From Data to Action: Leveraging GIS for Sustainable Urban Water Management

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Abstract

This Urban water management is a complex and challenging task that requires careful planning and decision-making to ensure the sustainable use of water resources. Geographic Information Systems (GIS) have emerged as a powerful tool for managing urban water systems, providing a range of benefits such as mapping, modelling, simulation, and data management. This paper explores the advantages of GIS in sustainable urban water management and provides a case study of how GIS has been used in the French city of Bordeaux to manage urban water intelligently and sustainably. The study highlights the importance of data management in urban water management and how GIS can be used to collect, store, and analyze data on water quality, rainfall amount, and drinking water production and consumption. The paper also discusses the role of GPS in collecting accurate geographic data for optimizing maintenance and rescue activities during floods. Overall, this paper demonstrates how GIS can help cities make informed decisions regarding urban water management to ensure the sustainable use of this vital resource.

Keywords: *GIS, urban water, smart and sustainable management, Bordeaux.*

1. Introduction

Urbanization The term "smart city" refers to the use of technology to improve the quality of life of its residents and the management of urban resources. It is differentiated by the effective and long-term use of information and communication technologies (ICTs) to improve the efficiency, sustainability, and livability of cities. As a result, the components of a smart city must be intelligent as well. Because urban water is such a valuable resource, it must be managed as smartly and sustainably as possible. However, due to population growth, rapid urbanisation, and climate change, urban water management is a critical issue for the smart city [5, 13].

Furthermore, intelligent and sustainable urban water management is a complicated issue that necessitates a global and integrated approach to enable effective and responsible resource management [8]. Thus, a systemic approach encompassing all stakeholders (people, local governments, businesses, civil society) and all components of urban water (drinking water, wastewater, and rainfall) may result in intelligent and sustainable urban

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water management. GISs can help to link these diverse parts and components of urban water [12].

Indeed, the smart city must contend with increased water demand, increasingly erratic rainfall, and deterioration in water quality. In terms of the environment, the smart city must handle issues like reducing surface and groundwater pollution, conserving aquatic ecosystems, and combating climate change and related threats like drought and floods. A smart city must offer equal access to drinking water for all people, manage the risks associated with floods and other natural disasters, and protect vulnerable populations [4]. Lowering the cost of managing drinking water, rain, and wastewater, as well as creating jobs in urban water management, are all economic advantages. Finally, the safety component includes safeguards against public health concerns about drinking water quality, as well as safeguards for water management infrastructure such as water treatment plants, drinking water storage and transportation facilities, and so on.

GIS is now used in almost all city functions and enterprises [3]. It will undoubtedly play an essential role in the smart city. The ability of GIS to collect, store, organise, and analyse geographic data underpins its contribution to urban water management. Water pollution sources, sewage networks and their exact locations, and flood-prone areas may all be visualised via mapping [9]. It may also be used to detect and geolocate water leaks, making intervention and prevention easier.

In terms of modeling, it allows for the development of computer models that replicate the behavior of urban water as a result of environmental parameters such as terrain, climate, and land use. These models, for example, help managers better understand hydrological processes, estimate the impact of climate change, and identify regions at danger of floods. Simulation may be used to evaluate various urban water management assumptions, such as the installation of new sewage networks or the implementation of water conservation measures. Managers can also use simulations to assess the possible impact of actions on the urban water system, such as replacing pipes in drinking water supply or sewerage networks.

Another important aspect of GIS is data management. Data on water quality, rainfall amount, and drinking water production and consumption may be collected and stored thanks to urban water management. This data may then be examined utilising modelling, simulation, and mapping tools, allowing for the most informed and sustainable urban water management decisions. Finally, the usage of GPS is an important component of GIS. GPS enables the collection of accurate geographic data in urban water management, such as the location of urban water equipment and networks [6]. This data is then utilised to optimise maintenance and rescue activities, for example, in the case of floods [7].

In this paper, we will highlight the benefits of GIS for the smart and sustainable management of urban water in the French city of Bordeaux. It is in fact a tangible example of how GIS has been used to intelligently and sustainably manage urban water in this French city, to which we have contributed. Despite major investment in cleaning the pipes, the Bordeaux Métropole study from 2011 revealed a rise in complaints about floods caused by wastewater overflows [1]. To address this issue, Bordeaux Métropole has launched an intensive urban water management project over the last twenty years [2, 10, 11]. This plan is primarily built on the use of geographic information systems (GIS) to manage, maintain, and intervene in the network. The goal is to minimise the amount of flooding complaints from households.

2. Methods and Materials

2.1. Study Area

The Bordeaux Metropolitan Area, located in southwest France between 44°50'16" to the north and 0°34'46" to the west, is made up of 28 communes (Figure 1) and spans a total surface area of 578 km2. Its sewerage network spans 3,952 kilometres (1,385 kilometres for sanitation, 1,786 kilometres for sewers, and 781 kilometres for mixed sewerage). This sewage system serves 161,922 dwellings and 714,558 people [1].

