CONCEPT PAPER

VENEZIA MODCEL CASE STUDY

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Background

The urban flood problem

Floods are natural and seasonal phenomena, which play an important environmental role, but when they take place at built environments, many losses may occur. Urban growth is one of the main causes of urban floods aggravation. Changes in land use occupation related with vegetation removal and high imperviousness produce greater run-off volumes flowing faster.

Thus, there is a paradox in the relation between the water and the cities: water is a key element for city life, but urbanisation is not always accompanied by the adequate planning and the necessary infrastructure provision to accomplish for the city growth (Gusmaroli et al., 2011). Other times, although the planning process is in place, urban growth is not adequately controlled.

The traditional approach for the drainage systems design focused on sanitation aspects in the first times of the city development, conveying stormwaters and wastewaters. However, this approach showed to be unsustainable along time. Flow generation increased and end of pipe solutions tended to just transfer problems to downstream. In this context, in the last decades, several approaches were developed, in order to better equate flow patterns in space and time. The water in the city needs to be considered in an integrated way and sustainable solutions for drainage systems have to account for urban revitalisation and river rehabilitation, better quality of communities' life, participatory processes and institutional arrangements to allow the acceptance, support and continuity of these proposed solutions.

Technical aspects

Urban environments may be responsible for a multitude of possibilities of flow when storm drains fail. It is quite usual that flow spilling out of the macro-drainage system causes inundation at extensive areas and urban structures may interact with the drainage system, creating a non-planned flow net that includes plain surfaces and streets, at the same time that

several undesired reservoirs are addicted to the system, with parks, public squares and buildings temporally retaining waters. This situation is difficult to solve, without the aid of a mathematical model. However, urban drainage models, concerning the drainage branched network simulation, may lead to a bare representation of the physical reality, because superficial flows may play a major role in the process. On the other hand, two-dimensional models are becoming more popular, due to present computation facilities. However, once again the physical representation may not be the most adequate. It is very difficult to have an urban flood situation that really represents an unique 2-D surface flow. Besides, the more recent flood control techniques involve source flow controls and other sort of distributed measures over the basin, demanding the recognition of an integrated system working on two different layers, one superficial and the other related to the underground pipe net. The superficial layer encompasses run-off processes, open channels and even open spaces, not directly connected to the stormwater sewers. Modeling needs for an urban area representation must consider the necessity to introduce rainfall-runoff transformation, to conjugate superficial flows with drainage system network, and to consider the different hydraulic structures present in urban environment. This concept paper proposes the use of MODCEL (Mascarenhas and Miguez, 2002, Miguez et al., 2011), which is a mathematical model based on the concept of flow cells (Zanobetti et al, 1970). This model conception will be briefly presented in the Methodology.

Rationale of case study

The lowland area of Mestre/Venezia is naturally subject to harsh flooding as part of it lies even below average sea level and is drained artificially. Dramatic events in 2006, 2007 led to a mandate to a special Commissioner who issued a specific law which introduced the "hydraulic invariance" concept. The idea is that if a new building/infrastructure would increase the peak discharge in a reference flood event (50 years return time) -owing to the loss of natural storage volume and infiltration capacity- then building concession can be granted only provided that suitable compensatory measures are put in place in order not to pass the same original peak value. This concept has been fully acquired by the **Piano Territoriale di Coordinamento Provinciale,** approved by Venetian Province administration (December 2010), which stated the need to elaborate specific Water Plans.

More recently, Regione Veneto, together with Veneto Agricoltura and the technical support of CIRF, issued guidelines for the ecological restoration of the extensive network of natural and artificial irrigation and drainage canals ("*Manuale per la gestione ambientale dei corsi d'acqua a supporto dei Consorzi di bonifica*" – www.venetoagricoltura.org), where several

concepts of sustainable water management and river restoration are included, much in line with SERELAREFA philosophy (see below for a short description of the project).

Within the framework of SERELAREFA project, a first study trip has been conducted in September 2010 during which project partners, amongst which prof. Marcelo Miguez from the Universidad Federal do Rio de Janeiro (Brazil), visited several sites of the Provincia di Venezia (and several other location in north-eastern Italy), and could understand the type of problems faced in that region. Prof. Miguez then (June 2011) participated, given his known experience in hydraulic modeling and planning of urban areas, in a relevant conference Acqua e Città held in Venezia and successively was invited to a specific workshop in Mestre (VE) organized by CIRF, hosted by AATO Laguna di Venezia and with the participation of several key actors, amongst which technical staff of hydro-geological defense of the Provincia di Venezia. There he presented the modeling framework and tool named MODCEL that is being developed and applied since long in several urban areas of the State of Rio de Janeiro, Brazil and particularly to the lowlands of Baixada Fluminense (a large flat, quite urbanized area close to Rio de Janeiro City). The interest arouse to test such modeling approach also within the territory of Venice.

