



HAL
open science

Advances in the investigation of the construction costs of Sustainable Urban Drainage Systems

Eduardo J Ariza, Luis Á Sañudo-Fontaneda, Juan Pablo Rodríguez

► **To cite this version:**

Eduardo J Ariza, Luis Á Sañudo-Fontaneda, Juan Pablo Rodríguez. Advances in the investigation of the construction costs of Sustainable Urban Drainage Systems. Novatech 2023, Graie, Jul 2023, Lyon, France. hal-04186409

HAL Id: hal-04186409

<https://hal.science/hal-04186409>

Submitted on 8 Sep 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Advances in the investigation of the construction costs of Sustainable Urban Drainage Systems

Avancées dans l'enquête sur les coûts de construction des systèmes de drainage urbain durables

Eduardo J. Ariza¹, Luis Á. Sañudo-Fontaneda¹, Juan Pablo Rodríguez²

¹ Civil, Environmental and Geomatic Research Group, University of Oviedo, Spain. UO290673@uniovi.es; sanudoluis@uniovi.es

² Centro de Investigaciones en Ingeniería Ambiental - CIIA, Universidad de los Andes, Colombia. pabl-rod@uniandes.edu.co

RÉSUMÉ

Cet article présente l'état d'avancement de la thèse de doctorat intitulée "Proposition d'une méthodologie de conception optimale pour les systèmes de drainage urbain durable (SUDS)". L'un des objectifs spécifiques énoncés consiste à concevoir et développer une technique d'optimisation des coûts permettant de trouver l'optimum économique compte tenu de la construction, de l'exploitation et de la maintenance des typologies SUDS. Dans la plupart des investigations, des tableaux reconnus de la littérature sont utilisés pour connaître les coûts de construction d'un SUDS ; cependant, il existe un écart quant au coût d'exécution d'un travail d'un type particulier de SUDS dans les contextes de la Colombie et de l'Espagne, qui sont de bons exemples de pays hispaniques à haut niveau de développement de SuDS. Pour y parvenir, des espaces de rapprochement ont été générés avec des acteurs clés dans la conception et la mise en œuvre des technologies SUDS en Espagne et en Colombie, parmi lesquels figurent principalement les chaussées perméables, les arbres pluviaux, les systèmes de biorétention, les baissières enherbées et les réservoirs de récupération des eaux pluviales. Les résultats attendus à cet égard consistent à comprendre la composition des coûts de construction, dont les aspects ont une incidence plus ou moins importante dans le budget des travaux, et à proposer une première approximation des fonctions de coût pour des techniques SUDS spécifiques.

ABSTRACT

This paper presents the progress of the doctoral thesis entitled "Proposal of an Optimal Design Methodology for Sustainable Urban Drainage Systems (SUDS)". One of the specific objectives outlined consists of designing and developing a cost optimization technique that allows finding the economic optimum considering the construction, operation, and maintenance of SUDS typologies. In most investigations, recognized tables from the literature are used to find out the costs of constructing a SUDS; however, there is a gap as to how much it costs to execute a work of a particular type of SUDS in the contexts of Colombia and Spain as good examples of the Hispanic countries with a high level of SuDS development. To achieve this, spaces for rapprochement were generated with key stakeholders in the design and implementation of SUDS technologies in Spain and Colombia, among which are mainly pervious pavements, stormwater trees, bioretention systems, grassed swales, and rainwater harvesting tanks. The expected results in this regard consist of the understanding of the composition of construction costs, which aspects have a greater or lesser incidence in the work budget, and proposing an initial approximation of cost functions for specific SUDS techniques.

KEYWORDS

Best Management Practices (BMP), costing, Low Impact Development (LID), Stormwater Control Measures (SCM), Water Sensitive Urban Design (WSUD).

1 INTRODUCTION

Some recent research papers guide the concept of optimized design of Sustainable Urban Drainage Systems (SUDS) to the type, location, and area, supported by decision-making tools (De Paola et al., 2018). The multi-objective optimization techniques that are used include minimizing runoff volumes, minimizing pollutant concentrations, and minimizing implementation costs (Duan et al., 2016).

However, compared to the implementation costs themselves, the SUDS budget is usually determined with unit costs (\$/m, \$/m², €/m², \$/m³/year), understood as capital costs only, without considering costs of operation and maintenance during the useful life of the SUDS structure. In the context of Spain, the tabular information on unit prices proposed in 2018 for the Madrid City Council is especially relevant, which has set a benchmark for engineers and developers in the country due to its practicality (Akhter et al., 2020; De Paola et al., 2018; Ghodsi et al., 2020; Liu et al., 2016; Perales Momparler & Calcerrada Romero, 2018). These unit construction costs are usually tabular values, but a methodology that allows the implementation cost of each SUDS to be calculated in a particular way based on the elements with the greatest weight in the final work budget is not delved into.

The purpose of this study is to understand the composition of the costs of some SUDS techniques according to the construction method, both in Spain and Colombia, and to be able to propose some construction cost equations that can be implemented within the proposal of an optimal design methodology for SUDS.

