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Sustainable Management of Urban Watercourses: The Vila Nova de Gaia Historic Center Case Study

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Abstract: Watercourses in the urban environment play a relevant role, promoting sustainability conditions and improving the life quality of the regions. In this context, the management of this resource has face up serious challenges over the years. Climate change associated with an increasing imperviousness of soils in urban centers are added problems, increasing peak flows and their impacts. The study of new methodologies to mitigate these problems are, therefore, an urgent need. This article aims to present the case study of the Vila Nova de Gaia Historic Center, a UNESCO World Heritage Site, where water streams have, historically, been the support on urban activities. As a result, structural and non-structural measures are proposal, which is believed to have direct and positive impacts in promoting a more efficient management of these watercourses – mitigating their negative effects, namely floods – and enhancing the sustainable development of the region.

Keywords: sustainable development; urban watercourses; watercourses management

The urban growth observed in the last decades (UNDESA, 2014), the increased imperviousness of the soils in the big urban centers, and the changes of the meteorological patterns – with great precipitation intensities in short periods of time – has been giving rise to situations in which the urban drainage systems do not respond to the objective for which they were designed (Howden *et al.*, 2007), leading to the need of requalification operations that guarantee the sustainability and efficiency of the entire grid (Meehl, *et al.*, 2007). On the other hand, a significant part of the urbanized space is near watercourses, and due to the specific characteristics of these urban basins – generally of small dimensions and with low concentration times – the effect of the urban growth has direct impact on water quality (Jha, Bloch & Lamond, 2012).

Therefore, an integrated and sustainable water management in the urban environment is crucial, resulting in economic and financial advantages for the municipalities and contributing greatly to the improvement of the cities livability as well as to mitigate the floods negative effects.

Hydrological phenomena can not be avoided but their effects can be reduced, depending on the magnitude of the flow conditions – water height, flow rates and velocity - and the frequency with which they occur. The main problem is that there are no hydrometric data that allow for significative statistical analysis and the definition of return periods for short period floods. Hydrological and hydraulic models can solve, in part, this problem (Lee *et al.*, 2012).

Thus, the main goal of this work was to characterize, analyze and present an integrated solution for a real case study affected by this type of problems.

The project includes three watercourses – Horto, Serpa Pinto and Santa Marinha –, located in the historic center of the city of Vila Nova de Gaia, Porto, Portugal, an area considered a World Heritage by UNESCO.

This zone has a high population density – associated to a high tourist presence –, with impervious soils and accentuated topographic slopes. Reports of floods are frequent. At the same time, the economic impact of the *Porto Wine* industry and tourism are very important for the development of the region.

Featuring similar characteristics, the three watercourses flow into the Douro river, near to the sea. Therefore, the effects of the variations in the Douro tides present significant impacts on the flow of the watercourse.
To mitigate these impacts the project was divided into two distinct phases: to improve the hydraulic and drainage conditions through interventions in the streams cross-sections and the development of processes to optimize the basin management and their existing Low Impact Development systems.
Truly efficient and reliable solutions must quantify the different flows types. Therefore, flood flows were estimated by applying the Rational Method and the Loureiro Method. Monthly average flow rates were also quantified through interpolations with basins in the vicinity. Finally, and given the complexity of the entire system, a modeling of the entire system was also carried out – using *EPA SWMM 5.1* software provided by the *United States Environmental Protection Agency* – to better understand the main factors that affect the flow in the watercourses.
Based on the results, it was perceived that the problems had their origin in two distinct components. A first one referring to the hydraulic and drainage conditions of the watercourses and another referring to the hydrological conditions of the watersheds.
Although some sections were quite generous, in situations of intense precipitation, where the flow rates are higher, associated with hight tides, there was a drowning of the entire system. This phenomenon causes, consequently, a reflux of the flow causing floods. Therefore, based on these information, the proposed solution involves a clear separation between the stormwater drainage system and the watercourses. This guarantees that, even in critical scenarios, the system ensures a pressure flow without flooding the surrounding areas. At the same time, the requalification of the watercourses cross-section – currently very degraded –, improve the security conditions and can be done in very specific areas without jeopardizing the existing and rich heritage.
Regarding the hydrological component, the solution is to optimize the management of the existing Low Impact Development systems along the streams. Therefore, specific locations have been defined where a pack of flow meters, pressure sensors and a hydrological station will be installed, making it possible to obtain information and data, practically in real time. With these systems, it is expected to define a management model based on continuous improvement, making direct relations between the precipitation intensities and the flows and present real-time decisions, anticipating and mitigating possible problems.
At the same time, it is important to say that this type of solution also has the great advantage of being easily replicable to other regions with similar characteristics.
Therefore, it is believed that this solution can greatly mitigate the effects of floods, contributing to the improvement of well-being in the urban environment.

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