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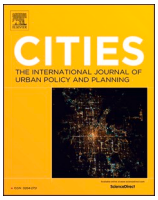

A data mining approach to explore the causal rules between environmental conditions of neighborhood parks and seniors' satisfaction

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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.

1. Introduction

Population aging has become a global demographic trend in the 21st century. The number and proportion of the population aged 60 years or over is expected to increase at an unprecedented rate in the next few decades (WHO, 2020). Healthy aging has become an important agenda for governments and societies in both developed and developing countries (Yen et al., 2022). WHO (2015) suggests that there is a positive relationship between the environment in which older people live and their well-being as they age, with the environment (highlighting society and community) seen in related studies as a key component of healthy aging (Keating, 2022).

In the process of aging, seniors tend to occupy the activity spaces they are familiar with and participate in social activities in a relatively stable social network (Bruine de Bruin et al., 2020). Previous studies have provided considerable evidence that living in a familiar environment has a positive effect on the satisfaction level with the place senior citizens lived in (Baysal et al., 2020), and also their function and well-being in advanced age (Wiles et al., 2017). In view of the global trend of aging in place, creating a supportive community built environment that allows seniors to maintain their autonomy and independence is one of the major areas in aging research. Among them, neighborhood park (also called neighborhood green open spaces), which are small-scale green spaces designed to serve local residents from neighboring communities (Gidlow et al., 2012), is thought to be the place that older adults are mostly dependent on for participating in recreational and social activities due to their reduced functional ability (Liu et al., 2022). A growing body of literature has verified that using NPs may provide older adults various benefits such as promoting social participation (Gaikwad & Shinde, 2019), reducing the risk of chronic diseases (Xie et al., 2018), reducing stress, anxiety, and depression (Li et al., 2019), and enhancing well-being (Chu et al., 2021).

Previous studies have shown evidence of the association between physical characteristics of NPs and the attitudes of senior users. Veitch et al. (2022) found that different features in parks have varying impacts on the park behavior and attitude of elderly individuals. Several studies have contributed to the development of quality assessment models for the physical environment of NPs, identifying key influencing elements such as accessibility (Chu et al., 2021; Kou et al., 2021; Li et al., 2023), recreational facilities (Yung et al., 2017), amenities (Veitch et al., 2020),

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natural features (Gibson, 2018), and incivilities (Chu et al., 2021). However, for the measures of the parks' environmental attributes, subjective measures (e.g., user perceptions) were mainly applied by the existing studies (e.g., Chu et al., 2021; Gibson, 2018; Kimic & Polko, 2022; Lu et al., 2022; Veitch et al., 2022; Yung et al., 2017), rather than objective measures (e.g., presence of facilities/amenities), which may weaken the guiding role of findings for park management practices.

Additionally, existing studies have primarily used correlation models to explore the relationships between park features and seniors' activity preferences and subjective attitudes. For example, regression analyses have been employed to examine the impact of park environmental features on seniors' pathway usage (Zhai & Baran, 2016), satisfaction (Yung et al., 2017), visitation motivations (Gibson, 2018), physical activity (Wagner et al., 2020; Zhai et al., 2020), and frequency of park visitation (Wang et al., 2021). However, these studies have relatively neglected to identify and construct the causal relationships between different park physical environment features and the attitudes of seniors. In addition, the statistical analysis techniques commonly used in these previous studies have operated based on the assumption that the relationships among the environmental features are independent. This study believes that previous related studies have neglected the combined effects of different environmental characteristics on the achievement of goals, and such limitations will lead to waste of resources (Tzeng & Shen, 2017) in a decision-making process of park design or maintenance. Therefore, this study aims to fill these gaps by answering the following two questions:

- What environmental elements in NPs are the key elements that influence the satisfaction of seniors?
- What are the combined effects of these environmental elements of NPs on the satisfaction of older adults?

By using Rough Set Approach (RSA), this study takes 142 NPs located in Xiangzhou District, Zhuhai, China as examples to explore the causal rules (i.e., if-then rules) of "environmental features -seniors' attitude" in NPs. This study extends previous case study research and conduct large sample analysis using data mining approach to make the research findings more widely applicable within the management of NPs under the target of aging in place. In addition, instead of the correlation analysis used in previous studies, this study conducts causal analysis to identify the unidirectional causal effects of park features on seniors' satisfaction. The findings of this study can not only contribute to the academic research of aging in place, but also provide a new perspective on identifying the resource allocation priorities for integrating the growing needs of seniors into the planning and maintaining of NPs in practice.

The rest of this paper is organized as follows. First, the literature review section builds the theoretical framework for the potential environmental variables that influence seniors' attitudes toward the NP usage, based on various audit tools and the relevant scholarship. This is followed by the study design and methodology section, in which RSA technique, the conditional and decision attributes for RSA, and also the selection of cases is introduced. And then, in Section 4 study results are presented, and Section 5 presents our findings in relation to the existing body of knowledge. Lastly, the conclusions and implications for the academia and also decision-makers are highlighted, followed by limitations and suggestions for the future studies.

2. Literature review

2.1. Potential environmental variables of NPs influencing older adults' attitudes

Different park environmental characteristics are thought to have varying effects on the experience and use of parks for older adults (Gibson, 2018). To identify the potential conditional elements of NP quality with respect to its effect on older adults' satisfaction, this section builds on both Neighbourhood Green Space Tool (NGST) and the relevant empirical research literature that have identified the attributes of NPs that have potentially impacts on older adults' attitudes or use.

Exploring the relationship between the objective characteristics of NPs and older adults' perceptive satisfaction is the scope of this study. Therefore, the selection of on-site audit tools suitable for NP objective conditions is the basis for further selection of NP conditional attributes that have a potential impact on user satisfaction. The NGST was chosen among numerous well-known park audit tools based on the following considerations. (1) The desktop auditing tools (e.g., Edwards et al., 2013; Taylor et al., 2011) were not considered in this study due to their limitation in capturing on-site environmental features (Gidlow et al., 2018). (2) The tools that focus on specific user groups who are not include senior users, such as C-POST (Crawford et al., 2008), PARK (Bird et al., 2015), QUINPY (Rigolon & Németh, 2018), and the features of public open spaces and physical activity among children audit tool (Timperio et al., 2008) were excluded. (3) The green spaces evaluated in this study are primarily located in urban areas dominated by residential zones and serve as small-scale open green spaces for local residents or people from nearby areas. There are many differences in functions and facilities between larger green open spaces that people travel to visit and smaller ones that tend to serve local residents only (Gidlow et al., 2012). Accordingly, the tools that include but do not specifically focus on neighborhood-scale green open spaces were excluded, such as SAGE (Byrne et al., 2005), NEST (Gidlow et al., 2018), RECITAL (Knobel et al., 2021), and the tool developed by Van Dillen et al. (2012). (4) The tools that focus on certain one type of use (e.g., physical activity), such as RFET (Cavnar et al., 2004), PARA (Lee et al., 2005), POST (Giles-Corti et al., 2005), EARPRS (Saelens et al., 2006), BRAT-DO (Bedimo-Rung et al., 2006), NZ-POST (Badland et al., 2010), CPAT (Kaczynski et al., 2012), READI Park Tool (Veitch et al., 2013), SPEAK (Lee, 2022), and the tool developed by Foster et al. (2006) were not considered. These tools often benefit from good reliability for characterizing the dimension on which they focus (Gidlow et al., 2018), but they have a limited capability to characterize other relevant key facilities that support other types of activity (Knobel et al., 2019).

In summary, considering the on-site use, functional applicability and the proven feasibility and reliability, NGST is the most suitable audit tool for assessing the quality of neighborhood green spaces for this issue. Based on the theoretical frameworks of the NGST, five potential quality assessment dimensions of NP conditions are applied, namely access, recreational facilities, amenities, natural features, and incivilities. Nevertheless, NGST is not specifically designed for seniors and was developed in the UK, there may be certain limitations when directly applying it to senior users within other cultural contexts. Therefore, the relevant empirical research literature is reviewed for supplementing more potential elements that potentially influence seniors' satisfaction under each dimension. These added ones are marked as "New" in Table 1.

2.1.1. Access

Whether seniors visit a park depends on their ability to access it safely, quickly, easily, and without impediment (Loukaitou-Sideris et al., 2016). Most seniors who visit parks almost daily do so by walking, and the proximity of the park to their residence is a determinant that encourages frequent park use among seniors (Gaikwad & Shinde, 2019). Additionally, when parks are located farther from their homes, seniors may choose other modes of transportation besides walking to reach the park. Nearby public transportation stops can fulfill seniors' autonomy needs, thereby increasing the likelihood of revisiting the park (Gibson, 2018). The use of cars can enhance seniors' mobility levels and provide more opportunities to visit parks; therefore, in cities that are highly dependent on cars, reserved parking at parks can better encourage them to use these spaces (Kou et al., 2021).

Compared to younger individuals, seniors may face more potential

Table 1
Potential auditing standards for NPs.