One of the objectives of SERELAREFA is to promote the exchange of experience and know-how and the development of case studies which can test and demonstrate the validity of River Restoration paradigm. Accordingly, the idea was born to set up an Italian case study around the Venetian area. This document defines this idea as a starting point. Of course, during development modifications as well as extensions are possible and welcome.

It is important to clarify that this project is conceived as an Academic opportunity of applied research; it is not a consultancy relationship, and because of this costs are very reduced. The SERELAREFA project will contribute by a small amount to support exchange missions of relevant staff, according to internal rules of the program IRSES-PEOPLE 2009 and the partners' agreement of the project.

Project idea

Take advantage of the similarities between the Baixada Fluminense (Rio de Janeiro) and Venetian areas, and of the links created by CIRF with the Brazilian research group of UFRJ, thanks to the SERELAREFA support, to achieve the following:

Objectives

- Investigate, understand and show to the Provincia di Venezia and related stakeholders what a powerful modeling tool, represented by the MODCEL model, developed by UFRJ specifically for urbanized areas, can offer to address planning of flood measures, in response to the recent disastrous hydrologic-hydraulic events;
- Broaden the range of possible intervention measures for urban flood control, exploring innovative solutions in the context of river restoration and sustainable urban stormwater management, including different uses of free spaces, and urban and peri-urban infrastructures;
- Test and improve MODCEL capabilities in a system characterized not only by high antropogenic pressure, but also by a strong artificial management (e.g. pumping, retention tanks) and, at the same time, significant data availability (not common in Brasil)
- Strengthen the links between two similar realities and create synergies of experiences to jointly improve to management of flood problem, while disseminating the adoption of River Restoration concepts.

Activities

- Creation of partnership and focusing of project idea and possible study areas (CIRF)
- Data needs specification and preliminary data collection (CIRF)
- Identification mission from UFRJ to Mestre (beginning of 2012), whit selection of specific project area, further data collection and surveys on the field, coordination with local partners for additional data collection needs, joint definition of case conception and alternatives to be considered
- Case study development (UFRJ, at its headquarter in Brazil, with support of CIRF staff through dedicated missions and virtual dialogues and workshops via mail and Skype): elaboration of data, setting up of model database, calibration; conception of alternatives; collection of additional field data; simulations and analysis of results
- Preparation of basic dissemination material (PowerPoint presentation; English report on case study) (UFRJ and CIRF)

- Participation to a dissemination public event in Italy and in Brazil (all partners).

Expected Products and Results

- Technical report (English) with: i) diagnosis of present flooding conditions at the selected case study watershed in the area of Mestre, and identification of its main causes and key factors; ii) proposal of alternative solutions, which will consider a sustainable approach for the drainage system integrated with land use control, as well as the possibility of introducing river rehabilitation measures; iii) comparative analysis of their physical performance; iv) identification of technical limitations of the analysis and directions for further improvement
- Policy brief (English and Italian) with: i) conclusions on the appropriateness, usefulness and applicability of MODCEL as a key tool for planning flood measures and recommendations for future developments; ii) recommendations, sustained by a number of concrete examples, of how Water Plans can lead to concrete measures which best achieve the safety objective, while incorporating the ecological and socio-economic objectives as well
- Academic papers.
- Increased experience on MODCEL and knowledge on the topic; raised awareness on innovative tools and approaches; strengthening of links amongst project partners; new perspectives for further developments.

Partners y roles

Provincia di Venezia: political direction of the initiative; effort to ensure the broadest publicity of information and the broad participation of stakeholders; starter funding (to be defined).
AATO (Autorità d'Ambito Territoriale Ottimale) "Laguna di Venezia", Consorzio di Bonifica "Acque Risorgive": identification of case study area; data provision; support to problem description and conceptualization; support to conception of alternative solution; discussion of results; support to dissemination (to be further defined along the project development). Other possible key partners to be involved along the case study implementation are ARPAV (Environmental Agency) and the local Flood Commissioner (in charge to manage recent flood emergencies).

UFRJ: core technical development (see Activities section) with missions to the study area and lab works at Rio de Janeiro installations.

CIRF (see Activities section): facilitators of the process at the organizational and technical level, input of expertise on River restoration concept, support in design and preparation of dissemination material, participation in dissemination public events.

Notice: during the project development, partnership could be fostered with additional subjects and channels.

