Economical Consequences of the Flood: modelling the impacts in an urban space

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Abstract

The assessment of flood effects in urban areas requires the analysis of direct and indirect impacts. Direct impacts concern damages caused by the physical contact of floodwaters with commodities and are therefore related to the physical deterioration of such commodities. Indirect impacts are much more complex to deal with. They originate from inconveniences caused to the community by flooding events. Each household, with its specific social, economic and location characteristics suffer different flood impacts and react differently.

The urban social net is the social and economic characteristics of households and their connections with other households, as well as with other economic units such as industry, commerce and service providers, in the city and even outside the city. These connections relate to basic social functions (e.g.: consumption, education, work and leisure). In the majority of flood impact assessment, only direct impacts are measured and discussed. The household behavior and socioeconomic connections are not frequently incorporated in the estimation. Besides, these models work in a static way, assessing damages in a specific place and moment, dismissing cumulative flood impact and multiplicative dimensions.

This paper intends to analyze these themes through the use of the agent based computational model (ABM) and network analyses elements. ABM is able to deal with a large variety of agents, presented with behavior attributes and rules, the so called “microbehavior”. Interactions among these agents create a “macroscopic structure”: the city. On the other hand, network analysis, used for the relational data analysis, can be employed to represent and examine these interactions. This model strategy is appropriate to analyze complex and interdisciplinary phenomena, such as those that involve environmental and social interactions. As an example, Axtell *et al*. (2002) model the time-path of a population showing the interactions between productive structure, family and environmental dimensions. These

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characteristics make the microsimulation based on agents an interesting tool in modeling economical consequences of floods in urban areas. Nevertheless, the use of these tools in flood disaster areas is still incipient. There are studies on resilience (Chang & Chamberlin, 2004), plan of actions during the disaster with strategies of rescue (Takahashi, 2006, Tang & Wen, 2009), population behavior in an emergency situation (Zarboutis & Marmaras, 2005) and distribution of the financial responsibility in catastrophes events (Brouwers & Verhagen, 2005). The network analysis studies are sometimes used for impact disaster assessment, but commonly for evaluating road system vulnerability with a physical-spatially approach (Chang & Nojima, 2001; Sohn, 2006). Especially noteworthy is the research of Helbing *et al*. (2006) about the possibility of miscommunications in strict hierarchical structure of disaster management organizations.

Following these studies, in the present paper we model an urban space with four subsystems: (1) the river system; (2) the household system; (3) the transport system and (4) the productive-distributive system. The river system generates the exogenous impact (flood) in the social net (the city). By a hydrological and hydraulic model some flood characteristics are estimated (flood depth, duration and flow velocity) for several events with different retours periods. The household system is modeled as a large set of households inside and outside the flood prone area, where they trade, consume, produce and work. Each household has several physical characteristics (e.g.: constructed area, the state of the building and its content etc.), as well as the residents (e.g. income, health status, age, school enrolment, work etc.). The productive-distributive system is a set of agents that represents economic activities dispersed in the city, and they provide the income and the work place. The distributive system supplies consumption goods and the place where the households spend income buying a bundle of goods. Finally, there is the transport system; in the case of Brazilian cities, it is represented only by the road system due to the almost absence of underground or tramway systems.

The hypothesis adopted in the present research is that these three systems, working together, are able to reproduce the basic dynamic of a city impacted by flood events, which is the fourth and exogenous system. Flood impacts in this urban system produce changes in household income, consumption levels and in their stock of assets, making possible to measure and evaluate changes that occur in the behavior of all agents due to floods, such as the loss of income, the increase in asset depreciation rates due to the contact with water, unemployment, lack of access to consumption goods etc. To simulate and test the model, a prototype was built with the significant elements of the intra-urban environment which can influence the magnitude of the flood impact.

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