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Vitality Decline in Residential Landscapes: A Natural Experiment Insight from Hefei, China

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Abstract: This study selected green spaces from three residential areas in Hefei as the research subjects, combining behavioral observation methods and a natural experiment to collect behavioral data from 2010 and 2024. The data were then compared using Poisson regression models. Additionally, home visits were conducted to gather residents' perceptions of the factors contributing to the decline in vitality. Based on the survey data, multilevel regression analysis was performed to explore the decline in RQGS usage vitality and its influencing factors in the context of rapid urbanization. This study found a significant decline in green space visits, particularly during the afternoon (16:00–18:00) and in areas adjacent to roadways. The main influencing factors include emerging leisure choices (such as taking the subway to large parks or preferring indoor activities) and residents' satisfaction with RQGS characteristics (such as functional zoning, noise pollution, and neighborhood familiarity). Notably, there was no significant correlation between "disposable leisure time" and visit frequency. These findings suggest that, despite the inherent advantages of proximity, the vitality of RQGS faces increasing challenges due to emerging diverse leisure demands and growing environmental disturbances. In contrast to the traditional emphasis on accessibility, this study recommends that future RQGS planning prioritize functional zoning (e.g., dog-walking areas, sports zones), address the needs of vulnerable groups, and focus on mitigating vehicle noise and air pollution rather than merely expanding parking facilities. Interventions should be scheduled for the afternoon and emphasize strengthening community interaction and cohesion to enhance user experience. This research provides valuable scientific evidence and practical guidance for urban planners and policymakers to optimize residential green spaces in the context of rapid urbanization, offering new perspectives for the empirical evaluation of RQGS upgrades.

Keywords: residential quarter green spaces (RQGS); physical activity; residential landscape space; natural experiment

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1. Introduction

With the continuous growth of the global population and rapid urbanization, urban per capita green space is on the decline [1,2], reducing daily human contact with the natural environment and exacerbating urban dwellers' disconnection from nature [3]. Extensive research highlights the importance of green spaces for residents' health, psychological restoration, social interaction, and overall well-being [4–7].

However, in densely built old cities, the challenge of finding and creating new urban green spaces is significant, prompting a shift toward exploring small-scale green alternatives [8,9]. This paper investigates the current use of residential quarter green space (RQGS) and offers recommendations for future enhancements. By transforming RQGS into green stepping stones within the urban fabric, this study aims to provide a valuable reference for urban planners and policymakers seeking to optimize these essential green spaces.

1.1. Residential Quarter Green Space (RQGS)

Residential quarter green spaces (RQGS), as semi-public green areas within gated communities [10–13], are strategically located adjacent to residential buildings. Their unique advantage lies in seamless integration into daily routines, offering mini-park amenities like lawns, trees, and fitness facilities [14].

Past discussions on residential green spaces have often been encompassed within broader studies of urban green spaces, focusing on three critical areas: ① spatial equity: low-income communities often face limited RQGS access, exacerbating health disparities [15] and residential segregation [16]; ② ecological functions: the mitigation of urban heat islands [17] and biodiversity enhancement [18], particularly through cultural ecosystem services like social integration [19]; and ③ public health: high-quality RQGS are associated with enhanced life satisfaction [20], reduced cardiovascular risks [21], stress relief [22], increased opportunities for physical activity [23], lower obesity rates [24], and reduced violent crime rates [25].

These studies have affirmed the importance of RQGS in various aspects. However, not all RQGS yield the expected positive outcomes. Identifying the key characteristics that encourage greater use of RQGS by residents is essential for effective management and planning. Zhang discovered that factors such as area, cleanliness, and maintenance of RQGS significantly influence the physical activity of young residents [26]. Features like open spaces for multiple activities, including pavilions or shaded trails, greatly increase the likelihood of residents using RQGS at least once a week [14]. Further studies on urban green space users have identified additional influential dimensions that all significantly impact the use of urban green spaces: environmental factors, such as facility adequacy [27] and road connectivity [28]; socio-demographic factors like age [29] and gender [30]; and personal factors including attitude toward nature [31] or fear of crime [32]. However, due to variations in scale, amenities, distance, and usage scenarios, these findings cannot be directly applied to RQGS.

Moreover, the swift advancement of urbanization has intensified lifestyle changes [33], continuously reshaping the demand for RQGS usage [34]. Improved transportation infrastructure provides residents with broader outdoor recreational options [35], while faster work and study paces reduce outdoor time [36,37]. Environmental issues such as noise and air pollution decrease the appeal of outdoor activities [38]. The widespread use of digital media and diverse leisure choices alter recreational preferences [39,40], and the increase in vehicles within residential areas impacts the space utilization and safety of RQGS [14]. These factors influence not only the frequency of RQGS use but also their social value and function. However, due to limited resources, most studies seldom incorporate the influencing factors of social dynamic changes in the investigation of RQGS usage.

The existing literature on community green space has developed a multidimensional exploration framework, but the influence mechanism of dynamic social factors remains underexplored. Early research focused primarily on structural factors related to spatial configuration. For instance, Liu Jiaming et al. revealed the rigid constraints of urban planning concepts, land supply patterns, and ecological security frameworks on suburban recreational land distribution [41]. Wu Bihu's team constructed a force model of residential

recreational choices through a case study in Hangzhou, confirming the significant impact of time constraints on location preferences [42]. As research became more refined, scholars began to focus on users' perceptual dimensions. Luo Wenbin et al. developed a satisfaction evaluation system, showing that quality indicators such as transportation accessibility and safety play a crucial role in the recreational land usage experience [43]. More recently, Zhang Lingfei et al. systematically reviewed the spatiotemporal evolution characteristics that constrain green space recreation, noting that emerging lifestyles, such as late-night leisure activities and increased commuting distances, have led to a structural mismatch between supply and demand [44]. However, existing studies predominantly focus on single time periods or static factors and have yet to form a comprehensive empirical research framework for the complex impacts of social dynamics in the context of rapid urbanization—such as the reshaping of entertainment preferences by digital media and the spatial security impacts of increased vehicle numbers. This theoretical gap has made it difficult for planning practices to accurately respond to the changing needs of residents.

1.2. Objectives and Methodology

To further enrich the research in this field, this study conducts a natural experiment comparing the number of visitors to RQGS over a span of fourteen years, providing empirical evidence on whether the attractiveness of RQGS has been impacted by changes in the social context. Additionally, this study employs a questionnaire survey of residents in the residential areas to evaluate the influence of social context variables on RQGS usage, capturing residents' assessments of these variables based on their life experiences. This understanding is essential for urban planners and policymakers to adjust and revitalize these spaces in accordance with contemporary urban demands. By integrating empirical data with residents' insights, this study aims to offer a comprehensive analysis that will inform the effective management and planning of RQGS, ensuring they continue to meet the evolving needs of urban residents.

This study attempts to answer the following questions: (1) Has the visitation to RQGS decreased in recent years? (2) What are the main behaviors and purposes of current RQGS usage? How have they changed compared to over ten years ago? (3) What factors contribute to changes in the behaviors and purposes of RQGS usage? (4) What is the respective importance of the socio-demographic factors, personal variables, leisure alternatives, and satisfaction with RQGS features that impact the frequency of RQGS usage?

This study aims to investigate the changes in the vitality of residential quarter green spaces (RQGS) and their influencing factors in three residential areas in Hefei, within the context of rapid urbanization, particularly focusing on the changes in RQGS attractiveness due to dynamic social environment shifts. The main objective is to identify the key factors influencing residents' frequency of RQGS use under social dynamics, including sociodemographic characteristics, personal factors, leisure choices, and RQGS satisfaction, and to assess their impact on RQGS usage frequency. The study hypothesizes that "the vitality of RQGS has significantly declined" and validates this hypothesis through a natural experimental comparison over a period of more than ten years. The study then combines quantitative and qualitative data to provide effective and sustainable management and planning recommendations that can adapt to the evolving needs of contemporary urban residents.

2. Materials and Methods

2.1. Study Area

This study focuses on three residential quarter green spaces located in Hefei, Anhui Province, China. Hefei was chosen for two reasons. ① Over the past 13 years, the gender

and age structures of Hefei's population have remained relatively stable. According to the National Bureau of Statistics, Hefei's permanent population grew from 4.91 million in 2010 to 9.47 million in 2023, reflecting a 20.1% increase. Among these, the population aged 0–14 accounts for 16.52% (an increase of 1.89 percentage points), those aged 15–59 make up 68.22% (a decrease of 3.44 percentage points), the population aged 60 and above constitutes 15.26% (an increase of 1.56 percentage points), and the subgroup aged 65 and above represents 11.99% (a rise of 2.8 percentage points). The age structure of Hefei's population in 2023 and the percentage change from 2010 are illustrated in Figure 1 (Data sourced from the National Bureau of Statistics of China).

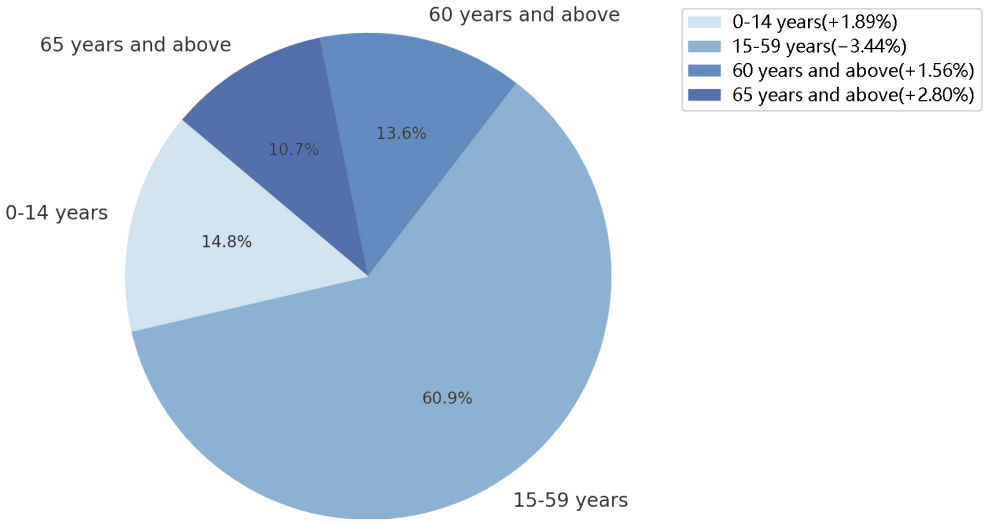


Figure 1. Age structure of Hefei's population in 2024 and percentage change from 2010.

② Unlike mega cities such as Beijing and Shenzhen, Hefei has a smaller urban area and population. As a result, there are several cities that share similar characteristics with Hefei. This research could therefore serve as a valuable reference for those cities, offering insights that are applicable to their urban development and planning strategies.