Domain	No.	Descriptions	Extension (evidence from senior group)	Source
Access	E_1	Access points	Gibson, 2018	NGST
	E_2	Pedestrian crossing, short cuts	Loukaitou-Sideris et al., 2016; Duan et al., 2018	NGST
	E_3	Pathways: number and quality	Loukaitou-Sideris et al., 2016; Zhai & Baran, 2016; Yung et al., 2017; Duan et al., 2018; Kou et al., 2021; Zhai et al., 2020; Zhai & Baran, 2017; Veitch et al., 2020; Levinger et al., 2018	NGST
	E_4	Public transit stops (e.g., bus, mass transit railway)	Loukaitou-Sideris et al., 2016; Yung et al., 2017; Levinger et al., 2018; Veitch et al., 2020	New
	E_5	Location (within a community, along an urban main road)	Gibson, 2018; Loukaitou-Sideris et al., 2016; Veitch et al., 2020; Gaikwad & Shinde, 2019	New
	E_6	Signage/notices (e.g., wayfinding signage, directional signs, help information flyers, park layout, entrance signs, maps, bulletin boards, etc.)	Loukaitou-Sideris et al., 2016; Yung et al., 2017; Gibson, 2018; Kou et al., 2021; Veitch et al., 2020	New
	E_7	Parking	Kou et al., 2021; Gibson, 2018; Loukaitou-Sideris et al., 2016; Veitch et al., 2020; Levinger et al., 2018	New
Recreational facilities	E_8	Play facilities (e.g., fitness equipment, exercise equipment, outdoor gym stations, chess tables, board games, etc.)	Loukaitou-Sideris et al., 2016; Duan et al., 2018; Zhai et al., 2020; Kou et al., 2021; Veitch et al., 2020; Gaikwad & Shinde, 2019; Yung et al., 2017	NGST
	E_9	Grass pitches (e.g., football courts, gate ball courts, bowling green, etc.)	Duan et al., 2018; Kou et al., 2021	NGST
	E_{10}	Hard courts (e.g., basketball courts; tennis courts, etc.)	Duan et al., 2018; Kou et al., 2021	NGST
	E_{11}	Skateboard ramps	–	NGST
	E_{12}	Amount/Quality of open space	Loukaitou-Sideris et al., 2016; Duan et al., 2018; Wang et al., 2021; Schmidt et al., 2021; Yung et al., 2017; Veitch et al., 2020	NGST
	E_{13}	Recreation facilities for children (e.g., swings, children's playground, etc.)	Duan et al., 2018; Veitch et al., 2020; Kou et al., 2021; Yung et al., 2017	New
	E_{14}	Playground	Duan et al., 2018	New
	E_{15}	Walking paths (e.g., circuits for the specific purpose of walking and jogging, sports paths, jogging track, perimeter path, etc.)	Loukaitou-Sideris et al., 2016; Duan et al., 2018; Gaikwad & Shinde, 2019; Kou et al., 2021; Veitch et al., 2020; Zhai et al., 2020; Levinger et al., 2018	New
	E_{16}	Cycle lanes	Kou et al., 2021	New
Amenities	E_{17}	Provision and quality of seating	Loukaitou-Sideris et al., 2016; Yung et al., 2017; Zhai & Baran, 2017; Gibson, 2018; Gaikwad & Shinde, 2019; Veitch et al., 2020; Kou et al., 2021; Levinger et al., 2018; Schmidt et al., 2021	NGST
	E_{18}	Bins	Loukaitou-Sideris et al., 2016	NGST
	E_{19}	Dog bins	–	NGST
	E_{20}	Lighting	Loukaitou-Sideris et al., 2016; Yung et al., 2017; Zhai & Baran, 2017; Kou et al., 2021; Veitch et al., 2020; Levinger et al., 2018	NGST
	E_{21}	Accessible facilities (e.g., handrails, accessible water stations, seating and pavement with contrasting colors, etc.)	Loukaitou-Sideris et al., 2016	New
	E_{22}	Toilets	Loukaitou-Sideris et al., 2016; Yung et al., 2017; Levinger et al., 2018; Gaikwad & Shinde, 2019; Kou et al., 2021; Veitch et al., 2020; Arnberger et al., 2017	New
	E_{23}	Shelter (e.g., shadowed pavilions, shade protection, undercover area, shade shelters, etc.)	Duan et al., 2018; Gibson, 2018; Schmidt et al., 2021; Loukaitou-Sideris et al., 2016; Yung et al., 2017; Veitch et al., 2020	New
	E_{24}	Highly distinctive and visible features (e.g., clock tower, fountain, historical sites, sculptures, war memorials, artistic sculptures, historical monuments, gazebos, etc.)	Veitch et al., 2020; Kou et al., 2021; Loukaitou-Sideris et al., 2016; Gaikwad & Shinde, 2019	New
	E_{25}	Safety facilities (e.g., emergency boxes, emergency phone boxes, lifeguard facilities along the coastal areas, fences, etc.)	Loukaitou-Sideris et al., 2016; Kou et al., 2021; Veitch et al., 2020	New
	E_{26}	Concession stands (e.g., cafes, kiosk, newsstands, etc.)	Kou et al., 2021; Veitch et al., 2020; Yung et al., 2017; Loukaitou-Sideris et al., 2016	New
	E_{27}	Picnic areas, picnic table	Loukaitou-Sideris et al., 2016; Veitch et al., 2020	New
	E_{28}	Drinking fountains	Loukaitou-Sideris et al., 2016; Arnberger et al., 2017; Veitch et al., 2020; Gaikwad & Shinde, 2019	New
	E_{29}	Outdoor reading room	Loukaitou-Sideris et al., 2016	New
Natural features	E_{30}	Provision/quality of grass	Loukaitou-Sideris et al., 2016; Duan et al., 2018; Gibson, 2018; Gaikwad & Shinde, 2019; Veitch et al., 2020; Kou et al., 2021; Zhai et al., 2020	NGST
	E_{31}	Provision/quality of trees/shrubs/plants	Loukaitou-Sideris et al., 2016; Arnberger et al., 2017; Yung et al., 2017; Gibson, 2018; Veitch et al., 2020; Kou et al., 2021; Zhai et al., 2020; Gaikwad & Shinde, 2019	NGST
	E_{32}	Provision/quality of flowers/flower beds	Loukaitou-Sideris et al., 2016; Yung et al., 2017; Zhai & Baran, 2017; Gibson, 2018; Kou et al., 2021; Schmidt et al., 2021; Veitch et al., 2020; Gaikwad & Shinde, 2019	NGST
	E_{33}	Provision/quality of water/water features/water body	Loukaitou-Sideris et al., 2016; Zhai & Baran, 2017; Arnberger et al., 2017; Yung et al., 2017; Veitch et al., 2020; Kou et al., 2021; Levinger et al., 2018	NGST
	E_{34}	Wildlife (e.g., birdlife, etc.)	Loukaitou-Sideris et al., 2016; Gibson, 2018; Veitch et al., 2020	New
	E_{35}	Opportunities for gardening flowers and vegetables	Loukaitou-Sideris et al., 2016	New
Incivilities	E_{36}	Dogs (e.g., several dogs on or off a lead)	Arnberger et al., 2017	NGST
	E_{37}	Extent of alcohol debris	Kou et al., 2021	NGST
	E_{38}	Extent of litter	Kou et al., 2021; Yung et al., 2017	NGST
	E_{39}	Extent of vandalism	Kou et al., 2021	NGST
	E_{40}	Extent of broken glass	Veitch et al., 2020	NGST

(*continued on next page*)

Table 1 (*continued*)

Domain	No.	Descriptions	Extension (evidence from senior group)	Source
	E_{41}	Extent of graffiti	Kou et al., 2021; Veitch et al., 2020	NGST
	E_{42}	Extent of drug paraphernalia	–	NGST
	E_{43}	Extent of noise	Loukaitou-Sideris et al., 2016; Yung et al., 2017; Gaikwad & Shinde, 2019; Veitch et al., 2020	NGST
	E_{44}	Maintenance personnel or equipment (e.g., CCTV, community volunteers, park wardens, security person, notice board, security person, etc.)	Loukaitou-Sideris et al., 2016; Kou et al., 2021; Veitch et al., 2020; Gaikwad & Shinde, 2019	New
	E_{45}	No skateboarding or cycling	Loukaitou-Sideris et al., 2016	New

risks during activities due to physical and functional decline (Crews, 2022). Seniors have expressed concerns about becoming lost in open spaces, and they emphasize the importance of wayfinding signage to enhance their sense of direction (Loukaitou-Sideris et al., 2016). Furthermore, signs in parks that detail available amenities, historical landmarks, and plant species can facilitate easier navigation for seniors and boost their confidence in using park facilities (Kou et al., 2021).

2.1.2. Recreational facilities

Seniors with different physical conditions may choose different activities in parks. Walking is the most popular activity in parks, and the presence of perimeter paths can promote walking among seniors, thereby encouraging physical activity (Veitch et al., 2020). Some may opt for low-impact exercises on walking paths (Duan et al., 2018; Loukaitou-Sideris et al., 2016), while others may engage in moderate and vigorous activities such as cycling (Duan et al., 2018). Additionally, creating opportunities for intergenerational park use can help attract seniors to parks (Loukaitou-Sideris et al., 2016). For example, the caring relationship between seniors and children may lead them to engage in ball games or other activities together (Duan et al., 2018). In this regard, children's playgrounds play a critical role in encouraging intergenerational use (Kou et al., 2021). In Hong Kong parks, playgrounds are common areas for children's physical activities, and seniors often perform fitness exercises in these areas, making playgrounds multifunctional for active seniors (Duan et al., 2018).

2.1.3. Amenities

In addition to the above-mentioned recreation facilities that support seniors' physical activities, the comfort facilities that meet other related activities (e.g., sitting, eating/drinking) can also affect their use of parks. For example, toilets can support seniors in using for extended periods within the park (Kou et al., 2021), while shelters and gazebos allow them to use the park in inclement or hot weather (Knight et al., 2018). Considering seniors' reduced mobility, visual impairment, and sensitivity to glare, park design needs to carefully consider accessibility features, such as handrails and the use of contrasting colors in seating and pavement (Loukaitou-Sideris et al., 2016). In terms of enhancing security, seniors mentioned during interviews the importance of safety features in parks, such as fences (Veitch et al., 2020), lifeguard facilities (Kou et al., 2021), and emergency boxes (Loukaitou-Sideris et al., 2016). In terms of encouraging social interaction, drinking water facilities can encourage seniors to spend more time in the park and increase opportunities for social interaction (Gaikwad & Shinde, 2019). Additionally, such as picnic/barbecue facilities, a café, and an outdoor reading room have been shown to promote social interaction among seniors in the park (Loukaitou-Sideris et al., 2016; Veitch et al., 2020). Furthermore, seniors generally believe that parks should retain features such as sculptures and the transformations of some historical sites to enhance the "feel of the place" (Kou et al., 2021).

2.1.4. Natural features

Seniors value contact with nature and are attracted to natural elements in parks such as flowers, greenery, views of water, wildlife, and fresh air (Loukaitou-Sideris et al., 2016). Previous empirical studies have shown that wildlife in parks can fulfill seniors' autonomy need, thereby increasing their frequency of visits (Gibson, 2018). Additionally, seniors in focus groups mentioned that providing spaces for gardening in parks can offer food, vegetables, and fruits for themselves and the community, while also creating opportunities for social and therapeutic activities, as well as offering flowers for the aesthetic pleasure (Loukaitou-Sideris et al., 2016).

2.1.5. Incivilities

The dimension of incivilities in NGST mainly involves two types of elements, namely environmental pollution and threats to users' safety caused by animals or other people.

In addition, it was found that the lack of security measures could also reduce seniors' willingness to visit parks (Loukaitou-Sideris et al., 2016). Security personnel and notice boards prohibiting ball games to create a safe and maintained physical environment were thought to be important elements for senior users (Gaikwad & Shinde, 2019). The presence of park wardens and "eyes in parks" makes seniors feel safer and more secure (Kou et al., 2021). Volunteers and camera surveillance were found to be useful for enhancing seniors' perceived security, and they can also serve as an intervention to discourage potential criminal behavior (Loukaitou-Sideris et al., 2016).

