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SESSION 03
SUSTAINABLE FLOOD RISK MANAGEMENT

INTEGRATING RIVER RESTORATION AND SUSTAINABLE DRAINAGE SYSTEMS FOR EFFECTIVE FLOOD RISK MANAGEMENT IN URBAN CONTEXTS

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ABSTRACT

Flood risk management is of prime concern for the protection of properties and economic assets. However, traditional flood control measures are one of the main drivers of river degradation. This paradox is particularly harsh where rivers flow through cities: the formers are important in the urban life for socioeconomic issues, but the urbanisation itself changes the fluvial equilibrium, resulting in flood aggravation and ecological alteration.

Even in this context, river restoration appears as a possibility for controlling floods and recovering the fluvial environment. If rural river restoration tends to focus mainly on the river corridor, in high altered urban basins one of the primary challenges is to recover hydrological patterns in order to enhance floods control. City development should be limited or at least rethought, while sustainable urban drainage practices must be introduced, controlling flow generation at its very source ("room for the river" water management).

The challenge to restore urban rivers brings a complex discussion, which needs to focus on the whole basin and to recognise the possible restoration limits. Probably it is not possible to recover the natural forms and processes, but certainly it is feasible to have better urban rivers, balancing natural and built environments.

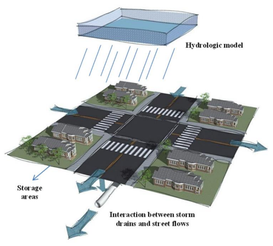
A comparative work has been conducted among Brazil and Italy under an International Cooperation project named SERELAREFA (www.serelarefa.com) and partially funded by European Community (FP7-IRSES). Two case studies, one in the Rio de Janeiro metropolitan area (Brazil) and another in Venice (Italy) mainland, have been developed to hold this discussion. In both cases, the main problem refers to urban floods and local contexts reveal the possibility of establishing a more sustainable approach in water and river management.

The analysis is based on mathematical modelling of design alternatives in terms of hydraulic effectiveness and an index is proposed to assess the urban river conditions improvement, thus allowing to carry out an integrated evaluation. Outputs present a relevant space for considering River Restoration - under given constrains- as a viable, suitable and valuable approach even in complex and fragile contexts.

MODCEL

MODCEL is an integrated model, which conjugates a simple hydrologic distributed representation with a hydrodynamic looped flow net, configuring a spatial representation, where two different layers of flow are vertically linked: a superficial layer, corresponding to the free surface channels and flooded areas; and an underground layer, related to free surface or drowned flows in storm drains. This model was designed to allow the representation of a basin, articulating the drainage system with the superficial flows that occur in typical elements of the urban landscape.

MODCEL is based in the basic principles of mass, energy and momentum conservation. The entire basin and its different elements may be represented by cells, including the rivers, channels, storm drains, flood plains, hills, urban areas, reservoirs, and other structures. Therefore, several urban structures and flow patterns can be simulated by the combination of a pre-defined set of cell types and hydraulic cell links, including the Saint-Venant dynamic equation.



URRIx – Urban River Restoration Index

Regarding River Restoration (RR), it is very difficult to act in urban areas and, most times, RR measures may be only partially applied with several limitations. However, considering the fluvial system integrated with the city, the importance of these areas and the positive tendency of treating rivers more naturally, it is important to access the improvements obtained from urban rivers actions as a gol to be followed. In this context, URRIx aims to assess the positive effects of river restoration measures in an urban basin. It is composed by four indicators: "general state of the basin", "connectivities", "riverbanks condition" and "hydraulic risk." The URRIx ranges from 0 to 1. The more critical areas are associated with lower values of the index, while more critical regions receive higher rates for it. Each of the considered factors has considered certain associated weight to represent their relative importance. This fact is mathematically translated in the final index equation.

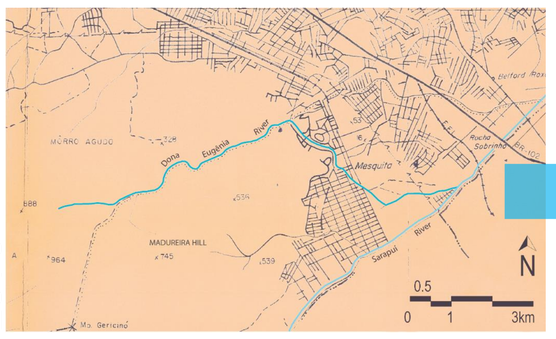
Furthermore, to operationalize indicators of distinct natures and units, normalization was employed, converting all indicators to the same scale of variation. The concept of URRIx considered a summation of effects. Thus, even if one of the factors is null, the result can be measured. The formulation of URRIx is given by

