Lyon, situated in France in the north of the Rhône valley, comprises 1.2 million inhabitants within 515 km ^{2}. With such a concentration of issues, policy makers and local elected officials therefore attach great importance to the management of hydrological risks, particularly due to the inherent characteristics of the territory.
If the hazards associated with these risks in the territory of Lyon have been the subject of numerous analyses, studies on the vulnerability of greater Lyon are rare and have common shortcomings that impair their validity. We recall that the risk is seen as the classic relationship between the probability of occurrence of hazards and vulnerability. In this article, this vulnerability will be composed of two parts. The first one is the sensitivity of the stakes facing hydrological hazards as urban runoff, that is to say, their propensity to suffer damage during a flood (Gleize and Reghezza, 2007). The second factor is their relative importance in the functioning of the community. Indeed, not all the stakes could provide the same role and contribution to the Greater Lyon. For example, damage to the urban furniture such as bus shelter seems less harmful to the activities of the urban area than that of transport infrastructure (Renard and Chapon, 2010).
This communication proposes to assess the vulnerability of Lyon urban area facing to hydrological hazards. This territory is composed of human, environmental and material stakes. The first part of this work is to identify all these issues so as to completeness. Then, is it required to build a "vulnerability index" (Tixier et al, 2006). Thus, it is necessary to use methods of multicriteria decision aid to evaluate the two components of vulnerability: the sensitivity and the contribution to the functioning of the community. Finally, the results of the overall vulnerability are presented, and then coupled to various hazards related to water such as runoff associated with heavy rains, to locate areas of risk in the urban area.
The targets that share the same rank of this vulnerability index do not possess the same importance, or the same sensitivity to the flood hazard. Therefore, the second part of this work is to define the priorities and sensitivities of different targets based on the judgments of experts.
Multicriteria decision methods are used to prioritize elements and are therefore adapted to the modelling of the sensitivity of the issues of greater Lyon (Griot, 2008). The purpose of these methods is the assessment of priorities between the different components of the situation. Thomas Saaty's analytic hierarchy process (1980) is the most frequently used because of its many advantages.
On this basis, the formal calculations of priorities and sensitivities of the elements have been conducted. These calculations are based on the judgments of experts. Indeed, during semi-structured interview, the 38 experts in our sample delivered a verdict on issues that seem relatively more important than others by binary comparison. They carry the same manner to determine sensitivity's stakes to hazard flooding. Finally, the consistency of answers given by experts is validated by calculating a ratio of coherence, and their results are aggregated to provide functions of priority (based on the relative importance of each stakes), and functions of sensitivity (based on the relative sensitivity of each stakes). From these functions of priority and sensitivity is obtained the general function of vulnerability.
The vulnerability functions allow defining the importance of the stakes of Greater Lyon and their sensitivity to hydrological hazards. The global vulnerability function is obtained from sensitivity and priority functions and shows the great importance of human issues (75 %). The vulnerability factor of environmental targets represents 12 % of the global vulnerability function, as much as the materials issues. However, it can be seen that the environmental and material stakes do not represent the same weight into the priority and sensitivity functions.

Indeed, the environmental issues seem more important than the material ones (17 % for the environmental stakes whereas only 5 % for the material stakes in the priority function), but less sensitive to an hydrological hazard (6 % for the environmental issues while 20 % for the material issues in the sensitivity function).
Similarly, priority functions and sensitivity are established for all stakes at all levels. The stakes are then converted into a mesh form (100 meters wide). This will standardize the collection framework and the heterogeneous nature of data to allow their comparison. Finally, it is obtained a detailed, consistent and objective vulnerability of the territory of Greater Lyon. At the end, to get a direct reading of risk, combination of hazard and vulnerability, it is overlaid the two maps.