Spatial supply-demand balance of health and failure consequence for urban sewage pipes.

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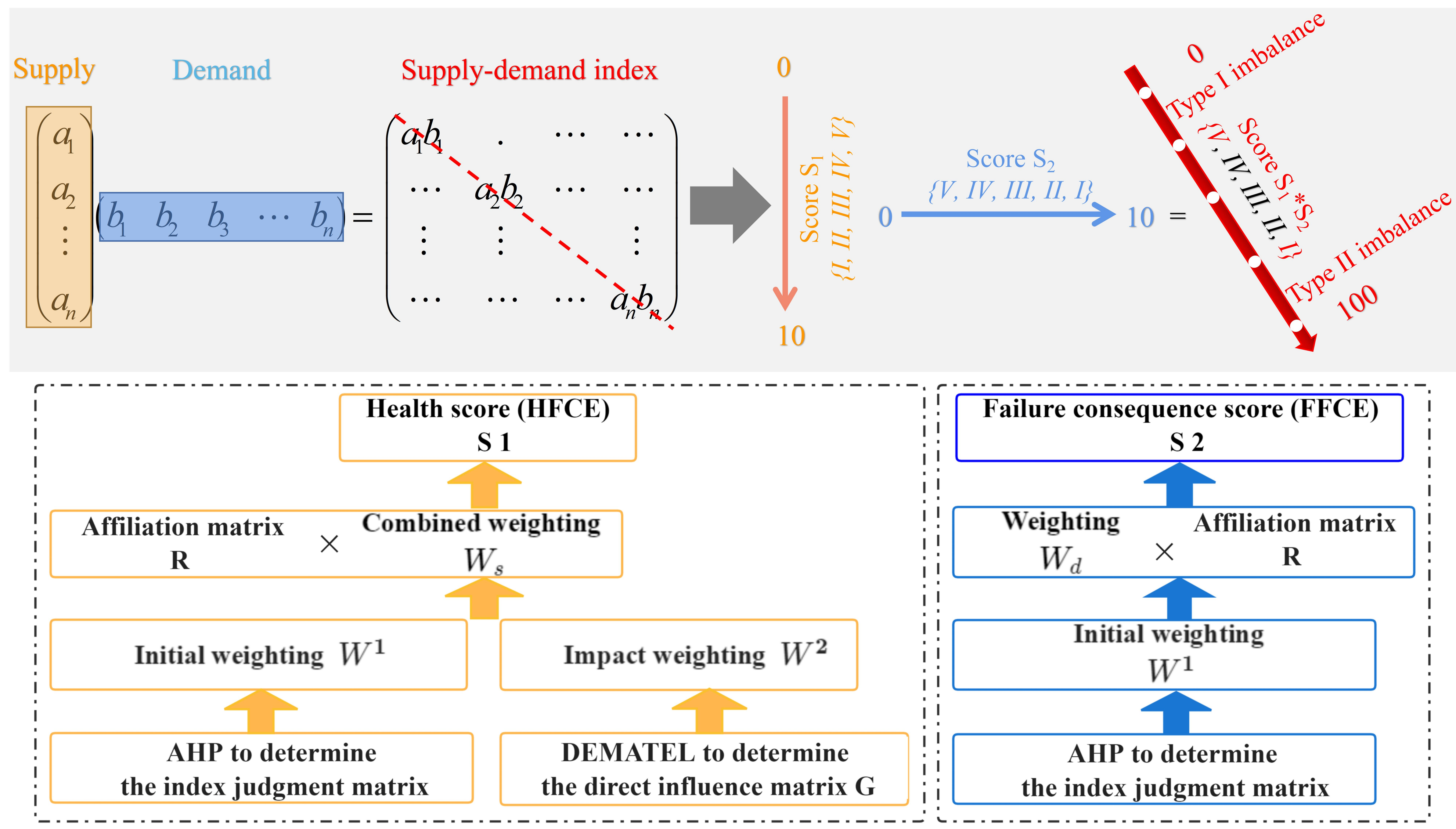
Objectives

Identifying the relationship between sewage pipe health and failure consequence is crucial for ensuring safe operation of urban sewage network. Sewage pipes with low health and severe failure consequence should be the primary focus of daily repair, maintenance, and operational management by the drainage management authorities, requiring immediate attention. Conversely, sewage pipes with high health and low failure consequence can be temporarily set aside under limited economic and time constraints, thereby reducing resource wastage. The aim of this paper is to overlay sewage pipe health and failure consequence spatially, with a specific focus on identifying two categories of imbalanced pipes and corresponding streets.



