Research Paper

Influencing Factors of Residential Satisfaction and Renewal Strategies in Old Neighbourhoods

Evidence from Xiangfang Old Industrial Base of China

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Abstract

Analyzing residential satisfaction with the environment is not only an accurate capture of residents' diverse needs, but also a key basis for making updated decisions. In this study, the gradient boosting decision trees (GBDT) and the impact-asymmetry analysis (IAA) methods are used and based on the data obtained from the questionnaire survey among the residents of residential areas built before the end of 2000 in Xiangfang Old Industrial Zone, Harbin, China. The influencing factors of residential satisfaction are analyzed, and the renewal strategies are put forward. The results show that: (1) There is both a linear and nonlinear relationship between environments and residential satisfaction. (2) The space area of the square and small garden, and the quality of the rest space in the green environment are the most important environmental factors for the residents' satisfaction with the old industrial base. (3) In terms of environmental renovation strategies, ensuring travel safety, improving accessibility and quality of leisure space, increasing electronic monitoring, and providing various leisure activities, could significantly improve residents' satisfaction. It is expected to provide empirical conclusions for the gradual renewal and transformation of old neighbourhoods.

Keywords

Residential satisfaction, Gradient boosting decision trees, Impact-asymmetry analysis, Old residential areas, Priority of renewal

1. Introduction

The decline of neighbourhoods environmental quality will have a negative impact on the consistency of environmental conditions and residents' needs (Galster and Hesser, 1981). In the 1980s and 1990s, to solve the housing shortage of employees in industrial enterprises, the Chinese government and state-owned enterprises developed many residential areas. However, in the past two decades, the lack of maintenance and renovation in the residential areas of industrial bases has led to problems such as dilapidated buildings and public service facilities, chaotic traffic systems and insufficient space for public activities (Cai, Yang and Li, 2017). Although the Chinese government has formulated a series of policies to improve residents' quality of life, government-led residential reconstruction often fails to accurately understand the main problems that residents want to solve (Yang, 2010). Therefore, it is necessary for

policy makers to understand the influencing factors of residents' environmental satisfaction in old industrial bases and make full use of limited resources to maximize the well-being of cities and residents.

Previous studies have examined neighbourhood satisfaction and its influencing factors. Lovejoy, Handy and Mokhtarian (2010) and Cao et al. (2020) scholars summarized the research progress of residential satisfaction from the 1980s to 2019. Jensen (2007), Kim, Park and Lee (2014) and Blečić, Canu and Cecchini (2016) have demonstrated the influence of road facilities, land use and service facilities on satisfaction through multi-level, multi-variable models and path analysis. Liu (2010) and LV, Ding and Sun(2019) found that supporting facilities, residential buildings, outdoor space, neighbourhood safety, etc. affected residents' satisfaction, through the logit model, factor analysis and IPA, in old communities.

However, in these empirical studies, a common assumption is that environmental factors have a linear influence on satisfaction, and they may ignore the potential nonlinear relationship between environmental factors and overall satisfaction (Matzler and Sauerwein, 2002; Zhang and Cao, 2017). Although the literature on satisfaction (Mikulić and Prebežac, 2011) fully recognizes the asymmetric relationship between service attributes and overall satisfaction, this relationship has received less attention in the research of residence satisfaction (Dong et al., 2019; Cao et al., 2020).

This study investigates residents living in old neighbourhoods in Xiangfang old industrial base of Harbin, China, and analyzes the impact of physical environmental factors in the neighbourhood on residential satisfaction. To answer the following questions: (1) What factors constitute residential satisfaction with neighbourhoods environments in old residential areas? (2) Do these factors have a non-linear influence on residential satisfaction? (3) Which factors should be prioritized for improvement to enhance residential satisfaction? In order to put forward transformation strategies for the old residential areas with declining environmental quality.

This paper is organized as follows. Section 2 introduces the study design, including an overview of the research area, the variable selection, data source, and the method of the gradient boosting decision tree and impact-asymmetry analysis; Section 3 presents research results that influence factors of residential environment satisfaction in old neighbourhoods, and the prioritized for improvement to enhance residential satisfaction; Section 4 discusses renewal strategies; Section 5 summarizes the key results of this study.

