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Aging-friendly Evaluation and Optimization Strategy of Public Space in Old Residential Areas: A Case Study of Suojincun Street in Nanjing

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Abstract: In recent years, the number of elderly people in China has been growing, and the problem of population ageing has been aggravated. The problem of population aging has aggravated by the fact that the quality of life of the elderly has become the focus of social attention. Most of the elderly in China mainly live in old neighborhoods, and improving the living space for the elderly is the key to improve the quality of life of the elderly. This study is based on the Suojincun street in Nanjing, and combines fieldwork and questionnaire survey methods to analyze the problems in renovating old neighborhoods from three aspects: transportation, greening and activity space. The research reveals several challenges in the aging of old residential areas, including disorganized internal traffic, limited green spaces with subpar quality, inadequate attention to needs of the elderly for activity space, underutilization of certain areas, and a lack of functional facilities.Based on the design principles of ageing community renovation, corresponding community optimization strategies are proposed, in order to provide certain reference and guidance for similar designs, so as to promote the development of residential areas for the elderly and improve their sense of well-being.

Keywords: Renovation of old residential areas, Landscape design, Suitable for aging, Spatial optimization

1. Introduction

Due to increased life expectancy and declining fertility rates, the number and proportion of older people in the population of almost every country in the world is growing. According to the current census results, developed countries such as Germany [1], Japan [2] and South Korea [3] are facing the problem of population aging, and China is also gradually entering the stage of population aging. As of February 2023, China had 280 million elderly people aged 60 or above, and the number of elderly people is expected to increase to 487 million by 2050 [4]. With the increase of the elderly population, pensions, medical care and long-term care will increase. Furthermore, the newly born population continue to decline, families will become smaller, and labor force shortage will occur, which will inhibit the high-quality development of regional economy [5-6]. In order to cope with the problems caused by the aging population, Japan has eased its labor shortage by admitting immigrants [7]. Netherlands has adopted a typical multi-pillar pension system structure [8]. The European Union

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countries deal with the problem of aging through the strategy of active aging [9]. The Chinese government is also continuously optimizing its population development strategy to cope with the problems arising from an aging society [10].

With the deepening of research on population aging, the concept of "aging-friendly design" has gradually emerged, which refers to the adaptive design, construction and transformation of the environment according to the physical and mental needs of the elderly, so as to create a good living environment for the elderly [11]. This philosophy is put into practice in architectural design, community planning, product design and service delivery. In the study of landscape design, the researchers conducted an in-depth study on the design of outdoor activity space for the elderly and the elderly's needs for nursing service facilities. In terms of transportation, Van et al. surveyed 38 older adults to explore age-appropriate design based on safe transportation, outdoor environments, digital environments, and the enhancement and optimization of age-friendly cities [12]. Zhang et al., employed questionnaires, focus group interviews, and user journey maps to explore the composition and connotation dimensions for designing community transportation services [13]. Chng et al. conducted a survey among community residents in Singapore to explore their perceptions and experiences regarding traffic calming measures [14]. Using survey and regression analysis,Lu et al. identified key outdoor environmental parameters in Hangzhou's age-friendly communities, emphasizing the importance of prioritizing weatherability when designing outdoor gathering Spaces [15]. In terms of environmental structure and space,through questionnaire surveys and fuzzy analytic hierarchy process, Mei et al. identified key indicators and weights of public environments in age-friendly communities, emphasized the importance of road systems and facilities, and proposed basic criteria to ensure the physical and mental health of older people [16]. Using the ecological model of aging,Zheng et al. found the importance of community environmental optimization in promoting active aging [17].

Suojincun street, Nanjing City, Jiangsu Province, China, serves as a typical case of old residential renovation with a significant aging population, where the elderly constitute a relatively high proportion of residents.The study takes Suojincun street as an example to conduct a detailed evaluation of the appropriate aging of public space in the old residential areas of Nanjing Suojincun street, and puts forward corresponding optimization strategies. This study aims to provide theoretical reference and practical basis for improving the age-appropriate level of public space in old residential areas, so as to meet the landscape needs of elderly residents, promote the age-appropriate improvement of community environment, and provide important reference and guidance for the transformation of similar old residential areas in Nanjing and nationwide.