2.2. Methodologies for exploring the relationships between park conditions and seniors' experience

Many studies have employed various correlation analysis techniques to discuss the park features that influence seniors' experience. For example, a study on parks in high-density old districts in Hong Kong using an ordered logit model found that internal planning-related factors, such as toilets, cleanliness of the park, and adequate lighting, are associated with improved seniors' satisfaction with park usage (Yung et al., 2017). In addition, a study using linear multiple regression analyses revealed that elements of park location and amenities are related to meeting seniors' autonomy needs, and further studies found that the fulfillment of autonomy needs is related to park visitation (Gibson, 2018). To explore the relationship between park design features and seniors' activity in Taiwan, researchers applied multiple stepwise regression analyses and found that natural areas and the presence of outdoor fitness equipment were positively correlated with seniors' total step count (Zhai et al., 2020). Furthermore, by using the hierarchical regression analysis, a study on seniors' use of the parks in Shanghai revealed that reserved activity spaces were important to seniors' physical activities (Wang et al., 2021).

Although existing literature has continuously expanded knowledge on the relationship between seniors' attitudes and park environmental features, methodological limitations of statistical correlation inferences prevent an understanding of causal effect of park conditions on seniors' attitudes. In addition, these statistical analysis techniques have operated based on the assumption that the impact of conditions on user judgement is considered to operate independently, which neglects the complexity of real-world settings (Tzeng & Shen, 2017) and falls short of capturing the combined impact of these conditions on users' judgement. Thus, there is currently a gap in research on the combined effects of park environmental features on seniors' attitudes. A systematic approach to understanding the interdependence between environmental cues is

essential for helping decision-makers allocate resources effectively when managing and improving physical environments (Zheng et al., 2024).

3. Empirical cases

3.1. Study design and methodology

This study aims to explore the causal rules between environmental conditions of NPs and seniors' satisfaction. Interventions and counterfactuals are taken as the foundation stones of causal knowledge. Rough sets are great at an automated change of data into knowledge by using only the notions of finite set, equivalence relation and cardinality, without any preliminary information about the data, and Rough Set Approach (RSA) is also thought to have the ability to answer questions about interventions and counterfactuals for the rules discovered in data (Yao et al., 2019).

Rough set theory, proposed by Pawlak (1982), is often regarded as a data mining technique used to clarify the core influencing variables behind complex phenomena and provide rules and logic that are easy for decision-makers to understand. (Fan et al., 2023; Mei et al., 2022).

In this study, RSA can extract decision-making behavior rules between the conditional attributes (i.e., the physical environment features of NPs) and decision-making attributes (i.e., senior users' satisfaction) in the classification function from a large number of data samples to solve the problem of inaccurate, inconsistent, and incomplete relationships in the knowledge. RSA has been applied to some similar types of topics dealing with clarifying the causal relationships between physical environments and user attitudes (e.g., Fan et al., 2023; Mei et al., 2022). Thus, RSA is suitable to be employed to generate decision-making rules between physical environment factors of NPs and seniors' attitudes.

Fig. 1 shows the overall research process. From an application point of view, the only prerequisite of RSA is that the data of both the conditional attributes (i.e., the physical environment features of NPs) and decision-making attributes (i.e., senior users' satisfaction) can be collected in the form of attribute-value tables from non-experimental cases, without any missing values and with all the attributes in the form of categorical variables (Yao et al., 2019).

For the conditional attributes, firstly, a preliminary list of potential evaluation elements for influencing seniors' satisfaction toward park use was established through the inductive analysis. This list was then used to conduct an on-site audit of 142 NPs in Zhuhai. Subsequently, environmental elements (i.e., X_{1-13}) suitable for Zhuhai were selected. As to the decision attribute, seniors' satisfaction judgements in each site was collected. For grading levels of satisfaction, a 5-point Likert scale (ranging from strongly dissatisfied to strongly satisfied) was used (Fig. 1). Secondly, the complete data collected from both the on-site audit and interview-administered survey for each attribute should be changed into discrete values by using the Natural Breaks (Jenks) method. Finally, this study applies the RSA technique to understand the causal rules (if-then rules) between condition and decision attributes. As a result, the causal knowledge of environment-attitude relationships is represented in the form of if-then rules. The detailed steps of RSA, following Fan et al. (2023), are presented in Appendix A.

3.2. Study areas

In this study, the NP cases in Xiangzhou District of Zhuhai City are applied as empirical cases (Fig. 2). The proportion of the population aged 60 and above in Xiangzhou District accounted for 10.18 % of the total population of this district (Xiangzhou District People's Government Zhuhai Municipality, 2021), while the ratio is higher than the commonly used international threshold for judging whether a society has become an aging society. In addition, Xiangzhou District has included the creation of a "15-minute elderly care service circle" focusing on environmental beautification, greening and facilities renovation for the elderly as its main task of urban development (Zhuhai Civil Affairs Bureau, 2023). As a result, there is a significant demand for high-quality, age-friendly public open spaces in Xiangzhou District.

For identifying NP cases, this study selected NPs in the Xiangzhou District that were created and managed by the public sector as preliminary cases (information from the Master Planning Map of Neighborhood Parks in Xiangzhou District released by Xiangzhou District Tourism Bureau and Zhuhai Planning and Design Institute in 2012), and made case deletions/additions based on these NPs. The criteria exclusion and inclusion are: (1) Independently designated green spaces that have basic recreational and service facilities, primarily serving residents within a specific community for nearby daily leisure activities (Ministry of Housing and Urban-Rural Development of the People's Republic of China, 2018; Zhuhai Municipal Housing and Urban-Rural Development Bureau, 2020) are included; (2) Parks that are less than 10 ha, located in predominantly residential urban areas with the primary/secondary purpose of formal/informal recreation, unrestricted access for public are included (Gidlow et al., 2012); (3) NPs in the map that are under construction/renovation during the study period and mismarked are excluded (Duan et al., 2018); (4) NPs in the map that have no residential areas within a 300-m buffer or have no senior respondents can be found for participation are excluded. As a result, some unbuilt and mismarked NPs, non-NPs (such as beaches and large-scale urban green spaces with parks larger than 10 ha) in the map are excluded, and some NPs are added by comparing remote sensing pictures, field surveys and the given map. A total of 142 NPs were selected. The locations and shapes of the selected NPs were drawn in ArcGIS (see Fig. 2; details in Appendices B and C). According to ArcGIS calculations, the total area of the 142 NPs investigated in this study is 132.36 ha, and the average area is 0.93 ha.

3.3. Condition attributes

Due to the potential limitations of the elements summarized in Table 1 of Section 2 when applied in different cultural or environmental contexts, it is therefore necessary to localize the elements. We recorded the quantity and categories of potential environmental features based on the on-site audit from all the NPs, and then conducted a screening of these elements for obtaining the conditional attributes used in the subsequent RSA process. Since the condition attributes in RSA require categorical variables, some continuous variables were converted into categorical variables, with detailed explanations provided for each classification.

3.3.1. Pretest

Before formally collecting data, five trained researchers conducted a pretest on-site audit of the presence of physical elements in NPs located in Xiangzhou District, Zhuhai, according to the list in Table 1. Auditors received standardized training to ensure they fully understood the audit content and adhered to consistent audit standards. A total of 17 NPs were audited, with auditors' cross-checking and consulting with each other to avoid any ambiguous description of the items.

As the elements in Table 1 are derived from the preferences of seniors all over the world, many of these criteria may not be suitable for the study area. Therefore, the researcher documented the objective conditions of the 142 NPs, and removed elements that were non-existent (e.g., alcohol debris, water features, etc.) or not mentioned by seniors (e.g., noise, etc.). At the same time, it is found in the survey that the vast majority of respondents live around the park, and most of them walk to the park and are very familiar with it. Therefore, some evaluation factors, such as guiding facilities in the park, public transportation, and parking lot, are not concerned or not mentioned by the elderly users of the park. According to the induction analysis of the answers to open-ended questions and also the on-site audits, the elements in Table 1 were merged or deleted (no addition) for localization, and finally a list of 13 elements was formed (Table 2).

