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Review

Research on Optimizing the Landscape Environment Design of Aging Communities from an Age-Friendly Perspective

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Abstract: Existing literature on elderly community landscape design primarily focuses on single optimization strategies, lacking systematic review and integration of research findings, and fails to establish a comprehensive yet practical design framework that deeply integrates the concept of age-friendliness with practical implementation. As global populations age rapidly, the demand for supportive living environments becomes increasingly critical to ensure the well-being and quality of life for older adults. This study employs a comprehensive literature review approach to systematically organize relevant research outcomes and integrate them into a holistic optimization framework for community landscape design from an age-friendly perspective. By synthesizing diverse studies, this framework addresses the fragmented shortcomings of current research and bridges the gap between theoretical concepts and practical urban planning. It provides a standardized reference system for subsequent studies, enriches theoretical advancements in age-friendly landscape design, and promotes the field's development toward systematic and standardized progress, holding significant academic value. Furthermore, the proposed design strategies emphasize the creation of accessible outdoor spaces that encourage social interaction, provide opportunities for physical activity, and reinforce feelings of connectivity to one another. Ultimately, this research highlights the necessity of multidisciplinary collaboration in urban design to foster inclusive, sustainable, and resilient communities that cater to the physical and psychological needs of aging populations.

Keywords: age-friendly design; aging communities; landscape design; optimization framework; urban planning

1. Introduction

Current research on elderly-friendly community landscapes primarily focuses on barrier-free standards for the physical environment, adaptive modifications to specific landscape elements, and the enhancement of safety in activity spaces. These studies have accumulated significant knowledge in design and gerontology, yet their perspectives often lean toward technical solutions, simplifying elderly needs into standardized functional checklists. A notable research gap lies in the limited systematic analysis of how various constraints interact under the context of constrained urban renewal, ultimately undermining the overall friendliness of the landscape environment [1]. The lack of exploration into "systemic resistance" and "synergistic mechanisms" hinders the translation of theoretical principles into effective community practices. This review aims to systematically examine and synthesize existing knowledge, clearly revealing the multiple gaps between design concepts and built environments, thereby laying a solid literature foundation for developing more practically interpretable and actionable design optimization strategies.

2. Theoretical Basis and Fundamental Principles of Age-Friendly Design

The Aging-Friendly Design's Practice incorporates ideas from Universal Designs, but it also has a particular emphasis on developing equipment that supports the needs of older

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adults as they age. The Environmental Match theory states that as our bodies age and change, the physical environment should also adapt to meet those different needs. The construction techniques associated with the Environmental Match theory utilize design principles to include the incorporation of additional safety features, such as additional handgrip areas located at various locations throughout a building's ramp, to help reduce the likelihood of falling or accidents occurring on ramps due to older adults using these devices. The Accessibility Principle states that the built environment should have continuous routes that are accessible by all, with sufficient regularly spaced opportunities for rest [1, 2].

3. Practical Challenges in Age-Friendly Renovation of Legacy Community Landscapes

3.1. Insufficient Renovation Funding and Uneven Resource Allocation

Due to the limited availability of funds for renovations, most updates in older communities can only be carried out selectively. Priority is often given to repairing the buildings themselves, leaving minimal or no budget for outdoor landscapes [3]. Consequently, many communities have only managed to level the main roads, while green spaces and activity areas located farther from the community center remain neglected. This uneven allocation of funding has resulted in long-term issues, such as deteriorating pavements and aging facilities. Furthermore, when resources are distributed, the varying degrees of aging across different communities are often overlooked. For instance, some communities with a significant elderly population may not receive the same level of renovation support as others, leading to notable disparities in the quality of public environments. These disparities directly affect the ability of elderly residents to participate in activities and social interactions, further exacerbating the challenges faced by these communities.