2. Methods

2.1. Overview of the research area

Harbin Xiangfang Old Industrial Zone, like other old industrial zones in Northeast China, has residential areas distributed around the industrial zone in addition to the factory zone with dominant functions. At present, most of the old residential areas in this area were built during the reform of the welfare housing distribution system in the 1980s and 1990s. L-shaped and U-shaped enclosures form a public area, with open construction along the street as the mainstay. The original architectural style is mainly red brick houses with three or four floors. With the market economy, the community pays more attention to the quality, the apartment type has grown from small to large, and the number of floors of the building is increased to 5 or 6 floors. Although the overall construction level has been improved, there are some environmental problems such as low safety, poor greening quality, and insufficient activity space. It is possible to improve the satisfaction of the living environment through environmental transformation. Therefore, this study takes the boiler factory, motor factory, steam turbine factory, and timber factory as the centre in Xiangfang District, and selects 25 residential areas in the 1980s and 1990s around the factories.

2.2. Data

The research data comes from a questionnaire survey among residents in residential areas from September to November 2020. Investigators are composed of eight graduate students, who randomly recruit respondents around the entrance and exit of residential areas and open spaces, and collect questionnaires on the spot. A total of 450 questionnaires were distributed, of which 433 were valid, with an effective rate of 96.22%.

2.3. Variable selection

Based on the basic situation of the residential area and combined with the perceived residential environment quality indicators (PREQIs) (Zhang and Zhang, 2017), 37 environmental factors that affect the satisfaction degree are identified as shown in Table 1. The questionnaire on environmental satisfaction is divided into three parts. First, residents' overall satisfaction with the residential environment; second, residents' sub-satisfaction with 37 environmental factors; third, the demographics of respondents. A 5-level satisfaction scale was designed, with "very dissatisfied" is 1, "relatively dissatisfied" is 2, "fair" is 3, "relatively satisfied" is 4 and "very satisfied" is 5. VIFs (coefficient of variance expansion) are all less than 3, so there is no multicollinearity problem.

Table 1 The complete list of influencing factors of environmental satisfaction

Index class	Environmental factors of residential satisfaction
Building quality	1. Spacing between buildings, 2. Aesthetics, 3. Colour, 4. Height, 5. Power supply, water supply and drainage, 6. Heating and heat preservation
Road	7. Roadway width, 8. Pedestrian width, 8. Pavement quality, 10. Dead-end roads and other road connectivity.
Traffic	11. Number of parking spaces, 12. Convenience to downtown, 13. Convenience to bus and subway.
Sanitation	14. Number of garbage dropping points, 15. Cleaning regularly, 16. Fresh air, 17. Noise, 18. Private building.
Service facility	19. Commercial retail, 20. Catering and entertainment, 21. Life service, 22. Medical and health care, 23. Education, 24. Aged care service.
Safe	25. Electronic monitoring, 26. Street lighting, 27. Access control equipment, 28. Public security, 29. Travel safety, 30. Falling objects and other potential safety hazards
Greening leisure space	31. The amount of greening in the residential area, 32. The space for rest and relaxation in greening, 33. The lighting, benches, trash cans and other facilities of green space and square area, 34. The open space size of the square and small garden, 35. The quality of space (fitness, walking, dancing, playing cards, etc.), 36. The convenience of reaching the leisure space, 37. Types of leisure activities such as culture, entertainment and health.

2.4. Model building

Modeling Analysis was performed with impact-asymmetry analysis (IAA) and gradient boosting decision trees (GBDT). The theoretical basis of IAA is three-factor theory (Matzler et al., 2003; Matzler, Sauerwein and Heischmidt, 2004). The Three-factor theory divides factors into three categories: (1) Basic factors: if the residents are dissatisfied with them, they will have a negative impact on overall satisfaction. (2)

Excitement factors: when performing well, they will greatly improve overall satisfaction. (3) Performance factors: usually have a linear influence.

Penalty-reward contrast analysis (PRC) is a common method to deduce the classification of factors (Busacca and Padula, 2005), and it is also a key link in IAA. Virtual variable regression is often used. In this study, the scores of 37 community environmental factors were made into virtual variables. 1 and 2 points of satisfaction are recorded as low performance, and re-coded as -1; Satisfaction evaluation 3 points are recorded as a reference class, and re-coded as 0; Satisfaction of 4 and 5 points is recorded as high performance, and re-coded as 1.

