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Using GIS to Evaluate the Vulnerability of Drainage Systems to Climate Change

Aicha Lamrani*

Department of Irrigation and Drainage, University of Catania, 95131 Catania, Italy

Introduction

Climate change has emerged as one of the most pressing challenges of the 21st century, affecting ecosystems, human health and infrastructure across the globe. Among the most vulnerable infrastructure systems are drainage networks, which play a crucial role in managing stormwater, preventing floods and maintaining urban health. Urban areas, particularly those with older infrastructure, face increasing risks due to more frequent and intense weather events, such as heavy rainfall, rising sea levels and prolonged droughts. As climate patterns become more unpredictable, existing drainage systems are being tested beyond their design capacities, leading to an urgent need for comprehensive assessments of their vulnerability to these changes [1].

Geographic Information Systems (GIS) offer an innovative solution for evaluating the vulnerability of drainage systems to climate change. By utilizing spatial data and advanced modeling techniques, GIS enables urban planners and engineers to assess the potential impacts of climate-related changes on drainage infrastructure, identify weaknesses and develop strategies for mitigation. This report explores the use of GIS in evaluating the vulnerability of drainage systems to climate change, providing insights into how GIS can support effective decision-making in infrastructure planning, maintenance and adaptation. The purpose of this study is to highlight the potential of GIS as a tool for enhancing urban resilience in the face of climate change and to examine the methodologies, challenges and applications involved in such assessments [2].

Description

Drainage systems are fundamental components of urban infrastructure, designed to manage and direct excess water, primarily from rainfall, away from streets, buildings and other critical areas. They are critical in preventing flooding, protecting public health and maintaining the integrity of the urban environment. There are several types of drainage systems, including surface, subsurface, combined and stormwater drainage systems. Surface drainage systems are open channels or ditches designed to convey water across the ground's surface, commonly found in rural areas or streets in urban zones. Subsurface drainage systems, on the other hand, consist of buried pipes or tunnels that transport water beneath the surface, typically employed in areas where surface drainage is impractical [3].

Combined systems handle both stormwater and wastewater within a unified network, often found in older cities, while stormwater drainage systems are specifically designed to manage runoff from rainfall, which is particularly critical in preventing urban flooding. The functionality of these systems relies on their ability to channel water efficiently, preventing it from accumulating in built-up areas where it could cause damage or public health risks. However, many of these drainage systems, especially in older urban areas, were designed decades ago and were not built to withstand the growing threats posed by climate change. Increased rainfall intensity, sea-level rise and shifts in seasonal weather patterns are exacerbating the pressures on these systems, leading to vulnerabilities such as blockages, capacity issues and structural damage. The need for assessing these vulnerabilities is critical to ensuring the continued effectiveness of drainage systems as climate patterns continue to change [4].

GIS plays a key role in this assessment by enabling the integration of spatial, meteorological and hydrological data to model the impacts of climate change on drainage infrastructure. GIS-based vulnerability assessments allow for detailed mapping and simulation of potential scenarios, helping to identify areas at high risk of flooding, as well as systems that may require strengthening or redesigning to handle future conditions. By using GIS tools, urban planners and engineers can evaluate the effectiveness of existing drainage systems, understand how they may fail under extreme conditions and plan for adaptation measures accordingly. The ability to visualize and analyze such data in a spatial context is invaluable in prioritizing resources and planning effective responses to the challenges posed by climate change [5].

Conclusion

In conclusion, the use of GIS to evaluate the vulnerability of drainage systems to climate change represents a significant advancement in urban planning and infrastructure management. As the impacts of climate change become more pronounced, it is essential that cities are equipped with the tools necessary to assess and adapt their infrastructure accordingly. GIS offers a comprehensive approach for identifying potential risks to drainage systems, from increased rainfall and extreme weather events to rising sea levels and changing hydrological patterns. By combining spatial data with predictive models, GIS enables a thorough analysis of how drainage systems may be affected and provides insights into necessary adaptations to enhance resilience.

While GIS-based assessments are powerful, they also present challenges, including the need for accurate and high-resolution data, technical expertise and the integration of multiple data sources. Nevertheless, GIS remains an essential tool for supporting evidence-based decision-making in the context of climate change adaptation. As technology evolves and more real-time data becomes available, GIS will continue to play an increasingly important role in shaping resilient urban infrastructure. Moving forward, further advancements in GIS techniques, along with interdisciplinary collaboration, will be crucial in developing drainage systems that can withstand the pressures of a changing climate, safeguarding communities and ensuring sustainable urban development in the future..

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Conflict of Interest

The authors declare that there is no conflict of interest.

***Address for Correspondence:** Aicha Lamrani, Department of Irrigation and Drainage, University of Catania, 95131 Catania, Italy; E-mail: aichalamrani@phd.unict.it*

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