A data mining approach to explore the causal rules between environmental conditions of neighborhood parks and seniors' satisfaction

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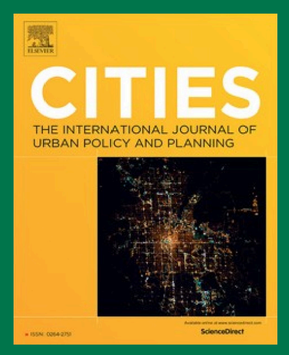

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Abstract

A growing body of research has investigated the associations between the physical environment features of neighborhood parks (NPs) and seniors' attitudes, usage intentions or behavior in the parks. However, research to date has not produced sufficient knowledge about the causal relationships between the physical features of neighborhood parks and seniors' attitudes. To fill this gap, this study takes 142 neighborhood parks located in Zhuhai of China as examples to explore the causal rules of the "environment-satisfaction" in neighborhood parks by using Rough Set Approach (RSA). This paper presents the results of 11 causal rules (i.e., if-then rules) between the physical features of neighborhood parks and seniors' positive/negative judgements. The findings can contribute to not only extending the academic research on the environmental preference of neighborhood green spaces among the seniors, but also to providing decision-makers with optimization strategies for designing or improving the neighborhood parks under the goal of aging in place.

Highlights

- 11 causal rules of between objective conditions of NPs and seniors' satisfaction are obtained.
- The effect of NP conditions on seniors' satisfaction is in the form of a combined rather than an independent effect.
- A data mining approach to analyze the audit and survey data from numerous NP cases
- 10 core conditional attributes affecting seniors' satisfaction in NPs are found.

Introduction

Population aging is intensifying the demand for age-friendly community environments. Neighborhood parks—small, local green open spaces—are among the places older adults rely on most for daily recreation and social interaction, supporting physical activity, stress reduction, and well-being. Prior studies have linked seniors' park attitudes to features such as accessibility, recreational facilities, amenities, natural features, and incivilities. However, existing evidence is dominated by correlation-based models and subjective assessments, which often assume independent effects among environmental features. Such approaches can overlook how multiple cues co-occur and jointly shape satisfaction, limiting their usefulness for resource allocation and park management. To address this gap, we investigate neighborhood parks in Xiangzhou District, Zhuhai, using objective on-site audits and an interview-administered satisfaction survey of senior users. We then apply the Rough Set Approach, a data-mining method designed to handle inconsistent real-world data, to identify core attributes and extract interpretable if–then causal rules linking environmental configurations to satisfaction outcomes. By revealing which combinations of park conditions tend to produce high or low satisfaction, this study advances evidence on age-friendly park design and offers actionable priorities for improving neighborhood parks under the goal of aging in place. These rules provide transparent guidance for planners seeking efficient, context-sensitive upgrades.