The gradient boosting decision trees (GBDT) model's basic algorithm is decision trees, and the GBDT model's goal is to minimize the loss function by iteratively explaining the prediction error until the loss function remains stable or reaches the minimum. Compared to traditional regression models, the GBDT approach's advantages are: It can give more accurate estimation results(Ding et al., 2016); There is no need for data to follow a specific distribution; It can avoid possible result deviation (Dong et al., 2019; Cao et al., 2020).

In this study, the GBDT was used to construct a model of the influence of environmental factors on satisfaction. The response is residents' overall satisfaction with the environment, and the predictors include demographic variables and 37 environmental factors. Set the learning rate to 0.001 to obtain a lower predictive variance and a reasonable number of decision trees. In order to achieve the best prediction accuracy and avoid over-fitting, five-fold cross-validation and tree pruning are carried out to improve the prediction ability under an appropriate number of trees(Ding, Cao and Næss, 2018; Tong, An and Liu, 2021).

According to Mikulić and Prebežac (2008), the impact-asymmetry analysis is applied. For each environmental factor, the overall satisfaction scores (POSS) obtained by the GBDT model show dissatisfied, neutral, and satisfied, which are respectively expressed as POSSd, POSSn and POSSs. The range of influence of overall satisfaction (RIOS) is the difference between POSSs and POSSd. Satisfaction-generation potential (SGP) is calculated as (POSSs-POSSn)/RIOS, dissatisfaction-generation potential (DGP) is calculated as (POSSn-POSSd)/RIOS. Impact-asymmetry (IA) index is SGP-DGP. In this study, in order to get finer results to guide the updating practice process, referring to the IA threshold proposed by Back and Lee (2015), the attributes are divided into the following five categories, and the corresponding updating priority suggestions are shown in Figure 1 and Table 2:

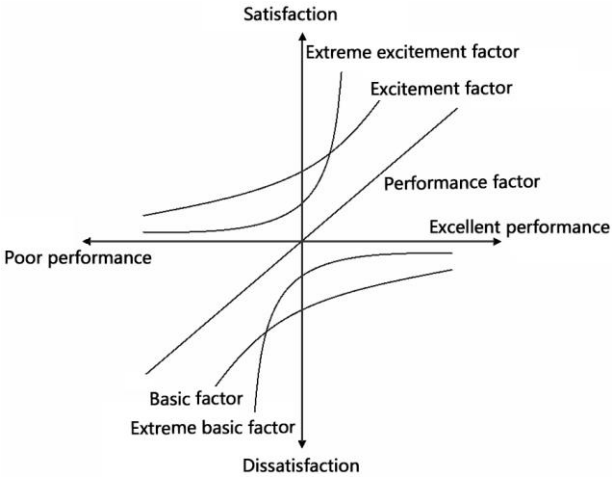

Figure 1 Schematic diagram of the influence of environmental factors on residential satisfaction. Source: adapted from Vavra (1997).

Table 2 Classification of environmental factors based on IAA and suggestions

Classification	IA index	Influence relation	Suggestions and reasons for updating priority under two types of performance (average score of environmental satisfaction)		
			Less than 3 points	No less than 3 points	Cause
Extreme excitement factors	IA index > 0.7	Non-linear	Secondary priority	Secondary priority	Even if the performance is poor, it will only have a small negative impact on residential satisfaction, as shown in Figure 1.
Excitement factors	0.2<IA index ≤0.7	Non-linear	Secondary priority	Secondary priority	
Performance factors	-0.2≤IA index ≤0.2	Linear	Priority	Secondary priority	
Basic factors	-0.7≤IA index < -0.2	Non-linear	Priority	Remain unchanged	When the performance is good, even if the improvement is made, the impact on residential satisfaction is limited, as shown in Figure 1.
Extreme basic factors	IA index < -0.7	Non-linear	Priority	Remain unchanged	

2.5. Descriptive statistical analysis of demographic characteristics

The social and demographic characteristics of the respondents, as shown in Table 3, including gender, age, education level, employment status, annual household income and car ownership. When recruiting interviewees, try to balance gender and age distribution. Among the respondents, men and women are balanced; Middle-income families are the most, while low-income and high-income families are relatively few; The number of people with university education is the largest, followed by high school education and vocational education. Demographic characteristics are basically in line with the demographic characteristics and social attributes of Xiangfang District and are representative.