The inherent characteristics of natural experiments make the research susceptible to various uncontrollable factors, such as the timing of site renovations or changes in project funding budgets [45]. Researchers conducting natural experiments cannot actively plan or direct the implementation of the experiment; instead, they must identify opportunities in long-term follow-up studies and assess changes in spatial use within the evolving social environment [46]. For the purposes of this research, the team selected three RQGS that had been thoroughly investigated 14 years ago (see Table 1). ① The New Xiyuan quarter, the earliest developed (1980s), was a benchmark residential area at the time and received the prestigious UN-Habitat Liguria International Special Honor Award. The area, which covers 11,711.33 m^2, is surrounded by a mix of medical, residential, and commercial zones. ② The Peaceful Living quarter, built in the 1990s, covers 5324.31 m^2 and was recognized as one of the Top 10 Residential Communities in Anhui Province in 2001. This residential area is strategically located near office buildings and commercial complexes, standing out in its design and construction for its era. ③ The Century Sunshine Garden quarter, the largest and most recently developed (2000s), occupies 45,716.3 m^2. This residential area is situated close to a university district, offering abundant commercial and infrastructure amenities, and has been awarded China's Real Estate Award: The Magnolia Award. The original research conducted 14 years ago was supported by the Humanities and Social Sciences Research Fund (09YJCZH030) and the National Social Science Fund (10CSH040), with detailed results available in the corresponding literature [47,48].

Table 1. Basic overview of the three RQGS.

Residential Quarter	Construction Era	Total Area (m^2)	Surrounding Land Use Type	Awards
New Xiyuan quarter	1980s	11,711.33	Residential land, medical and health facilities, commercial land	UN-Habitat Liguria International Special Honor Award
Peaceful Living quarter	1990s	5324.31	Residential land, office land, commercial land	Top 10 Residential Communities in Anhui Province in 2002
Century sunshine garden quarter	2000s	45,716.3	Residential land, university land, commercial land	China's Real Estate Award: The Magnolia Award

The selection criteria for these three residential areas are based on the following points:

① Construction Period: All three residential areas were built between 1980 and 2000, following the implementation of Hefei's commercialization reform policies. Unlike previous forms such as unit courtyards, affordable housing, and collective dormitories, these commercial residential complexes were designed and constructed to meet the high standards of that time. They emphasized factors like location, internal living environment, and structural quality, which now give them considerable potential for renovation.

② Location and Condition: These residential areas are situated in Hefei's high-density central city, offering good accessibility and preserved spatial characteristics. They are equipped with complete facilities and have not undergone significant upgrades or renovations between the two observation periods. Moreover, they are well-maintained, making them representative of typical RQGS in Hefei (see Figure 2).

③ Infrastructure Developments: Between 2010 and 2024, new infrastructure, such as subway stations, shared bike docks, and shopping centers, was added around these residential complexes. These improvements have allowed residents to benefit from urban growth, offering more travel options and potentially shifting their demand for RQGS usage.

④ RQGS Features: Each RQGS includes activity spaces with common features such as plazas, fitness facilities, and landscaped leisure areas. These spaces were constructed with well-planned layouts and top-tier design standards for Hefei at the time, making them prime examples of well-designed residential green spaces in the city (see Table 2).

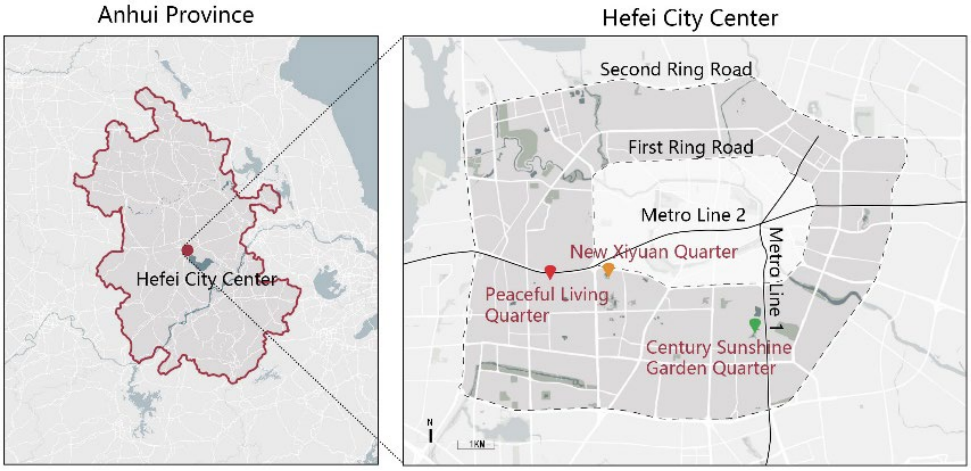


Figure 2. Study area and its location (Sources: Gov.cn [49]).

Table 2. Maps and zones of the three residential quarter green spaces.

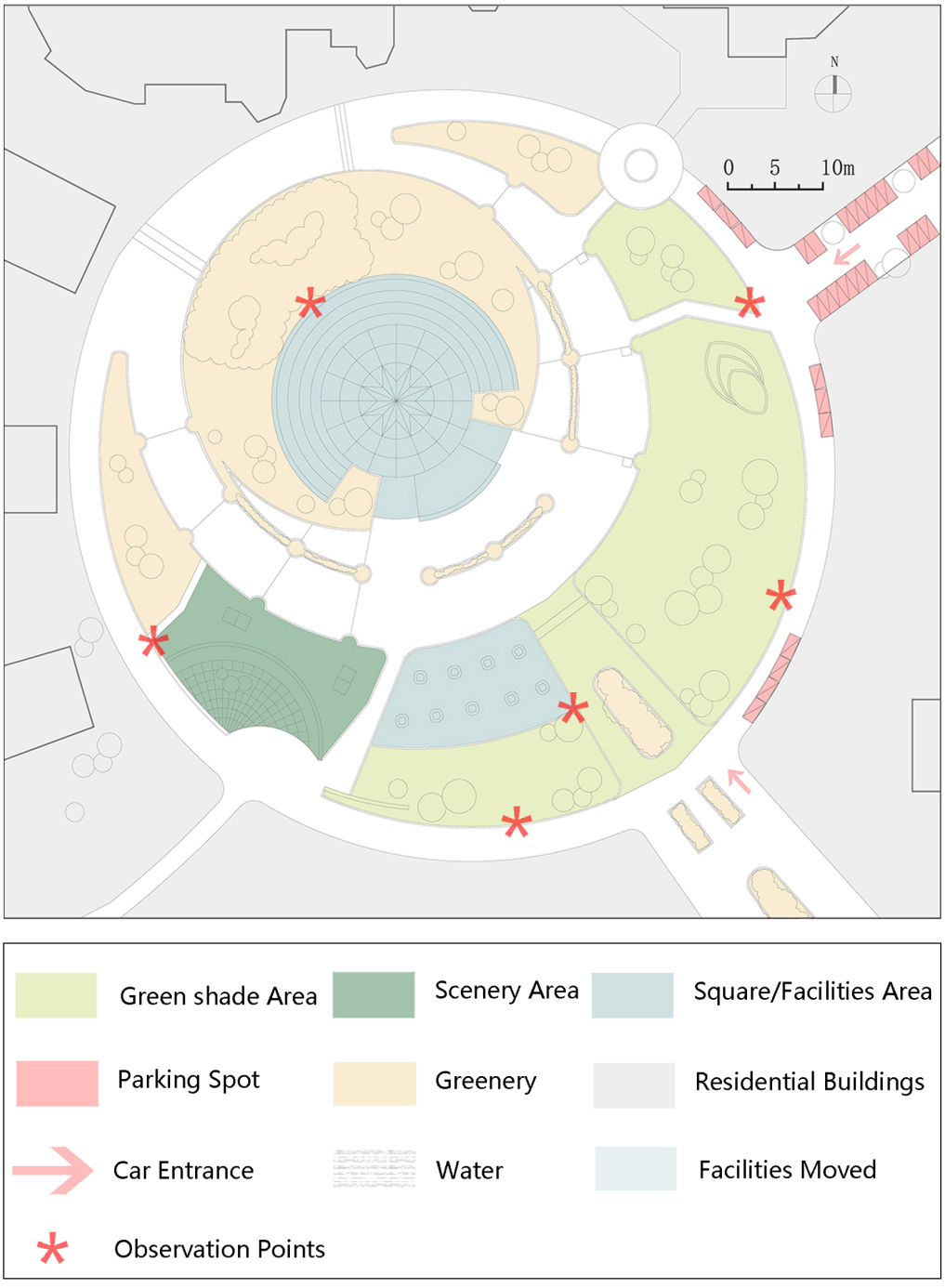
Name	Residential Quarter
Peaceful Living Quarter	

