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Optimization of Water Pipeline Routes Using a GIS-Based Multi-Criteria Decision Analysis and a Geometric Search Algorithm

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Abstract : The Metropolitan East region of Rio de Janeiro state, Brazil, faces a historic water scarcity. Among the alternatives studied to solve this situation, the possibility of adduction of the available water in the reservoir Lagoa de Juturnaíba to supply the region's municipalities stands out. The allocation of a linear engineering project must occur through an evaluation of different aspects, such as altitude, slope, proximity to roads, distance from watercourses, land use and occupation, and physical and chemical features of the soil. This work aims to apply a multi-criteria model that combines geoprocessing techniques, decision-making, and geometric search algorithm to optimize a hypothetical adductor system in the scenario of expanding the water supply system that serves this region, known as Imunana-Laranjal, using the Lagoa de Juturnaíba as the source. It is proposed in this study, the construction of a spatial database related to the presented evaluation criteria, treatment and rasterization of these data, and standardization and reclassification of this information in a Geographic Information System (GIS) platform. The methodology involves the integrated analysis of these criteria, using their relative importance defined by weighting them based on expert consultations and the Analytic Hierarchy Process (AHP) method. Three approaches are defined for weighting the criteria by AHP: the first treats all criteria as equally important, the second considers weighting based on a pairwise comparison matrix, and the third establishes a hierarchy based on the priority of the criteria. For each approach, a distinct group of weightings is defined. In the next step, map algebra tools are used to overlay the layers and generate cost surfaces, that indicates the resistance to the passage of the adductor route, using the three groups of weightings. The Dijkstra algorithm, a geometric search algorithm, is then applied to these cost surfaces to find an optimized path within the geographical space, aiming to minimize resources, time, investment, maintenance, and environmental and social impacts.