Table 3 Demographics of respondents living in Old Neighbourhoods

Category		Proportion
Gender (%)	Man	49.88
Age (%)	18-28 years old	21.71
	20-40 years old	23.56
	40-55 years old	24.02
	6-65 years old	13.86
	Over 66 years old	14.55
The employment rate (%)		60.74%
Category		average/mean value
Average education level		3.40

Average annual household income	3.54
Private vehicles (car/home)	1.51

Note: 1. Average education level: 1= Primary school and below; 2= Secondary school; 3= High school and vocational high school; 4= Specialist; 5= Bachelor degree or above; 2. Average annual household income (yuan): 1 = Less than 10,000; 2 = 10,000-30,000; 3 = 30,000-80,000; 4 = 80,000 to 120,000; 5 = 130,000 to 200,000; 6 = more than 200,000; 3. Private vehicles: 1= none; 2=1 vehicle; 3=2 vehicles; 4=3 or more vehicles.

3. Results

3.1. The relative influence of environmental factors on residential satisfaction

Among the 37 environmental factors, 13 environmental factors contribute 2% or more to predicting overall satisfaction, as shown in Table 4. Among them, the size of open spaces that can provide activities, such as squares and small parks, has the greatest impact on residents' satisfaction, reaching 11.26%; Secondly, the quality of space for relaxation in greening, the relative influence of lighting, garbage cans and other facilities are ranked second and third in turn. The factors that affect the top three are all related to the greening and leisure space near the place of residence. Therefore, it can be seen that the renovation of Xiangfang old industrial residential area before the end of 2000 needs special attention to improve the greening and recreation space.

Table 4 The relative influence of variables in predicting overall residential satisfaction

Rank	Environmental factors	Relative influence (%)
1	The open space size of square and small garden	11.26
2	The space for relaxation in greening	9.14
3	The lighting, benches and other facilities of green space and square area	6.69
4	The convenience of reaching the leisure space	5.87
5	Electronic monitoring	5.30
6	Travel safety	5.03
7	Falling objects and other potential safety hazards	4.24
8	Noise	4.22
9	Types of leisure activities such as culture, entertainment and health	4.13
10	Public security	4.12
11	The amount of greening in the residential area	4.08
12	Cleaning regularly	3.10
13	Quality of fitness, walking, dancing, playing cards and other spaces	2.85

Note: The relative impact below 2% is considered insignificant, so it is not listed in the table.

3.2. Gradient boosting decision trees and impact-asymmetry analysis

Among the 13 factors that have an important impact on residential satisfaction, only two are the performance factors, which are linearly related to the overall satisfaction, as shown in Table 5: the quality of space for relaxation and travel safety. The influence of other factors on residential satisfaction is nonlinear. Four factors, including the convenience of reaching the leisure space, electronic monitoring, the types of leisure activities such as culture, entertainment and health, and the quality of space such as fitness, walking, dancing and playing cards, are classified as excitement factors and extreme excitement factors. The remaining seven factors are divided into basic factors and extremely basic factors.

Table 5 Analysis of the priority of residential renovation by the integration of GBDT and IAA

Environmental factors	RIOS	SGP	DGP	IA	Classification	Updating priority	Satisf-action mean
The open space size of square and small garden	0.37	0.28	0.72	-0.44	Basic factors	-	3.06
The space for relaxation in greening	0.28	0.42	0.58	-0.15	Performance factors	-	3.03
The lighting, benches and other facilities of green space and square area	0.18	0.05	0.95	-0.89	Extreme basic factors	-	3.08
The convenience of reaching the leisure space	0.22	0.79	0.21	0.59	Excitement factors	Secondary priority	2.94
Electronic monitoring	0.19	0.88	0.12	0.76	Extreme excitement factors	Secondary priority	2.96
Travel safety	0.23	0.55	0.45	0.11	Performance factors	Priority	2.97
Falling objects and other potential safety hazards	0.14	0.01	0.85	-0.85	Extreme basic factors	-	3.06
Noise	0.20	0.31	0.69	-0.38	Basic factors	-	3.04
Types of leisure activities such as culture, entertainment and health	0.15	0.65	0.35	0.31	Excitement factors	Secondary priority	3.00
Public security	0.17	0.28	0.72	-0.45	Basic factors	-	3.03
The amount of greening in the residential area	0.11	0.22	0.78	-0.56	Basic factors	-	3.04
Cleaning regularly	0.13	0.34	0.66	-0.31	Basic factors	-	3.04
Quality of fitness, walking, dancing, playing cards and other spaces	0.07	0.90	0.10	0.81	Extreme excitement factors	Secondary priority	2.99