Table 2. *Cont.*

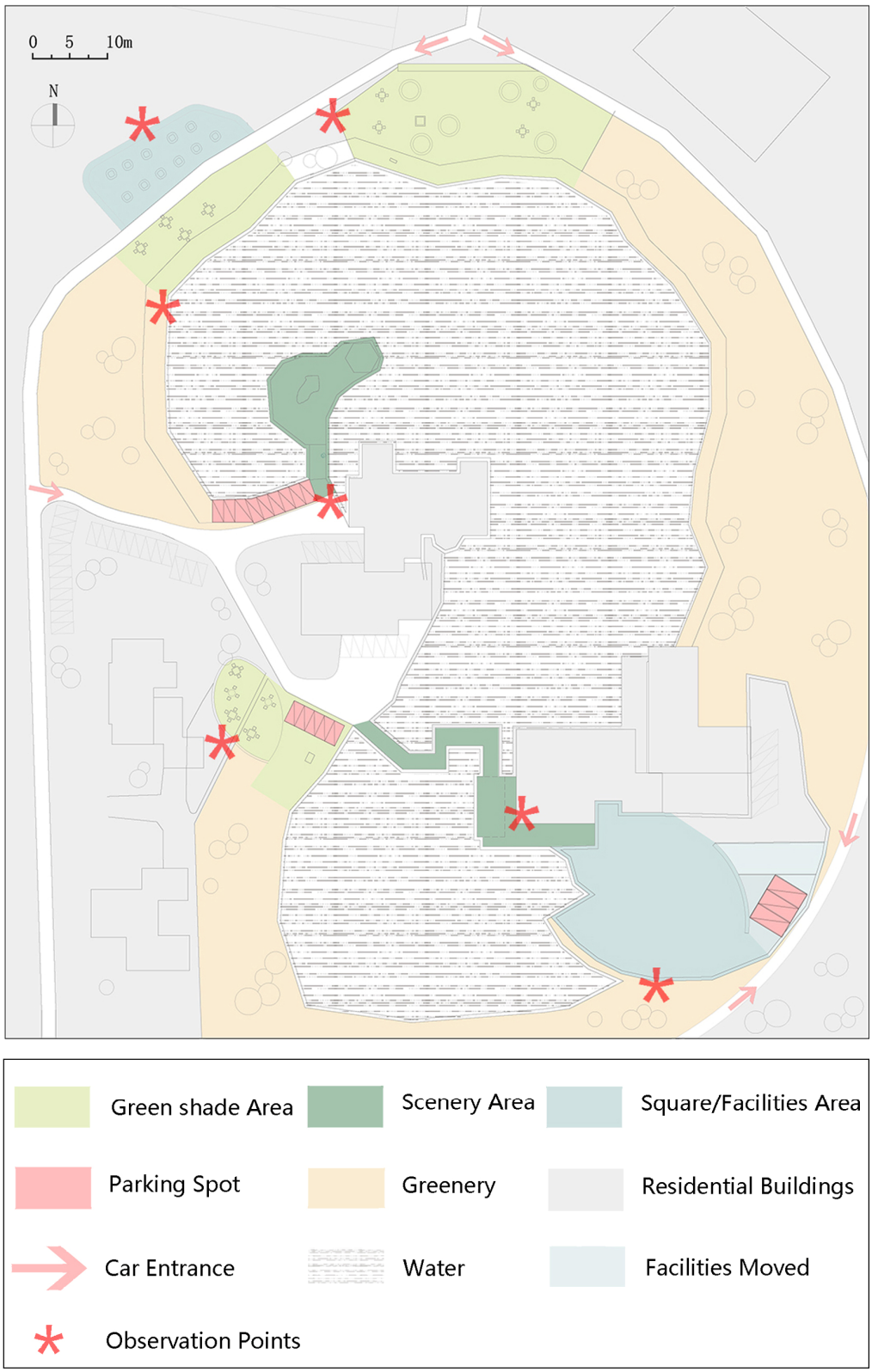
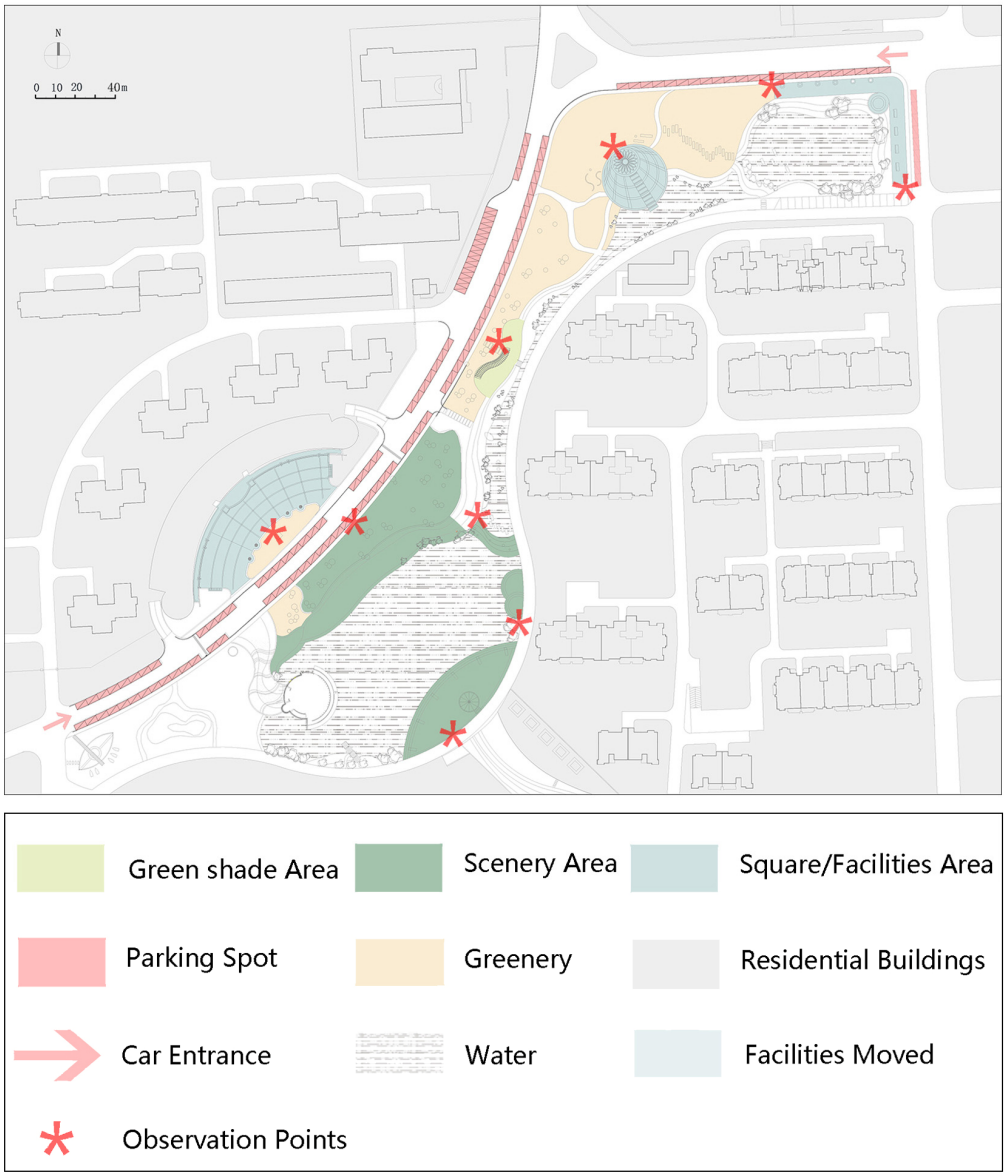
Name	Residential Quarter
New Xiyuan Quarter	

Table 2. *Cont.*

Name	Residential Quarter
Century Sunshine Garden Residential Quarter	

2.2. Behavior Mapping

We applied the same behavior mapping method used 14 years ago to compare the usage of the three RQGS over this period. Behavior mapping involves directly observing users in each RQGS to collect data on their characteristics and activities. This method has been proven to be a reliable and objective tool, and it has been widely applied in similar studies [50]. Before conducting observations, the landscape spaces in the three residential areas were divided into 4 to 7 zones, based on factors such as location, paved boundaries, and the range of human activities. According to the landscape characteristics of each zone, we classified the landscape types into three categories, as shown in Table 3: ① square/facilities area: general plazas or open spaces equipped with outdoor fitness facilities for recreational activities; ② scenery area: areas for appreciating natural landscapes, such as water features or garden views; and ③ green shade area: zones shaded by trees, providing shaded spaces for relaxation. Greenery refers to green spaces that are inaccessible or unsuitable for human activities, primarily consisting of ornamental vegetation. Notably,

the fitness facility area in the New Xiyuan Quarter was relocated from the southeast to the northwest, near the main vehicle entrance (indicated in light blue in the figure showing the location of the fitness area in 2010).

Table 3. Photos of the behavior settings.

	Scenery Area	Square/Facilities Area	Green Shade Area
2010			
2024			

A standing point was selected within each zone, ensuring that the observer could clearly see all areas of the site while being able to sequentially record the usage of the space without significantly disturbing its users. The observer marked their position on a paper map as a point and recorded the gender, age group, and activities of the users, taking notes every half hour. Baseline assessment data (T1) were collected in 2010, with some data derived from the observation records of the study "Investigation of the relationship between place characteristics and child behavior in residential landscape spaces: a case study on the Century Sunshine Garden Residential Quarter in Hefei". Detailed information about the study design has been published in other literature [48]. The fourteen-year follow-up assessment was conducted in 2024 (T2), with similar weather conditions on the observation days (see Table 4).

Table 4. Outline of investigation at T1 and T2.

	Season	Time	2010 (T1)			2024 (T2)		
			Date	Weather	Temperature	Date	Weather	Temperature
Peaceful Living Quarter	Autumn	7:00 to 19:00	7 October (Sunday)	Cloudy-clear	15–25 °C	1 October (Sunday)	Cloudy-clear	18–23 °C
New Xiyuan Quarter			26 September (Sunday)	Cloudy-clear	18–23 °C	22 September (Sunday)	Cloudy-clear	14–22 °C
Century Sunshine Garden Quarter			7 October (Sunday)	Cloudy-clear	15–25 °C	1 October (Sunday)	Cloudy-clear	18–23 °C

Trained researchers recorded the following characteristics of the visitors: age (senior $\geq$ 60 years, adult = 21–59 years, adolescent = 13–20 years, children with action capacity, children with little action capacity), gender, activity type (walking, exercising, sightseeing, etc.) and activity level (sedentary, moderate or vigorous), and occurred time (morning at 7:00 am–11:00 am, noon at 11:00 am–14:00 pm, afternoon at 14:00 pm–17:00 pm, and evening at 17:00 pm–19:00 pm). Each target area was observed by 12 researchers who assessed its accessibility (not closed for repair), facility usability (payment required or affected by damage), and specific organizational activities. All target areas and facilities were accessible and usable on observation days. Lighting equipment was not needed dur-

ing daylight hours, and the prevalence of observing organized activities in the residential landscape spaces was low. Therefore, these variables were not included in the analysis.

2.3. Questionnaire

After obtaining the comparative analysis results from the two observation experiments, we conducted household interviews within the residential area and designed a formal survey questionnaire based on the feedback from these interviews. The respondents were aged 17 and above and had used the RQGS both before and after the 14-year period, as the study aimed to assess the impact of specific factors on RQGS usage. The questionnaire was structured into four parts: ① socio-demographic data: this section gathered basic information about the RQGS users; ② motivation, barriers, and frequency of use: this part explored what motivates or hinders residents' use of RQGS and how frequently they use these spaces; ③ personal information and leisure choices: this section investigated users' personal details and other recreational preferences; and ④ user satisfaction with RQGS attributes: the final part assessed how satisfied residents were with various features of the RQGS.

Before officially distributing the questionnaire, a pilot test was conducted with 30 RQGS visitors, who were not included in the final sample. The pilot aimed to check the clarity, reading level, language, and format of the questionnaire. No issues were reported by the pilot participants. The formal survey took place in October 2024. Interviewers explained the purpose and significance of the survey to the respondents and shared the results of the previous two observation experiments. A total of 1050 questionnaires were distributed, resulting in 1024 valid responses. Based on the number of households in each residential area, 507 questionnaires were collected from New Xiyuan Quarter, which consists of 3564 households; 336 from Peaceful Living Quarter, with 2361 households; and 182 from Century Sunshine Garden Quarter, which has 1277 households. All surveys were administered by trained data collection personnel to ensure accuracy and consistency.