Study design and methodology

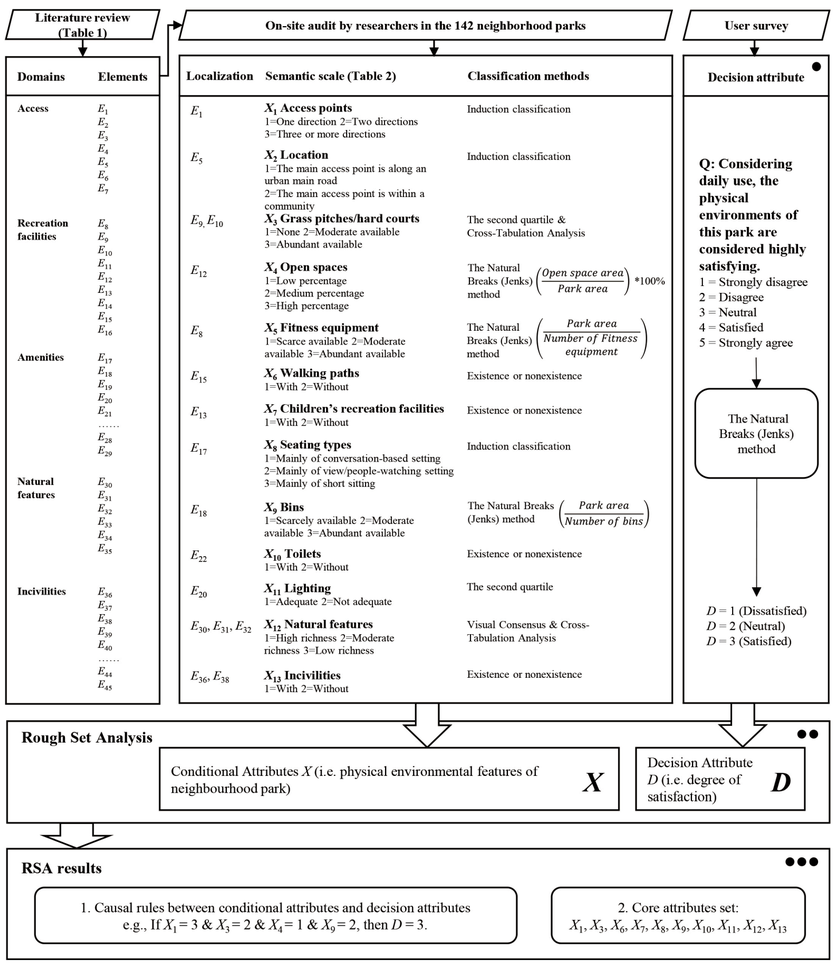


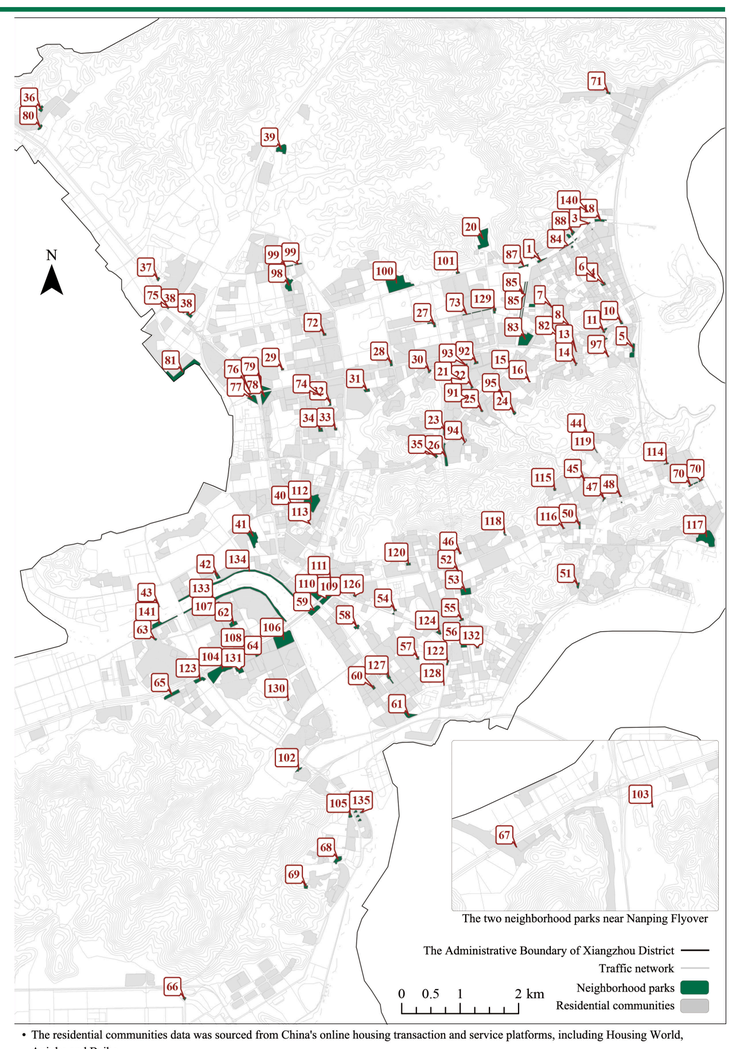
Fig. 1. Research methods and process.

Study Design and Methodology

As shown in Fig. 1, this study applies a data-mining workflow to derive interpretable causal rules between objective park conditions and seniors' satisfaction. After an inductive review and pretests, trained researchers conducted standardized on-site audits and finalized 13 condition attributes (X_1–X_{13}) covering access, recreational facilities, amenities, natural features, and incivilities. Because Rough Set Approach (RSA) requires categorical, complete attribute–value tables, continuous indicators were discretized using multiple schemes: Natural Breaks (Jenks) for long-tailed variables, second-quartile thresholds, and induction/cross-tabulation/visual-consensus classifications where appropriate.

Study Area and Empirical Data

As shown in Fig. 2, the empirical setting comprises 142 neighborhood parks in Xiangzhou District, Zhuhai, China. Parks were drawn from publicly managed neighborhood-scale green spaces and field-verified to represent daily-use parks serving nearby residential communities; sites under construction, mismarked, or lacking eligible senior users were excluded. Seniors' satisfaction was collected via interview-administered questionnaires using a 5-point Likert item, with respondents recruited through purposive and snowball sampling from senior key opinion leaders (KOLs) who were highly familiar with park use, and then aggregated to the park level. In total, 548 valid questionnaires were obtained to support the subsequent RSA analysis.



• The residential communities data was sourced from China's online housing transaction and service platforms, including Housing World, Anjuke and Beike.

Fig. 2. The location of 142 neighborhood parks.

