Mapping natural disaster risks to guide responsible urbanization in Brazil

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A planned urbanization is an important step to avoid life and economic losses due to natural disasters. In this context, “Geotechnical Maps for Urban Planning” is a project to elaborate such maps detecting natural disasters vulnerability for urban land use change in municipalities of the metropolitan region of São Paulo, Brazil. The Brazilian Federal Law 12.608/2012, establishing the National Protection and Civil Defense Policy, considers the Geotechnical Map related to natural disasters one of the instruments of planning and municipal management focused on disaster prevention. This tool should be developed by all Brazilian municipalities, characterized by risk situations due to landslides, flash floods, and geological or hydrological processes.

A team of professors of the Federal University of ABC (UFABC) leads the project, supported by the Ministry of Cities of Brazilian Government. The main mapped disaster risks are mass movement and hydrological processes, including flood and saturated soil subsidence in potential future building areas. The main users of these maps are the municipal governments and private entrepreneurs involved in land allotments, subdivisions, real estate undertakings, land regularization, and housing policy. The research team already concluded maps for the municipalities of Santo André, São Bernardo do Campo, Rio Grande da Serra, and Ribeirão Pires, and new maps are currently being elaborated for Caieiras, Itapecerica da Serra, Santana do Parnaiba and Itapevi (Figure 1), all of them are located in the Metropolitan Region of São Paulo. The mid-term goal is to complete the maps for the whole metropolitan region.
Figure 1 – Location map of completed and under development maps

Figure 2 illustrates the main steps of the project for each municipality. The first step is the participatory engagement with local stakeholders, in order to understand the main needs and territorial processes, and to incorporate local knowledge and data. In sequence, the research group and the municipal government decide what will be the mapped area. In principle, the maps exclude consolidated urban areas and natural preservation unities, while current and future urban sprawling areas are prioritized.

Figure 2 – Project methodology

The studies comprise many components, such as geosciences (hydrology, geology, geotechnics, geomorphology and soils), biotic and anthropic aspects. The hydrological component combines flood plain mapping, hydromorphometric indexes, hydraulic simulations and delimitation of legally protected riparian native vegetation. The main hydromorphometric
The index used is HAND (Height to the Nearest Drainage), which has been extensively applied in Brazil and around the world as a proxy for flood vulnerability, as well as for mapping distinct gradients of hydrological-edaphic-ecological interactions. On the rim of large rivers, flood may be a higher concern, but the vulnerability maps also take into account the streamside wetlands as an important restriction for urbanization, not only because of geotechnical limitations, but also for the conservation of hydrological and ecological services. Both flood-prone areas and wetlands are considered together to delimitate restricted areas for urbanization.

The spatial results of the natural disaster risks have been analyzed together with the land use change processes and trends, in order to develop scenarios. These scenarios help to understand the areas with higher vulnerability, both currently and in the near future. Subsequently, the local stakeholders discuss these scenarios with the research team, in order to elaborate directives for land use planning. The results of this participatory activity are decision trees of policy directives. Figure 3 presents one specific decision tree for the hydrological risks. The final map (Figure 4) of urbanization suitability incorporates these decision trees and explains what are the risks and their associated policy directives regarding urbanization for each area. The Geotechnical Maps contain three major classes regarding occupation: favorable, improper, or with restrictions. The maps already completed and their GIS databases are publicly available in the National Infrastructure of Spatial Data (Infraestrutura Nacional de Dados Espaciais - INDE) of the Brazilian Government.

Figure 3 – Decision tree for policy directives regarding wet zones and floodplains
Figure 4 – Example of completed synthesis map of urbanization suitability in the city of São Bernardo do Campo.

After the successful results in the first municipalities, the research team is prospecting new improvements for the next maps. Some of these improvements include the integration of space-time rainfall data series, calibration of the Hand index for distinct geomorphological contexts and land use change models for scenario building. The main challenge is to continue helping cities to become more resilient to natural disasters.