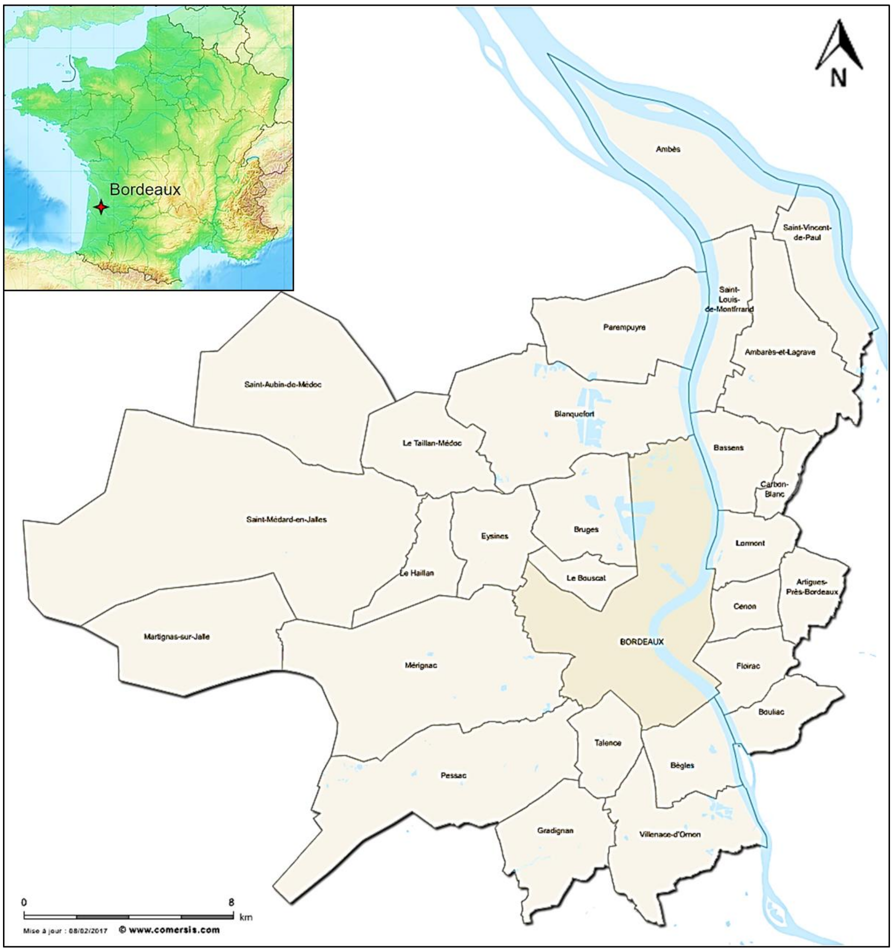

Figure 2. Communes (Municipalities) of Bordeaux Métropole (Source: https://www.bordeaux- metropole.fr/)

2.2. Methodology

We first constructed a database in order to put up a sanitation GIS for the Bordeaux metropolitan region. This is fed by information supplied by field employees. Field activities are planned in response to resident complaints or scheduled routine inspections. For each field intervention, each field technician must complete an intervention form, which includes the information shown in Table 1.

Table 1. Example of an Intervention Form

Flood Data	Type of Information	Comments
Address and Location Data	N°/Street/ district	Obtained from the initial complaint (telephone call) and confirmed during the intervention.
Identification of the Component Causing the Flooding	Component name and number	Enables component data to be used (characteristics, maintenance history)
Flood Data	Data of any kind	
Duration of Intervention	Duration	Estimate the duration of each intervention
Identifying the Complaint	Number and type	To link claims data and intervention data
Rain Information	All types of rain data	
Causes of Flooding	Describe the cause	A generic list of causes is suggested below

3. Results and Discussion

The results of the two years of intervention (2009 to 2011) are illustrated in Table 2.

Table 2. Summary of Interventions in Bordeaux Métropole between 2009 and 2011 [2].

Year	**Number of Floods Requiring Intervention**	**Potential Causes of Flooding**
2009	81	Natural: 53 Human resources: 28 Unknown: 19
2010	77	Natural: 58 Human resources: 31 Unknown: 11
2011	193	Natural: 56 Human resources: 30%. Unknown: 14
Total	361	Natural: 56 Human resources: 30%. Unknown: 14
Year	Number of floods requiring intervention	Potential causes of flooding
2009	81	Natural: 53 Human resources: 28 Unknown: 19
2010	77	Natural: 58 Human resources: 31 Unknown: 11

The results demonstrate that flooding can be caused by either natural or man-made sources, although in some situations, technicians are unable to pinpoint the reason of the flooding (unknown). Based on these thorough data, we created many maps with the GIS we created. At the operational size of Bordeaux city centre, Figure 2 depicts the locations most vulnerable to floods. The portrayal of these locations on an operational scale allows for the identification of drainage network elements responsible for flooding as well as the causes of this flooding. This map, created with ArcGIS 10.8 software, demonstrates how flooding zones fluctuate based on whether they are connections or drains, as well as the kind of obstruction. For example, links increase the visibility of Bordeaux's city centre.