2. Basic Project Overview

Suojincun Street is located in Xuanwu District, Nanjing, Jiangsu Province (Figure 1). Spanning an area of 6.01 square kilometers, the street falls within the administrative jurisdiction of seven communities. Established in 1984, it covers approximately 7 square kilometers and accommodates a population of nearly 70,000 residents. It comprises seven communities, including the five mentioned in this paper (Table 1).

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Table 1: List of Nanjing Suojincun street investigation.

Community	Approximate area	Number of dwellings	Total population	Over 60 years old	Proportion
Suojincun street 1community	13000m^2	11	487	237	48.67%
Suojincun street 2 community	34000m^2	22	973	481	49.43%
Suojincun street 3 community	29000m^2	20	2020	896	44.36%
Suojincun street 4 community	50000m^2	38	3158	1347	42.65%
Suojincun street 5 community	30000m^2	14	1578	563	35.68%

Figure 1: Survey scope diagram(Suojincun Street, Nanjing, Jiangsu Province, China).

3. Research Method

3.1. Interview and Questionnaire Methods

The questionnaire for assessing the satisfaction of elderly individuals in public spaces within old communities has been developed to encompass three key aspects: road traffic, green landscapes, and activity spaces. It is available in Appendix 1. Elderly participants are encouraged to freely articulate any discomfort they experience while engaging in activities within public spaces. To ensure data authenticity and scientific rigor, as well as to minimize errors stemming from potential misunderstandings among elderly respondents, a one-on-one offline questionnaire scoring method was employed during the survey process. This involved randomly selecting elderly individuals of varying genders and age groups across different locations within five old residential areas.

3.2. Field Study Method

Through conducting a field investigation on the living environment of the elderly in Suojincun street, we gained an understanding of their needs and identified existing problems. The investigation comprehensively examined three aspects: public activity spaces, traffic infrastructure, and greenery landscapes. By observing and communicating with residents, we assessed their satisfaction levels and concerns regarding the current environment. The findings were analyzed and summarized to determine the specific requirements for improving the living environment for the elderly.

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4. Results

4.1. Field Mission Results

4.1.1. Traffic Analysis

4.1.1.1. Road Distribution

The findings from the field visits indicate that the road network of Suojincun street presents the characteristics of dense road network, which is mainly divided into two levels of roads, the width of the main road is 4-6 meters, and the distribution begins at the main entrance of the whole residential area. Secondary roads have a width of 1.5-3 meters and are mainly distributed in the interior of residential areas (Figure 2).

The overall road network density in Suojincun street is generally suitable. However, there are some issues that need to be addressed. For instance, the road network in Suojincun street 2 to 3 communities lacks organization, resulting in a relatively chaotic layout. Additionally, the classification and function of roads in Suojincun street 2 to 4 communities are unclear. Moreover, the arrangement of main roads in Suojincun street 5 community is not optimally planned. These problems contribute to a mixed flow of pedestrians and vehicles, posing safety risks for elderly pedestrians and hindering the development of pedestrian-friendly residential areas.

In addition, the pedestrian traffic from Suojincun street 1 to 5 communities has problems such as excessive road slope, road damage, untidy road surface, excessive exit slope, road curb damage, and so on. These problems seriously affect the safety, comfort and convenience of pedestrian transportation Spaces for the elderly (Table 2).

Figure 2: Distribution map of the road network in Suojincun street.

Table 2: Problems in road design.

	
Road damage, untidy road surface	Excessive road slope, road curb damage

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4.1.1.2. Entrance and Exit Analysis

The residential entry space, also known as the interface between the road within the residential area and the residential units, serves as a crucial link connecting the interior and exterior of the building. Through investigation, it has been observed that frequent interpersonal exchanges occur within this area. Being in close proximity to residential buildings and easily accessible from outdoors, the residential entry space offers convenience for elderly individuals to swiftly descend downstairs and engage in interactive activities (Table 3).

After conducting the investigation, it has been observed that there is a frequent disorderly parking and littering at the entrance and exit of vehicles (Table 4). The indiscriminate parking not only tarnishes the overall image of the community but also hampers residents' quality of living. Furthermore, field research revealed a shortage of garbage bins, leading some residents to dispose of their waste in an unsuitable manner at the entrance and exit instead of waiting or finding appropriate locations.

Table 3: Entrance and exit space research.