Costs and funding

As stated in the beginning, this project is conceived mainly as an Academic exercise in line with the SERELAREFA conception. Because of this, most of the costs are implicitly assumed by UFRJ, as a contribution to the cooperation spirit. In return, a thorough database will be provided to UFRJ which will allow to develop the case study, taking advantage of an area where data availability is decidedly higher than in Brazil, what constitutes an important and challenging opportunity for testing the proposed model. In addition, the technical support from local relevant actors and CIRF will be ensured.

CIRF, through the SERELAREFA project, will be able to partially support the cost of exchange missions (estimated in about 2.5 man-months of permanence in Italy of UFRJ staff and of 2 man-month of CIRF staff in Brazil [1]).

Provincia di Venezia will support the project with a grant (to be defined) to cover CIRF organizational effort and the time dedicated to the project locally, according to the activities listed above.

AATO "Laguna di Venezia" and Consorzio di Bonifica "Acque Risorgive" will support the project by allocating sufficient time from relevant experts and technicians, will provide the necessary data, will host meetings and possibly public events, according to needs.

Additional funding and support will be discussed later in order to cover additional activities (as for instance to collect additional data or to produce specific dissemination material), if required.

[1] Notice that EU-IRSES regulation only allows staff formally belonging to the official partners of SERELAREFA project to benefit from UE financial support; hence, the project cannot cover mission costs of other partners specific to this case study only.

About SERELAREFA (www.serelarefa.com)

The Project SERELAREFA – *SEmillas REd LAtina Recuperación Ecosistemas Fluviales y Acuáticos* (seeds of a Latin American network for the restoration of fluvial and aquatic ecosystems), funded by the UE programme FP7 IRSES-PEOPLE 2009, aims to improve the way water courses are managed by achieving benefits for both the environment and socio-economic activities. It fosters the adoption of River restoration concept. Exchange missions, study trips, collection of experiences, setting up of case studies and pubblications are the main activities.

The Project started in september 2010 and lasts three years. Partners are:

- Italia - Centro Italiano per la Riqualificazione Fluviale – CIRF coordinator (www.cirf.org)
- España - Universidad Politécnica de Madrid - UPM
- Brasil - Universidade Federal do Rio de Janeiro - UFRJ
- México - Universidad de Guadalajara - UdG
- Chile - Dirección de Obras Hidráulicas – DOH
- Chile - Universidad de Concepción - UdeC

Technicalities on the modeling approach and case study

MODECEL key concepts

In general lines, the urban space is represented through different shaped cells, acting as homogeneous compartments and comprising the whole basin area, even outside the main drainage net. The cells interact with each other depending on the hydraulic functions that represent the flow between them. This model conjugates a simple hydrological distributed model with a hydraulic-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 a subterranean one, related to free surface flows or drowned flows in storm galleries. The resultant mesh of cells composes a hydrodynamic looped network. In this context, this arrangement can be interpreted as a pseudo 3D-model, although all mathematical relations written are one-dimensional. The main equation used to represent the channel flows is the dynamic Saint Venant Equation, but weirs, orifices, gates, pumps, and several other structures are also represented. The mass balance is applied to all cells. So, at each time step, the stored amount of water in one cell is a function of the discharges that occurred between this cell and its neighbors, also considering the rainfall contribution through a rainfall run-off transformation.

MODCEL was designed to allow the representation of a basin, articulating the drainage system with typical elements of the urban landscape, aiming to reproduce different types of spatial flooding patterns. Urban land representation is a key element for this modeling process.

Strengths and limitations

MODCEL has a natural vocation for integrating superficial flows with the drainage system, representing the urban landscapes and the different structures that compose the flow net. This is a crucial point, however. To obtain sound results, MODCEL depends on an adequate pre-interpretation on how the system works, because the proposed mesh of cells and their hydraulic relations will determine the possible patterns of flow. Another restriction that may limit MODCEL final results is related with real two-dimensional flows, where very high water depths may be able to generate a unique water surface flooding great areas.

This is why a pilot case study in an area where data availability is decidedly higher than in Brazil constitutes an important and challenging opportunity for testing.

Selected case study area description

To be still identified.

Data needed

- topography , in 1/2000 scale, in digital format
- land use, at the same scale (if possible)
- natural/artificial superficial channels and the major storm drains (cross sections, slopes, materials)
- hydraulic structures: where, what they intend to do, the main geometric characteristics, and specific hydraulic equations (if existent).
- measured rainfall and discharges/water levels and flows. Time interval depends on the characteristics of the basin. Time steps should be more detailed than the concentration time.
- the definition of a design rainfall (related to recurrence time) – for proposed solutions simulations.

Bibliography

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