

SERELAREFA PROJECT

PROPOSAL of specific project for a case study

TITLE:

An alternative for RIVER RESTORATION in an URBAN AREA in Rio de Janeiro, BRAZIL: the case of DONA EUGÊNIA RIVER, Baixada Fluminense

This document

The Project “SERELAREFA”

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 publications are the main activities.

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

- Italia - Centro Italiano per la Riqualficazione 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

This concept paper integrates a set of proposed studies, conducted by Universidade Federal do Rio de Janeiro-UFRJ, in the context of the SERELAREFA Project. In particular, the case studies treated in this concept paper intends to present and discuss the situation of Baixada Fluminense Lowlands, in the metropolitan area of Rio de Janeiro City, using a mathematical model as a simulating tool to represent Iguaçu-Sarapuí River basin in a systemic way.

This area is densely urbanised and suffers from floods. In this context, flood control projects are one of the main concerns and, many times, one of the causes of fluvial degradation. This context is surely a very difficult situation in terms of river restoration, but the authors of this study pose that the urban environment may not be forgotten and the challenges must be faced, in order to find a better balance between natural and built environment, seeking for opportunity to recover as much as possible the natural characteristics of the river and its basin. This way, new concepts of sustainable urban drainage, urban planning and development actions and possibilities of river restoration, even partially, will be integrated in a discussion, where past development and traditional solutions are being complemented or replaced by new concepts that are still evolving to also consider fluvial ecosystems needs.

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7-PEOPLE-2009-IRSES) under Grant Agreement n.247522



An Alternative for River Restoration in an Urban Area in Rio de Janeiro, Brazil: the case of Dona Eugênia river, Baixada Fluminense

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Revision: A. P. Veról (April 07, 2012)

Revision: M.G.Miguez (April 19, 2012)

Background

Dona Eugênia River catchment is situated in the metropolitan area of Rio de Janeiro, crossing two cities of a lowland region called Baixada Fluminense – Nova Iguaçu City and Mesquita City. Some information describing the catchment is given below.

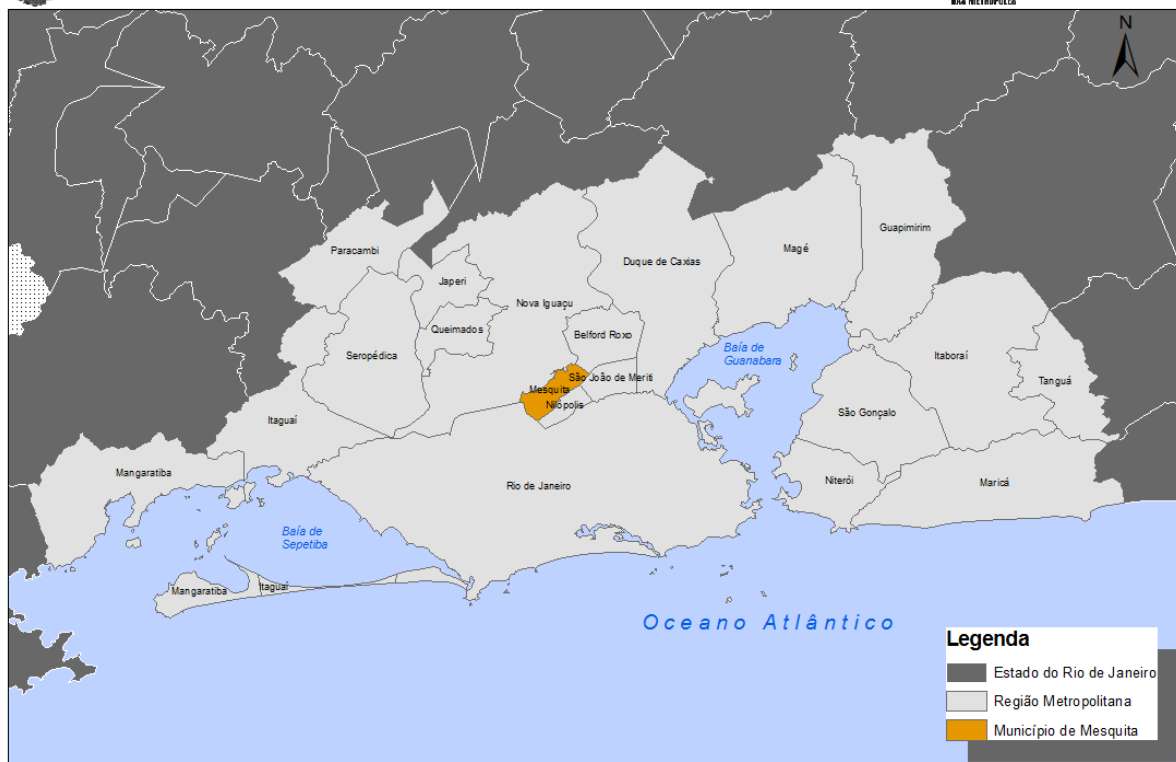
- The catchment's climate is hot and humid with summer rainy season. It has an average annual temperature of 22°C and an average annual rainfall of 1.700mm.
- It has a drainage area of 18km²;
- The river is about 10 km long – the first 4 km are in Nova Iguaçu City, the subsequent 6km are in Mesquita city, where it crosses the urban area until its outfall, on Sarapuí River.
- The river spring is located inside an environmental preservation area called Gericinó, in Nova Iguaçu City.
- Near this area, there is a park called *Nova Iguaçu Natural Municipal Park*, created in 1998, in the Madureira Mountains.



Localização do Município de Mesquita - Estado do Rio de Janeiro



Observatório das Metrópoles



Estruturação do Mapa: Observatório das Metrópoles
IPPUR - ÚFRJ

0 5 10 20 30 40 Km

Figure 1: Mesquita City localization in the State of Rio de Janeiro



Figure 2: Dona Eugênia River Catchment.