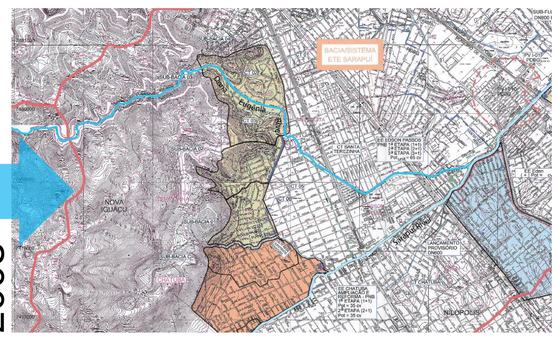
$$URRIx = \sum_{i=1}^{n} I_i^{URRIx} \cdot p_i^{URRIx}$$

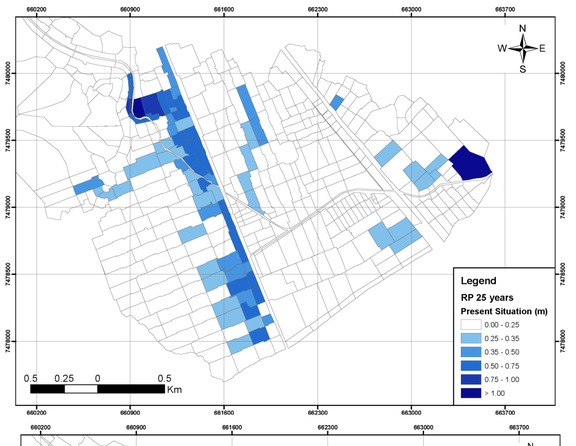
where n is the total number of indicators; I_i^{URRIx} is the ith indicator, previously normalised, ranging from 0 to 100; p_i^{URRIx} is the weight associated with the ith indicator, according to its relative importance and that should meet the constraints of the equations

