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Modeling urban water demand dynamics: Integrating population growth and per capita consumption patterns

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The sustainable management of water resources in urban areas necessitates accurate projections of future water demand. Population growth and changing per capita consumption patterns are critical drivers influencing the dynamics of municipal water demand. This study presents a comprehensive modeling approach to estimate future urban water demand by integrating projections of population growth and per capita consumption trends. The formulation is grounded in rigorous mathematical analyses of global population data and historical municipal water consumption statistics.

Notably, this modeling approach, which has been recently presented and published in a scientific article, entails deriving a quadratic function, P(y), to capture the nonlinear accelerating trajectory of population growth over time. This function is obtained through polynomial regression analysis of historical population data, yielding a robust equation with an exceptional goodness of fit (R-squared = 99.9%). Additionally, a linear function, C(y), is derived to model the evolution of per capita water consumption patterns, based on regression analysis of consumption data from 18 cities spanning 20 years.

The integral formulation, $QPG(y) = \int P'(y)dy \cdot \int C'(y)dy$, combines the projected population growth and per capita consumption trends to estimate the aggregate future municipal water demand. The model incorporates detailed mathematical considerations, including the determination of integration constants tailored to the inherent characteristics of the dataset, ensuring a comprehensive and precise integration process.

The proposed modeling approach offers a powerful tool for water resource planners and policymakers to anticipate future urban water demand accurately. By accounting for both population dynamics and evolving consumption patterns, the model enables proactive strategies for sustainable water supply management, infrastructure planning, and resource allocation in urban contexts. The robust mathematical foundation and integration of key demand drivers contribute to the model's reliability and applicability across diverse urban settings.

Biography

Holger Benavides-Muñoz, a Civil Engineer, brings extensive experience in research, teaching, and consulting within hydraulic and environmental engineering. His work prioritizes sustainability in urban and rural water cycles, focusing on enhancing hydraulic and energy efficiency and conducting studies to reduce unaccounted-for water. With a robust academic background, including a Master's Degree and a Doctorate, Benavides actively contributes to advancing knowledge in his field. He is recognized for his collaborative approach, engaging stakeholders to tackle complex water management challenges. Benavides' dedication and commitment to innovative solutions position him as a valuable asset in Civil and Hydraulic Engineering.