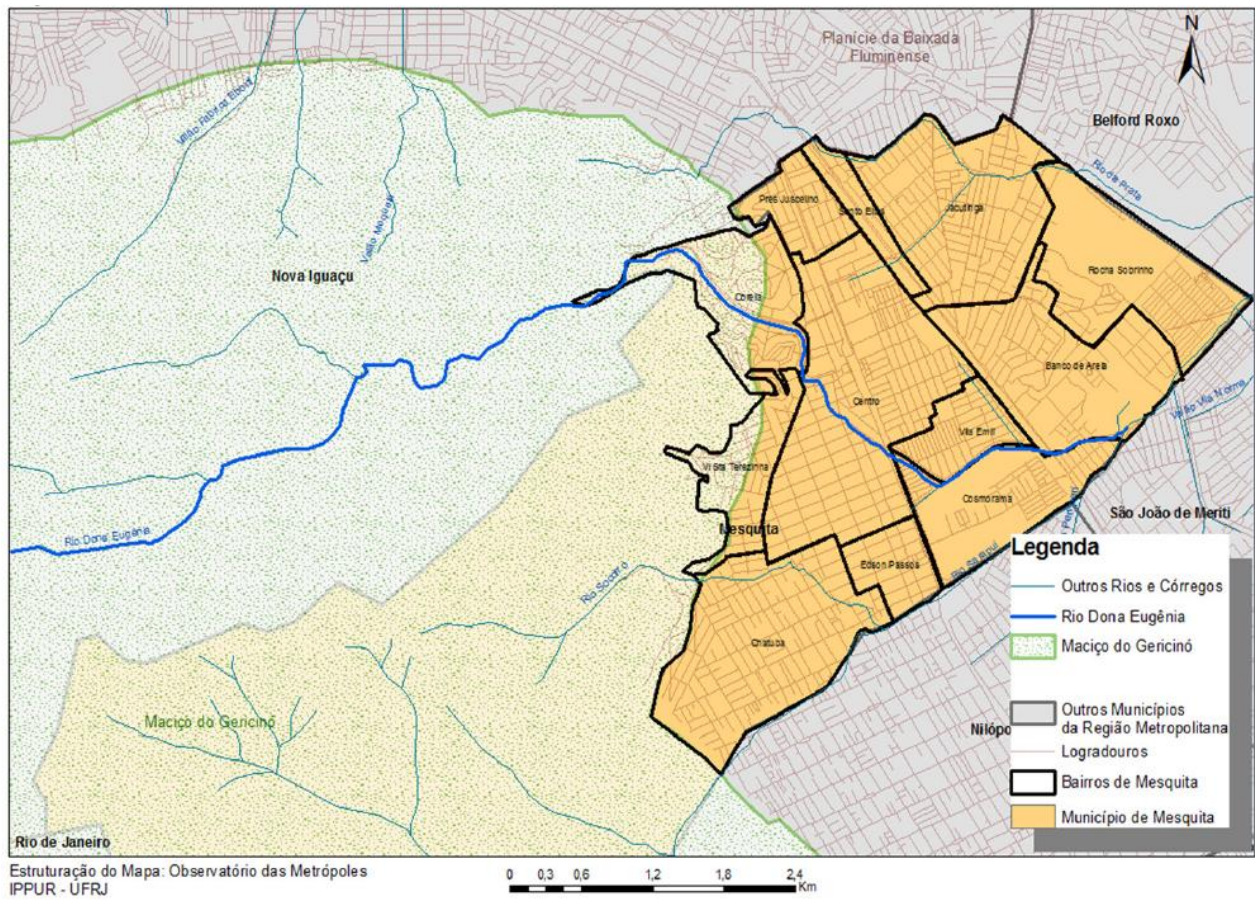


Figure 3: Dona Eugênia River through Mesquita City (Britto, 2011).



Figure 4: Dona Eugênia River inside the environmental preservation area (Aniszewski, 2009).

Inside *Nova Iguaçu Natural Municipal Park*, there is a dam, called Epaminondas Ramos. This dam was, until 1981, responsible for the water supply of great part of the population who lived nearby. It was deactivated because of the contribution of irregular discharge of sewage originated from illegal sites.



Figure 5: Epaminondas Ramos dam. (Aniszewski, 2009).

Mesquita municipality has many problems of infrastructure. In the most populated areas of the city, there are numerous illegal allotments. Even regular lots, but resulting from intense fragmentation of the land, without any infrastructure or improvement, appear frequently.

Another important question is that, due to the lack of adequate housing programs, there are many hill slopes occupied by low income population in a disorderly way, without taking into consideration environmental risk factors.



Figure 6: Areas without adequate infrastructure in the municipality of Mesquita. (Extra, 2010).

Problems

- Intense and irregular occupation of riverine areas;
- There are some river reaches that were “canalized” by the houses built along their banks;
- Sedimentation at various points of the river;
- Discharge of sewage and solid waste in the river, with visible environmental degradation and health hazard;
- Recurrent problem of flooding, which affects about 80% of the population;
- Degradation of the urban environment.



Figure 7: Dona Eugênia River, 2011.



Figure 8: Dona Eugênia River, 2011.



Figure 9: Flooding in an area near Dona Eugênia River, December 2008.

Project Background

Some studies were already developed for the studied area in the past. A brief summary of each one is given below.

1. *Iguaçu-Sarapuí Rivers Water Resources Master Plan (1996) – COPPE/UFRJ:*

- In 1996, it was developed the *Iguaçu-Sarapuí Rivers Water Resources Master Plan*. In this study, it was made a diagnosis of the situation in the catchment, in terms of flooding.
- In that opportunity, a dam was proposed to control the urban floods. The proposed dam was located upstream the urban reach, in an area where the river has a high slope, a bedrock, and where the catchment's cover still had natural vegetation.
- It was also part of this study an evaluation of the river sediments movement (1994).

