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CHANGING THE URBAN DRAINAGE PARADIGM FROM A PLANNING PERSPECTIVE. A METHODOLOGICAL PROPOSAL

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I. INTRODUCTION AND SUBJECT MATTER

The major socioeconomic changes which began in Europe after the industrial revolution have generated enormous densification and expansion of cities which have led to a heightened level of impermeabilization of urban surfaces (Lavalle et. al, 2001; Montanarella, 2007). The main effect of this phenomenon on the urban water cycle has been the reduction in the surface's ability to infiltrate and retain water. This has caused an increase in surface run-off that is making the traditional sanitation networks collapse (Ren et al., 2013), causing an increase in flooding with catastrophic consequences, especially in fluvial areas (Burghardt et. al, 2004; EEA, 2010). This phenomenon, which is already serious, is expected to worsen in coming years due to the rise in the intensity of rainfall which is predicted by current climate change model. (Olsson et. al, 2009).

This situation brings to light the need for a change in the urban drainage management paradigm, which has become an unsustainable model, based on the continued and constantly insufficient sanitation networks (Olsson et. al, 2009). This change also needs to be integrated into urban planning as a tool for the control of the impermeabilization of land and the improvement of urban sustainability. (Rodríguez-Rojas et al., 2014).

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Accordingly, since the nineties, a strategy which is more consistent with these principles has been developed by using the systems called 'sustainable urban drainage systems' or 'SUDS' (CIRIA C697, 2007; MWB, 2013). Countries such as the U.S.A, the United Kingdom, Canada, France and Australia have been using SUDS for more than a decade (CIRIA C521, 2000), mostly as a tool to mitigate the effects of soil sealing. In recent years a new comprehensive water-land model has been considered called 'water sensitive urban design' (WSUD), which is defined as *"the integration of urban planning into the management, protection and conservation of the urban water cycle, in such a way as to ensure a form of water management which is sensitive to hydrological and ecological processes."* (COAG, 2004). This model goes beyond SUDS, taking it further than simple timely involvement leading to the implementation of these systems; it considers a more sustainable occupation of territory, which is consistent with hydrological processes, incorporating the design of urban elements (such as streets, buildings, public spaces,…) as a valuable opportunity for restoring the environmental quality standards of cities (Rodríguez-Rojas et. al, 2014).

There are currently very few references which work to this model (CIRIA C687, 2010), the specific manuals on SUDS still predominate (CIRIA C697, 2007; SWD 101, 2012; MWB, 2013), which show the process of the technical execution of these systems in detail but do not deal with the aspects related to their integration into planning. This lack of information defines the main objective of this article, to provide a methodological tool which defines and integrates the requirements of WSUD in the planning process, therefore contributing to the development of water sensitive projects and as a consequence, to the improvement of the environmental quality standards of cities and the sustainability of water management.

II. PLANNING METHODOLOGY FOR WATER SENSITIVE URBAN DESIGN

In order to facilitate the incorporation of WSUD into the planning process, it must be added to every stage, ensuring viability, profitability and their related benefits. According to the author, the methodologies used in planning develop through different work stages, even though the following points can be observed in all of them (Rebstock et al., 2011): preparation of the plan (preliminary discussions with the parties who are involved and analysis and assessment of the existing situation), design and evaluation of strategic proposals, implementation, and execution of projects which develop the defined lines of work and monitoring, and follow up on the results obtained. Then, a methodological proposal is presented for the implementation of WSUD into this structure, so that water becomes a requirement and another opportunity in the planning process (Fig. 1).

II.1. Preliminary discussions

In the first phase of planning, a discussion process must be established with the different **social agents** involved in the project (such as communities of residents, associations, and educational centers), with the aim of making WSUD public knowledge and explaining its importance for the improvement of the environmental quality standards of cities and citizens well-being. Likewise, meetings with **politicians and experts** (local and regional authorities, land and water management organisms, and water network management organizations) must

take place so that regulatory contradictions and overlaps with other projects do not happen. In parallel to this discussion process, it is important that all the **disciplines** necessary for dealing with the complexity of urban problems related to water (such as urbanism, geography, engineering, environmental sciences, landscaping, legislation, and sociology) are integrated into the team.

II.2. Analysis and assessment

Once the preliminary discussions are finished, the phase dealing with the evaluation of the current situation of the work environment starts. For this an analysis and assessment of existing problems will be carried out, making it necessary to know the **physical characteristics** of the area which are related to water (such as topography, geology, and climatology), urban setting (such as streets, surfaces, and green spaces) and hydrological-hydraulic characteristics (such as drainage networks, flow, and flood areas).