Methods

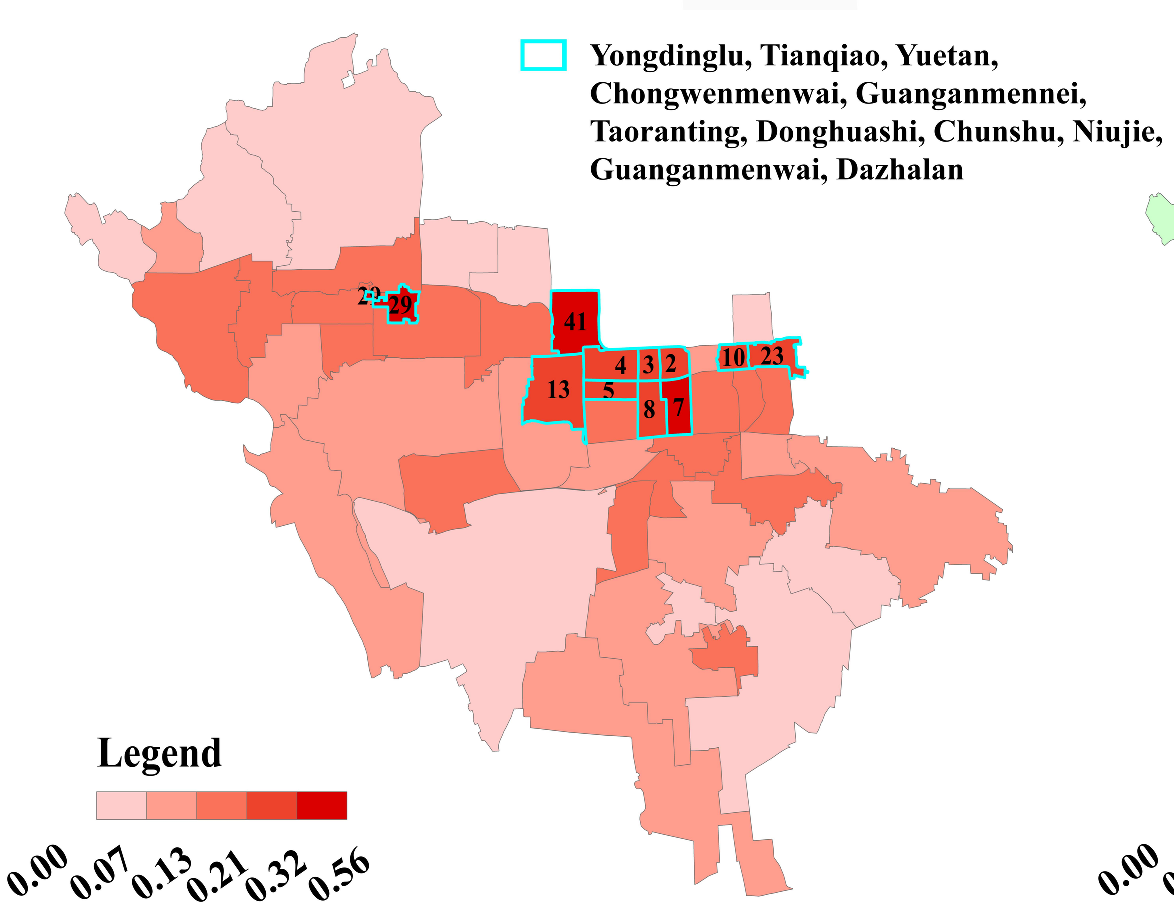
Spatial supply-demand balance theory was used to analyze the overlay relationship. On the supply side, it comprehensively integrated urban sewage pipes defect factors, operational conditions, and social environmental elements to establish an indicator system. Furthermore, it formulated the Health Fuzzy Comprehensive Evaluation model(HFCE) by incorporating a combined weighting approach based on AHP and DEMATEL. On the demand side, economic and societal environmental factors were introduced to develop the Failure Consequence Fuzzy Comprehensive Evaluation (FFCE) model. The identification of type I and II imbalance pipes can be effectively achieved through matrix multiplication.