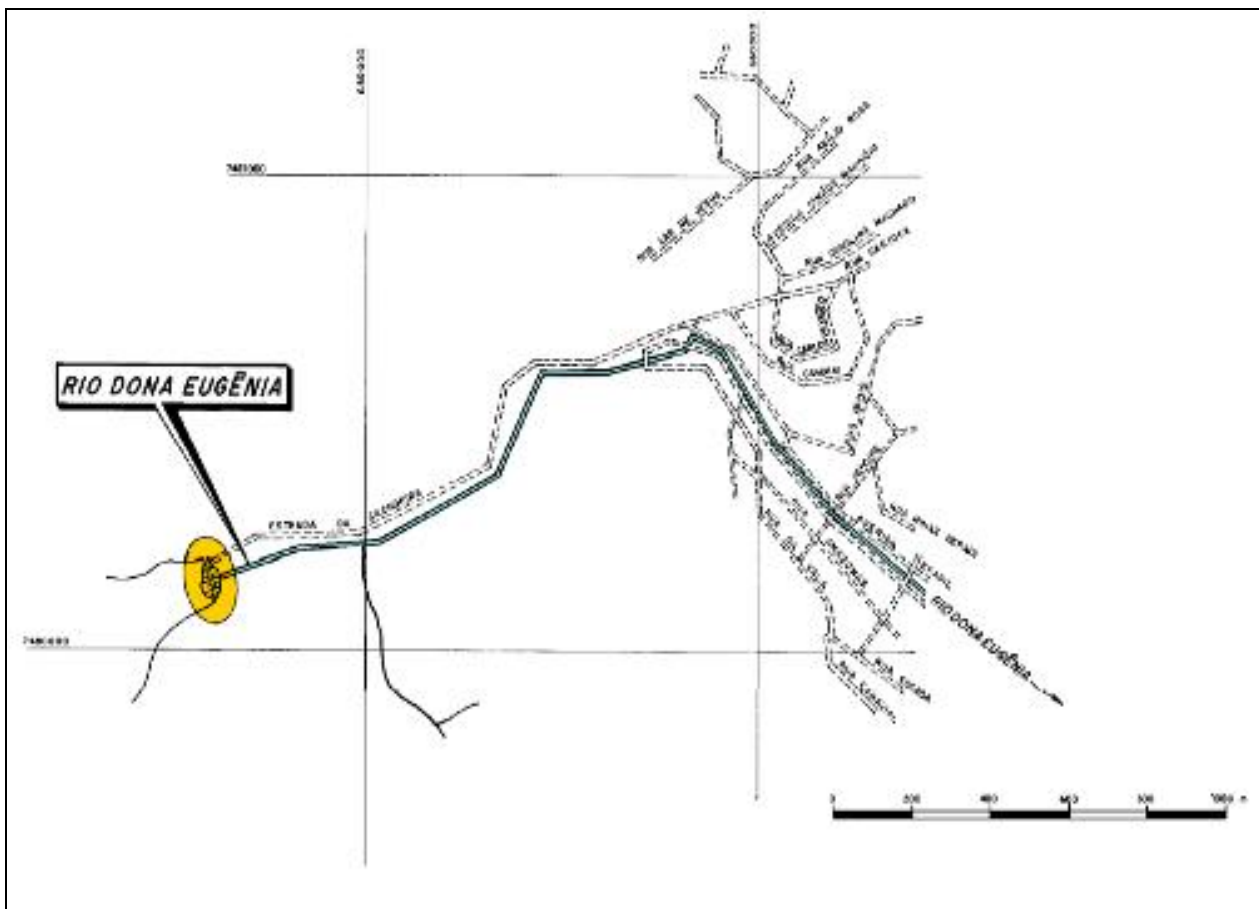


Figure 10: Location of the proposed dam in Dona Eugênia River, 1996.

2. *Review of Iguaçu-Sarapuí Rivers Water Resources Master Plan (2009):*

- In 2009, the Master Plan suffered a revision.
- In this opportunity, it was introduced the concept of sustainable drainage, with the proposition of an urban park typology, which consisted of parks with different functions, ranging from riverbanks protection to temporary storage and maintenance of pervious rates (Carneiro, 2006):

Urban River Park – Longitudinal parks with the purpose of protecting water course banks, also avoiding their irregular occupation by low income population.

Urban Flooding Park – Longitudinal parks, purposefully deployed in areas with low elevations, to allow frequent inundation, which will help to laminate floods.

Urban Environmental Park – Large parks, flat or not, with the purpose of environmental preservation and land use valuing, with the aim of minimizing runoff generation.

- Another important element introduced by this new plan was the proposition of some
- The solution for Dona Eugênia catchment, however, remained dependent on the dam proposed in the first study.
- The proposed dam was adjusted for present situation and its simulation of the designed flood control indicated a reduction of 84% in Dona Eugênia river flood flows (Figure 11).