2.3.1. Factors Impacting RQGS Visitation

To gain a more comprehensive understanding of how changes over time have influenced RQGS usage, we designed a series of open-ended questions after explaining the purpose of the study and the results of the observational experiment to the respondents (Table 5). These questions explored respondents' visitation motivations, usage frequency, and barriers. Examples included: "How often do you visit RQGS?", "Has your visitation frequency changed compared to more than ten years ago?", "What are your main reasons for visiting RQGS?", "What are the main constraints preventing you from visiting RQGS?", and "What type of area do you prefer to visit now? What were your preferences in the past?". The answers to these qualitative questions provided valuable guidance for the selection of model variables and helped identify key factors influencing RQGS usage.

Table 5. RQGS usage patterns and evolution: qualitative interview findings.

Question	Probe
• How often do you visit your RQGS?	• Do you wanted to visit RQGS more frequently or less?
• Has your frequency increased or decreased compared to over a decade ago?	• Why?
• What are the reasons for your visit?(now/past)	• Why?
• What are the main reasons that prevent you from visiting RQGS?	• Now?/Past?
• Which type of area do you prefer to visit? (now/past)	• Why?/Why not?

The process for selecting model variables followed these steps: First, a comprehensive evaluation was conducted to identify the factors influencing visitors' use of RQGS, which formed the initial variable pool. Next, we interviewed 30 users to explore the main variables affecting their use of RQGS. Finally, we consulted with five experts in architecture and management to validate the selection of variables.

Based on this, the dependent variable 'How often do you visit this park?' was coded as follows: 1 represents 1–3 times per month; 2 represents 1–3 times per week; 3 represents 4–6 times per week; 4 represents 1–2 times per day; and 5 represents more than 2 times per day. Independent variables include visitors' socio-demographic characteristics: age, gender, income, and self-assessed health status; leisure alternatives factors: willingness to use newly available transportation facilities for leisure, willingness to use nearby modern leisure facilities, frequency of trips, and screen time for entertainment.

Visitors' personal attributes include whether they feel increased stress compared to the past and the amount of leisure time they have. Spatial functions, facility configurations, noise and air pollution, neighborhood familiarity, and maintenance were used to assess user satisfaction with RQGS features. Satisfaction with these features was evaluated using the following question: "Please rate your satisfaction with the following RQGS features". The questionnaire used a five-point scale, where 5 represents the highest satisfaction and 1 represents the lowest.

2.3.2. Statistical Analysis

Data from Behavioral Observations:

To explore the number of RQGS users across different years, zone types, time periods during the day, and with or without vehicle interference, this study specifically analyzes gender and age differences, examining the interaction between each independent variable and the year. Data analysis was conducted using SPSS 22.0, employing a multilevel structural model (Level 1 = Zone, Level 2 = RQGS) to examine the measurements from different years (Level 1 = Time of Day, Level 2 = Year). Comparisons were made by pairing years and analyzing the relationship between independent variables (such as time of day, vehicle interference, and spatial type) and the dependent variable (number of users) [51]. Count variables were analyzed using Poisson regression with a log-link function, and the significance level was set at $\alpha = 0.05$.

Data from the Questionnaire Survey:

This study used hierarchical regression analysis to explore the relationships between variables and assess the relative importance of specific categorical factors, including socio-demographic characteristics, leisure choices, personal traits, and RQGS ratings [52]. Hierarchical regression analysis compares multiple regression models based on the variance differences explained by each model. In traditional multiple regression analysis, the semi-partial correlation of any predictor variable excludes overlapping effects, so the semi-partial correlation of a predictor variable is influenced by other predictor variables [53]. However, in hierarchical regression analysis, overlapping effects are considered before entering the model, allowing for the distinction of each variable's unique contribution and its relative importance in backward prediction. This study divided the independent variables into four categories: socio-demographic variables, leisure alternatives, personal variables, and RQGS attributes. These categories were entered into the model in the order mentioned above [54].

3. Results

3.1. Behavioral Observation: Comparing the Number of Users at Two Time Points

Among the three RQGS, 5945 users were observed at baseline, but after 14 years, only 3346 users were observed. The largest decline in the number of users was observed in New Xiyuan Quarter, followed by the Century Sunshine Garden Quarter and the Peaceful Living Quarter (as shown in Figure 3).

According to the results of the Poisson regression model analysis (see Table 6), the trend of decreasing numbers of users showed significant differences when comparing the total sample, as well as the male, female, adolescent, adult, and child-carrying sub-samples. The elderly group was the only one that did not show significant changes. Specifically, at different times of the day, the number of visitors in the morning and noon did not show significant differences compared to 14 years ago. However, in the afternoon, the number of RQGS users significantly decreased, especially among males and adults, with a notable decline in their visits during the evening.

Table 6. Poisson models.

Independent Variables	Children/Adolescent Observed Users		Child-Carrying Observed Users		Adult Observed Users		Senior Observed Users	
	t	*p*	t	*p*	t	*p*	t	*p*
Year type (ref = 2010)								
2022	−2.185	0.031 *	−2.399	0.018 *	−2.956	0.004 **	−1.905	0.059
Time of day (2022–2010)								
Morning	−1.394	0.166	−0.889	0.376	−0.545	0.586	−1.501	0.136
Lunch	−1.522	0.131	−0.391	0.696	−1.154	0.251	−0.318	0.751
Afternoon	−1.994	0.048 *	−2.067	0.041 *	−2.009	0.047 *	−1.969	0.051
Evening	−1.155	0.251	−1.086	0.279	−2.003	0.047 *	−1.466	0.145
Vehicle disturbing (2022–2010)								
Yes	−2.049	0.043 *	−2.500	0.014 *	−2.802	0.006 **	−1.971	0.051
No	−1.339	0.183	−1.355	0.178	−1.265	0.208	−0.879	0.381
Type of landscape setting (2022–2010)								
Green shade	−1.216	0.227	−1.140	0.256	−2.525	0.013 *	−1.997	0.048 *
Square/Facilities	−2.411	0.017 *	−1.710	0.090	−1.151	0.252	−0.837	0.404
Scenery	−1.069	0.287	−0.947	0.346	−1.180	0.240	−0.355	0.723
Independent Variableswoxiang	**Total Number of Observed Users**		**Female Observed Users**		**Male Observed Users**			
	t	*p*	t	*p*	t	*p*		
Year type (ref = 2010)								
2022	−2.608	0.010 *	−3.114	0.002 **	−2.336	0.021 *		
Time of day (2022–2010)								
Morning	−1.463	0.146	−1.353	0.179	−1.125	0.263		
Lunch	−1.409	0.162	−1.481	0.141	−0.977	0.330		
Afternoon	−2.681	0.008 **	−2.744	0.007 **	−2.374	0.019 *		
Evening	−1.864	0.065	−1.092	0.277	−2.169	0.032 *		
Vehicle disturbing (2022–2010)								
Yes	−2.555	0.012 **	−2.853	0.005 **	−2.299	0.023 *		
No	−1.064	0.289	−1.285	0.201	−1.574	0.118		
Type of zone (2022–2010)								
Green shade	−2.456	0.015 *	−2.434	0.016 *	−2.203	0.029 *		
Square/Facilities	−1.805	0.074	−2.813	0.006 **	−1.488	0.139		
Scenery	−1.072	0.286	−1.570	0.119	−1.418	0.159		

* $\alpha < 0.05$, ** $\alpha < 0.01$. Child-carrying observed users refer to individuals accompanying children with limited mobility who require supervision at the RQGS.

In terms of spatial location, the number of users observed in areas near vehicular roads significantly decreased in the total sample. In contrast, areas farther from the vehicular roads showed no significant changes in the number of visitors compared to 14 years ago. This phenomenon was observed in the male, female, adolescent, adult, and child-carrying groups, but no such trend was observed in the elderly group. Furthermore, there was a significant decline in visits to shaded areas, particularly among the male, female, elderly, and adult groups, although no significant changes were observed in the adolescent and

child-carrying groups. It is worth noting that in the plaza and fitness facility areas, only the female and child groups showed a significant decrease in visits compared to 2010.

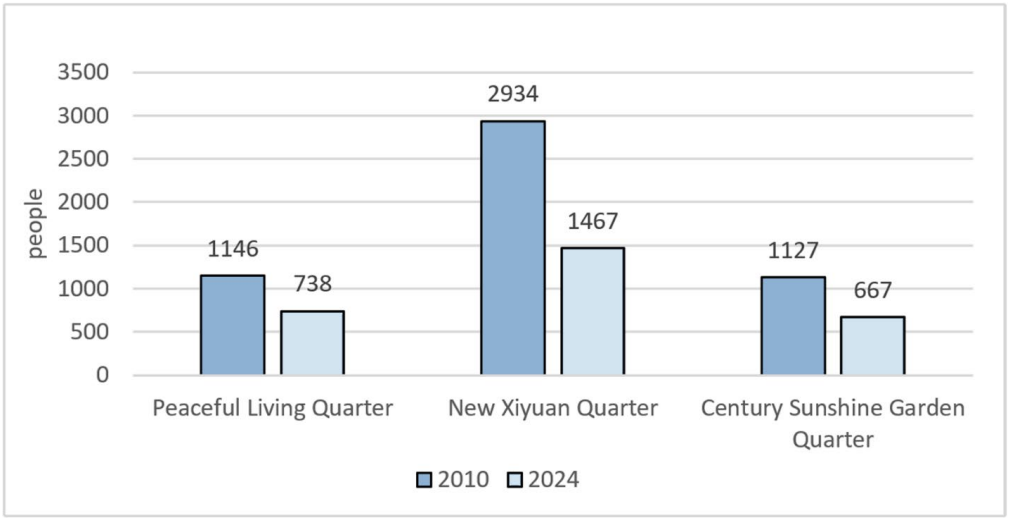


Figure 3. Comparison of the number of visits to RQGS in 2010 and 2024.

Additionally, we created a crowd distribution map to more clearly compare the distribution of visitors within the RQGS. As shown in Table 7, compared to 2010, the visitor density in areas near roadways has decreased.

3.2. Interview Insights: Perception of the Decline in RQGS Usage

Table 8 summarizes the potential factors mentioned by interviewees that contribute to the decreased frequency of RQGS use, focusing on personal factors, leisure alternatives, and satisfaction with RQGS features. The interview results provide a reference for the design of questions in the formal survey. Fifty percent of respondents identified increased life stress as a key factor leading to the reduced frequency of RQGS use. With the acceleration of modern life pace and increasing work burdens, many people find they lack the time and energy to engage with traditional RQGS activities. Additionally, 32% of respondents noted that the rise of electronic social media has gradually replaced the social functions of traditional public spaces, leading to a decrease in their frequency of RQGS use in real-life environments.