Results

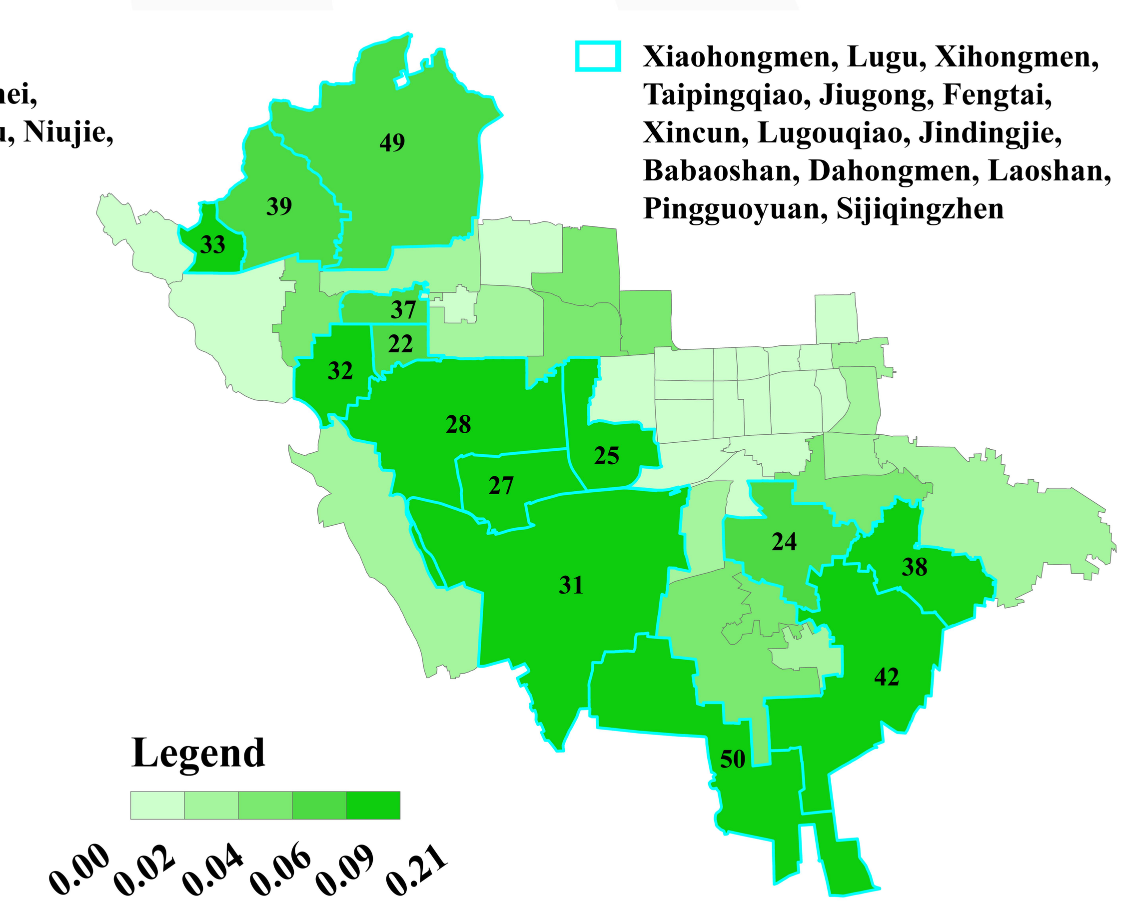
(1) HFCE model: Indicators such as sewage pipe load status, blockage, and flow velocity exerted a significant influence on sewage pipes health status. Sewage pipes were classified as having low health levels (V and IV) constituted 10.23% and 4.43% of the total, respectively.
(2) FFCE model: Greater emphasis was placed on assessing the proximity of sewage pipes to sensitive facilities. The spatial distribution of failure consequence grades was determined, with V, IV, III, II, and I constituting 10.97%, 16.77%, 17.43%, 18.72%, and 36.11% of the total, respectively.
(3) Supply-demand balance model: The percentage of type I and II imbalanced pipes accounted for 14.24% and 6.80%, respectively.

Conclusions

(1) In dealing with a complex multi-indicator evaluation system, the utilization of the AHP-DEMATEL combined weighting method proved more adept at capturing the interrelationships among these indicators. This resulted in a more objective and rational distribution of weights.
(2) The identification of two categories of imbalanced pipelines and streets facilitated the precise delineation of areas with urgent sewage pipe maintenance requirements. Furthermore, it accounted for situations where financial resources were limited, and certain areas were not immediately considered. This approach allowed for a more accurate and comprehensive determination of maintenance prioritization and resource allocation, thereby optimizing the utilization of existing resources.



a) Percentage of type I imbalance pipelines



b) Percentage of type II imbalance pipelines