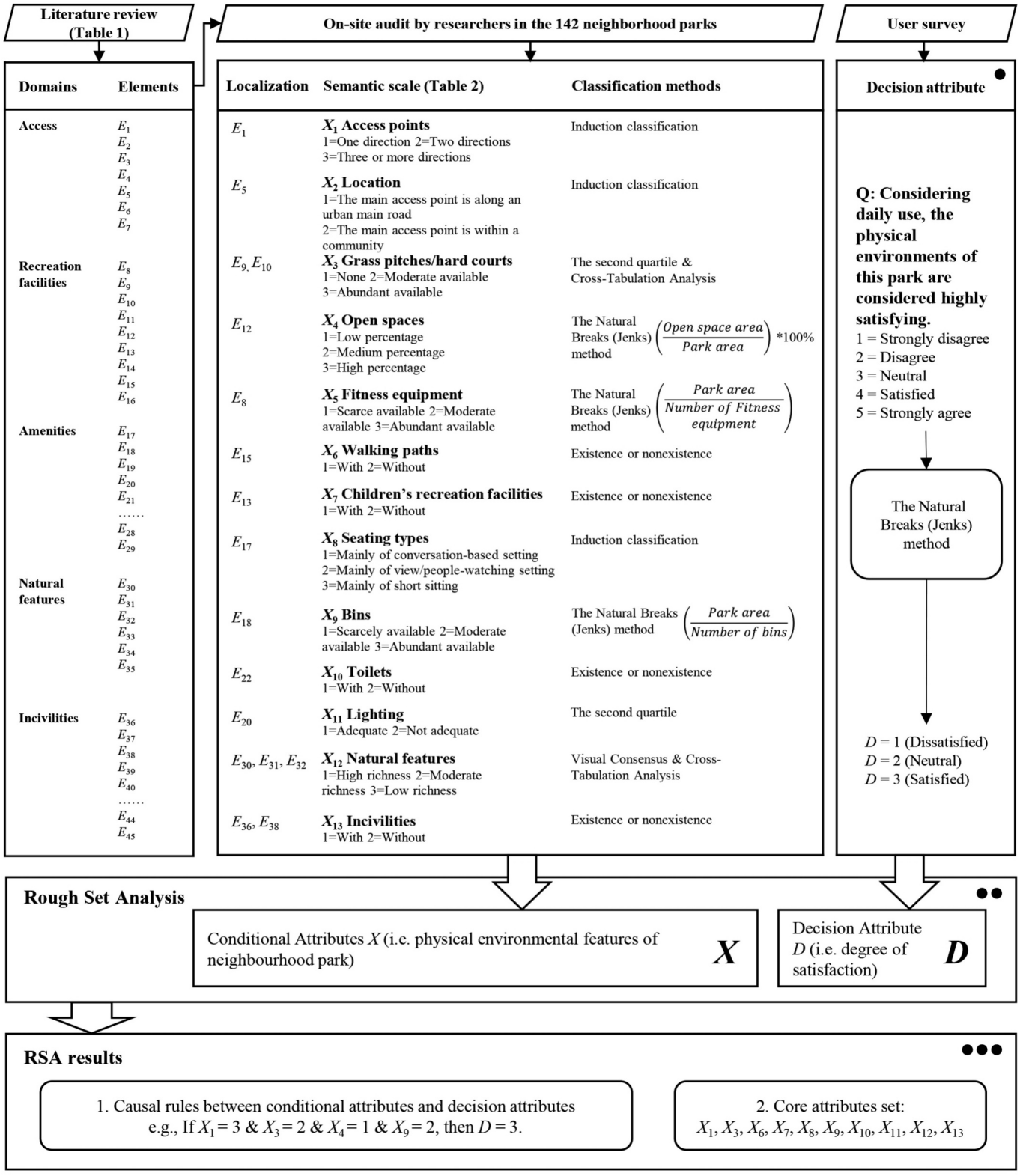
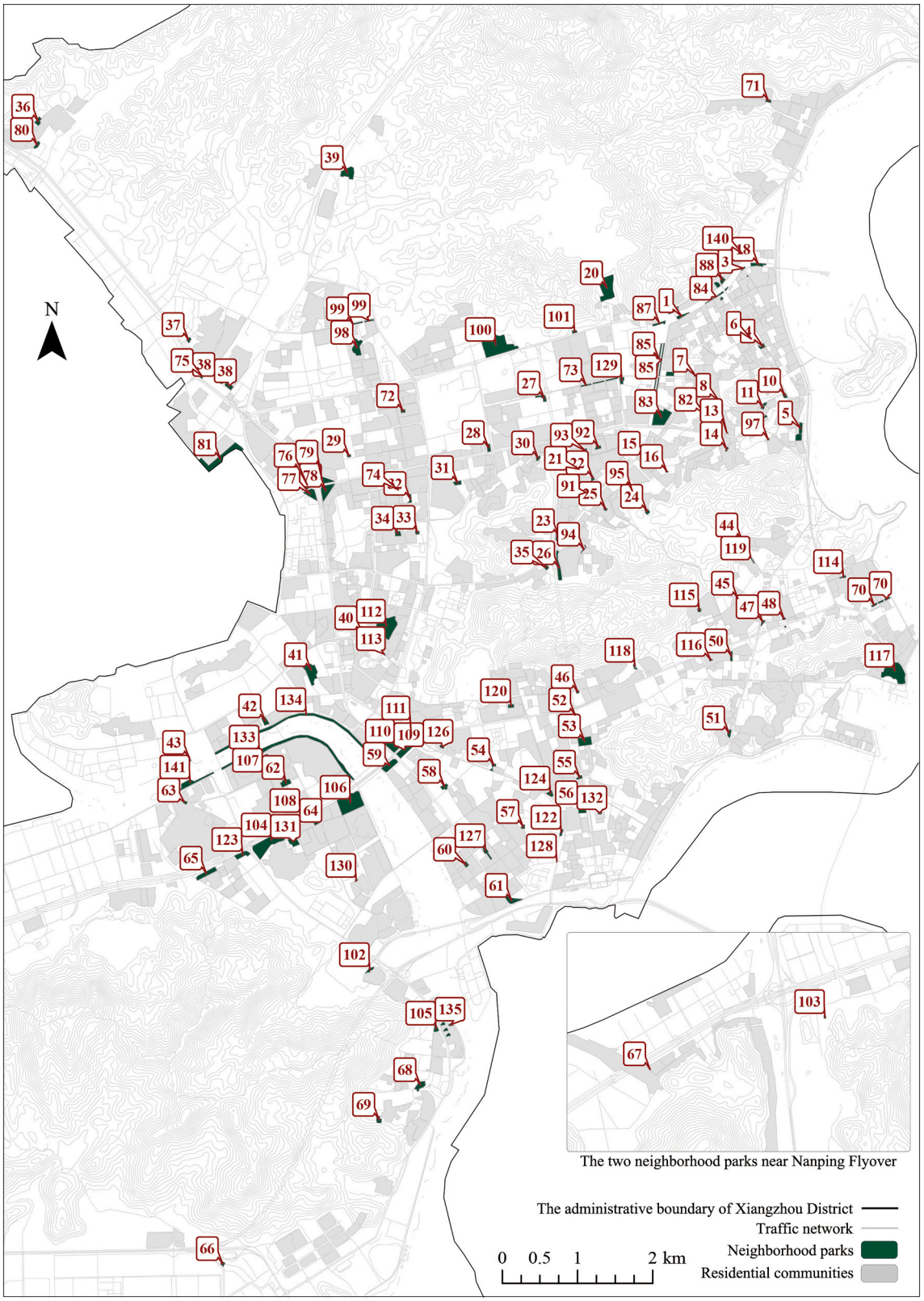


Fig. 1. Research methods and process.

3.3.2. *On-site audit measurements*

From May 6 to June 19 of 2023, two trained researchers conducted a formal on-site audit of specific characteristics of physical environmental conditions in the 142 NPs. As to the on-site audit, 13 variables contain 7 categorical variables and 6 continuous variables. Seven categorical variables are "Walking paths" (X_6), "Children's recreation facilities" (X_7), "Toilets" (X_{10}), "Incivilities" (X_{13}), "Seating types" (X_8), "Location" (X_2) and "Natural features" (X_{12}), and the former four are judged using a "with/without" scale. Among them, "Location" is recorded based on whether the main access point(s) of NPs is/are along an urban main road or within a community. As to seating types, the seats in Zhuhai NPs were mainly divided into three types (Fig. 3), and researchers judged the main



• 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.

belonging type based on the types and proportions of seats in each NP. The richness of "Natural features" was also inducted based on visual consensus of the subjective judgement of the three researchers (Fig. 4).

Since RSA requires data to be presented in categorical form (Beynon & Peel, 2001), the seven categorical variables should be subjected to a process of discretisation. Among the seven continuous variables, the data of three ones -the proportion of "Open spaces" (X_4) to total area, the density of "Fitness equipment" (X_5) and "Bins" (X_9)- presents a "long tail" distribution curve. Therefore, the Natural Breaks (Jenks) method (Jenks & Caspall, 1971) was used to generate the thresholds of the categories, this method can iteratively calculate and compare the sums of the squared difference between observed values within each class and the class means, in order to achieve the most effective grouping of values (Daccache et al., 2015).

In addition, the number and categories of "Fitness equipment" (X_5) and the proportion of the area covered by nighttime "Lighting" (X_{11}) in the entire activity area of an NP were transformed into categorical variables by using the second quartile. The attribute of "Access points" (X_1) was transformed into categorical variables based on the consensus of the three researchers, and it is divided into three categories, according to the number of directions in which the entrances and exits are located in an NP. As to the "Grass pitches/hard courts" (X_3), cross-tabulation analysis of quantity and variety was used to obtain categorical variables. Table 2 presents all the classification scales used in this study.

3.4. Decision attribute

The pretest survey of seniors' satisfaction questionnaire was conducted from February 13 to March 1. For the pretest of satisfaction questionnaire, communication with senior users was conducted 55 satisfaction questionnaires in the 17 NPs, in order to develop a sampling strategy and improve the question statements. In the first version, the satisfaction rating question was asked first, followed by an open-ended question ("Do you have any dissatisfaction with or suggestions for improving the park"). However, a contradiction finding emerged during the investigation. Respondents in the study area often gave high

Table 2
Key condition attributes and their semantic scales.

No.	Domain	Key condition attributes	Source	Semantic scale (key features)	Number of compliant NPs (%)	Descriptive statistics	Classification method
X_1	Access	Access points	E_1	1 = One direction 2 = Two directions 3 = Three or more directions (or the park boundary is open)	20 (14.08) 32 (22.54) 90 (63.38)	–	Induction classification
X_2		Location	E_5	1 = The main access point is along an urban main road 2 = The main access point is within a community	94 (66.20) 48 (33.80)	–	Induction classification
X_3	Recreational facilities	Grass pitches/ hard courts	E_9, E_{10}	1 = None (Category 0 & Num 0) 2 = Moderate available (Category 1–3 & Num 1–13) 3 = Abundant available (Category 1–3 & Num 14–27; Category 4–7 & Num 1–13; Category 4–7 & Num 14–27)	55 (38.73) 70 (49.30) 17 (11.97)	–	The second quartile & Cross-Tabulation Analysis
X_4		Open spaces	E_{12}	1 = Low percentage (0.00 %–14.37 %) 2 = Medium percentage [14.37 %–40.16 %) 3 = High percentage [40.16 %–89.90 %]	113 (79.58) 25 (17.60) 4 (2.82)	Avg: 10.34 % Min: 0.00 % Max: 89.89 %	Natural Breaks (Jenks)
X_5		Fitness equipment	E_8	1 = Scarce available (248.76 m^2–+∞m^2) 2 = Moderate available (64.80 m^2–248.76 m^2] 3 = Abundant available (24.82 m^2–64.80 m^2]	109 (76.76) 29 (20.42) 4 (2.82)	Avg: 746.64 m^2 Min: 0.00 m^2 Max: 16779.5 m^2	Natural Breaks (Jenks)
X_6		Walking Paths	E_{15}	1 = With (Code "with" if the park has any pathways) 2 = Without (Code "without" if the park has no pathway)	71 (50) 71 (50)	–	Existence or nonexistence
X_7		Children's recreation facilities	E_{13}	1 = With (Children's recreation facilities exists) 2 = Without (No children's recreation facility exists)	58 (40.85) 84 (59.15)	–	Existence or nonexistence
X_8	Amenities	Seating types	E_{17}	1 = Mainly of conversation-based setting 2 = Mainly of view/people-watching setting 3 = Mainly of short sitting	15 (10.56) 109 (76.76) 18 (12.68)	–	Induction classification
X_9		Bins	E_{18}	1 = Scarcely available (905.80 m^2–+∞m^2) 2 = Moderate available (281.21 m^2–905.80 m^2] 3 = Abundant available (115.58 m^2–281.21 m^2]	98 (69.01) 40 (28.17) 4 (2.82)	Avg: 1447.79 m^2 Min: 0.00 m^2 Max: 9511.39 m^2	Natural Breaks (Jenks)
X_{10}		Toilets	E_{22}	1 = With (Code "with" if the park has any toilets) 2 = Without (Code "without" if the park has no toilet)	66 (46.48) 76 (53.52)	–	Existence or nonexistence
X_{11}		Lighting	E_{20}	1 = Adequate (the nighttime lighting area over the entire activity area of an NP at night; if the ratio of light cover more than 50 %) 2 = Not adequate (Approximately measure the lighting area over the entire activity area of the park at night; if the ratio of light cover not more than 50 %)	89 (62.68) 53 (37.32)	–	The second quartile
X_{12}	Natural features	Natural features	E_{30}, E_{31}, E_{32}	1 = High richness (Large number & variety) 2 = Moderate richness (Large number & medium variety; Large number & small variety; Medium number & Large variety; Medium number & Medium variety; Medium number & Small variety; Small number & Large variety; Low number & Medium variety) 3 = Low richness (Low number & Low variety)	54 (38.03) 56 (39.44) 32 (22.53)	–	Visual consensus & Cross-tabulation analysis
X_{13}	Incivilities	Incivilities	E_{36}, E_{38}	1 = With (Code "with" if the park has any uncivilized behavior) 2 = Without (Code "without" if the park has no uncivilized behavior)	14 (9.86) 128 (90.14)	–	Existence or nonexistence

satisfaction scores initially, but later response expressed a range of concerns or dissatisfaction in the open-ended questions. Thus, we placed the open-ended questions first, followed by satisfaction ratings. To obtain more genuine feedback, the order of questions was adjusted in the formal survey, with open-ended questions asked first, followed by the satisfaction ratings. Moreover, survey data in pretest were collected through field-based interview-administered surveys in an opportunistic sample (followed Gidlow et al., 2012). Based on this sampling strategy, most of the respondents we met were highly vigilant about the investigators, and their responses showed an obvious bias of social desirability. Individuals often tend to align their responses with social expectations, which can lead to distorted results (Holtgraves, 2004; Paulhus, 1991; Paulhus, 2002). However, opinion leaders within groups can act as bridges for communication between internal and external parties, assisting researchers in accurately understanding and conveying the genuine opinions of the group (Burt, 1999). Accordingly, after the pretest, a purposive and snowball sampling from key opinion leaders (KOLs) of senior users was adopted.