2 METHODS

Meetings were scheduled with engineers and architects in charge of leading the SUDS design processes in public entities in Colombia and private and public companies in Spain. As a result of these meetings, it was possible to access primary information on SUDS projects designed and/or executed, which made it possible to start creating a bank of real SUDS projects. In the Spanish environment, work budgets for a total of 30 SUDS were compiled, including pervious pavements, rainwater harvesting tanks, infiltration tanks, filter drains, and green roofs. In the Colombian case, information was collected on projects of 232 SUDS, which include stormwater trees, bio-retention systems, filter drains, and grassed swales. Although the prices of raw materials increased between 2021 and 2022, with which the inputs for the construction of SUDS also presented an increase in costs, as much information as possible is being collected to assemble a bank of executed SUDS projects, that allow to have enough data to normalize.

There are some SUDS work budgets that correspond to pilot projects, whose costs are not necessarily representative since projects are more expensive on a small scale than on a large scale, for which reason these budgets should be analyzed with caution. Similarly, implementing SUDS in new developments can be more economical than in an already built-up environment. Additionally, SUDS are closely linked to the landscape and a part of the construction costs are associated with urbanization, in which case vegetation can influence the costs of a given SUDS.

In the Spanish environment, information was collected on the costs of supplying inputs for the construction of 30 projects that include 2 permeable pavements, 2 storage tanks for reuse of rainwater, 1 infiltration tank, 6 hybrid structures between permeable pavements and storage tanks, 7 filter drains, and 2 green roofs. Some information was also collected from another project developed in Barcelona whose difficulty was the language since the documentation was in Catalan.

Regarding the context of Colombia, there is a public entity in the capital of the country, the Institute of Urban Development of Bogotá, which has a public access database with 232 types of SUDS, which includes 205 raingarden tree pits, 17 bioretention systems, 7 filter drains, and 3 grassed swales. However, the main barriers to analyzing the information on construction costs of these projects is due to the fact that there is no quality

control over what information is uploaded to the entity's online database, in charge of water consulting firms, nor is there a standard for all projects to store the information in the same way, and the information is only loaded after executing the works to satisfaction being able to distance the official work budget from the stage of studies and designs. Therefore, when reviewing such database in detail, the information promised by the Institute is not found, and it is only possible to access it by signing confidentiality agreements and reservation of information management.

The secrecy of construction firms that develop private projects regarding the provision of primary information on SUDS implementation costs has partially made it difficult to study real construction costs in private urbanization projects.

3 EXPECTED RESULTS

It is expected to have a better understanding of the construction methods of those SUDS typologies with more quality information compared to the quantities and budget of the work, as well as the most important items of the cost of the work and their respective incidence within the total cost of the project work. It is also expected to be able to propose construction cost functions for some types of SUDS, as a result of the analysis of the factors described above, both for the environment of Spain and Colombia.

In the next stage of the investigation, the flow of information will be achieved by the Institute of Urban Development of Bogotá in Colombia through the respective confidential information management clauses to carefully study the cost composition of the 232 SUDS designed for the city of Bogotá, and understand the breakdown of the costs of the detailed work budgets, to study the incidence of the different items and propose an initial approximation of a cost function of some types of SUDS for the Colombian context. The same will be done with the information from the 30 SUDS designed in the Spanish context, with the limitations of lower quality of information that may exist without this reducing the significance in the development of the study as a European country.

4 INITIAL CONCLUSIONS

Although it has been possible to collect information from SUDS projects designed, of which some have been built, difficulties have arisen in the process of obtaining such primary information for multiple reasons:

- Construction firms reserve SUDS work budgets due to competition between developers in the private sector.
- Public entities only upload information on settled contracts that have all the signatures of the responsible professionals.
- In the public sector, information is uploaded to the entities' repositories, but there is no quality control.
- Language barrier for projects in a language other than English or Spanish.

LIST OF REFERENCES

- Akhter, F., Hewa, G. A., Ahammed, F., Myers, B., & Argue, J. R. (2020). Performance evaluation of stormwater management systems and its impact on development costing. *Water (Switzerland)*, *12*(2). <https://doi.org/10.3390/w12020375>
- De Paola, F., Giugni, M., Pugliese, F., & Romano, P. (2018). Optimal Design of LIDs in Urban Stormwater Systems Using a Harmony-Search Decision Support System. *Water Resources Management*, *32*(15), 4933–4951. <https://doi.org/10.1007/s11269-018-2064-8>
- Duan, H. F., Li, F., & Yan, H. (2016). Multi-Objective Optimal Design of Detention Tanks in the Urban Stormwater Drainage System: LID Implementation and Analysis. *Water Resources Management*, *30*(13), 4635–4648. <https://doi.org/10.1007/s11269-016-1444-1>
- Ghods, S. H., Zahmatkesh, Z., Goharian, E., Kerachian, R., & Zhu, Z. (2020). Optimal design of low impact development

-
- practices in response to climate change. *Journal of Hydrology*, 580. <https://doi.org/10.1016/j.jhydrol.2019.124266>
- Liu, Y., Cibir, R., Bralts, V. F., Chaubey, I., Bowling, L. C., & Engel, B. A. (2016). Optimal selection and placement of BMPs and LID practices with a rainfall-runoff model. *Environmental Modelling and Software*, 80, 281–296. <https://doi.org/10.1016/j.envsoft.2016.03.005>
- Perales Momparler, S., & Calcerrada Romero, E. (2018). Guía básica de diseño de Sistemas de Gestión Sostenible de Aguas Pluviales en zonas verdes y otros espacios libres. In *Ayuntamiento de Madrid*.