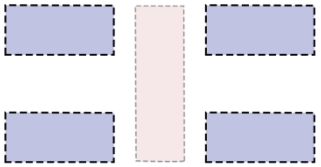
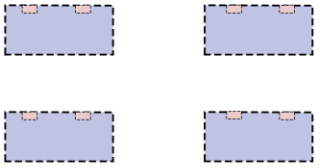
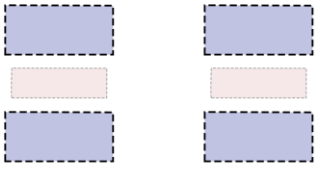
Space classification for accessibility		The present photograph	The spatial characteristic
Access space for residential properties			Long shape, large space, there are cars on both sides of the parking, the space is strong
The designated area for accessing the corridor			The corridor space does not affect each other, the space is small, and it is mainly used for entering the building
Access space between houses			The space is long, and the walking is weak, which is mainly used for static activities

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Table 4: Problems in access space.

	
Disorderly parking	Littering

4.1.2. Greenery Landscape Analysis

The greenery landscape space serves the purpose of enhancing the community's environment, providing visually pleasing aesthetics, and improving the microclimate. Within these green spaces, elderly residents often utilize inter-house areas to display potted plants and enjoy leisure time (Table 5). However, there are also some problems, such as Suojincun street five communities vegetation is too simple, lack of diversity of plant species. At the same time, the late maintenance work of some landscape Spaces is not in place, resulting in disorderly growth of plants. There are also some trees that grow too high, blocking the sunlight on the ground floor, and these low-rise homes are mainly where the elderly live (Table 6).

Table 5: The current status of greenery landscape spaces.

 
Useing space in the house to place and grow potted plants

Table 6: The current prolems of greenery landscape spaces.

	
Tangled vegetation	Single vegetation

4.1.3. Activity Space Analysis

The activity space plays a crucial role in facilitating various activities and extensive communication among the elderly. The survey found that interactions among older adults were frequent and varied, including solo and social interactions. Since Suojincun street 3 and 4 communities have two open

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venues for elderly activities, interaction is the most frequent. On the other hand, three other residential areas are relatively weak (Table 7).

During the investigation process, it was discovered that interactive activities among the elderly exhibit characteristics of activity, communication, and companionship. However, the current seating arrangements in Suojincun street's interactive spaces are insufficient in number, poorly distributed, and inadequately designed to meet the comfort and flexibility needs of elderly individuals. Additionally, these arrangements fail to satisfy their communicative and participatory requirements for residential area interaction spaces. Furthermore, rest facilities located in the middle of roads impede pedestrian flow while also resulting in low pavilion usage rates (Table 8).

Table 7: Current situation of activity space.

	
A variety of interactive activities for seniors	

Table 8: Problems of activity space.

	
Single movement	The unreasonable layout of leisure facilities

4.2. Questionnaire Results and Analysis

After the questionnaire survey, SPSS software was used to analyze the reliability and validity of the obtained data. A total of 908 questionnaires were received, of which 78 were invalid and 830 were valid (Table 9).

According to the data analysis results of the 830 questionnaires collected, the majority of respondents expressed satisfaction with the scope of public activity space, leisure facilities, sports amenities, landscape greening, and plant conservation. However, there were concerns regarding overall satisfaction with the living environment, community road smoothness, and parking arrangement. These findings indicate that while commendable progress has been made in terms of public activity space and landscape greening within the community, improvements are needed in road conditions as well as accessibility and organization of parking spaces. Additionally, it is worth noting that some respondents expressed dissatisfaction with lighting on residential floors; thus further consideration and optimization may be required (Table 10).