Results & Discussion

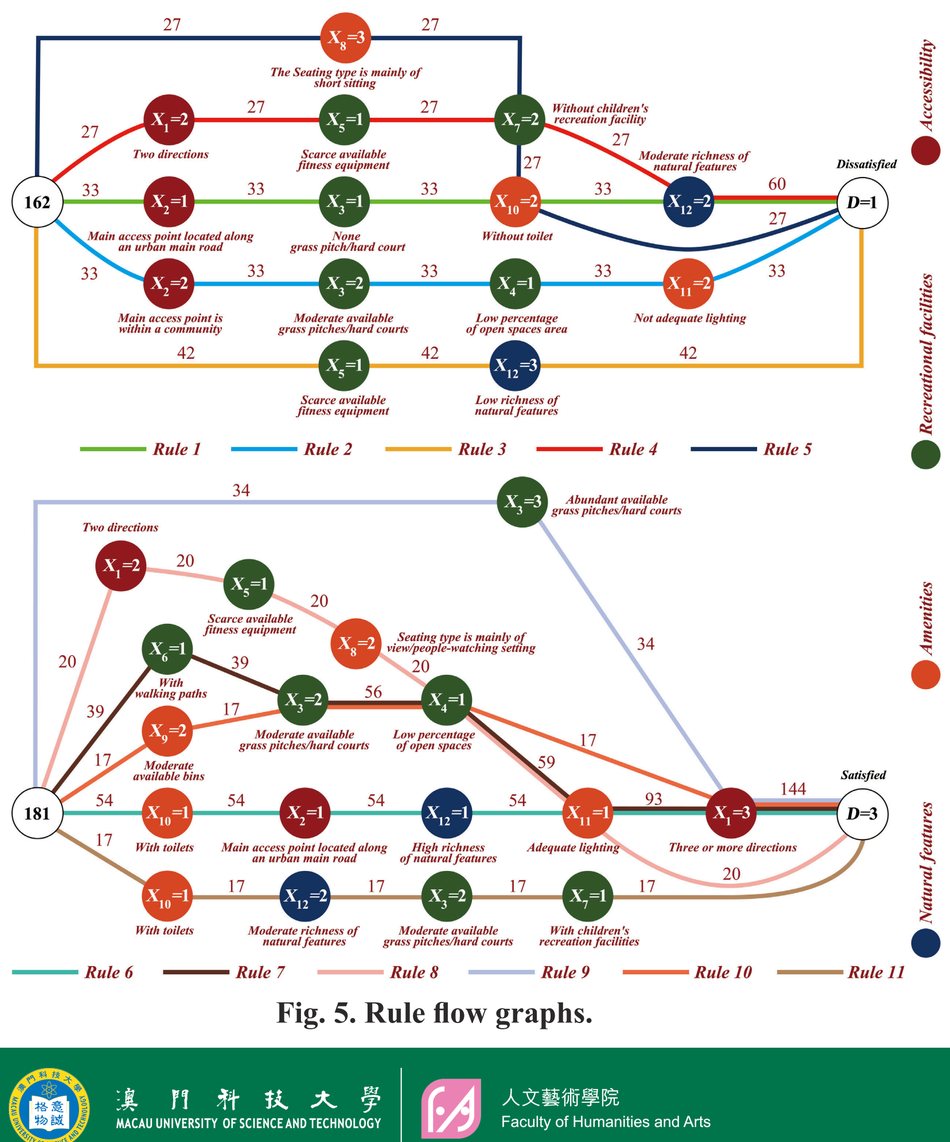


Fig. 5. Rule flow graphs.

Using RSA, we achieved a high classification quality (0.9789) and identified 10 core environmental attributes shaping seniors' satisfaction in neighborhood parks: access points, courts, walking paths, children's facilities, seating types, bins, toilets, lighting, natural features, and incivilities. We extracted minimal covering if–then rules (strength >10%) that reveal configurational causality: satisfaction is driven by combinations rather than any single feature (as shown in Fig. 5). For example, high satisfaction (D=3) is consistently associated with ≥3 access directions, adequate lighting, and richer natural features, often together with toilets and suitable facility mixes; conversely, low satisfaction (D=1) emerges when unfavorable bundles occur, such as no toilets and inadequate lighting combined with specific location/facility contexts. Importantly, the same attribute can flip its effect across different configurations, highlighting the need for context-sensitive, resource-efficient park upgrades based on rule bundles rather than isolated indicators.

Contribution

- **Synergetic effects:** This study applied the perspective of multiple conjunctural causation to advocate and attempt to empirically prove that the synergetic effects of NP environmental conditions on seniors' satisfaction is in the form of a combined rather than an independent effect.
- **Causal rules:** Compared to previous research using correlational analysis, our study contributes the knowledge of the causal-effective relationships between the physical environment of NPs and seniors' satisfaction, providing valuable information to assist decision-makers in more precise and rational resource allocation, which is crucial for the development and redevelopment of an NP.
- **Multiple cases:** This study used a data mining approach to analyze the audit and survey data from numerous NP cases with a range of characteristics in conditional attributes, to provide more generalizable results than those obtained from small-sample case studies.
- **More specific recommendations:** This study focuses on identifying causal rules between objective conditions of NPs, rather than perceived conditions, and seniors' satisfaction; which enables decision-makers to obtain more specific recommendations on the physical environmental conditions according to the satisfaction outcome.

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