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An Analysis of Water Supply System Losses: A Case Study of Santa Catarina State, Brazil

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Abstract

Water losses are critical indicators of operational and commercial efficiency in water supply systems. This study investigates the determinants of water distribution losses in the state of Santa Catarina, Brazil, using official data from the National Sanitation Information System (SNIS) for the year 2022, encompassing 293 municipalities and a population of approximately 7.6 million. A three-phase analytical approach was adopted: exploratory analysis and dimensionality reduction through Principal Component Analysis (PCA); classification of municipalities using the CHAID decision tree algorithm; and interpretation of the resulting predictive model. The results identified 28 key variables explaining 75% of the variance in the dataset. Water consumption index, revenue loss, macro-metering, and water export volumes emerged as significant predictors of loss rates. The study found an inverse correlation between water consumption and loss rates - municipalities with consumption indices below 55.8% exhibited average losses of 52.5%, while those above 68.6% had losses reduced to 21.4%. The findings emphasize the need for integrated metering, infrastructure optimization, and tailored strategies based on municipal cluster profiles to reduce water loss and improve system performance. This methodology provides a replicable framework for data-driven decision-making in public water management.

Keywords
Water Loss, Water Supply System, Decision Tree Classification, Multivariate Analysis

Biographies
Andréia May is a PhD candidate in the Graduate Program in Industrial Engineering at the Universidade Federal de Santa Catarina (UFSC). Her research focuses on operations management and efficiency analysis in the water supply and sanitation sector. She holds both a Bachelor's and a Master's degree in Sanitary and Environmental Engineering from UFSC and currently works as a Sanitary Engineer at Companhia Catarinense de Águas e Saneamento (CASAN), the state-owned water and sanitation company of Santa Catarina.

Carlos Ernani Fries is a Full Professor in the Department of Industrial and Systems Engineering at the Universidade Federal de Santa Catarina (UFSC). He earned his Bachelor's degree in Civil Engineering, as well as his Master's and Doctoral degrees in Industrial Engineering, all from UFSC. Over the course of his academic career, Professor Fries has taught a wide array of subjects, including Operations Research - particularly with applications in efficiency

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analysis - manufacturing and logistics, decision theory, statistical methods, and forecasting models. His research interests lie in the areas of manufacturing systems, simulation, mathematical optimization, management-oriented serious games, and the application of data analytics to support operational decision-making.

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