In terms of leisure alternatives, 26% of respondents indicated a preference for taking the subway to nearby large parks instead of engaging in activities at community green spaces. This trend reflects the increasing demand for larger and more diverse recreational experiences, with improved urban public transportation offering residents more options, thereby weakening the competitiveness of RQGS. At the same time, 22% of respondents preferred indoor board games and card activities, while 21% favored going to the gym rather than using the community's outdoor fitness facilities. Additionally, 13% and 11% of respondents mentioned that short-distance road trips and digital entertainment activities have become their main forms of leisure. These diverse leisure choices have undoubtedly diverted groups that might otherwise engage with RQGS, further diminishing its vitality.

Table 7. Behavior maps showing visitor distribution in RQGS (2010 vs. 2024).

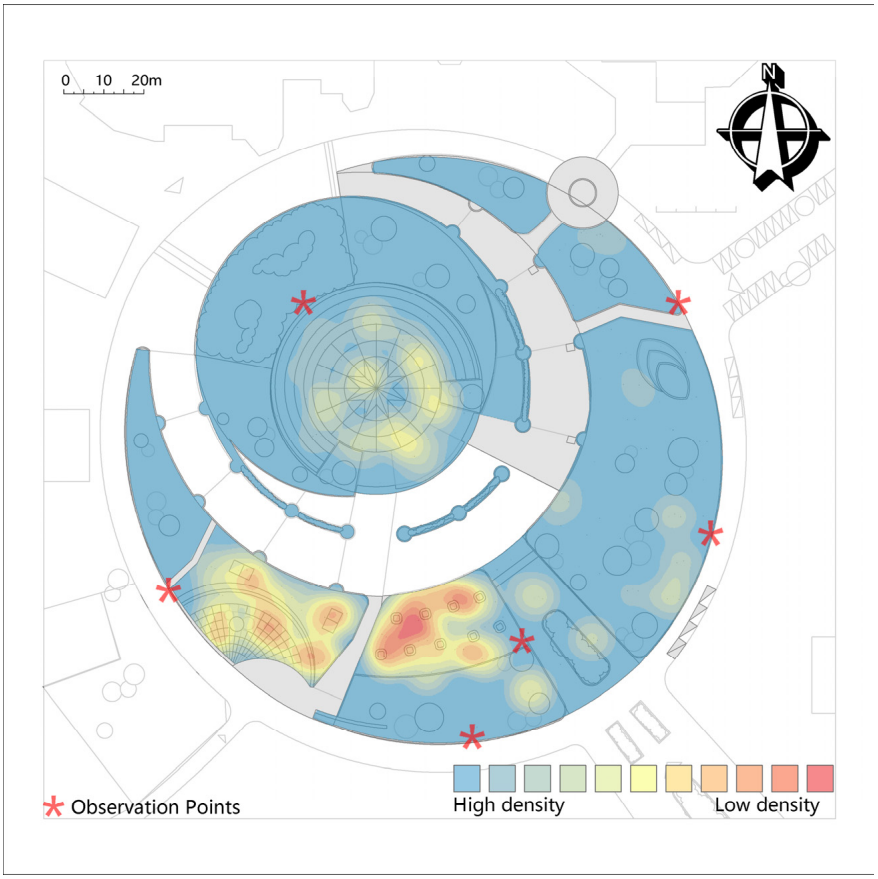
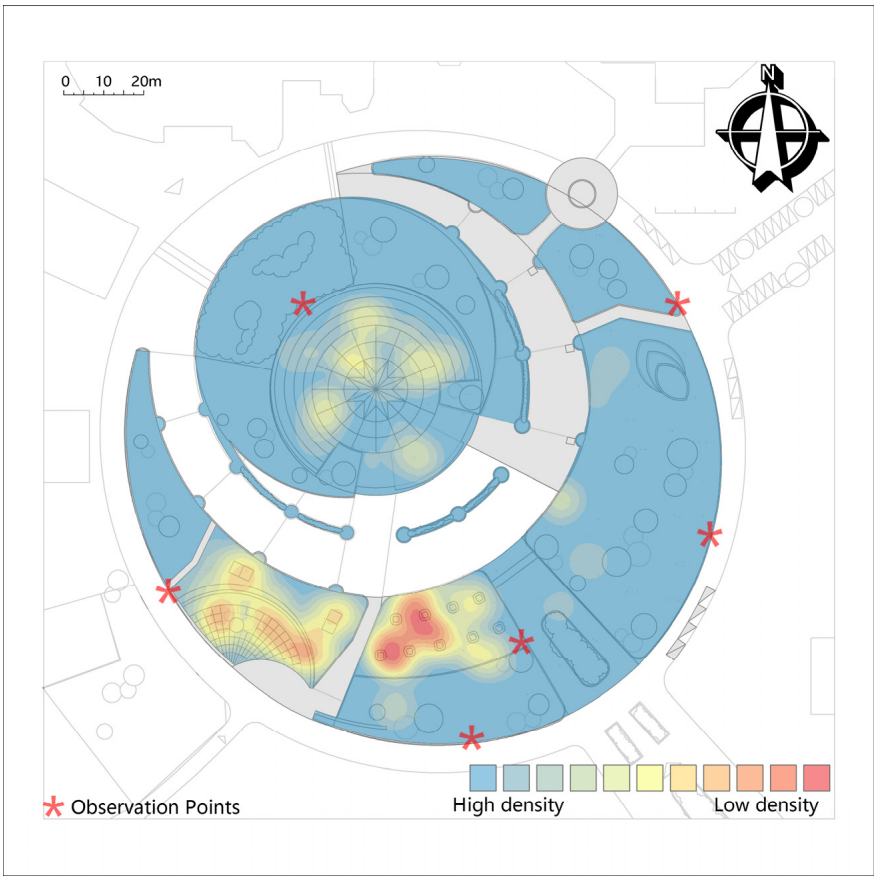
Peaceful Living Quarter	2010
	
	2024
	

Table 7. *Cont.*

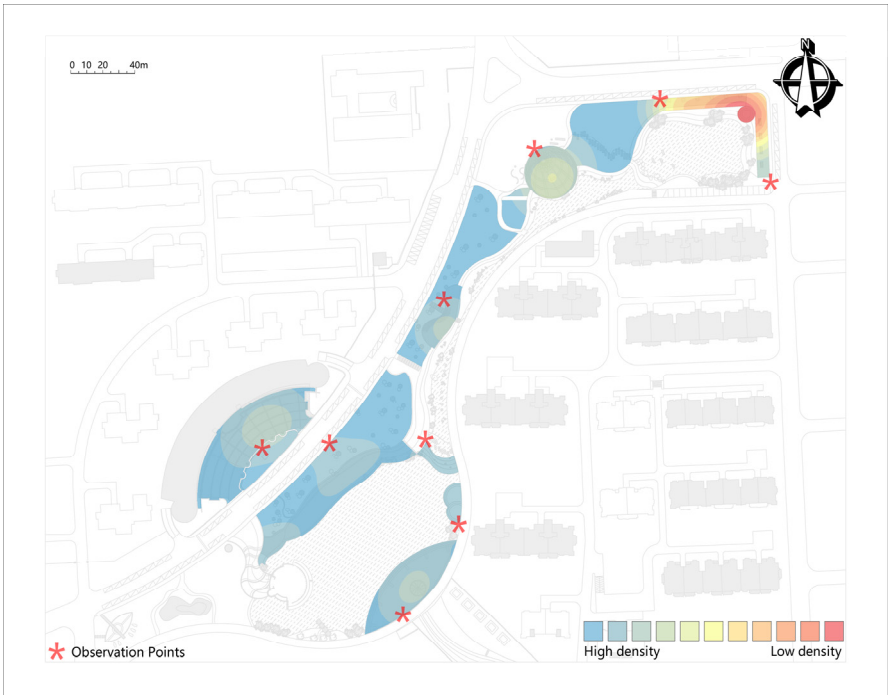
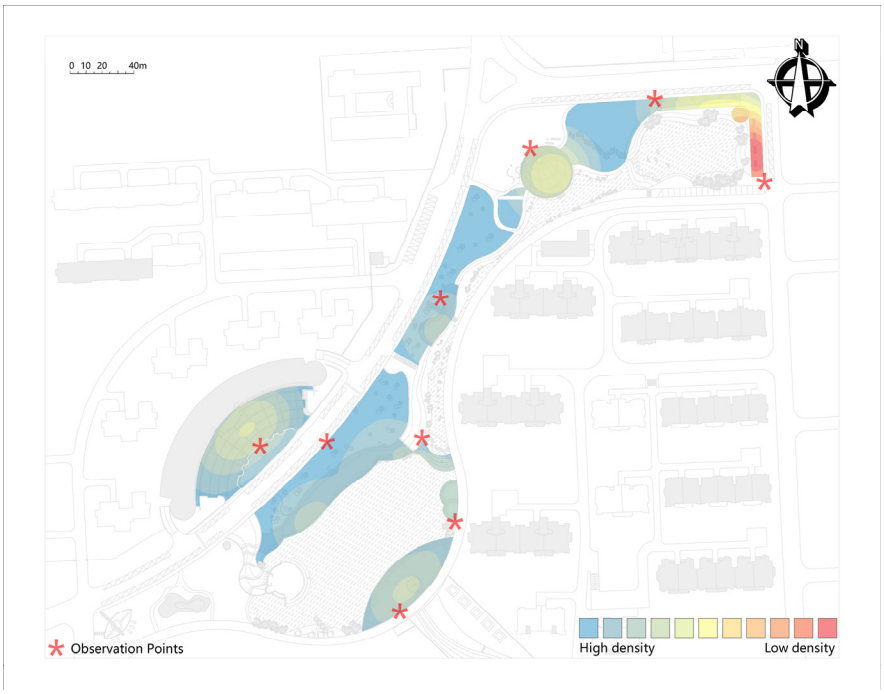
Century Sunshine Garden Quarter	2010	
	2024	