The distribution of questionnaires of the decision attribute (i.e., satisfaction) was carried out, under the suitable temperature and weather conditions for senior citizens' outdoor activities during March 5 to June 19. The satisfaction questionnaires were distributed to KOLs of the senior users in the 142 NPs. The questionnaire mainly consists of two parts: (1) demographic information, and (2) overall satisfaction with an NP. A purposive and snowball sampling was adopted, involving interaction with senior users at the site to gather information and schedule interview appointments with the KOLs they recommended, or to conduct on-site visits. The participants were required to meet the following criteria: (1) KOLs should be aged 50 years or older; (2) They are very familiar with the physical environments of the NPs; (3) They are well acquainted with the elderly groups that primarily use the park; and (4) KOLs should be frequently participating in park activities and enjoy a high reputation and influence within the local community, and are considered capable of representing the opinions and needs of the majority of senior users. The key opinion leaders were recommended by users we met in selected NPs. After excluding 38 invalid questionnaires due to incomplete responses, a total of 548 (range from 1 to 21 respondents per NP) valid questionnaires were finally collected, the characteristics of respondents are showed in Table 3.

The question of overall satisfaction is "Do you agree with the following statement? Considering daily use, the physical environments of this park are considered highly satisfying". The responses were assessed using a semantic scale ranging from "strongly disagree (1)" to "strongly agree (5)". Then the average satisfaction for each park was converted into three categories of the decision attribute by using the Natural Breaks (Jenks).

4. Results

We employed the ROSE2 (Rough Set Data Explorer) software, developed by the Laboratory of Intelligent Decision Support Systems at Poznan University of Technology, to extract core attributes and generate our decision rules. ROSE2 is a widely recognized rough set toolkit designed to analyze uncertainty and fuzziness in data. It provides a range of powerful features that support key operations, such as attribute reduction and rule generation. The decision rule extraction program, based on RSA, can generate a large number of rules about seniors' satisfaction with NPs.

The first result obtained is the approximations of the decision classes and the quality of their classifications. The overall quality of classification is 0.9789, and the approximate accuracy of the three decision classes is shown in Table 4. The findings indicate that this dataset exhibits roughness, making it suitable for analysis using RSA. In RSA, any vague concept can be replaced by a pair of precise concepts called the lower and the upper approximation of the vague concept (Yao et al., 2019). When the upper and lower approximations of a set coincide, the set is considered exact. If not, it constitutes a rough set. The accuracy of the approximation for a decision class is evaluated by the ratio of the lower approximation to the upper approximation.

Next, in the process of attribute reduction, we identified non-removable attributes by gradually removing attributes that did not affect the results. This is because removing these attributes would result in the loss of basic classification information. In information tables, redundant attributes that do not affect classification can be removed (Liou et al., 2016). A minimal set of attributes achieves the same classification quality as the full set. Systems may have multiple such minimal sets, and their intersection, known as the core, contains the system's most critical attributes for classification (Mckee, 2000). The core considers 10 attributes $\{X_1, X_3, X_6, X_7, X_8, X_9, X_{10}, X_{11}, X_{12}, X_{13}\}$. This result indicates that these 10 conditional attributes are considered key environmental attributes for achieving satisfaction goals among seniors in NPs, and have a stronger impact on rule influence, which should be taken into consideration by decision makers. The remaining attributes $\{X_2, X_4, X_5\}$ were found to have no significant impact on classification quality or other results during the reduction process. However, considering that in some cases, non-core attributes may demonstrate significance when combined with other attributes, we retained all attributes in the analysis of causal rules.

Through RSA, we generated a total of 39 rules, of which 11 rules were applicable to the bad class, 15 rules to the medium class, and 13 rules to the good class. Among these rules, some of them have a lower ability to distinguish the satisfaction of seniors for NPs features, thus, referring to previous research (e.g., Liou et al., 2016; Wang et al., 2010), this research set a threshold (i.e., minimal covering rules with strength exceeding 10 %) for selecting valid rules under each decision class, which is calculated as the ratio of the number of objectives supporting the rule to the total number of NP cases (also called "objects"). In order to better observe the rules that affect the overall perception of seniors, this study only focused on 6 rules of the good class ($D = 3$) and 5 rules of the bad class ($D = 1$). Thereby, we can obtain the environmental condition combinations that NPs should avoid or approach (Table 5).

Based on the 11 causal-effect rules, two flow graphs were drawn (Fig. 5). The flow graph, developed by Ford & Fulkerson in 1962, serves as an effective tool to delineate a path-dependent relationship utilizing

Fig. 3. Main categories of seating types.

Fig. 4. Main categories of natural features.

Table 3
Characteristic of respondents (N = 548).

Variables	Categories	Frequency	Proportion (%)
Gender	Male	232	42.34
	Female	316	57.66
Age	50–59	99	18.07
	60–69	307	56.02
	70–79	113	20.62
	80–89	26	4.74
	90+	3	0.55
Living arrangement	Living in own house	487	88.87
	Living in the children's house	48	8.76
	Else	13	2.37
Living alone or not	Not alone	483	88.14
	Alone	65	11.86
Difficulty seeing	No	494	90.15
	Yes	54	9.85
Difficulty moving	No	527	96.17
	Yes	21	3.83
Difficulty hearing	No	541	98.72
	Yes	7	1.28
Means to go to neighborhood parks	By walking	524	95.62
	By driving	7	1.28
	By public transportation	10	1.82
	By cycling	7	1.28
Frequency of visits to neighborhood parks	4 or more times a week	521	95.07
	1–3 times a week	21	3.83
	Less than once a week	6	1.10
Distance to the neighborhood parks	Within 15 min walk	502	91.61
	More than 15 min walk	46	8.39
Satisfaction rating	Very dissatisfied	43	7.85
	Dissatisfied	97	17.70
	Neutral	130	23.72
	Satisfied	166	30.29
	Very satisfied	112	20.44

the decision rules of rough sets (Wang et al., 2010). According to Liou et al. (2016), the model, guided by the flow graph and Bayes' theorem, elucidates the decision processes inherent within flow network graphs. Each branch in the flow graph is described as a decision rule, and the overall flow graph constitutes a comprehensive decision algorithm (Liou et al., 2016). The flow graphs make rules more intuitive and give researchers/readers detailed observable information.

Two flow graphs can illustrate the combined effects of NP environmental features on achieving either a "strongly satisfied" or "strongly unsatisfied" outcome. For example, Rule 1 states that an NP with the main access point along an urban main road ($X_2 = 1$), lacking hard courts ($X_3 = 1$) and without toilets ($X_{10} = 2$), and having moderate richness of natural features ($X_{12} = 2$), will lead to great dissatisfaction among seniors ($D = 1$). Among them, the environmental conditions with the largest flow (20) are $X_{12} = 2$ and $X_{10} = 2$, which implies that these conditions are important for causing low satisfaction. If a park fails to meet the needs behind both these key conditions and the ones that work with them, it is likely to receive a poor satisfaction judgement. As to the class of good performance ($D = 3$), several tributaries show a clear convergence at several points such as $X_1 = 3$ (59), $X_{11} = 1$ (46), and $X_4 = 1$ (31), which indicates that the number of access points directions, lighting, and whether there is a small amount of open activity space should be taken more attention. Park managers can develop improvement strategies on these conditions based on these upper and lower limits of the audit data from the supporting cases.

5. Discussions

5.1. Combined effects of environmental conditions of NPs on seniors' satisfaction

Previous statistical analysis techniques have been employed to examine the impact of park environmental features on seniors' pathway usage (Zhai & Baran, 2016), satisfaction (Yung et al., 2017), visitation motivations (Gibson, 2018), physical activity (Wagner et al., 2020; Zhai et al., 2020), and frequency of park visitation (Wang et al., 2021), and they have been operated based on the assumption that the impact of conditions on user judgement is considered to operate independently, which neglects the complexity of real-world settings (Tzeng & Shen, 2017). In contrast, by using the RSA, this study has found the combined effects of different environmental characteristics on the different levels of seniors' satisfaction.

In the research on subjective perception, many theoretical perspectives emphasize that the influence of physical environment on subjective experiences is comprehensive rather than isolated, and the effects of these factors should not be considered in isolation (e.g., Koehler, 1929; Koffka, 1935; Mattila & Wirtz, 2001). Bove and Benoit (2020) further clarify that the overall effectiveness of different types of signals may not

Table 4
Quality of classification and quality approximation of decision classes.

	Class	No. of objects	Lower approximation	Upper approximation	Accuracy
Quality approximation of decision classes	1	47	47	47	1.0000
	2	37	36	39	0.9231
	3	58	56	59	0.9492

Notes: Quality value of classification is 0.9789.

Table 5
Minimal covering rules with strength exceeding 10 % of bad and good class.