For example, connections expose the Bordeaux city core to floods. Flooding caused by clogged pipes, on the other hand, is more concentrated towards the south. Local governments may frequently make strategic choices regarding each sub-area based on this sort of map, such as allocating people and financial resources, enhancing monitoring, and increasing routine inspections.

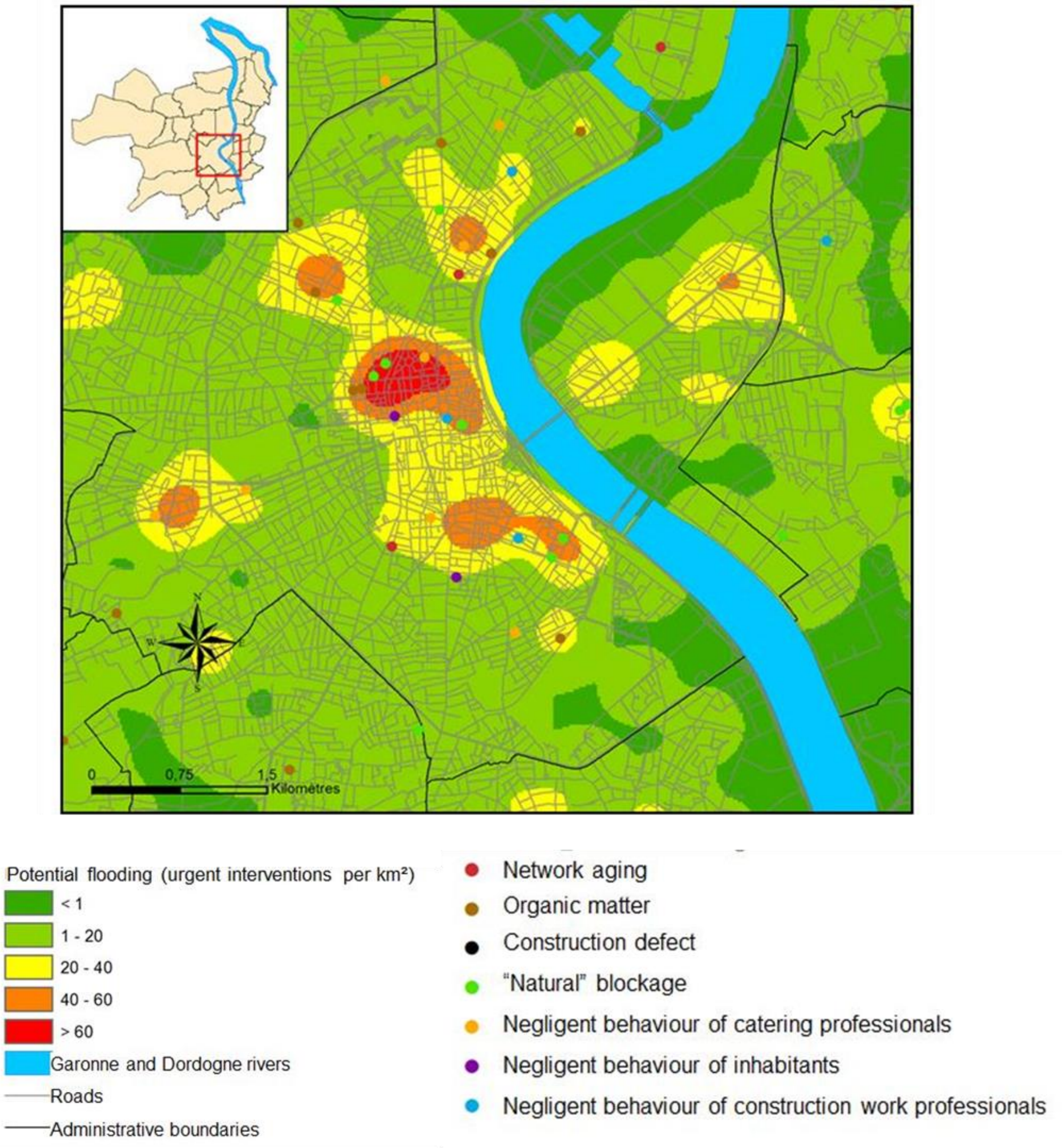

Figure 2. A Map Generated Using ArcGIS Representing the Number of Floods in the City Centre of Bordeaux Métropole and the Causes of these Floods.

Conclusion

Pipe cleaning activities are now coordinated on one hand with the trees and green spaces department and on the other hand with the street cleaning department in order to clean both the roads and the network, thanks to the GIS built on behalf of Bordeaux Metropole. The goal is to coordinate network-cleaning activities by taking into account the work done by these departments (tree trimming, street cleaning, and grass cutting). In addition to coordinating actions, the representational capacity, clarity, and speed with which GIS maps may be created means that decision-makers can make appropriate judgements at several scales and at the same time.

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