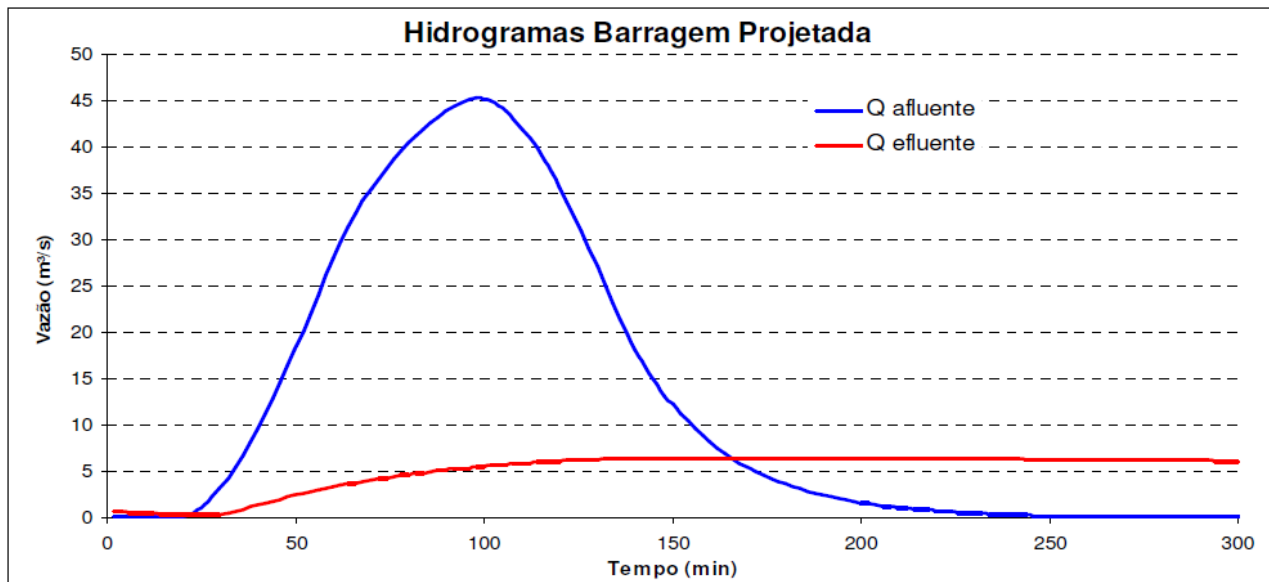


Figure 11: Simulation of the designed flood control dam operation.

3. Master Thesis of the Urbanism Program/UFRJ: “Environmental Restoration of Urban Rivers – Guidelines for the Botas river in Baixada Fluminense lowlands” (Royse, 2009):

- In this thesis, it was proposed a methodology for the environmental restoration of Botas River, in Baixada Fluminense lowlands, focusing on the treatment and management of its riverbanks, to enable a new relation between the local people with the river, where the use of the floodplains as possible recreational spaces is highlighted. This methodology integrated physical, socio-cultural, political and environmental aspects. The project for Botas River is showed in Figure 12.
- The project proposed in this study provides a possible methodology to be adapted and applied on other rivers of the same catchment. In this context, it can be considered the case of Dona Eugênia River.



Figure 12: Proposals for Botas River (Royse, 2009).

4. A pilot study for the implementation of a multifunctional landscape in the urban area of the municipality of Mesquita (Rezende, 2010):

- A case study of flood control project using a stormwater retention pond, designed to allow multiple use of an urban space, under the concept of multifunctional landscapes, was developed.
- The interest area for implementation of the retention basin proposed in this paper is located in the city of Mesquita, metropolitan region of Rio de Janeiro. The urban occupation of the city is very dense, with few open spaces. This characteristic claims for a solution that is concerned about social urban space use, valorising degraded areas and giving them different possibilities of use.
- This area occupies a flood plain downstream Dona Eugênia river outfall on Sarapuí River.
- The chosen area for deployment of the stormwater damping device is located at the left margin of Sarapuí River, receiving the draining water of an urban watershed with 628,136 m². The catchment is relatively plain, with an average slope of 0.0054 m/m and a maximum elevation of 34.5 meters. Figure 13 shows the level and density of occupation of the study area.

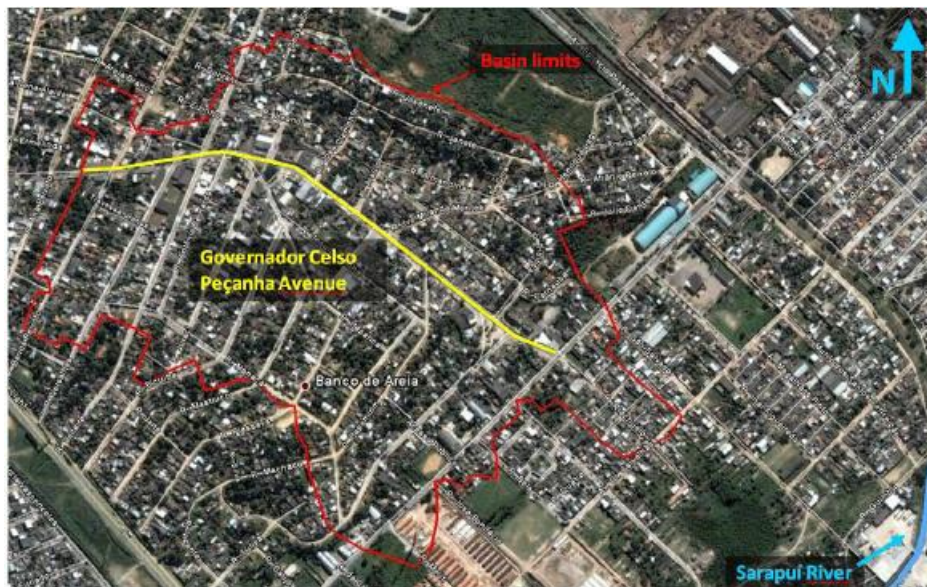


Figure 13: Urban basin of Governador Celso Peçanha Avenue. Source: Google Earth.

- The designed retention basin implementation required a range of interventions like *ground excavation to shape the different levels, construction of a semi-circular canal to carry water between the two lakes and implementation of a circular gallery with a one-way gate (type Flap Gate) to link designed channel with Sarapuí River*. The schematic drawing is displayed at Figure 14.

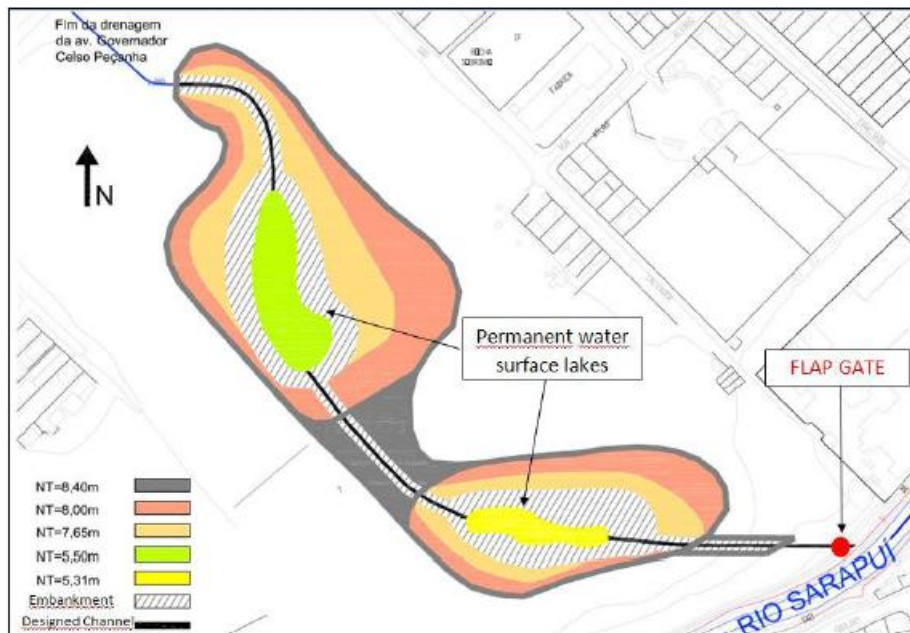


Figure 14: Ground levels (NT) inside Celso Peçanha retention basin.