NO.	Conditions	Decision	Number of objects
1	$(X_2 = 1)$ & $(X_3 = 1)$ & $(X_{10} = 2)$ & $(X_{12} = 2)$	Bad class $(D = 1)$	11 (23.40 %)
2	$(X_2 = 2)$ & $(X_3 = 2)$ & $(X_4 = 1)$ & $(X_{11} = 2)$	Bad class $(D = 1)$	11 (23.40 %)
3	$(X_5 = 1)$ & $(X_{12} = 3)$	Bad class $(D = 1)$	14 (29.79 %)
4	$(X_1 = 2)$ & $(X_5 = 1)$ & $(X_7 = 2)$ & $(X_{12} = 2)$	Bad class $(D = 1)$	9 (19.15 %)
5	$(X_7 = 2)$ & $(X_8 = 3)$ & $(X_{10} = 2)$	Bad class $(D = 1)$	9 (19.15 %)
6	$(X_1 = 3)$ & $(X_2 = 1)$ & $(X_{10} = 1)$ & $(X_{11} = 1)$ & $(X_{12} = 1)$	Good class $(D = 3)$	22 (37.93 %)
7	$(X_1 = 3)$ & $(X_3 = 2)$ & $(X_4 = 1)$ & $(X_6 = 1)$ & $(X_{11} = 1)$	Good class $(D = 3)$	16 (27.59 %)
8	$(X_1 = 2)$ & $(X_4 = 1)$ & $(X_5 = 1)$ & $(X_8 = 2)$ & $(X_{11} = 1)$	Good class $(D = 3)$	8 (13.79 %)
9	$(X_1 = 3)$ & $(X_3 = 3)$	Good class $(D = 3)$	14 (24.14 %)
10	$(X_1 = 3)$ & $(X_3 = 2)$ & $(X_4 = 1)$ & $(X_9 = 2)$	Good class $(D = 3)$	7 (12.07 %)
11	$(X_3 = 2)$ & $(X_7 = 1)$ & $(X_{10} = 1)$ & $(X_{12} = 2)$	Good class $(D = 3)$	7 (12.07 %)

Notes: Core attributes are X_1, X_3, X_6, X_7, X_8, X_9, X_{10}, X_{11}, X_{12} and X_{13}.

simply be the sum of the effectiveness of individual signals. For instance, the effectiveness of signals interacting with other types of signals under certain conditions may be less than that of signals operating in depend. Therefore, the causal relationship between environmental attributes and user attitudes is inherently complex, necessitating a systematic perspective to consider the interdependencies among environmental attributes.

This study employs the RSA from a data mining perspective, building on the foundation of existing findings to explore the causal relationships between NP environmental attributes and senior satisfaction in a more comprehensive and systematic manner. Firstly, we obtained 11 causal rules (if-then rules) which show that when a particular combination of NPs environmental attributes, appearing after "if' is present, it will lead to a specific senior attitude, as described after "then". There is no rule in the results that a single element leads to an outcome, which once again supports the Koffka's view that elements act in a comprehensive manner, which has been rarely discussed in previous studies. For example, previous studies have found that providing toilets is associated with improving the use satisfaction among seniors (Yung et al., 2017). However, our study found that the effect of this condition on user satisfaction is in conjunction with other environmental conditions, rather than in the independent effect. For instance, in Rule 6, when an NP's main access point is located along an urban main road ($X_2 = 1$), there are access points from three or more directions ($X_1 = 3$), with high richness of natural features ($X_{12} = 1$), adequate lighting ($X_{11} = 1$), and the presence toilet ($X_{10} = 1$) will lead to the satisfied of seniors ($D = 3$).

5.2. Different effects of some conditions on users' judgement in different combination scenarios

Moreover, a very interesting point was found from the rules, that is, the same elements may have different effects on users' satisfaction in different combination scenarios. For example, both Rule 2 and Rule 7 have two condition attributes -moderate available courts ($X_3 = 2$) and less open spaces ($X_4 = 1$)- but the decisions are completely different when these two conditions are combined with different elements. In Rule 7, when combined with $X_6 = 1$, $X_{11} = 1$ and $X_1 = 3$, the seniors are satisfied with an NP ($D = 3$); whereas in Rule 2, when combined with $X_2 = 2$ and $X_{11} = 2$, they are dissatisfied ($D = 1$).

From a general statistical perspective, two condition attributes that are identical in two rules are often considered insignificant in terms of their impact on the outcome. However, from the perspective of component matching in RSA, they can be two indispensable factors in the composition of the rules. Such rules may show further in-depth investigation directions such as user segmentation based on their visit motivations and activities. According to observations from on-site walking talks, we found that the motivation of the senior groups in Rule 7 is mainly to come here for sport activities at night, and this kind of users prefer that the park can provide as many sport spaces (such as tennis courts and basketball courts), rather than open spaces for flexible use. They are more concerned with having adequate lighting (X_{11}) and convenient access (X_1). In Rule 2, the subgroup of users primarily uses NPs for non-physical activities at night, such as socializing or taking children outdoors. They tend to focus on lighting conditions (X_{11}), accessibility (X_2), and hard-paved open spaces for flexible use (X_4). However, these seniors are highly averse to sports fields, perceiving them as overly noisy (e.g., cheering), occupying recreational space, and significantly contributing to a heightened sense of insecurity, making sports fields undesirable in their view. Bove and Benoit (2020) highlighted that the interpretation of which environmental cues are important to users is subjective and is often dependent on specific contextual conditions. Seniors' enjoyment of parks will be determined by both the type and quality of experience (Mullick, 1993), and the environmental design should respond to their various needs (Gibson, 2018). The findings of differences in environmental effects on users' judgement provide an opportunity to identify different environmental condition combinations for segmented groups with different use motivations.

5.3. Local differences of user preference

Previous studies on this issue usually adopt small park samples (e.g., Gibson, 2018; Yung et al., 2017). This study used audit and survey data from numerous NPs with a wide range of conditional attribute characteristics, providing more generalizable results than those of small-sample case studies.

There is heterogeneity in the preferences and habits of park use among senior users from different regions (Duan et al., 2018). The interpretation of what environmental cues are important to users is subjective and it is often dependent on specific contextual conditions (Bove & Benoit, 2020), such as geographical features, cultural practices, etc. This study provides evidence based on the NPs from an age-friendly city in China and reveals findings that differ from those reported in previous empirical studies. For example, previous studies have found that park recreational facilities, access, amenities, incivilities and natural features can impact seniors' experiences of parks (Kou et al., 2021; Loukaitou-Sideris et al., 2016). The results of this study at the domain level are similar to the findings of previous studies, but this study found that incivilities were not among the conditions that affects the seniors'

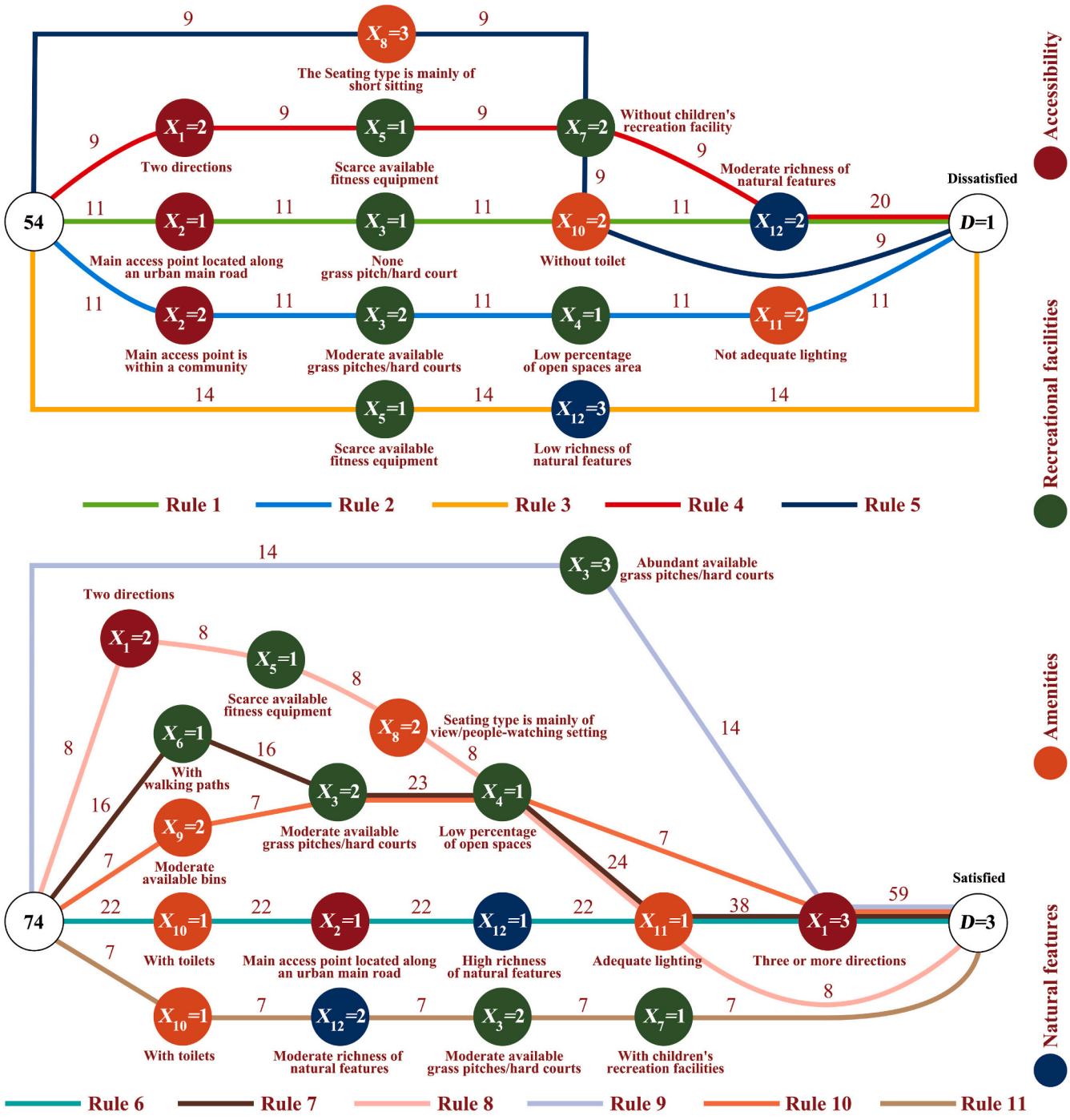


Fig. 5. Rule flow graphs.

satisfaction judgements in the study area.

Moreover, objective and perceived physical environments that yield similar impact outcomes for respondents may not align (Guo et al., 2021). Previous research mainly focuses on exploring the relationship between seniors' attitudes and perceived environmental features of parks (e.g., Chu et al., 2021; Yung et al., 2017). 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. For example, prior research has revealed that parks designed to cater to seniors can effectively encourage their engagement in park activities by increasing the multi-use hard floor space (Duan et al., 2018). However, in Rules 7, 8 and 10 of this study, the recommendations for open space (X_4) are more specific, suggesting an allocation ranging from 0.00 % to 14.37 % of the total park area. Therefore, the rules of this study are based on an objective environmental audit, and the conclusions can provide more specific recommendations for investment in the design and improvement of NPs.

6. Conclusion

This study uses data mining techniques to identify causal rules between the physical environmental conditions of NPs and seniors'

satisfaction, providing significant theoretical and managerial implications:

- **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.