$$0 \leq p_i^{URRIx} \leq 1 \text{ and } \sum_{i=1}^{n} p_i^{URRIx} = 1.$$

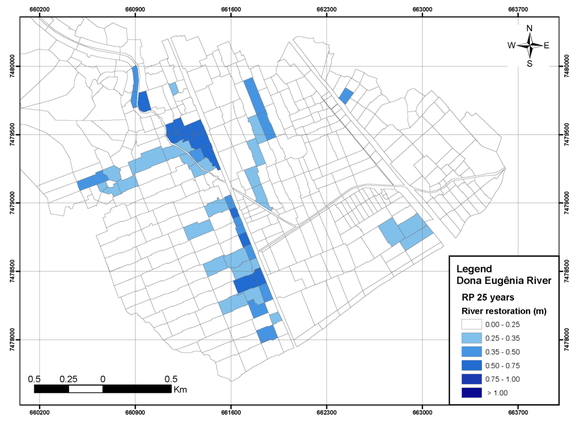
DONA EUGÊNIA RIVER - BRAZIL







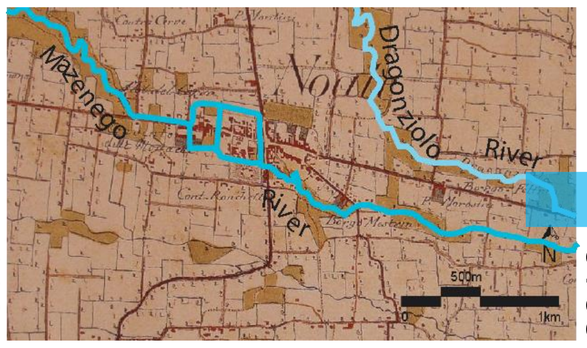
URRIx
0.28

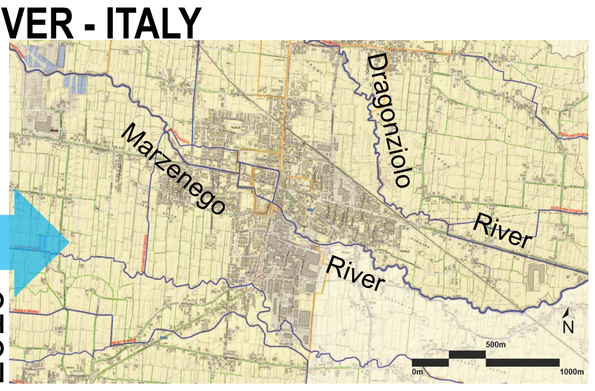


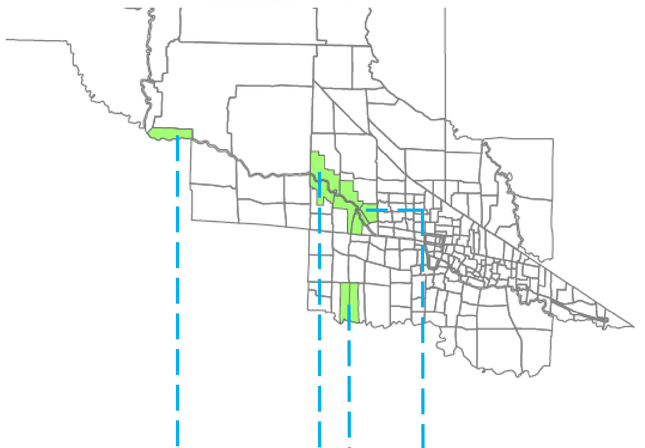
URRIx
0.49

COSTA, I. A.; NASCIMENTO, M.B.; FURTADO, V.M. **Revitalização do rio Dona Eugênia: o estudo de caso da cidade de Mesquita**. 5º lugar na Jornada de Iniciação Científica da UFRJ. Rio de Janeiro, 2011.

MARZENEGO RIVER - ITALY







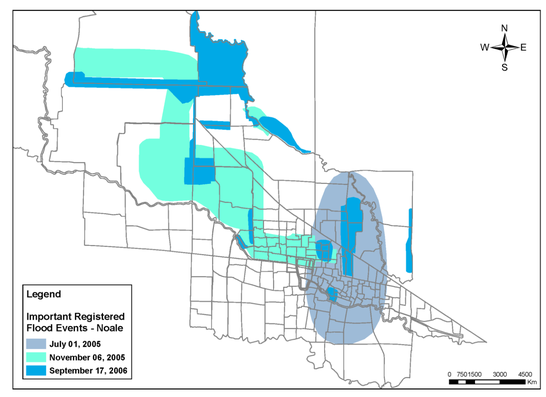
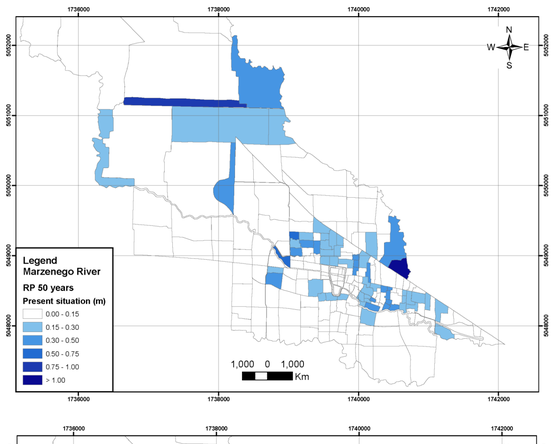
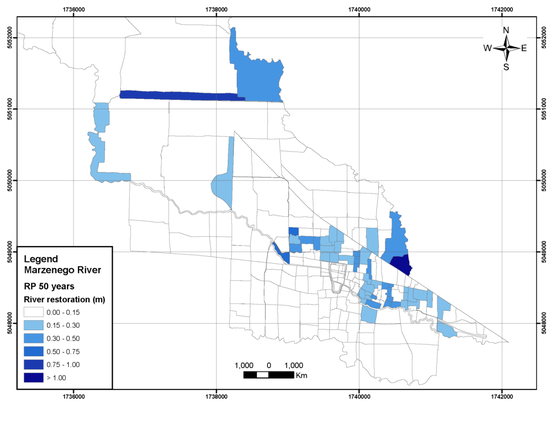


Image Base by: GOOGLE. **Software Google Earth 7** (http://Earth.google.com.br). Noale, Province of Venice. Cnes/Spot Image, Digital Globe, 2012.





CONCLUDING REMARKS

Two case studies were conducted in parallel, involving Brazilian and Italian urban rivers. In Brazil, especially in urban areas, river degradation and urban floods are both great problems. This is the case of Mesquita City, in Rio de Janeiro Metropolitan area. In Italy, the city of Noale, in Venice lowlands, is naturally subject to harsh flooding and is artificially drained by a complex drainage net. The old city centre has a low dike where overflows occur. The interaction among Brazilian and European researches are being done in these two realities, which are linked by a similar physical situation. In both cases, the main proposal referred to give room to the rivers, reconnecting them with their flood plains. This work must be considered the first step in this research, which is still in progress. In the preliminary results, both Mesquita and Noale answered positively to the river reconnection with flood plains. The centres of both cities reflect these results, although there are still things to be done. In Noale, for example, the discharge of Marzenego River is halved downstream the city. An important observation made in the two cases shows the necessity of working also in the basin scale, in order to reorganise the urban water cycle, greatly altered by the city growth. The expectation with the particular study of Baixada Fluminense lowlands was to rise the opportunity to look for complementary actions, integrated with the river restoration possibilities. Both Mesquita and Noale cases will evolve to a sustainable urban drainage system approach in order to cope with the river restoration purpose.

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