- No natural water body is responsible for draining the water precipitated over the study watershed. The drainage of this area is conducted superficially through the streets and improvised galleries for sewage collection, often built by the residents themselves. The storm water runoff mixed with contaminated water is directed to Sarapuí River through Governador Celso Peçanha Avenue, which is called Riachuelo Street after the intersection with Coelho da Rocha Avenue, acting as the basin main collector. A storm drain runs until the end of the street Riachuelo simply releasing water into the natural terrain, forming a kind of highly unhealthy swamp, by receiving all contribution of sewage from this basin. On the left bank of Sarapuí River, at the downstream of the flooded area, there is still an irregular occupation of a 140m strip by poor dwellings. These characteristics can be viewed at Figure 15.

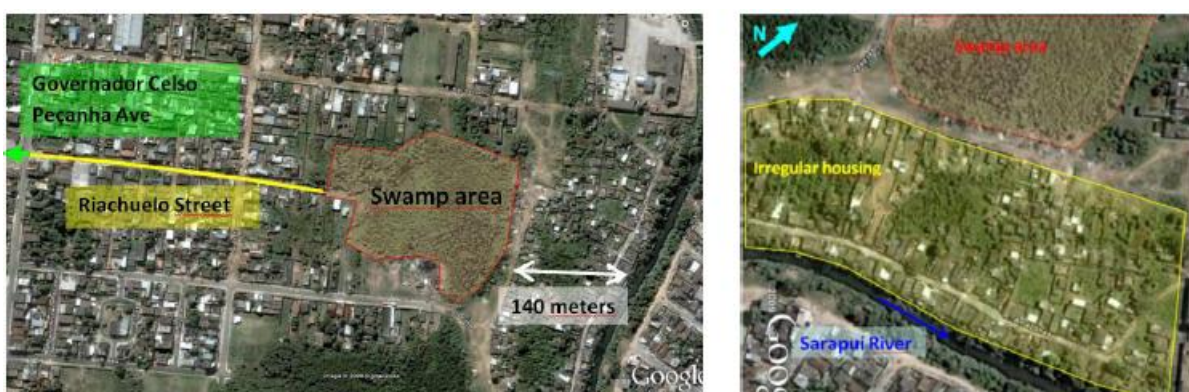


Figure 15: Images of project area, highlighting the swamp and the irregular housing areas.

- The designed device showed efficiency to control runoff in the region, achieving a maximum damping value of 61.7% when considering the event with 50 years recurrence time.

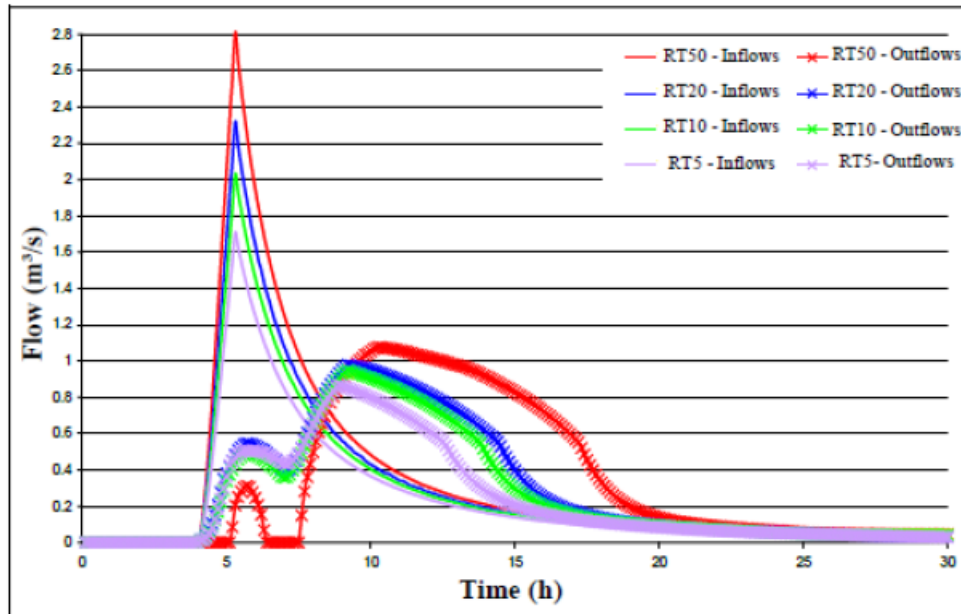


Figure 16: Inflow and outflow design hydrographs of the proposed retention basin.

5. A pilot study to solve the flood problems of Mesquita City, with the support of river restoration practices – Graduation Project (Amaral, 2012):

- The project was developed as a pilot study with the intention to check the catchment response to some proposed interventions, inspired in river restoration practices and comparing with the dam proposed at Iguaçú-Sarapuí Project.
- The catchment was modelled with the support of a mathematical model, MODCEL, based on the concept of flow cells (Figure 17). The flood map for the current situation is showed in Figure 18.