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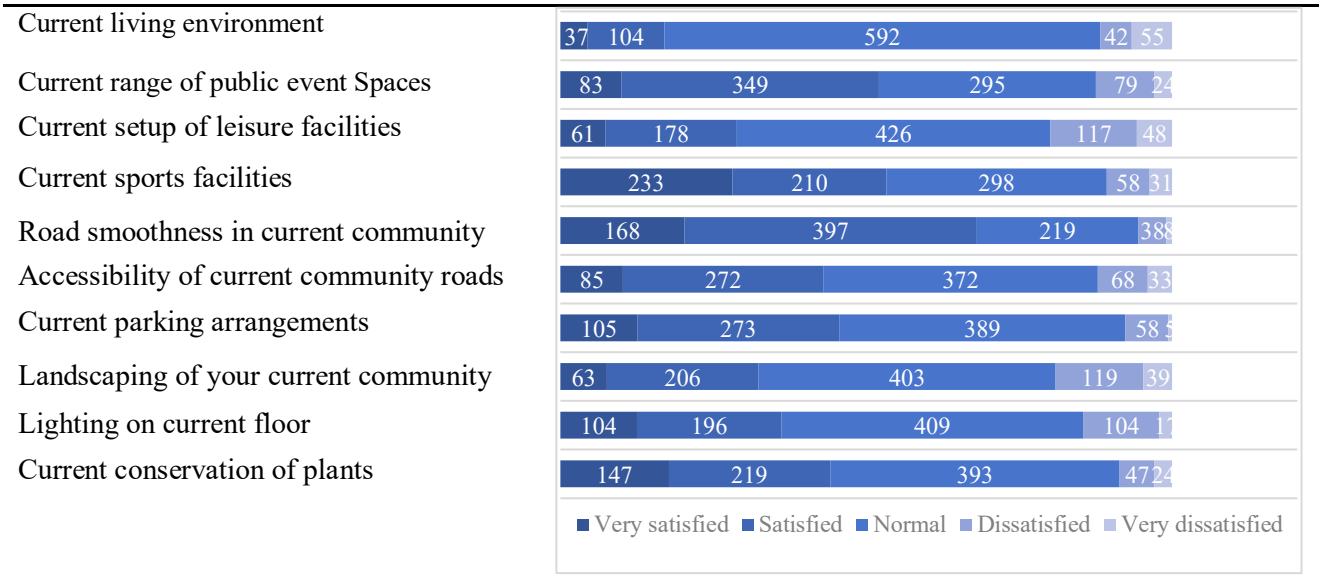
Table 9: Survey object information statistical table.

	Classification	Number of people	Proportion
Age	Under 60 years old	413	49.76%
	60-70 years old	228	27.47%
	70-80years old	137	16.51%
	Over 80 years of age	52	5.27%
Occupation	Unemployed	87	10.48%
	Teacher	233	28.07%
	Worker	157	18.92%
	Framer	353	42.53%
Gender	Male	407	49.04%
	Female	423	50.96%
Place of Residence	Suojincun street 1 community	56	6.75%
	Suojincun street 2 community	110	13.25%
	Suojincun street 3 community	207	24.94%
	Suojincun street 4 community	331	39.88%
	Suojincun street 5 community	126	15.18%

Table 10: Community satisfaction survey statistics.

Summary of community satisfaction



5. Optimization Design Strategies for Older Neighborhoods

5.1. The Strategy of Design Transformation

5.1.1. Traffic

During our investigation it was determined that there are several issues with regards to road infrastructure between Suojincun street 1 to 5 communities such as narrow spaces which lack proper organization leading to mixed usage by various types of transportation vehicles as well as residents. This has resulted in unclear usage rights for roads along with worsening traffic conditions. To address these concerns while adhering to principles of accessibility [18-21], we propose optimizing existing roads through measures such as segregating pedestrian walkways from vehicular lanes implementing one-way traffic flow thereby establishing a comprehensive slow-traffic system [22] (Figure 3).

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Additionally creating a circular slow-traffic network will enhance public spaces internally while also providing designated areas for elderly activities separate from vehicular zones alongside recreational amenities. Furthermore enhancing barrier-free facilities inclusive of specialized ground surfacing ramps tactile pathways handrails etc., will ensure high-quality road surfaces (Figure 4).

A.before transformation B.after transformation

Figure 3: Road optimization design.

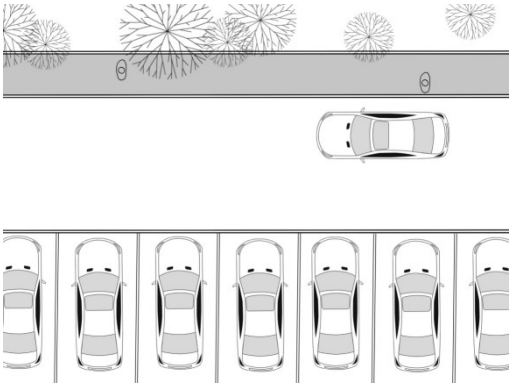

Figure 4: Road quality suitable for aging design.

