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Urban flood risk mitigation: from vulnerability assessment to resilient city

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In France, as in Europe and more generally throughout the world, river floods have been increasing in frequency and severity over the last ten years, and there are more instances of rivers bursting their banks, aggravating the impact of the flooding of areas supposedly protected by flood defenses. Despite efforts made to well maintain the flood defense assets, we often observe flood defense failures leading to finally increase flood risk in protected area during major flood events. Furthermore, flood forecasting models, although they benefit continuous improvements, remain partly inaccurate due to uncertainties populated all along data calculation processes. These circumstances obliged stakeholders and the scientific communities to manage flood risk by integrating new concepts like stakes management, vulnerability assessments and more recently urban resilience development. Definitively, the goal is to reduce flood risk by managing of course flood defenses and improving flood forecasting models, but also stakes and vulnerability of flooded areas to achieve urban resilience face to flood events.
Vulnerability to flood is essentially concentrated in urban areas. Assessing vulnerability of a city is very difficult. Indeed, urban area is a complex system composed by a sum of technical sub-systems as complex as the urban area itself. Assessing city vulnerability consists in talking into account each sub system vulnerability and integrating all direct and indirect impacts generally depending from city shape and city spatial organization. At this time, although some research activities have been undertaken, there are no specific methods and tools to assess flood vulnerability at the scale of the city. Indeed, by studying literature we can list some vulnerability indicators and a few Geographic Information System (GIS) tools. But generally indicators and GIS are not developed specifically at the city scale: often a regional scale is used. Analyzing vulnerability at this scale needs more accurate and formalized indicators and GIS tools. The second limit of existing GIS is temporal: even if vulnerability could be assessed and localized through GIS, such tools cannot assist city managers in their decision to efficiency recover after a severe flood event. Due to scale and temporal limits, methods and tools available to assess urban vulnerability need large improvements.
Talking into account all these considerations and limits, our research is focusing on:
• vulnerability indicators design;
• recovery scenarios design;
• GIS for city vulnerability assessment and recovery scenarios.
Dealing with vulnerability indicators, the goal is to design a set of indicators of city sub systems. Sub systems are seen like assets of high value and complex and interdependent infrastructure networks (i.e. power supplies, communications, water, transport etc.). The infrastructure networks are critical for the continuity of economic activities as well as for the people's basic living needs. Their availability is also required for fast and effective recovery after flood disasters. The severity of flood damage therefore largely depends on the degree that both high value assets and critical urban infrastructure are affected, either directly or indirectly. To face the challenge of designing indicators, a functional model of the city system (and sub systems) has to be built to analyze the system response to flood solicitation. Then, a coherent and an efficient set of vulnerability of indicators could be built up. With such methods city stakeholders will be informed on how and how much their systems are vulnerable. It is a

first level of information that has to be completed to become a real decision making tool. Indeed, we have seen that major floods cause almost always failures in the flood defense system. So potentially the city could face a flood event and managers recovery works. Knowing the vulnerability of the city, direct and indirect impacts, how can managers optimize recovery actions? Our research will focus first on proposing recovery scenarios based on the city system and second on vulnerability indicators to first limit damages during floods and to speed up recovery actions.

At last, a GIS will be developed to assist stakeholders to take spatial measures to reduce city system weakness before a flood event and to help them to decide on how to optimize recovery actions after a flood event. Dealing with these two temporal scales will allow obtaining more flood resilient cities.