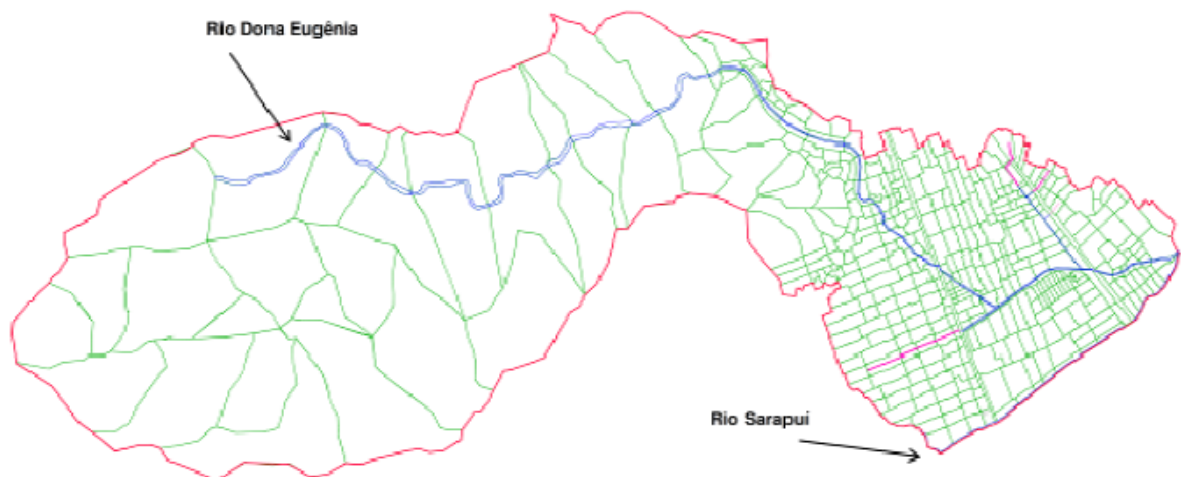


Figure 17: Dona Eugênia river catchment divided in flow cells.

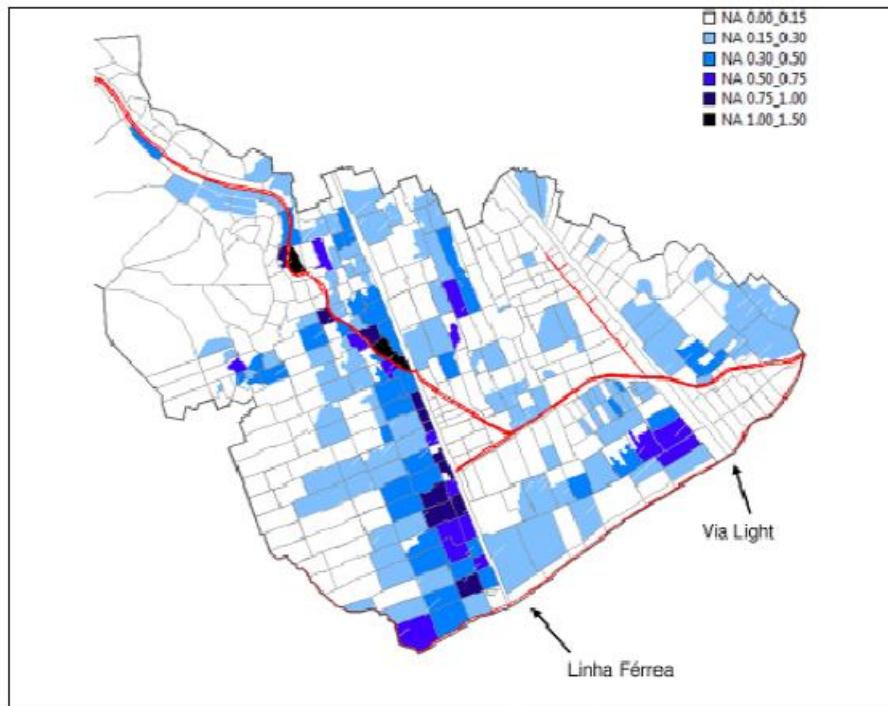


Figure 18: Dona Eugênia river catchment flood map.

- 2 scenarios were initially proposed: one to evaluate the catchment behaviour when removing the existing constructions along the river, considering 30m of each side, to meet the requirements of a marginal protection area for the river, and another scenario considering some distributed measures in the catchment, in a first approach, considering the necessity to work over the entire basin.
- A third scenario considering the flood control dam was also simulated.
- The simulated scenarios with their corresponding flood maps are showed in Figures 19, 20 and 21.

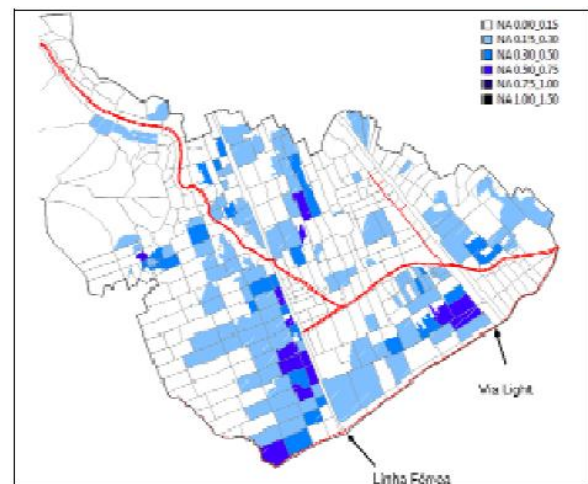


Figure 19: Scenario 1: a) proposal of a fluvial corridor along the river; b) flood map.