5.1.2. Greenery Landscape

The plants in older communities often suffer from neglect or destruction, leading to a decline in the ecological function of public spaces. In response, the following suggestions are proposed: timely conservation and restoration of greenery in public spaces. Additionally, introducing plants with health benefits can help promote the physical and mental well-being of elderly residents. Given the limited space in older residential areas, increasing the quantity and level of landscaping through strategic use of fragmented space, three-dimensional greening, roof greening, and other methods can expand green areas. Furthermore, trees can be utilized as the primary form of greenery in parking lot design, replacing hard paving bricks with grass bricks to improve space utilization [23].

5.1.3. Activity Space

5.1.3.1. Spatial Arrangement

The activities of the elderly in the community are diverse and abundant, encompassing individual, small group, and large collective activities. To cater to these various needs, the following suggestions are proposed: Establish semi-private spaces by incorporating greenery and landscape facilities on site, as well as adding semi-open spaces such as a landscape gallery pavilion and forest area to facilitate gatherings for the elderly. When designing and planning, it is essential to consider the requirements for large-scale collective activities, ensuring ample space within the venue while incorporating fitness

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equipment, seating areas, flower beds, and other elements along the perimeter. In response to the preference of elderly individuals for gathering activities, leisure facilities can be integrated to accommodate chess games, card games, discussions, tea ceremonies etc.; Simultaneously incorporate safety features such as ramps and reflective strips at entrances to ensure a secure environment for elderly activities (Figure 5).

A.before transformation B.after transformation

Figure 5: Community public space design.

5.1.3.2. Fitness and Leisure Facilities

The elderly may experience fatigue after walking for approximately 10-15 minutes. The utilization of fitness facilities not only enhances the physical well-being of the elderly, but also provides enjoyment, making it a popular form of exercise for many seniors. A survey revealed that, apart from Suojincun street 3 and 4 communities, there are two similar areas with limited activity facilities. In Suojincun street 1, 2, and 5 communities, rest and fitness facilities are scarce. To address this issue, we should optimize the original site by considering space and function when designing seating layouts. Seats should be evenly distributed throughout the community to provide comfort using materials with low thermal conductivity and removable cushions to accommodate seasonal changes in climate (Figure 6). Real-time monitoring functions can be incorporated between seats along with LED displays integrated with street lamps for emergency assistance and information retrieval by the elderly. Relevant departments should conduct regular maintenance on fitness facilities to ensure their safe use over an extended period.

A.before transformation B.after transformation

Figure 6: Recreation facilities design.

6. Conclusion and Prospect

The study focuses on the old residential area of Suojincun street in Nanjing, using aging suitability as the research entry point. It combines field investigation, questionnaire survey, and interviews to conduct research on five typical old residential areas of Suojincun street. The study summarizes the current situation and evaluates aging suitability from three aspects: road traffic, green environment,

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and activity space. Based on this evaluation, the paper proposes an aging adaptation strategy for public spaces in old residential areas in Nanjing. The qualitative evaluation study reveals problems such as chaotic traffic, simple and poor green environment, unmet demand for activity space by the elderly, low utilization rate of some spaces, and lack of functional facilities. By combining with renovation policies of old residential areas nationwide and conducting local optimization and renovation based on specific requirements identified through the evaluation results, an aging design strategy is proposed. The paper elaborates on road traffic, green environment, and activities before demonstrating further application of transformation strategies in practice.

In the future, the paper will continue to focus on in-depth research into improving public space for elderly residents in old residential areas,strengthening its alignment with actual conditions,and carrying out practical verification to make greater contributions towards enhancing their quality of life. Through ongoing efforts and research, it aims to provide more comprehensive and effective results for improving public space in old residential areas, promote the introduction and implementation of relevant policies,and create a more livable community environment for elderly residents.

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Appendix 1 questionnaire

Age occupation gender Place of Residence					
satisfaction	Very satisfied	satisfied	normal	dissatisfied	Very dissatisfied
How satisfied are you with your current living environment?					
How satisfied are you with the current range of public event Spaces?					
How satisfied are you with the current setup of leisure facilities in public event Spaces?					
How satisfied are you with the current sports facilities in the public event space?					
How satisfied are you with the road smoothness in your current community?					
How satisfied are you with the accessibility of your current community roads?					
How satisfied are you with the current parking arrangements in your community?					
How satisfied are you with the landscaping of your current community?					
How satisfied are you with the lighting on your current floor?					
How satisfied are you with the current conservation of plants in your community?					
What improvements do you propose for traffic roads					

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(pedestrian, bicycle, vehicular, etc.)? What do you think could be improved in your living environment? What amenities or services would you like to add to your living environment?	