The study findings must be considered within the context of their limitations. Firstly, this study employed purposive sampling, the target respondents of the survey were opinion leaders among seniors. Although these respondents possess in-depth insights into the opinions of main senior users in an NP, for greater representativeness, a more diverse senior population should be taken into consideration in future studies. Furthermore, this study takes NPs in Xiangzhou District of Zhuhai as examples to provide a novel approach to explore the seniors' satisfaction with NPs. Although case selection has given some consideration to the diversity and representativeness of environmental features, caution is required when applying the obtained rules to interpret satisfaction among the elderly population on a broader scale. Accordingly, further studies could incorporate more general NPs of various regions (such as China or Asia) and with various characteristics, in order to yield more generalizable interpretations. In addition, as this study did not collect data on users' motivations, the interpretations of how environmental elements differentially impact the attitudes of user subgroup with different motivations are speculative and based on observations from on-site surveys. In the future, users can be further divided according to population characteristics and motivations on the basis of this study, so as to further discuss the satisfaction differences of different subgroups of users.

This study focused on seniors' satisfaction with design and maintenance factors. Future research could further explore the combined relationship between planning-level factors (e.g., area, location distribution) and internal factors on influencing the overall satisfaction with the quality and planning of NPs. Additionally, future research could differentiate the roles of objective and perceived built environment on seniors' satisfaction.

CRediT authorship contribution statement

Kaiyang Wang: Writing – original draft, Visualization, Investigation, Data curation, Conceptualization. **Xin-Yang Li:** Writing – original draft, Investigation, Formal analysis, Data curation. **Bo-Wei Zhu:** Writing – review & editing, Writing – original draft, Validation, Methodology, Conceptualization. **Lei Xiong:** Writing – review & editing, Writing – original draft, Project administration, Data curation, Conceptualization. **Gwo-Hshiung Tzeng:** Project administration, Methodology, Conceptualization.

Institutional review board statement

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We did not use the generative AI and AI-assisted technologies in the writing process.

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Declaration of competing interest

None.

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Appendix A

Step R1: building an information system can be represented as S.

$$S = (Z, A = X \cup D, W, f) \tag{1}$$

- Let Z denote a finite non-empty set of objects, referred to as the universal set;
- A is a finite non-empty set of attributes, consisting of conditional attributes X and decision attributes D;
- $W = \cup_{a \in A} W_a$, where W_a is the domain of attribute a;
- f is an information description function, defined as $f : Z \times A \rightarrow W$. This function assigns values to each object for each attribute.

Step R2: Confirming indiscernibility relation.

For any subset of condition attributes $B \subset X$, the corresponding equivalence relation is defined as Eq. (2).

$$IND(B) = \{(ky) \in Z \,|\, \forall a \in B, f_a(k) = f_a(y)\} \tag{2}$$

- *IND*(B) represents the *B*-indiscernibility relation, which means that the pair of objects $(k, y) \in Z$ are indistinguishable under the subset *B*. *IND*(B) partitions the universe *Z* into equivalence classes $Z/IND(\mathrm{B}) = \{I_B | k \in Z\}$, where each equivalence class I_B contains all $y \in Z$ that are indiscernible from *k* under the attribute set *B*. This partition helps to identify the relationships between the condition attributes and the decision attributes in later steps.

Step R3: Setting of lower and upper approximations.

$$\underline{B}K = \left\{ k \in Z | I_B[k] \subseteq K \right. \tag{3}$$

$$\overline{B}K = \{ k \in Z | I_B[k] \cap K \neq \varnothing \tag{4}$$

- The set $B(B \subset K)$ is a subset of condition attributes;
- $I_B[k]$ represents the equivalence class function assigned to each element by the subset *B*;
- The lower approximation $\underline{B}K$ is the set of all objects that are definitely members of the target set *K*. In other words, an equivalence class will be included in the lower approximation set only if all objects in an equivalence class belong to the set *K* (Eq. (3)).
- The upper approximation $\overline{B}K$ contains all possible objects that belong to the target set *K*. Even if only some of the objects of an equivalence class belong to *K*, this equivalence class will be included in the upper approximation set (Eq. (4)).
- Positive region refers to the area that can be divided into the set *K*, that is, the object does not have any uncertainty and clearly belongs to *K*. It is denoted by $POS_B(K)$.

Step R4: Confirming dependency of condition attributes.

The degree of dependency of condition attributes is used to measure the dependency relationship between the condition attribute set *B* and the decision attribute set *D*, that is, how the condition attributes influence or determine the decision attributes. This concept is mainly used to determine the extent to which the condition attributes can accurately predict or classify the decision attributes. Through Eq. (5), the universe *Z* is partitioned based on the indiscernibility relation of decision attribute *D*:

$$Z/IND(D) = \{D1, D2, \ldots, Dn\} \tag{5}$$

The universe *Z* is considered as the union of several partitions D_i (from $i = 1$ to n), where the lower approximation BD_i of each partition is determined by the subset of condition attributes *B*. Additionally, the subset of condition attributes *B* forms the positive region for decision attribute *D*, as detailed in Eqs. (6)–(7):

$$POS_B(D) = \cup_i^k POS_B(D_i) \tag{6}$$

$$POS_B(D_i) = \underline{B}D_i = \{ x \in U | I_B[x] \in D_i \} \tag{7}$$

The dependency relationship between condition attribute *B* and decision attribute *D* is described by Eq. (8):

$$\gamma_B(D) = \frac{|POS_B(D)|}{|Z|} \tag{8}$$

- Here, $|POS_B(D)|$ and $|Z|$ represent the cardinalities of $POS_B(D)$ and *Z*, respectively.
- The degree of dependency $\gamma_B(D)$ measures how much decision attribute *D* relies on condition attribute *B*. This can be classified into three cases:
  1. If $\gamma_B(D)$=0, then *D* does not depend on *B*;
  2. When $\gamma_B(D)$=1, it indicates that *D* completely depends on *B*;
  3. If $\gamma_B(D)$ is between 0 and 1, it means that *D* partially depends on *B*, implying that the dependency is not absolute.

Step R5: Deriving knowledge rules

The simplification of the condition attribute set maintains the key relationship between the condition attributes and decision classes. Therefore, it is possible to extract rules from the decision table to facilitate the decision-making process. The expression of a decision rule is explained in Eq. (9):

A decision rule in *S* is expressed as $\Phi \rightarrow \Psi$ and read as *if* Φ *then*, Ψ (9)

All decision rules $\Phi \rightarrow \Psi$ have a coverage factor/coverage (CR). It is defined as the frequency/number of times it appears in that decision level $cov_s(\Phi, \psi) = sup_S(\Phi, \psi)/card(\|\psi\|_S)$. Thus, the strength of that decision rule can be simply expressed as a ratio that can be obtained by dividing the number of facts classified by the decision rule by the number of facts in the data table.

Appendix B

Appendix C

No.	Name	Address
1	Fenghuang River Neighborhood Park (Section of Weinong)	East side of the intersection of Yanhe East Road and Zijing Road
2	Fenghuang Bridge Beautiful Street Corner Neighborhood Park	East side of the intersection of Yanhe East Road and Fenghuang North Road
3	Beiti Neighborhood Park	West of the Dangqun Service Centre In Beiti Community, East Yanhe Road
4	Xiangwan P*aradise* Neighborhood Park	Intersection of Fenghuang North Road and Leyuan Road
5	Haixia Neighborhood Park	Intersection of Haixia Road and Dongfeng Road
6	Fire Fighting Culture Theme Neighborhood Park	Intersection of Education road and Fenghuang North Road
7	Nankeng Neighborhood Park	East side of Nanxia First street
8	Fire Protection Culture Neighborhood Park	Northwest side of the intersection Taoyuan Road and Xiamei Road
9	Xiangmeiyuan Neighborhood Park	Southwest side of the intersection Taoyuan Road and Xiamei Road

(*continued on next page*)

(*continued*)