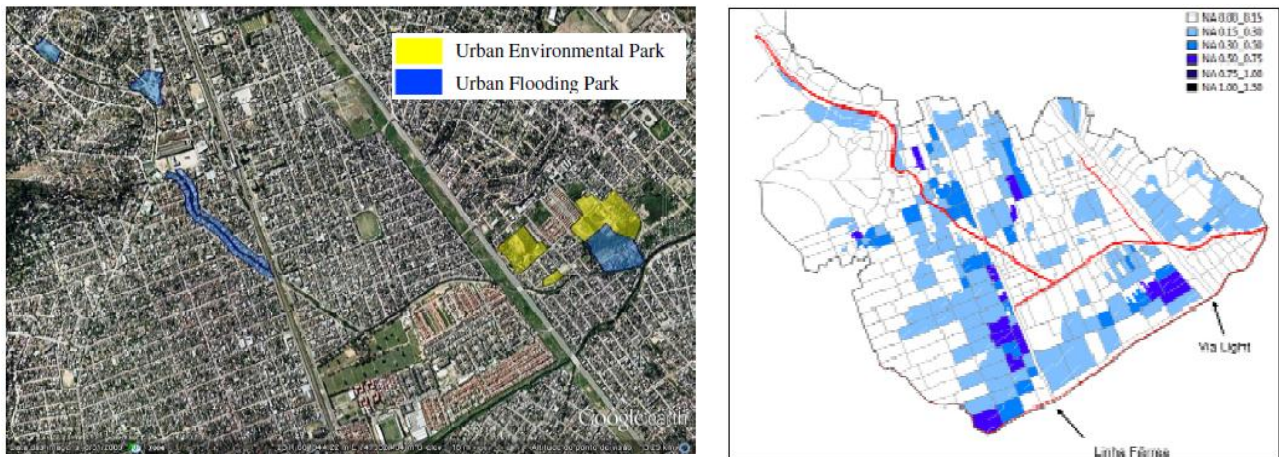


Figure 20: Scenario 2: a) proposal of parks distributed over the catchment; b) flood map.



Figure 21: Scenario 3: a) proposal of a flood control dam; b) flood map.

- The proposed scenarios showed acceptable results in the reduction of the flood level in Dona Eugênia catchment, when compared to the current situation, mainly controlling water levels in main water course.
- The comparative analysis between the 3 scenarios, from the systemic point of view, points out that, in general, the results for scenario 1, considering the introduction of the green corridor, were more efficient for the basin. However, the results observed were not sufficient to completely eliminate the negative impacts generated by urban floods, which spread over the catchment as a result of unplanned urbanization, with insufficient infrastructure and without caring for the generation of runoff. It is important to stress that the best results for the main channel were obtained by the dam, but this fact is not replicated for the neighbour river areas, because river banks occupation and urban inundation generated by exceeding superficial flows are not affected by the dam
- So, it is possible to say that the third scenario, considering the dam, adequately controls the river flow, maintaining it within the channel, but has no effective action out of the main river channel. The restoration of a fluvial corridor also keeps the flows under control in the river channel and generates benefits for the catchment, mainly in the vicinity of this corridor. However, the heavy changes on the surface of the catchment as a whole still maintain some degraded and flooded areas
- Thus, in the 3 scenarios, the critical urban problems, related to the disorder in the land use and its illegal occupation, had to be treated in a broad sense, and the development of the city itself should be reconsidered. The expansion of the concept of river restoration for the context of the whole catchment is a possibility to be verified in the study proposed in this concept paper.

Project Studies in Course (March 2012)

1. *The landscape design as an instrument for the river restoration in urban rivers – Dona Eugênia river, Mesquita/Rio de Janeiro – MSc. Thesis (Lourenço, 2010-2012)*

- The general objective of this M.Sc. thesis is to demonstrate the importance of the landscape design in the recovery and restoration of urban water courses and provide guidelines and design solutions that attest to the sustainable management of cities.
- The thesis will be developed using Dona Eugênia River as a case study.

2. *Development of sustainable solutions of urban water management integrated to the city development – DSc. Thesis (Veról, 2010-2013)*

- The general objective of this D.Sc. thesis is the development of sustainable solutions of urban water management integrated to the development of the city aiming at reducing the impact on the flood hydrograph, focusing on the use of distributed compensatory measures and on the possibility of urban rivers restoration, with the aid of mathematical modelling.
- The thesis will be developed using Dona Eugênia River as a case study.

Motivation of the proposed case study

- River degradation in Brazil, especially in urban areas, is a great problem. Urban planning is a process not always present, poverty plays an important role and informal cities (conforming slums) are, sometimes, as significant as the formal cities areas. Vegetation removal, riparian areas occupation, wastewaters and solid waste disposal directly on the rivers, these are some of the problems faced in Brazilian growing cities. Urban flood problems are becoming more frequent and more severe. In this context, it is common to find cases of flood control design that express concerns on river restoration. The academic community and part of the technical community usually propose more sustainable approaches, trying to recover, as well as possible, the original aspects of the water cycle. This situation contrasts with the traditional projects, which are still very frequent in technical practices, focusing in canalisation actions. However, even in those more sustainable projects, and even when concerning river restoration, what is usually found is the flood control concern related with a possible urban revitalisation. This is surely an important aspect, but when the river is not adequately considered, it is also a loss of opportunity. Sometimes, water quality concerns appear, related to better sanitation needs. These aspects affect river restoration, but this subject is not seen in its complete form. This is where the rationale of this case study arises with greater strength. The SERELAREFA vision on river restoration and river rehabilitation, considering systemic aspects and a better ecological result from the river point of view, is an important complement for the design processes frequently developed in Brazilian cases.
- The expectation with this particular study of Baixada Fluminense lowlands is to rise the opportunity to look for complementary actions, integrated with the river restoration possibilities, at least in part, but considering the river as the main subject. Therefore, the results obtained here, with the aid of mathematical modelling, will allow the construction of different scenarios that intend to generate knowledge and examples to be used in future projects, expanding the horizons in this matter.
- Another interesting possibility refers to the comparison with another concept paper, proposed in the context of SERELAREFA Project, which is related to the lowland area of Mestre/Venice. This area is naturally subject to harsh flooding as part of it lies even below the mean sea level and is drained artificially. The Brazilian group will participate in this study, concerning rural/natural and urban areas, with the use of the same mathematical model proposed here – MODCEL. The interaction among Brazilian and European researches will be done in these two realities, which are linked by a similar physical situation. It is important to say that after the dramatic events in 2006, 2007 in Italy, a specific law introduced the “hydraulic invariance” concept, which is very similar to the “compensatory techniques” in Brazil. The idea is that if a new building/infrastructure would increase the peak discharge in a reference flood event - 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 to do not surpass the 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).

