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## ► To cite this version:

Claudia Rocío Suarez Castillo, Alejandra Yuddy Castro Oregón, David Saenz Guerrero. Strategies for the appropriation of novel forms of runoff water management and their influence on the sustainability of drainage systems in urban growth areas of the city of Tunja, Boyacá, Colombia.. Novatech 2023, Graie, Jul 2023, Lyon, France. hal-04186652

**HAL Id: hal-04186652**

**<https://hal.science/hal-04186652>**

Submitted on 8 Sep 2023

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## **Strategies for the appropriation of novel forms of runoff water management and their influence on the sustainability of drainage systems in urban growth areas of the city of Tunja, Boyacá, Colombia.**

Stratégies d'appropriation de nouvelles formes de gestion des eaux de ruissellement et leur influence sur la durabilité des systèmes de drainage dans les zones de croissance urbaine de la ville de Tunja, Boyacá, Colombie.

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### **RÉSUMÉ**

La recherche examine les stratégies pour l'adoption de nouveaux types de gestion des eaux de ruissellement. Elle examine également l'influence que leur adoption a sur les acteurs clés du territoire sur la durabilité des systèmes de drainage urbain. En prenant le concept de la consolidation des significations collectives autour des processus de planification territoriale et en l'appliquant aux systèmes de drainage urbain durable (SUD), nous prenons comme unité de travail des petites villes avec des économies en croissance, spécifiquement Tunja, Boyacá, Colombie, et utilisons les quartiers dans le processus de consolidation comme unité d'analyse. Une approche mixte de collecte d'informations, utilisant des groupes de discussion et des enquêtes, est utilisée pour établir la méthodologie d'une étude basée sur l'explication. La comparaison de ces deux approches permettra de construire les significations partagées des acteurs clés du territoire avec un impact direct sur la planification territoriale. L'originalité de la recherche réside dans le fait que, à partir de l'élaboration de significations partagées, un art de la construction sociale émerge du point de vue des différents acteurs du territoire. L'identification des éléments centraux de la planification et de la gestion du territoire se fait à travers la participation des participants. Ces participants servent de sources d'information et deviennent un apport important pour la conception d'outils de gestion durable, notamment les systèmes de drainage urbain.

### **ABSTRACT**

The research examines strategies for the adoption of novel types of runoff water management. It also examines the influence that their adoption has on key actors of the territory on the sustainability of urban drainage systems. Taking the concept of the consolidation of collective meanings around the processes of territorial planning and applying it to sustainable urban drainage systems (SUDs), we take small cities with growing economies as a work unit, specifically Tunja, Boyacá, Colombia, and use the neighborhoods in the process of consolidation as a unit of analysis. A mixed approach to information collection using focus groups and surveys is used to establish the methodology of an explanation-based study. Comparing these two approaches will enable the construction of the shared meanings of the key actors of the territory with a direct impact on territorial planning. The research is original in that, from the elaboration of shared meanings, an art of social construction emerges from the perspective of the different actors in the territory. Identifying the central elements of territorial planning and management is achieved through the participation of participants. These participants serve as sources of information and become an important input for the design of sustainable management tools, specifically urban drainage systems.

### **MOTS CLÉS/KEYWORDS**

Aide à la décision, participation sociale, planification urbaine, plan de gestion des eaux urbaines.

Decision support, social participation, Urban planning, Urban water management plan

## 1 INTRODUCTION

Management of water resources is a fundamental human right. This is because it is an essential element of the sustainability of communities. This is why guaranteeing its supply and equitable and quality access has become a key axis for the achievement of sustainable development in the territories. In Sustainable Development Goal (SDG) number 11, the goal is to make cities and human settlements inclusive, safe, resilient, and sustainable. It includes improving urban planning and management ; increasing sustainable urbanization; reducing the number of deaths caused by water-related disasters; reducing the impact of cities; and including the implementation in cities of policies to build resilience to disasters. Aside from ensuring water distribution and management, Goal 6 of the SDGs targets the integrated management of water resources, the protection of water-related ecosystems, and the participation of communities in water management (UNDP, 2020).

Based on the information outlined above, Sustainable Urban Drainage Systems (SUDS) are capable of reducing runoff water from an area to decrease flooding risk, and also provide improved water quality and thus reduce pollution. These systems include capture, infiltration, abatement, storage, and treatment of runoff water on site and preferably on the surface. In addition to the benefits of reducing the risk of flooding, these systems usually have aesthetic benefits as many of them are green systems with plants. In addition, these systems establish or improve habitat for various species. In addition, communities benefit in terms of improved health and well-being (Woods-Ballard et al., 2007).