No.	Name	Address
10	Haiyan Neighborhood Park	Intersection of Kangning Road and Fenghuang North Road
11	Dongfeng Neighborhood Park (South)	South side of intersection of Dongfeng Road and Kangning Road
12	Dongfeng Neighborhood Park (North)	North side of intersection of Dongfeng Road and Kangning Road
13	Red Flag Neighborhood Park	East side of intersection of Xiamei Road and Renmin East Road
14	Huwan Neighborhood Park	Inside the north side of community on Huwanli Fourth Street
15	Nanxiangli Neighborhood Park	Inside the Nanxiangli Community on Huwan Road
16	Xiangning First Street Neighborhood Park	Inside the Xiangning New Village Community on Xiangning First Street
17	Huazishi Neighborhood Park	West side of intersection of Meihua East Road and Fenghuang North Road
18	Fenghuang River Neighborhood Park (Section of Bitao)	East of the Dangqun Service Centre in Beiti Community, Yanhe East Road
19	Cuixiangyinhua Neighborhood Park	East of the Liuhe Building on Yinhua Road
20	Dajingshan Neighborhood Park	Next to the Zhuhai Water Bureau on Jingshan Road
21	Xinzhu Neighborhood Park	Next to the Post And Telecommunication New Village Community on Xingning street
22	Shuangzhu small garden Neighborhood Park	West side of No.5, Shuangzhu Street
23	Ningxihongtai Neighborhood Park	Northeast side of intersection Ningxi Road and Yingbin North Road
24	Xiangning South Neighborhood Park	South side of Xiangning Garden Community on Xiangning Second street
25	Qingzhu Neighborhood Park	Inside the Qingzhu Garden Community on Xiangxi Road
26	Ningxi Neighborhood Park	Southwest side of Jinxiuningxi Community on Jinning Road
27	MeihuaYinhua West Neighborhood Park	Southwest side of intersection of Yinhua Road and Yingbin North Road
28	Hongshan Road small garden Neighborhood Park	Southwest side of intersection of Hongshan Road and Renmin West Road
29	Meihuaxinhua Neighborhood Park	Inside the Baoyuan Garden Community on Changye Road
30	Nanhong Neighborhood Park	Southeast side of Nanhong Second Street
31	Meihuarenheng Neighborhood Park	Intersection of Cuiyu Street and Xingyuan Road
32	Meihuayuecheng Neighborhood Park	Southeast side of intersection of Honghu Street and Shanghua Road
33	Anjuyuan Neighborhood Park	Inside the Anjuyuan Community on Cuifu Road
34	Cuiqian Neighborhood Park	Inside the Xinghuayuan Community on Cuifeng Road
35	Cuidong Neighborhood Park	Southwest side of intersection of Cuiwei East Road and Yingbin South Road
36	Lijiechong Neighborhood Park	Inside the Jieyong New Village Community on Jieyongcun Tuanjie Road
37	Nanxi Neighborhood Park	Next to the Nanxi Avenue
38	Changshaxu Neighborhood Park	Entrance of ChangShaXinYuan on Gudu Boulevard
39	Dongkeng Neighborhood Park	Next to the Dongkeng Community on Lvyou Road
40	Haihong Neighborhood Park	Intersection of Cuiqian South Road and Yixian Road
41	Daishan Neighborhood Park	East side of Lewen Road
42	Yinghuiwan Neighborhood Park	Southwest side of intersection of Daishan Road and Rongtai Road
43	Nanshawan Neighborhood Park	Next to the Gree Garden Community on Jinji Road
44	Jidajingshan Cultural Neighborhood Park	The north and east sides of Jishui Road
45	Bailian Road Neighborhood Park	Next to the Southeast Gate of Zhuhai No. 4 Middle School
46	Zhuyuan Neighborhood Park	South side of Longxing Street
47	Haida Neighborhood Park	North side of CR Bank Building on Jingshan Road
48	Jida New Village Neighborhood Park	Inside the Jida New Village Community on Jinglin Street
49	Nanshan Neighborhood Park	No.1263, Jiuzhou Boulevard East
50	Lianhuashan Neighborhood Park	East side of the Lianhuashan Community on Jishi Road
51	Shuiwan Road Corner Neighborhood Park	Next to the Shuiwantou Bus stop
52	Jida Canon Neighborhood Park	Southeast side of intersection of Jiuzhou Boulevard and Yingbin South Road
53	Jiangjunshan Neighborhood Park	Southeast side of intersection Yingbin South Road and Shihua West Road
54	Baishi Neighborhood Park	Northeast side of intersection Yuehai Middle Road and Baishi Road
55	Lingnan Neighborhood Park	North side of Yu Garden Community on Yingbin South Road
56	Liangfengqiao Neighborhood Park	Intersection of Yingbin South Road and Yuhai East Road
57	Huaping Neighborhood Park	Inside the Xiawan New Village Community on Huaping Road
58	Poshi Neighborhood Park	Intersection of Changping Road and Gang Second Road
59	Gangchang Neighborhood Park	Southwest side of intersection of Gangchang Road and Zhuhai Boulevard
60	Changsheng Neighborhood Park	Southeast side of Hairongxinyuan on Xiawan Road
61	Changping Neighborhood Park	Intersection of Changsheng Road and Gangchang Road
62	Nanpinghuafa Neighborhood Park	Inside the Guangzhu Garden Community on Shoufeng Road
63	Shier Village Neighborhood Park	Intersection of Pingbei Second Road and Fenghua Road
64	Xiuyu Neighborhood Park	Intersection of Zhuhai Avenue and Xianqiao Road
65	Nanpinglianquan Neighborhood Park	Intersection of Zhuhai Boulevard East and Nanquan Road
66	Nanpingpingdong Neighborhood Park	Northwest side of Lianping Village on Baobei Road
67	Nanpingguangchang Neighborhood Park	East side of Zhuwu Street
68	Wanzaibifengtang Neighborhood Park	Next to Wanzai Seafood Street
69	Guiyuan Neighborhood Park	Inside Fuhua New Village Community on Huamei Road
70	Haizhou Neighborhood Park	North side of Haizhou Road
71	Shenqian Neighborhood Park	West side of the Zhonghaitaohuayuan Community on Shenqian Road
72	Hongyun Garden Neighborhood Park	Inside the Hongyun Garden Community on Jianmin Road
73	Xingye Neighborhood Park	The section from Wenyuan Road to Xingye Road on the south side of Yinhua Road
74	Hongye Neighborhood Park	West side of Xinghaiyuan Community on Cuiqian North Second Street
75	Kangjiting Neighborhood Park	East side of Nanxi Bus Passenger Transport Station on Nanfu Road
76	Mingzhu North Neighborhood Park	Northwest side of intersection of Renmin West Road and Mingzhu North Road
77	Cuiping Neighborhood Park	Southwest side of intersection of Renmin West Road and Mingzhu North Road
78	Cuijing Neighborhood Park	Southeast side of intersection of Renmin West Road and Mingzhu North Road
79	Shangchong Neighborhood Park	Northeast side of intersection of Renmin West Road and Mingzhu North Road
80	Jieyonghoushan Recreation Neighborhood Park	Inside the Jieyong New Village Community on Gudu Boulevard
81	Tod Town Neighborhood Park	Next to the Future Hui Tod Apartment on Yunfeng Road
82	Guangming Street Neighborhood Park	Inside the Guangming Street Community, on the southwest side of the intersection of Taoyuan Road and Xiamei Road
83	Sanjia bridge Neighborhood Park	Intersection of Renmin East Road and Zijing Road

(*continued on next page*)

(*continued*)

No.	Name	Address
84	Fenghuang River Neighborhood Park (Section of Fenghuang Bridge)	West side of intersection of Yanhe East Road and Fenghuang North Road
85	Fenghuang River Neighborhood Park (Section of Yinhua Road)	On both sides of the Fenghuang River (from Xinghua Road to Renmin East Road)
86	Xinghua Neighborhood Park (Section of Zijin bridge)	West side of intersection of Meihua East Road and Zijing Road
87	Xinghua Neighborhood Park (Section of Jianghai Electronics Company)	Next to the Jianghai Electronics Company
88	Yanhe East Road Neighborhood Park	East side of intersection of Meihua East Road and Fenghuang North Road
89	Bitao Beautiful Corner Neighborhood Park	Next to the Qifu Garden Community on Bitao Road
90	Zijing Bridgehead Neighborhood Park	East side of intersection of Meihua East Road and Zijing Road
91	Xinzhuer Neighborhood Park	Inside the Xinzhu Garden Community on Ningxi Street
92	Beiyuan Neighborhood Park	Inside the Beiyuan New Village Community on Beihuan Street
93	Changhuan Neighborhood Park	Inside the Changhuan New Village Community on Beihuan Street
94	Funing Neighborhood Park	East side of Jinning Road
95	Xiangxizhuang Neighborhood Park	Inside the Xiangxizhuang Community on Xiangxi Road
96	Zhongxin Street Neighborhood Park	Inside the community of South side of Zhongxin Street
97	Xinguangli Socialist Values Theme Neighborhood Park	South of Zhuhai People's Government on Renmin East Road
98	Jinan Garden Neighborhood Park	Inside the Jinan Garden Community on Jingye Road
99	Fenghuang Primary School Neighborhood Park	West side of intersection of Meijie Road and Jianmin Road
100	Xiangshan Posthouse Neighborhood Park	Next to the Zhuhai Transportation Bureau on Meihua West Road
101	Guyuan Art Gallery Neighborhood Park	East side of the Guyuan Art Gallery on Meihua East Road
102	Nanlian Neighborhood Park (Nanshan Theme Park)	Inside the Nanlian Village Community on South side of intersection of Nanwan South Road and Changsheng Road
103	Guangsheng Neighborhood Park	North side of Shuangshi Street
104	Beishan Neighborhood Park	Southeast side of intersection of Zhuhai Boulevard and Nanwan North Road
105	Wanzai Neighborhood Park	The northernmost east side of Zhongsheng Road
106	Macao Regression Memorial Park	Intersection of Zhuhai Boulevard and Maofeng Road
107	Fenghua Neighborhood Park	Inside the Huafa New Town Community on Fenghua Road
108	Shuixian Neighborhood Park	Intersection of Zhuhai Boulevard and Shoufeng Road
109	Xiangzhou Tennis Neighborhood Park	East side of intersection of Gangchang Road and Zhuhai Boulevard
110	Zhongguang Neighborhood Park	North side of intersection of Gangchang Road and Zhuhai Boulevard
111	Qianshanqiaoxia Neighborhood Park	Under the Qianshan Flyover of Yuehai Middle Road
112	Maanshan Neighborhood Park	Southeast side of intersection of Anlian Road and Cuiqian South Road
113	Zhongshan Pavilion Memorial Neighborhood Park	No.256, Yixian Road
114	Yuanlinnan Neighborhood Park	Inside the Yuanlin Garden Community on Yuanlin Road
115	Bailian Neighborhood Park	Inside the Bailian New Village Community on Bailian Road
116	Lianhua Neighborhood Park	Inside the Lotus Mountain Community
117	Zhouzai Neighborhood Park	South side of intersection of Qinglv South Road and Zhouzai Road
118	Zhuyuandong Neighborhood Park	Inside the Zhuyuan New Village Community on Jiuzhou Boulevard Middle
119	Small street corner park on the south side of Jingshan Neighborhood Park	East side of Jishui Road
120	Lanpu Neighborhood Park	Inside the Lanpu Garden Community on Jiuzhou Boulevard West
121	Huaning Neighborhood Park	Inside the Huaning Garden Community on Gangchang Road
122	Guihuanan Neighborhood Park	Southwest side of intersection of Xiawan Road and Guihua North Road
123	Firefighting Theme Neighborhood Park	Southwest side of intersection of Zhuhai Boulevard and Nanwan North Road
124	Gongbei Community Cultural and Sport Neighborhood Park	No.2, Guihua North Road
125	Qianshan Street Baishi Neighborhood Park	Northwest side of intersection of Yuehai Middle Road and Baishi Road
126	Xinghua Neighborhood Park	Inside the Xinghua Garden Community on Yuehai Middle Road
127	Huaning Garden Neighborhood Park	Inside the Huaning Garden on Gangchang Road
128	Borderless Street Corner Neighborhood Park	Intersection of Zhuping Road and Qiaoguang Road
129	Cuixiang Street Garbage Sorting Education Neighborhood Park	Intersection of Yinhua Road and Xingye Road
130	Dongqiao Neighborhood Park	No.2, Dongqiao Avenue
131	Celebrity Sculpture Neighborhood Park	Southwest side of intersection of Beishan Road and Xiuyu Road
132	Yuehua Neighborhood Park	Inside the Binhai Garden Community of Lianhua Road
133	Qianshanbinhe Neighborhood Park	East side of Qianhe South Road
134	Qianshanyanhe Neighborhood Park	South side of Qianhe North Road
135	Hongjing Garden - Small Square Neighborhood Park	Inside the Hongjing Garden Community on Nanwan South Road
136	Hongjing Garden - Lotus Pond Neighborhood Park	Inside the Hongjing Garden Community on Nanwan South Road
137	Hongjing Garden - Taijihefeng Neighborhood Park	Inside the Hongjing Garden Community on Nanwan South Road
138	Hongjing Garden - Children's Park Neighborhood Park	Inside the Hongjing Garden Community on Nanwan South Road
139	Jingdu Garden Neighborhood Park	Inside the Jingdu Garden Community on Yanhe East Road
140	Haihong New Village Neighborhood Park	Inside the Haihong New Village Community on Meihua East Road
141	Shoreline Neighborhood Park	North side of Pingbei Second Street
142	Suzhaozheng Comrade Neighborhood Park	Intersection of Haicheng Road and Haixia Road

Data availability

Not applicable.

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