4. Renewal strategies

Classification has an impact on determining the priority of updates. The Updating priority of environmental factors is shown in Table 5. First, paying attention to the issue of travel safety will improve residents' satisfaction most effectively. Through investigation, it is found that in some residential areas, due to the disrepair of pavement and serious damage, there are some problems such as the lack of traffic markings and the impact of waste piling on traffic. As shown in Figure 2, this has seriously affected the residents' satisfaction with the environment, and it is necessary to give priority to solving them in the reconstruction to improve the unsatisfactory environmental performance factors and achieve the expected effect of residents.

Figure 2 The pavement and roadway are in disrepair and piled up with waste. Source: author.

After the unsatisfying factors of performance factors, basic factors and extreme basic factors are improved, it is suggested to improve the excitement factors and extreme excitement factors to greatly enhance residents' satisfaction with the environment. According to the results in Table 5, add paths to leisure activity spaces, and set leisure activity spaces with different levels and functions. Thus, paths and open spaces can enhance the space penetration ability in both directions, so as to improve the convenience of reaching leisure activity spaces.

At the same time, it is necessary for the safety management department to analyze the blind spots and spatial dead spots in the community, and reasonably add monitoring equipment to obtain full coverage of the observation perspective, to reduce the blind spots of monitoring.

In addition, it is necessary to greatly improve the quality of fitness, walking, dancing, playing cards and other spaces. The survey also found that the quality of activity space in the community has not yet met the residents' recreation and leisure functions, as shown in Figure 3. Therefore, investigating the residents' demand for fitness equipment and leisure space functions, and greatly increasing the facilities' configuration of activity places, as well as the area and quality of venues, will probably greatly improve residents' satisfaction.

Moreover, adding a variety of cultural, recreational and health facilities such as chairs, flower boxes, tree pool frames, slides and climbing walls in the activity places to enhance the types of leisure activities will stimulate the potential of public space in the community and bring the possibility of greatly improving satisfaction.

Figure 3 Quality of public activity space in old residential areas. Source: author

5. Conclusion

This study provides scientific and universal environmental factors for the evaluation of the satisfaction degree of the residential environment in old industrial areas in Northeast China and can be widely used in other studies on the impact of residential environment on satisfaction degree in old neighbourhoods. The linear and nonlinear influences of environmental factors were considered, and the relative influence order was obtained after the interaction of various factors. IAA is effective in resource allocation based on satisfaction scores. The combination of GBDT and IAA can identify the order of renovation of old residential areas by scientific means, and in the case of limited resources, formulate the renovation scheme with the best effect on improving residential satisfaction as soon as possible, thus avoiding the waste of resources caused by the subjective decision of renovation order in the past.

During the renovation, it is suggested to give priority to the renovation of the performance factors, basic factors and extreme basic factors of residents' dissatisfaction, so as to eliminate residents' dissatisfaction with the environment; Secondly, the excitement factors and extreme excitement factors should be transformed to greatly improve residents' satisfaction. Therefore, this study has practical significance in formulating the renewal strategies of the old neighbourhoods in the old industrial areas of Northeast China.

In the old neighbourhood of Xiangfang old industrial zone, even though the size of open spaces such as squares and small gardens is the environmental factor that has the greatest impact on residents' satisfaction, it is the basic factor to achieve residents' satisfaction. Therefore, there is no need for renovation. At present, in order to improve residents' satisfaction, it is suggested that: firstly, the possible travel safety problems in the community should be eliminated; Secondly, improve the convenience of reaching leisure space; Then, add electronic monitoring for the community; Finally, improve the quality of fitness, walking, dancing, playing cards and other spaces, and implant a variety of cultural, entertainment and health facilities such as chairs, flower boxes, tree pool frames, slides and climbing wall to provide residents with a variety of leisure activities.

This study provides a new conceptual framework of renovation priority for the old neighbourhoods in Xiangfang old industrial zone of China. In the future, we will further consider the cost of renovation, formulate renovation plans and analyze the income and cost of specific renovation projects, and improve the living environment quality of the old neighbourhoods in China in practice.

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