With the **urban setting**, it is necessary to carefully analyze the proposed or existing roads in relation to topography, in order to locate which streets do not have steep enough slopes to evacuate run-off on their own and could therefore flood (we will call them "lake streets") as well as to identify which streets are so steep that they could generate dangerous run-off speeds (we will call them "river streets").

The second variable to be studied is permeability. A specific study must be carried out on existing land use in order to determine what type of surfaces can be designed and/or modified in the area of intervention, so that run-off infiltration is assisted as much as possible and its retention time is maximized. It is also necessary to identify all the deteriorated urban areas which can be rehabilitated and /or restored through the reconditioning of surfaces or through the implementation of SUDS which are designed for this end (such as swales and wetlands). Finally, it is necessary to identify green areas and multifunctional areas which can be used for temporary collection and storage of rainwater for later infiltration and retention, since their role will be crucial in avoiding floods.

Regarding the **hydrological-hydraulic setting**, it is necessary to know the existing surface drainage network in detail in order to carry out safe urban planning, as well as the flow rate of the network and areas which could flood.

II.3. Proposals

In the intervention phase, responsive relationships must be established between the urban settings and hydrologic settings analyzed, so that the actions which are carried out concerning one do not cause negative effects for the other. Firstly, the urban framework which has been proposed and/or modified must generate a drainage network which prolongs the presence of water as much as possible and avoids the creation of "river streets" and "lake streets" In order to achieve this, modifications will be made to the slopes of those streets which need them, leading to the creation of new drainage routes or **"blue corridors"** which will have been designed for storage, infiltration and retention using what are known as "run-off interceptors".

Secondly, the level of **permeability** of existing and /or planned surfaces must be increased through redesign (such as repaving, incorporation of green cover, and filtering trenches), or, if necessary, carrying out a change in use of those areas which have a high flood risk.

Those problems which are not eliminated by using the previous proposals can be minimized by **integrating SUDS** into the urban framework. When choosing the most appropriate typology, two variables must be considered; the location of the project area and its existing urban use. The location will condition the use of a system which can promote infiltration, retention, and reuse, and the use of the land will specifically determine the type of SUDS to be used depending on the aims and benefits required by the system.

Finally, developing a **maintenance plan** which involves the users who are affected by the proposals is necessary, in order to guarantee the success of the proposed measures. This ensures the required conservation and maintenance of the systems.

II.4. Evaluation

Once the proposals have been defined and before their execution, it is important to do a **presentation and discussion** for the social agents, politicians and experts who are involved in the process, in order to confirm that all parties are in favor of the execution of the proposed projects and the corresponding maintenance plan. Furthermore, it is advisable to evaluate **the results obtained, quantifying** the improvements which the completed proposals have generated when considered in respect to the situation regarding the urban renewal projects prior to this plan, and/or the situation of conventional design which would be carried out in the new developments. In order to achieve this, it is necessary to calculate:

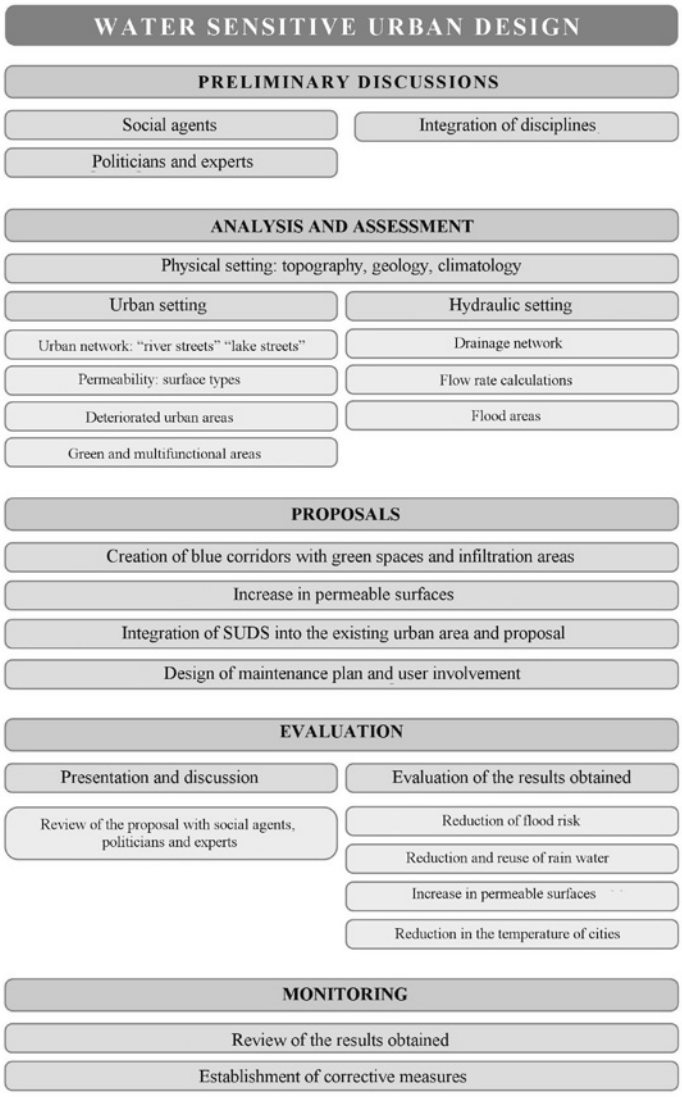
- The decrease in flooding which has been achieved (applying once again the hydrological-hydraulic model used in the analysis phase).
- The reduction of the total run-off volume in the urban framework and the amount of water reused to different ends.
- The increase of permeable surfaces and green spaces.
- The decrease in average temperatures produced in urban settings.