Table 7. *Cont.*

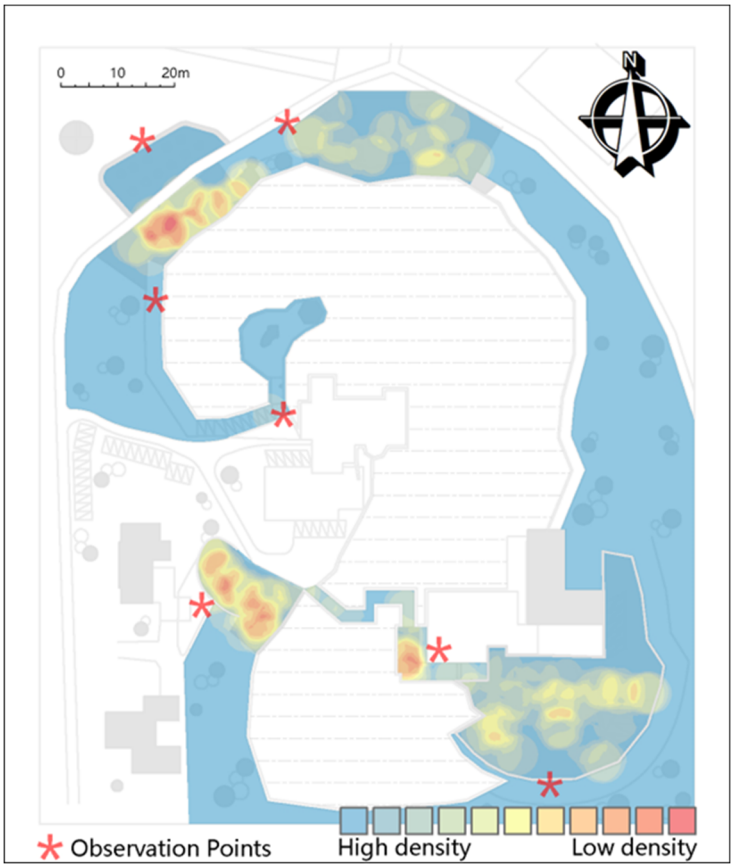
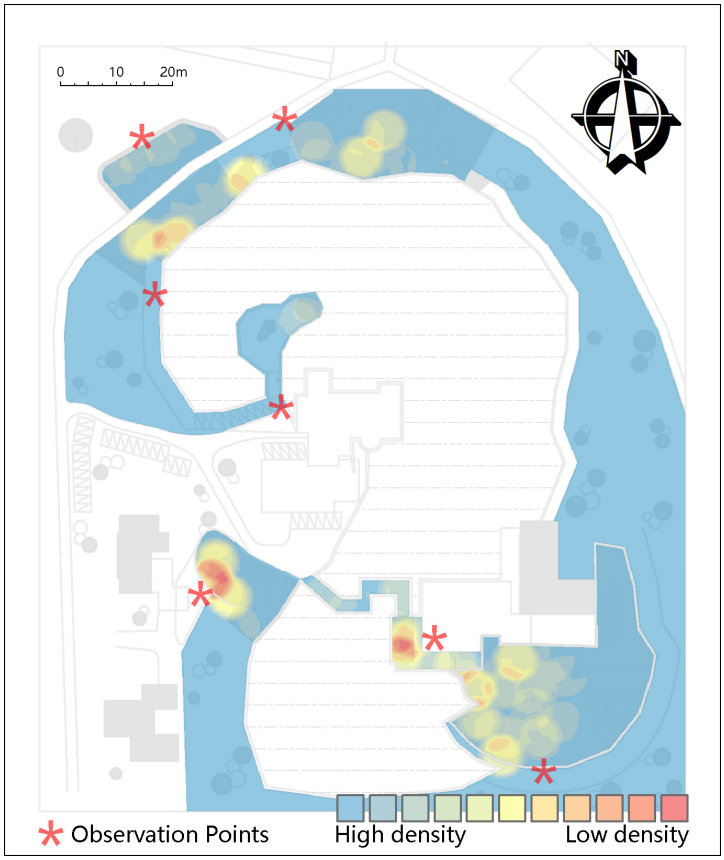
New Xiyuan Quarter	2010	
	2024	

Table 8. Factors contributing to the decline in RQGS usage frequency.

Key Construct	Reasons Why People Do Not Use RQGS (Compared to Over a Decade Ago.)	Proportion
Personal variables	Increased life pressure has robbed me of leisure time.	50%
	Electronic social media has replaced the social functions of RQGS.	32%
Leisure alternative variables	I prefer to take the subway to the nearby park.	26%
	I prefer visiting the nearby indoor chess and card room over the green-shaded area tables.	22%
	I favor the gym nearby rather than the playground and outdoor fitness facilities.	21%
	I prefer taking short road trips in my private car.	13%
	I tend to prefer digital entertainment.	11%
Satisfaction with RQGS features	The increase in vehicles now has led to serious noise and air pollution.	26%
	Neighborhood changes make me unwilling to socialize with strangers.	24%
	I feel apprehensive about participating in activities alongside children.	22%
	The surrounding area is frequently occupied by parked vehicles.	16%
	The surface of the playground is unsuitable for engaging in sports activities.	15%
	Other reasons	2%

In terms of satisfaction with RQGS features, the most frequently mentioned factors by respondents were related to the increase in vehicles within the residential area. Among them, 26% of respondents pointed out that noise and air pollution caused by vehicles seriously affected their willingness to use the space; 16% mentioned that the frequent occupation of surrounding areas by parking spaces hindered their activity space. Additionally, 24% of respondents stated that, due to changes in the neighborhood over the past decade, a sense of unfamiliarity had developed, leading to resistance to socializing within the RQGS. This may be related to the maintenance of long-term community cohesion. Furthermore, 22% of respondents noted that many spaces in the RQGS need to be shared with children, making the use of these spaces inconvenient, which further impacted the frequency of RQGS usage. Lastly, 15% of respondents mentioned that the cement flooring in RQGS could not meet the diverse sports needs of today, thus reducing their frequency of visiting RQGS.

3.3. Interview Insights: Motivations for Using RQGS

Table 9 presents the three most common reasons for using RQGS: chatting and resting (32%), walking dogs (26%), and attending art performances (24%). Additionally, other reasons for visiting RQGS include physical exercise (18%), playing chess or cards (14%), and playing games (11%).

Table 9. Motivations for using RQGS.

Motivations	Proportion
Chatting and rest	32%
Walking the dog	26%
Artistic performance	24%
Physical exercise	18%
Play chess or cards	14%
Playing games	11%
Others	2%

3.4. Survey Questionnaire: Characteristics of the Sample and Description of Factors

As shown in Table 10, among the 1024 respondents, the gender distribution was approximately equal. The age distribution of respondents was diverse, with 16.2% aged 20–30, 16.6% aged 30–40, and 17.5% aged over 60. The gender distribution was 50% male and 50% female. Regarding income levels, 22.9% of respondents had a monthly income between 3000 and 6000 RMB, 22.9% earned between 6000 and 9000 RMB, and 20.1% earned over 9000 RMB. Meanwhile, 38.3% had a monthly income of less than 3000 RMB, which is lower than the average annual income of Hefei residents in 2023 (107,630 RMB, source: 2023 Hefei Statistical Yearbook).

Regarding park visitation frequency, 1.8% of respondents visited parks 1–3 times per month, 29.7% visited 1–3 times per week, 55.9% visited 4–6 times per week, 12.6% visited 1–2 times per day, and only 0.1% visited parks more than twice per day.

Table 10. Characteristics of the sample and description of variables.

Variables (N = 1024)		Percent/Mean (s.e.)	Variables (N = 1024)	Percent/Mean (s.e.)
Socio-demographic Variables			Travel Frequency	
	Self-rated Health	3.28	1–2 times a year	24.1%
Age	<20	15.5%	3–4 times a year	25.1%
	20–30	16.2%	1–2 times a month	27.1%
	31–40	14.3%	3–4 times a month	23.6%
	41–50	18.4%	Digital entertainment (H/week)	
	51–60	18.2%	<8 h	19.2%
	>60	17.5%	8–15 h	20.7%
Gender	Male	50.0%	16–22 h	19.8%
	Female	50.0%	23–29 h	20.2%
Income (RMB/month)	<3000	35.8%	>29 h	20.0%
	3000–6000	21.1%	**Ratings of RQGS**	
	6000–9000	22.9%	Maintenance	4.36
	>9000	20.1%	Facility configuration	3.06
Personal Variables			Neighbor strangeness	2.97
	Has life pressure increased	48.0%	Noise&Air pollution	2.97
Weekly average leisure time (H/week)	Less than 10 h	20.0%	Parking occupancy	2.94
	10–20 h	18.2%	Functional zoning	2.96
	20–30 h	21.6%	**Dependent variable:**	
	30–60 h	20.3%	Park visit frequency	
	>60 h	19.9%	1–3 times a month	1.8%
Leisure Alternative Variables			1–3 times a week	29.7%
	Visitor who is willing to visit nearby entertainment facilities	49.0%	4–6 times a week	55.9%
	Visitor who is willing to visit nearby urban green spaces	50.0%	1–2 times a day	12.6%
			>2 times a day	0.1%

In terms of personal factors, 48% of respondents indicated that life stress has increased compared to the past. The distribution of weekly leisure time was broad, with 20.0% spending less than 10 h on leisure, 18.2% spending 10–20 h, 21.6% spending 20–30 h, 20.3% spending 30–60 h, and 19.9% spending over 60 h per week on leisure.

For leisure alternatives, 49% of respondents expressed a preference for visiting nearby entertainment venues, while 50% preferred to visit nearby urban green spaces. In terms of travel frequency, 24.1% of respondents traveled 1–2 times per year, 25.1% traveled 3–4 times per year, 27.1% traveled 1–2 times per month, and 23.6% traveled 3–4 times per month. Regarding participation in digital entertainment, 19.2% of respondents spent less than 8 h per week, 20.7% spent 8–15 h, 19.8% spent 16–22 h, and 20.2% spent more than 23 h per week.

Among the six features of RQGS, this study evaluated features that might be affected over time and through social development, including maintenance, automobile pollution, facility configuration, neighborhood familiarity, parking occupancy, and spatial zoning. Maintenance received the highest score (4.36). Among the remaining five features, satisfaction with facility configuration was the highest (3.06), while satisfaction with parking occupancy was the lowest (2.94). Neighbor strangeness and noise/air pollution both received a score of 2.97, and spatial zoning scored 2.96.

3.5. Hierarchical Regression Model

Based on the results of the formal questionnaire, the study used multi-level regression models to analyze the impact of socio-demographic factors, leisure alternatives, personal factors, and satisfaction with RQGS on the frequency of RQGS use (Tables 11 and 12). Table 11 shows the results of the hierarchical regression model, analyzing the influence of four categories of factors on RQGS use frequency, with statistical significance at $p \leq 0.001$. Table 12 reports the significance levels of each specific factor.

Table 11. Model summary and analysis of variance (ANOVA) of the hierarchical regression models.

Statistics	Model 1 (Socio-Demographic Variables)	Model 2 (Leisure Alternative Variables)	Model 3 (Personal Variables)	Model 4 (RQGS Features Variables)
F	8.47	51.36	46.49	78.30
Significance	0.000	0.000	0.000	0.000
Adj R^2	0.028	0.283	0.308	0.547
△Adj R^2		0.255	0.025	0.239
Predictors	Age, Health	Being willing to visit entertainment facilities; Being willing to visit nearby UGS Travel frequency	Life pressure increased	Pollution; Neighbors; Zoning

Table 12. Associations and relative importance of factors on RQGS visitation in full model of hierarchical regression analysis.