- With these two cases – the one proposed in this concept paper, related with Baixada Fluminense Lowlands, and the other, stated for Mestre/Venice lowlands, one of the objectives of SERELAREFA may be exercised: to promote the exchange of experience and know-how. Besides, this case opens the possibility of discussing alternatives for better rivers in better cities, in the context of SERELAREFA. The proposition of more sustainable approaches, illustrated by quantitative analysis based on mathematical modelling, may be an opportunity to open a door for different engineering actions to be considered among or instead historical traditional measures, considering its role and integration in a river restoration process.

Therefore, resuming in brief the motivation discussed and stressing the main aspects, it is possible to state:

- The solution presently proposed for controlling urban floods in D. Eugênia River Catchment considers the implementation of a dam;
- The dam controls river overflow, but is not sufficient to improve inundation conditions over the basin system as a whole;
- Several studies developed offers a background base to evolve towards a more sustainable solution;
- Urban design and landscaping may be used together with civil and environmental engineering to improve city conditions as well as helping to develop an appropriate urban river restoration discussion, generating sustainable alternatives in the basin context, not only for the fluvial corridor;
- The case of D. Eugênia River will be developed with the purpose of integrating these different subjects, focusing in river restoration and urban revitalisation, respecting the city constraints, but trying to formulate a general procedure to improve results in both areas;
- These proposed procedures are expected to be used as a reference for other interventions in the context of Baixada Fluminense lowlands, as well as to other urban cases;
- SERELAREFA Project and the relations established with Mestre case study may be able to give a better visibility for the proposed procedures, what may help to avoid historical past errors in flood control projects and help to disseminate these new concepts;
- In practical terms, the particular design concepts that will be proposed by this case study, for D. Eugênia River, may be useful as a complementary alternative for the dam, helping to give to Mesquita city a better future perspective.

Project Idea

Based on past experience, it is intended to:

- Update the full diagnosis of the catchment;
- Update the sedimentology diagnosis of the catchment;
- Assess the fluvial morphology situation of the river;
- Study the different streams of the river, in the area of the forest reserve, in the middle and still rural stream and in the low urban areas, in order to work according to the needs and difficulties;
- Aggregate aspects of urban design and enhancement of the urban environment in the solutions supported on the river restoration, bringing to this context a social debate;
- Create a fluvial corridor connecting the upstream forest reserve to the city areas;

- Design interventions for the reorganization of the urban space, using the river restoration as a starting point, defining river marginal protection areas, reconnecting the river with its floodplains, alternating the use of urban fluvial parks with more natural areas, also acting on the water quality, with classical sanitation measures and with distributed BMPs measures, to minimize the impact of urban diffuse pollution.

Objectives of the proposed project

General

The general objective of this case study is to act in an integrated and transdisciplinary way in Dona Eugênia catchment, dealing with questions of land use and occupation, architecture and urban planning, landscaping, sanitation, flood control, housing and river restoration, involving the Municipality, various institutional actors and the local population, in the construction of a rehabilitation project for the municipality of Mesquita considering the river as the starting point element.

Specific

- Diagnose the hydrodynamic and hydrological behaviour of Dona Eugenia river catchment, which is subject to profound impacts on the land use and occupation, due to the urbanization process.
- Use practices of river restoration in Dona Eugênia river catchment, with a focus on reducing the levels of flooding.
- Use concepts and practices of sustainable urban drainage systems and water sensitive urban design.
- Analyze the resulting benefits in hydrology and hydraulics behaviour due to the restoration of Dona Eugênia river catchment and the use of sustainable drainage practices.
- Compare the implementation of a flood control dam with the result obtained by the river restoration proposals.
- Analyze and discuss the possible benefits of an integrated project of urban flood control, taking the whole catchment as a stage for actions.

Activities

- 1) **Diagnosis:** just some items will be detailed – those where the activity is less intuitive.
 - a) Morphological characterization;
 - b) Hidromorphological risk;
 - c) Hydrology;
 - d) Socio-economic activities;
 - e) Scenarios of future development and possible plans/projects.
- 2) **Vision and objectives:** construction of a common vision, definition of objectives and collection of solution alternatives.
- 3) **Solution alternatives:** proposition of different alternatives.
- 4) **Alternatives evaluation**

- a) *Definition of a methodology* and criteria of integrated evaluation of cost-benefits, environmental impacts, including financing sustainability.
 - b) *Prediction of effects* with mathematical modelling
 - c) *Analysis* of the information
 - d) *Integrated* evaluation of the alternatives
- 5) **Final design of physical interventions.**
- 6) **Diffusion:** development of informative material (report, PowerPoint presentation, posters, booklets, videos, CD,...) to spread the concepts developed at a Brazilian and Latin American national level and, using the SERELAREFA network, meetings, workshops, participation at conferences.

Expected products

- Technical report (Portuguese* and English) with: i) historical aspects of urban development and river degradation in Baixada Fluminense; ii) diagnosis of present flood situation; iii) actions in motion; iv) 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 restoration measures; v) mathematical modelling for comparative analysis; vi) identification of technical limitations and constraints related to built environment
- Final graduation course projects on Civil Engineering, master thesis, doctoral thesis and 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.

** Portuguese report is important for local diffusion and dissemination of obtained results*

Partners and roles

- UFRJ
- INEA
- CIRF
- UPM (España)

Working team

Required skills:

- Fluvial hydraulics engineering (mathematical modelling)
- Hydrology
- River restoration practices
- Urban drainage and flood control
- Urban planning and development
- Landscape composition
- Participatory processes and conflict management

Work team structure:

- Project manager
- Sectoral experts
- Post-graduate students

- Undergraduate students
- Logistic

Costs and financing

This project is conceived mainly as an Academic exercise in line with the SERELAREFA conception. Most of the costs are implicitly assumed by UFRJ, as a contribution to the cooperation spirit. Because of this, and considering that no external financing support is expected from other fonts, the main working force in this concept paper will be undergraduate and post-graduate students in their final projects, master thesis and doctoral thesis.

Plants and bases are available and complementary services of field survey will be provided by the University.