With this information a cost-benefit analysis can be performed for completed proposals which could be implemented into the viability of the plan. Therefore, the authorities could consider the creation of economic and fiscal incentives related to the improvements produced, which could in turn lead to a general cost reduction.

II.5. Monitoring

The final stage of the methodology consists of periodic evaluation of the results obtained, so that it can be ensured that the proposed designs work correctly and that the objectives set out in the plan are attained. To achieve this, the results obtained must be **re-evaluated** and, if necessary, the appropriate steps must be taken in order to avoid a decrease in performance of the implanted systems and the effectiveness of the completed proposals.

Figure 1
METHODOLOGY FOR THE INTEGRATION OF WSUD INTO PLANNING



Source: Own work.

III. RESULTS

The review carried out in this article on the problems caused by land impermeability and its impact, confirm the need for carrying out a change in the urban drainage paradigm, in which urban planning is established as a tool for improving the sustainability of cities. In

order to do this, a work methodology has been proposed whose main objective is the integration of the principals of 'water sensitive urban design' (WSUD) into planning (Fig. 1), so that the impact generated by soil sealing is eliminated and/ or mitigated at its root. Accordingly, some design and planning criteria have been established which include the integration of 'sustainable urban drainage systems' (SUDS) in urban settings, making their use easier for the planners.

However, the implementation of this model into planning will require progress to be made on the current situation, since very few references exist which work using the definition and application of WSUD. The examples which are putting water sensitive urban design into practice are generating numerous short and medium-term benefits for cities, but their implementation is also meeting with some difficulties, especially concerning coordination between administrative bodies to allow the developed proposals to meet both urban and water requirements. This problem could be resolved through the definition of a series of documents which could become common practice in territorial and hydrological plans. This would make the strategies of both plans act in each other's interests concerning both water and land. Accordingly, the methodology proposed could be very useful, as it would establish the forms of analysis which would be necessary to carry out this integration, as well as establishing the principles which should be taken into account in the writing of these documents.

IV. CONCLUSIONS

The continued impermeabilization of urban land has caused an increase in the volume of run-off which sanitation networks have not been able to cope with, in spite of them having been continuously extended in recent years. This situation has generated an unsustainable management model which requires a new way in which to treat rainwater which is more consistent with environmental principles. Accordingly, SUDS have been used in many countries of the world in recent years as instruments to recover, as far as possible, the natural water cycle in cities, through the infiltration, retention and reuse of rainwater. In spite of having brought about progress in the search for more sustainable ways to manage this resource, on most occasions, these systems have been implemented as palliative measures to minimize the future impact of soil sealing. As the root of these problems can be found in the current model of urban occupation, the need for the development of a new model called 'water sensitive urban design' has begun to be recognized. The main objective of this new model is to implement water requirements in city planning. In this way, problems generated by the impermeabilization of land will be eliminated and/ or mitigated, generating a more sustainable urban model which uses rainwater as a tool for the enhancement of urban settings and the improvement in the quality of landscaping and the environmental quality standards of cities.

This article clearly states that urban planning must be a frame of reference into which this new concept must be integrated, not as an isolated element, but as part of a planning process based on the recovery of the natural water cycle. Therefore, this article proposes a methodological tool which integrates the requirements of WSUD into the planning process, therefore contributing to the development of water sensitive projects, to the improvement of the environmental quality standards of cities and a rise in the sustainability of the water resource.