Variables	St.Beta	Sig.	Variables	St.Beta	Sig.
Intercept		0.000 ***	Personal variables		
Socio-demographic variables			Has life pressure increased	0.165	0.000 ***
Age	0.139	0.000 ***	Weekly average leisure time	−0.010	0.631
Gender	0.032	0.126	RQGS features variables		
Health	−0.102	0.000 ***	Maintenance	−0.043	0.044
Income	−0.029	0.204	Automobile Pollution	0.300	0.000 ***
Leisure alternative variables			Facility professionalism	−0.030	0.157
Being willing to visit nearby entertainment facilities	−0.163	0.000 ***	Neighborhood familiarity	0.296	0.000 ***
Being willing to visit nearby UGS	−0.123	0.000 ***	Parking occupancy	0.001	0.970
Travel frequency	−0.456	0.000 ***	Spatial zoning	0.282	0.000 ***
Digital entertainment (H/week)	0.001	0.959			

*** $\alpha < 0.001$.

The first model includes four socio-demographic variables: age, gender, income, and health status, which together explain 2.8% of the variance in RQGS use. This model is statistically significant ($p < 0.001$), with age and health factors having a significant impact on the frequency of RQGS use. The second model includes variables for the willingness to use nearby parks, entertainment facilities, short-trip frequency, and digital entertainment leisure time as leisure alternatives. The results show that leisure alternatives contribute 25.5% to the overall model. This model is highly significant ($p < 0.001$), with the use of entertainment facilities, increased travel frequency, and the willingness to use nearby urban green spaces all being significantly related to RQGS use ($p \leq 0.001$). In the third model, personal factors (including increased life stress and reduced leisure time) explain 2.5% of the variance, with life stress showing a significant negative correlation with RQGS use ($p \leq 0.001$). The final model examines satisfaction with the physical and environmental features of RQGS, explaining 23.8% of the variance in RQGS use. The results indicate that functional zoning, automobile pollution, and neighborhood familiarity are significantly correlated with RQGS use ($p \leq 0.001$), while parking occupancy, maintenance, and facility professionalism did not show significant correlations.

3.6. Summary

This study conducted a natural experimental comparison to analyze the changes in the number of users at three typical RQGS sites in Hefei. By combining qualitative and quantitative research methods, the study identified the specific factors influencing residents' frequency of RQGS use. The comparison of observational data validated our hypothesis that, over time, the frequency of RQGS use has significantly declined, particularly among male and adult groups. The most significant decrease in visits occurred in the afternoon, and areas near traffic roads also showed a marked reduction in visitor numbers.

The analysis of the hierarchical regression model further clarified the contributions of four categories of influencing factors on the overall model results: sociodemographic factors (key factors: age and health), leisure alternatives (key factors: frequency of short trips, willingness to visit urban parks, and willingness to visit entertainment facilities), personal factors (key factor: increased life pressure), and satisfaction with RQGS features (key factors: functional zoning, automobile pollution, and neighborhood familiarity). These factors collectively contributed to the changes in RQGS usage frequency, revealing the multidimensional impact of various factors.

4. Discussion

4.1. Behavioral Observation: Observed Decline in RQGS Usage

This study, through a natural experiment, confirmed a significant decline in RQGS users over the 14-year period, with the most notable reductions occurring in the afternoon (14:00–17:00) and evening (17:00–19:00). Interestingly, these time periods align with previous findings on urban park visitation in China, where users typically visit parks in the afternoon (15:00–17:00) and evening (18:00–20:00) [55]. Further quantitative analysis revealed a significant negative correlation between the frequency of using newly developed transportation infrastructure and RQGS visitation.

Existing research suggests that the expansion of transportation infrastructure [56,57] and the construction of nearby transportation stations [58] during the two observation periods greatly increased residents' access to urban parks. Moreover, data from the Hefei Forestry Bureau indicate that between 2010 and 2022, the per capita urban park green space in Hefei increased from 12.25 square meters to 13 square meters, alongside the development or renovation of 375 urban parks [59]. Compared to 2010, residents now have significantly greater opportunities to visit urban parks. If validated by future research, these findings suggest that intervention measures to promote RQGS usage could focus on afternoons and evenings during weekends, which currently see the lowest usage but coincide with peak times for large urban parks.

The experimental results indicate that in areas affected by vehicle disturbances (such as those near roads or parking areas), residents' access to RQGS significantly decreases. However, no statistically significant difference was observed among the elderly group. According to the literature, this could be attributed to the interaction of two factors: firstly, the elderly are more dependent on community green spaces than other age groups [60,61]. This dependency may lead them to adapt by adjusting their schedules (e.g., avoiding peak traffic hours) or changing activity types (e.g., opting for static activities) to overcome spatial disruptions [44], consistent with the findings of this study. At the same time, research shows that the elderly are more concerned with traffic safety when using open spaces [62], which differs from the present results. The discrepancy may stem from the fact that the RQGS is located within a residential area where vehicle speeds are lower [63,64]. The elderly exhibit better adaptability to low-speed traffic environments—previous studies have shown that they often cope with traffic barriers by extending walking times or taking

breaks, which may mitigate the direct impact of vehicle disturbances through this "resilient use pattern" [65].

Additionally, due to the relatively low vehicle speeds, the vehicle-related pressures in RQGS primarily stem from noise disturbances [66] and spatial encroachment [67]. Qualitative investigations in this study confirm the frequent mention of these two issues, but the quantitative analysis reveals that the negative correlation between parking space encroachment and visitation rates is not statistically significant (Table 12). This contradiction can be explained by the "activity type-space demand" matching mechanism: Currently, the use of RQGS is primarily dominated by static activities (e.g., resting, playing chess) and small-scale dynamic activities (e.g., Tai Chi, walking), which require less continuous space and are less impacted by intermittent parking encroachment. In contrast, activities that require large-scale continuous space (e.g., ball sports) are less frequent due to the lack of suitable facilities for such activities in existing RQGS, leading to parking issues not being fully reflected in the statistical model. However, both static activities and light exercises like walking require a quiet environment free of car exhaust. Therefore, activity levels significantly decrease in areas adjacent to roadways, where vehicle interference is present. This finding suggests that future planning should adopt differentiated intervention strategies: for dynamic activity spaces, the priority should be to resolve parking space encroachment, while for spaces dominated by static activities, the focus should be on optimizing noise buffer facilities, air purification systems, and the layout of resting nodes.

In landscape areas, no significant differences in visitation were observed across groups. However, in areas designed for physical activities, such as outdoor fitness facilities or plazas, the number of visits by adolescents and females significantly declined. While existing studies widely suggest that installing fitness facilities [68] and reserving open spaces [69] in green spaces effectively promote their usage, this study uncovers unexpected behavioral shifts in these two groups. This decline may stem from adolescents' diverse interests and broader needs for dynamic sports activities, which are not fully accommodated by the static and unchanging fitness facilities in RQGS [70,71]. Similarly, females often take on caregiving roles, such as supervising children, which influences their visitation patterns and aligns them closely with those of adolescents [72,73]. As a result, previous conclusions regarding strategies to enhance the attractiveness of green spaces may not be entirely applicable to RQGS.

A significant decline in chess and card activities among both elderly and adult participants was observed in the green shade area. This may be related to the indoor chess rooms opened nearby, as mentioned in the respondents' reports. This phenomenon raises concern as the green shade area has traditionally served as a multifunctional center for intergenerational interaction. Its decline could weaken social connections as indoor facilities typically segregate users by age or interests [74]. Moreover, while indoor venues offer better environments, they reduce opportunities for physical activity (e.g., walking to or within the green shade area) and exposure to sunlight [75]. Therefore, future designs could consider promoting semi-open venues that retain natural connectivity or integrate projects (such as outdoor chess competitions promoted in indoor venues) to increase overall participation.

4.2. Interview Insights: Motivations for Visiting SUGS

Our findings indicate that residents frequently choose to chat and rest in RQGS (32%), a result consistent with studies on other urban green spaces (UGS) [54]. As the closest natural environment to urban residents, RQGS provides a tranquil and comfortable space that helps individuals relax and alleviate stress and anxiety from daily life. Unsurprisingly, this contributes to enhancing residents' overall life satisfaction [14].

According to research by Veitch et al. [76], approximately one-quarter of frequent active visitors to UGS are dog walkers. In this study, 26% of respondents identified dog walking as their primary motivation for using RQGS (see Table 9). Due to its proximity to residential buildings, RQGS offers a unique advantage, making it an ideal location for dog walking. In the New Xiyuan Quarter survey, nearly one-third of respondents stated that dog walking was their main reason for visiting. Previous research highlights that dog walking increases physical activity and promotes overall physical health [77,78]. To attract more dog walkers, green space management policies could include allowances for off-leash activities or the addition of pet-friendly facilities, such as enclosed off-leash zones [79].

Additionally, 24% of respondents reported using RQGS as a place to practice musical instruments, sing, or dance, establishing its role as a key space for fostering cultural life within communities. Despite their relatively small size, RQGS spaces have a stable visitor base that enhances community bonding and fosters a sense of belonging [80]. Cohen emphasized that activities in open natural areas and periodic interactions in public spaces are strongly associated with higher levels of social capital [81]. Over the past decade, rising social capital levels in China have spurred greater attention to artistic performances and cultural exchange activities, particularly among older adults [82]. Dancing and singing, often part of senior education programs, are commonly observed in RQGS. For instance, in the Century Sunshine Garden Quarter and Peaceful Living Quarter, many residents engage in self-organized activities such as dancing and singing. To further enhance the appeal and activity experience of RQGS, community managers could introduce diverse community events, competitions, and activity clubs. These initiatives would enrich the cultural experiences within RQGS, attract more users, and foster stronger community connections. Ultimately, such efforts would enhance the vitality and multifunctionality of RQGS, making them integral to urban life.

