A socio-ecological robustness approach for evaluation of urban Green Infrastructure effectiveness in a dense precarious settlement

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The implementation of Green Infrastructure (GI) for hazard management has been studied and evaluated for reducing the risk of and increasing resilience to flood events, flooded areas and damage costs. Still, less attention has been given to the governance aspects involved in the implementation of GI. We present the GI assessment through a robustness approach, where the urban environment is referred to as a socio-ecological system. Robustness can be assumed as the “maintenance of system performance either when subjected to external, unpredictable perturbations, or when there is uncertainty about the values of internal design parameters” (Carlson and Doyle, 2002). In this sense, it is required to investigate the socio-ecological configurations of GIs as a new component introduced within the urban system in addition to their technical aspects. We use the Robustness of Coupled Infrastructure Systems Framework (Anderies et al., 2019) to analyse the dynamics of the system through the connections between its components (resource users, public infrastructure, public infrastructure providers and natural infrastructure) and to evaluate the associated robustness through their critical feedback structures links, by analysing human behaviour (relationships and perceptions), monitoring actions, conflicts, and resource appropriation limits. In this way, it is possible to assess the changes [MEV1] that influence the functioning of the system. We applied this framework to a case of a dense precarious urban settlement subject to flash floods in Brazil. We developed three scenarios considering the application of GI, and they were simulated using SWMM model: (i) the current one; (ii) the implementation of three infiltration-based GI (permeable pavements, bioretention systems, and infiltration trenches) throughout the catchment, not only in public areas but also inside the lots, aimed at reducing flooding hotspots; (iii) the implementation of low-storage rainwater harvesting systems in all households within the catchment. We used a representative heavy rainfall event capable of producing flash floods as input for simulation of all scenarios. The SWMM was parameterised for the current land use and land occupation, representing the spatial patterns that determine runoff overflow propagation, producing, for each scenario, the spatial distribution of flooding hotspots throughout the catchment. In the current state scenario, the system has exhibited poorly robust links, furthermore flooding spots have been detected along the catchment. By applying the infiltration-based GI, besides all flooding spots have been mitigated, the system has the potential to acquire robustness by enabling trust in relationships, improvement in users’ perception of resources, monitoring of actions and conflict resolution. The implementation of rainwater harvesting systems could strengthen the robustness through popular participation, processes perception by the users and appropriation limits, apart from
reducing 26% of the flooding spots. The robustness analysis points out that the implementation of GI in the catchment will be effective only if it is reached a household-level engagement, resource importance and a proper environment for conflict resolution, besides the mitigation of flood events.