Therefore, this research proposes strategies for the appropriation of novel forms of runoff water management. This will influence the sustainability of drainage systems in neighborhoods in the process of consolidation in the northern area of the city of Tunja, Boyacá, Colombia. In the first instance, it is identified that there is a need to define a baseline of concepts acquired with respect to territorial planning by the key players on the ground and the management of runoff water, and then in the next step, to determine the factors of urban planning for the management of runoff water that will ensure the system's sustainability in the neighborhoods during the consolidation of the northern area of the municipality, and finally to consolidate the shared meanings of those involved around the planning of the municipality, thus ensuring sustainable management of runoff water.

## 2 METHODOLOGY

This research approach uses a non-experimental design, since it is based on the observation of existing circumstances in order to find correlations between variables in a natural setting (Hernandez, Fernandez, & Baptista, 2014). In terms of the research approach, and due to the types of instruments and information processing techniques, this research will move in the dialectic of qualitative and quantitative approaches, since the objectives enable both paradigms to interact and produce a holistic review, that allows the triangulation of data, analyzing quantitative data gathered by means of surveys with Likert scales, and environmental modeling, with qualitative information gathered from semi-structured interviews and focus groups, that will enable us to identify the shared meanings of key actors in the planning of the municipality around. Based on the above, and given the relevance of the construction of shared meanings in the planning and sustainable management of water resources, it should be noted that from the perspective of qualitative research it is understood that this is "focused on understanding the phenomena, exploring them from the perspective of the participants in a natural environment and in relation to their context" (Sampieri, R. H., Collado, C. F., & Lucio, M. P. B. 2014, p. 358). The qualitative approach in this study will enable participants to build concepts and meanings about the determinants that will influence the implementation of SUDS in the neighborhood in the process of consolidating the municipality of Tunja, while the design will be ethnographic, which is often used when "it is intended to describe, understand, and explain a social system" (Sampieri, R. H., Colado,lado, C. F., & Lucio, M. P. B. 2014, p. 471).

Similarly, focus groups or in-depth sessions are used for the analysis of data. The instrument mentioned in this research is considered by some authors as: "A kind of group interview, which consists of meetings of small or medium-sized groups (three to ten people), in which participants talk in depth about one or more topics in a relaxed and informal atmosphere under the guidance of a specialist in group dynamics. Beyond asking the same question to several participants, its objective is to generate and analyze the interaction between them and how they construct group meanings" (Morgan, 2008; and Barbour, 2007). (Sampieri, R. H., Collado, C. F., & Lucio, M. P. B. 2014, p. 409). In this sense, the mixed method approach that is used in the study will facilitate a deductive - inductive reasoning process. The inductive stage will be based on qualitative research techniques. These techniques enable the interpretation and structuring of information provided by the different actors for the creation of shared meanings of the variables under study. From the deduction stage, we will derive quantitative

research techniques, which will enable us to confirm and quantify the shared meanings and analyze the established variables. Finally, gaining an integrated vision of the results obtained with the different instruments for data analysis will result in the fulfillment of the established objectives.

### 3 PARTIAL RESULTS

Tunja is a city located in the Colombian Andes; it has a population of 202,219 inhabitants. It has an annual rainfall of 644 mm, and an average temperature of 12.9 °C. It has two periods of precipitation: from April to June and from October to November interspersed with periods of low rainfall. The neighborhoods in the process of consolidation are in the northwestern part of the city. This is an interesting place to implement SUDs as it receives runoff water from a wide area of contribution. Runoff from higher areas reaches the lower parts of the northern neighborhoods causing environmental problems. These neighborhoods do not have a drainage system that divides domestic water from rainwater, nor do they have control systems for runoff water.

#### 3.1 BASELINE OF GENERAL CONCEPTS OF THE STUDY AREA POPULATION

The first part of the study analyzed the actions leading to the recognition of concepts as dynamizers of responses to possible flood risks in the area under study. Information was collected from interviews and surveys to identify the perceptions and knowledge of the population about drainage systems. The results are presented below in relation to the proposal of actions that lead to citizen understanding of critical concepts regarding the problems present in the study area, from the bibliographical review of documents and scenarios historically present:

- Sustainable Urban Drainage Systems

As part of the Urban Sustainable Drainage system, the landscape condition, the architectural environment, and the urban uses present in the area are all examined.