4.3. The Association and Relative Importance of Independent Variables

Leisure alternatives and satisfaction with RQGS features were identified as the two main factors influencing RQGS usage rates, accounting for 25.5% and 23.8% of the variance, respectively. This finding contrasts with previous research on urban green space (UGS) usage. For example, studies on UGS in Beijing found individual variables to be the most significant factors, increasing R^2 by 26% [52]. Similarly, Pengwei Wang (2021) and colleagues concluded that sociodemographic variables played a dominant role in explaining visitation rates for small UGS, contributing 23% to the R^2 increase [54]. In this study, however, satisfaction with park features accounted for only 3% of the variance. This discrepancy may be attributed to the unique characteristics of RQGS, which distinguish it from typical UGS. As an integral part of residents' living environments, RQGS serves not only as a leisure option but also as a functional part of daily life. This proximity and convenience, while advantageous, may lead to aesthetic fatigue, as frequent exposure to the space diminishes its novelty and attractiveness over time. Compared to UGS, the findings indicate that external leisure alternatives and internal feature satisfaction play a larger role in determining RQGS usage. This underscores the importance of addressing challenges from the broader social environment and ensuring RQGS remains appealing over time through innovative design and management strategies. Future research and practice should focus on integrating flexible and diverse design elements and providing varied activity options to sustain the long-term value and appeal of RQGS for residents.

Among sociodemographic factors, this study identified a negative correlation between health status and RQGS visitation rates, while age showed a positive correlation. This suggests that, unlike general urban green spaces [83], individuals with poorer health are more likely to use RQGS. This may be due to the unique advantages of RQGS, which offer

accessible and restorative leisure environments close to residential areas. These findings emphasize the need for RQGS planning and management to focus on the specific needs of individuals with poorer health. For example, accessible facilities, such as paths designed for those with limited mobility, could be incorporated into the design. Additionally, health-promoting activities tailored to this group could be introduced to further enhance their engagement with RQGS. This underscores the critical role of RQGS in the urban health landscape, particularly as an essential resource for improving the quality of life for vulnerable populations.

Interestingly, leisure time did not show a significant correlation with RQGS usage among personal factors. This challenges the common assumption that people fail to visit green spaces due to busy schedules. Combined with the results of the natural experiment, this finding may reflect the impact of modern lifestyles: even with more free time, individuals tend to prefer other leisure options, such as indoor entertainment facilities or short trips, over visiting RQGS. This highlights the need for more targeted strategies in RQGS planning and management to sustain their appeal amid diverse modern leisure alternatives. Innovative design, creative event planning, and enhancements to the user experience could help ensure that RQGS remains a viable and attractive option within the broader landscape of 'real-world' leisure activities.

Among leisure alternative factors, individuals who frequently use newly developed transportation facilities, modern leisure facilities, and travel more often were less likely to visit RQGS. This finding highlights the competitive dynamic introduced by diversified leisure options in the context of societal development. It aligns with the observations of John Scriven et al., who identified distinct "market segments" in leisure activities, where overlapping user groups create competition for participation [84]. In the context of diversified leisure competition, individuals rarely abandon one activity entirely for another but are more inclined to explore multiple leisure options. While some activities may dominate their choices, users tend to engage in a variety of activities within the same leisure category. This underscores that the success of a leisure "product" depends more on the total number of users it attracts than on the intensity of use or users' participation in other activities [85]. For RQGS managers or designers, this insight suggests that future research and strategies should prioritize understanding non-users—who they are and why they choose not to use RQGS—over solely focusing on increasing usage frequency among existing users. By addressing barriers and designing targeted interventions, RQGS can attract a broader audience and remain competitive within the growing leisure market.

In the satisfaction ratings for RQGS, the maintenance score was relatively high, which is related to our sample selection. To reflect the impact of uncontrolled "real-world" changes as accurately as possible, the residential areas selected for this study were all well-maintained. Additionally, although facility configuration received a relatively high satisfaction score in the RQGS features (3.06), its predictive effect on the frequency of public space use was not statistically significant. This discrepancy may reflect the prevalent "facility primacy" tendency in current residential renewal practices [86]. Local governments and developers often prioritize increasing the visibility of physical facilities in public space renovations, such as large-scale hard-surfaced pavements and standardized fitness equipment installations [87]. While this "quick-fix" renovation approach may improve the aesthetic quality of the environment in the short term, it could neglect functional suitability and social inclusiveness, leading to a disconnect between facility usage efficiency and residents' actual needs [88]. The findings of this study further reveal that such formalized renovations may fall into a "high investment–low utility" trap: although objective indicators of facility configuration (e.g., per capita fitness equipment) significantly improve following renovations, their motivating effect on residents' space usage behaviors is often overestimated. Future

research should move beyond the traditional "quantity–satisfaction" linear paradigm in facility provision and shift toward reconstructing the "quality–behavior" relationship. The use of participatory design methods could help identify "key missing functions" in facility configurations through resident demand profiling. Furthermore, a "post-use effectiveness evaluation" system should be established, incorporating indicators such as facility usage frequency and population coverage into the acceptance criteria for renewal projects in order to mitigate the policy risks associated with formalized renovations.

Consistent with previous studies, Jiang et al. found that the probability of visiting RQGS at least once a week was more than twice as high when surface traffic and parking were separated from RQGS compared to when they occupied the same space [14]. Similarly, Zhan, Hu et al. noted that satisfaction with traffic-related issues significantly influenced park revisit rates [55]. However, given spatial and budgetary constraints, creating a fully independent traffic system for RQGS is nearly impossible. This necessitates managers to delve deeper into and address the root causes of vehicle interference. As discussed earlier, in RQGS, the impacts of vehicles are primarily concentrated on air and noise pollution. Additionally, the layout of functional areas significantly influences usage frequency. Therefore, in future upgrades and renovations of RQGS, planners should prioritize zoning for dynamic and static activities and consider setting up sound barriers and plantings that absorb sound, which may be more effective in encouraging the use of RQGS than simply improving parking facilities.

Compared to certain physical features, enhancing neighborhood familiarity may be more effective in increasing residents' utilization of RQGS. This conclusion aligns with findings in the existing literature. For instance, higher neighborhood familiarity typically reflects stronger community ties and a greater sense of community belonging, encouraging residents to engage in leisure and social activities in nearby green spaces [89]. However, studies also indicate that when residents engage more in activities beyond their neighborhood, a broader "social horizon" may weaken their sense of identification, a phenomenon particularly pronounced among younger residents [26,73]. Therefore, in the context of rapid urbanization, the planning and renewal of RQGS should prioritize maintaining and fostering neighborhood familiarity as a key strategy to enhance their utilization.

Through quantitative analysis of the relationship between user satisfaction and usage frequency, we aim to reveal the relative importance of these factors when acting together. This analysis helps to more accurately identify which specific features may have a positive impact, thus providing data support for setting the priorities of RQGS upgrades and development.

4.4. What Knowledge We Added to Previous Research in This Field

Although urban green space visitation behavior has been extensively studied from various perspectives using multiple methods, natural experimental studies specifically focusing on RQGS remain relatively scarce. This original research not only validated some existing conclusions but also provided new insights.

Our study highlights that leisure alternatives and ratings of RQGS features play a greater role in explaining usage rates than sociodemographic and personal factors. Additionally, the research confirmed that despite the proximity advantages of RQGS, visitation rates can decline significantly over time, even for well-maintained RQGS, as societal dynamics evolve.

Unlike previous studies, this research found that while time constraints are frequently cited as barriers to visitation, our quantitative analysis revealed no significant correlation between these constraints and visitation frequency. Furthermore, the study evaluated various strategies for upgrading RQGS and their relative importance. The results indicate

that addressing automobile pollution, enhancing neighborhood familiarity, and optimizing functional zoning are the most impactful factors in encouraging residents to visit RQGS.

5. Limitations and Future Research

Like all studies, this research has some limitations. First, the natural experiment only reports the observed usage of RQGS over a 14-year period. Due to the uncertainties introduced by the 14-year time span, this study includes only the landscape spaces of three residential areas in Hefei, and the results should be considered exploratory. Future research should expand the sample size and geographic coverage, selecting more residential areas, particularly for comparative studies of different types and cities, to reflect the impact of regional cultural backgrounds, economic conditions, and urban development stages on RQGS usage, avoiding broad generalizations based on a limited number of cases. Furthermore, future studies should explore the specific impact of "temporal factors" on RQGS usage, such as incorporating policy changes (e.g., urban renewal and the renovation of old residential areas). Additionally, research should consider including non-users, using both qualitative and quantitative methods to analyze the reasons for their non-use of RQGS and proposing improvement plans based on these insights, with the goal of developing strategies to attract non-users to RQGS.

6. Conclusions

RQGS is a vital component of urban green spaces (UGS). This study, through a natural experiment, provides empirical evidence of the decline in RQGS visitation over time and reveals the relationships between sociodemographic factors, personal factors, leisure choices, and ratings of RQGS features with the visitation rates of three RQGS in Hefei. Previous studies have rarely evaluated RQGS specifically. The main conclusions can be summarized as follows: (1) People now primarily use RQGS to meet functional needs (e.g., chatting, relaxing, dog walking, and participating in cultural activities) rather than for aesthetic purposes. (2) Compared to the past, RQGS usage has significantly decreased, particularly in the afternoon. (3) While no significant decline was observed in the usage of landscape areas, shaded areas and activity zones have become significantly less attractive to specific groups. (4) Leisure choices and ratings of RQGS features are more determinative of RQGS usage than personal and sociodemographic factors. Specifically, new transportation infrastructure, modern leisure facilities, and more diverse travel options are negatively correlated with RQGS visitation. (5) Although leisure time is often cited as a constraint on RQGS usage, quantitative analysis revealed no significant correlation between leisure time and actual visitation. (6) RQGS is particularly attractive to individuals with poorer health conditions.

This study combines natural experiments and surveys to assess changes in RQGS usage. First, through behavioral observations and field data collected in 2010 and 2024, significant changes in visit frequency were revealed. To further analyze the influencing factors, the study collected data on residents' personal characteristics, leisure preferences, health status, and satisfaction with RQGS facilities through surveys. Poisson regression analysis was used to assess how sociodemographic factors (such as age, gender, and income) and individual factors (such as health status and leisure time) affect visit frequency. The study found no significant correlation between leisure time and visit frequency, challenging the traditional "time constraint" hypothesis. Additionally, factors such as transportation accessibility, modern leisure facilities, and diversified travel modes were negatively correlated with RQGS usage, indicating that transportation and leisure infrastructure have a significant impact on RQGS use. This comprehensive approach enhances the reliability of

the research results, revealing the multidimensional factors influencing RQGS usage and providing scientific support for policy recommendations.

This study provides the following insights for future RQGS updates and management strategies: (1) Instead of focusing solely on landscape features, RQGS design should prioritize functional zoning to accommodate diverse needs, such as dedicated areas for dog walking and sports activities. (2) Interventions to enhance RQGS usage should focus on the afternoon period when visitation is at its lowest. (3) Addressing noise and air pollution caused by increased vehicle use should take priority over planning better parking facilities. (4) Greater attention should be given to the needs of vulnerable groups in using RQGS. (5) Efforts should emphasize maintaining and fostering neighborhood familiarity to increase interactions among residents.

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