The community does not consider SuDS due to lack of information and knowledge of the improvements they can bring.

Regarding the information provided to the population, the importance of the creation of a network of Sustainable Urban Drainage Systems (SuDS) is expressed.

- Runoff

The community views this variable as a formation process due to the high rainfall in the area.

There is evidence of a relationship between the terms precipitation, rainfall, and runoff.

#### 3.2 SCENARIO CONSTRUCTION

##### 3.2.1 *Scenario One - Pessimistic Scenario*

Using this scenario, radical changes are incorporated and feared changes are imagined. This is a problematic scenario that will be governed by a territorial planning system. This system is not concerned with the construction of shared meanings around the sustainable management of runoff water, and, therefore, ignorant of its effects on communities. The lack of knowledge of concepts for the implementation of Sustainable Urban Drainage Systems brings with it the non-collaboration of the community to avoid flooding around "Barrio las Quintas", and the inadequate management of rainwater.

##### 3.2.2 *Second Scenario - Trend Scenario*

This scenario is based on current environmental conditions. No positive or negative change is expected, i.e. it is a scenario that has a high probability of occurrence. This scheme proposes a territorial planning approach that incorporates regulatory strategies for improving flood scenarios, with the participation of actors in the proper management of wastes and graywater, in order to recognize possible solutions and to avoid the rejection of Sustainable Urban Drainage Systems (SUDS), given the lack of knowledge about sustainable alternatives.

##### 3.2.3 *Third Scenario - Trend Scenario*

The problem to be solved is not defined in a single way. Instead, different visions of the actors involved are considered. The visions of each of the actors are considered. Solutions rely on these same visions, which are diverse and complex over time.

The design of SuDS is carried out through several stages including

Establish strategic surface water management objectives : After analysis of applicable regulations, stakeholder consultation, environmental impact assessment, and flood risk/consequences assessment, local objectives should be established. These objectives include water quality management, flood risk, habitat, community and amenities requirements, climate change adaptation needs, and water supply.

Conceptual design : Through the design, the main components of the SUDs and their interactions are proposed. Having the site and development characteristics, as well as the objectives defined in the previous phase, the feasible discharge points, surface water sub-catchments and flow routes are found, the SUDs components for the management train are selected, and this Management Train is optimized to obtain the final design.

The design criteria should meet objectives relating to water quantity, water quality, amenity, and biodiversity; take into account established surface water management objectives; take into account the opportunities, challenges and constraints identified on the site and in the development characterization process; and maximize the benefits of the overall scheme design. For this it is useful to use indicators for each criterion, in order to subsequently evaluate the effectiveness of the designed scheme.

At this point a conceptual design of the strategy is reported, which must be approved by stakeholders. This conceptual design should include: Definition of strategic objectives; identification of challenges and synergies; the requirements of a broader water management strategy; standards and criteria relating to water management, water quality and biodiversity; constraints and opportunities for SUDs (infiltration potential, permeability, building features, etc.); potential costs and benefits of the various options; the results of stakeholder consultations; definition of land use types, flow paths, runoff fate and management train options; design methods to be used; space requirements; and considerations relating to construction and maintenance issues.

## 4 CONCLUSIONS

Around the world, SuDS have demonstrated their effectiveness for managing runoff water, while generating environmental benefits. The main barriers to their implementation are the high costs of switching from conventional systems to these sustainable ones, as well as the need for expert knowledge of their design and implementation (Srishantha and Rathnayake, 2017). Their implementation in marginal areas, with poor or absent runoff water management systems, has been shown to be a cost-effective solution for integrated water management and for improving the quality of life of their inhabitants. However, the issue of availability of space, as well as the generation of knowledge in the community about its operation and maintenance are critical for its success (Malulu, 2016).

To identify priority aspects for the key stakeholders in the territory in relation to the urban drainage system, meetings, surveys, etc. Typically, studies are conducted based on concepts previously acquired about the study variables from the stakeholders involved in planning the territories. In order to define the objectives and their relative weight, different methodologies can be used, including the soft systems methodology (SSM) developed by Checkland (2013), among others. Stakeholders include planning authorities, the community and its representatives, non-governmental organizations, and the public. This interaction allows for community engagement, awareness, education, and interaction, as well as the generation of opportunities for improvement and learning.

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