3.2. Conflicts between Existing Spatial Structures and Age-Friendly Requirements

Physical features in established communities often hinder the ability of senior citizens to perform their day-to-day activities. Variations in the physical characteristics of older communities, such as inconsistencies in height, stairs without handrails, and damaged or uneven curbs, create challenges for elderly individuals. These conditions increase the likelihood of falls and reduce the ability of seniors to travel independently over longer distances. Additionally, the significant distance between activity destinations can limit access to adequate shelter during adverse weather conditions, such as rain or extreme temperatures [4, 5]. Furthermore, the current design of some communities does not foster an environment conducive to local socialization or outdoor physical activities for seniors. These limitations often result in senior citizens spending a larger portion of their day indoors, rather than engaging in outdoor neighborhood social activities or participating in outdoor exercise.

3.3. Low Elderly Participation and Inadequate Needs Expression

Generally, older adults do not actively participate in current community renewal or housing redevelopment processes by providing feedback or supporting the development process [6]. When reviewing formal design proposals, older adults often struggle to articulate their ideas and instead tend to accept existing information without suggesting changes. Many of their practical needs are rooted in the smaller details of their daily lives, such as their perception of inadequate lighting in specific areas of a room or their preferences regarding the design of the backrest of a chair [7]. Traditional methods of data collection, such as surveys and symposiums, fail to capture these nuanced, detail-oriented perceptions. As a result, the current process excludes a significant amount of relevant input from older adults. Additionally, there is frequently a disconnect between the information conveyed by community workers and the final built environment, which often fails to fully address the evolving needs of the older adult community.

3.4. Incomplete Design Evaluation Systems

Evaluation of current systems is based on one or more quantitative indicators that primarily relate to how well-engineered or accepted buildings meet a given expectation; however, it does not adequately track or evaluate user experiences associated with their physical environment. Evaluation criteria for each type of newly constructed building often reference the normative standard requirements set for the new building, without regard to how these requirements apply to the specific needs and challenges of older buildings, as well as to how they may affect the behavior of senior members of society. For instance, an evaluation may state that the sidewalk material used to build the new sidewalk meets the Anti-Skid Coefficient standard, but fails to address how the elderly might perceive the degree of smoothness of the sidewalk or the height difference between the sidewalk and the road. Although evaluations may include some components of visual inspection after the completion of construction, the primary focus is often limited to a visual inspection done shortly after renovation with little consideration for seasonal variations and daily situations experienced by users, such as insufficient shade during summer or wet/slippery pavement during winter months. Additionally, following the submission of an evaluation report, no closed loop is currently being established to convert user feedback into opportunities for continuous improvement.

3.5. Lack of Community Management and Maintenance Mechanisms

The maintenance of aging community landscapes often stagnates due to insufficient funding and unclear allocation of responsibilities. A one-time renovation investment is inadequate to address the natural wear and tear that occurs over time, such as loosened outdoor seating or partially sunken pavement, which cannot be repaired promptly. Property management or community committees typically focus on basic cleaning and order maintenance, lacking the expertise and budget required for comprehensive upkeep of landscape facilities. Ambiguities in management responsibilities have resulted in issues such as peeling paint in corridors or overgrown plants obstructing views being neglected under various pretexts [8, 9]. The absence of effective maintenance mechanisms undermines the sustainability of newly developed aging-friendly environments and may even lead to safety hazards due to the accumulation of minor defects.

4. Comprehensive Age-Friendly Landscape Design Framework

4.1. Planning Strategies for Resource Coordination and Phased Renovations

To develop an effective strategy for coordinating resources and renovating existing buildings over time, a community's limited fiscal resources, spatial resources, and manpower must be systematically integrated and prioritized. A community can conduct on-site surveys and interviews with residents to identify specific routes frequently used by seniors and pinpoint obstacles that hinder their mobility. This information serves as the basis for determining which routes will receive federal funding first. In the integration of resources, successfully managing the finances and resources required to establish a footpath network necessitates the creation of defined subsidy sources at the street office, a routine property management maintenance budget, and contributions from residents. Additionally, clear oversight responsibilities for funding sources must be established [10]. The implementation process should begin with the creation of a barrier-free walking network, focusing on repairing broken or uneven pavement, improving insufficient lighting, and addressing steep grades leading to entrances. Subsequently, public activity areas should be enhanced with rest benches, railing structures, and low-intensity exercise equipment suitable for seniors. Finally, environmental comfort and a sense of community identification can be fostered through improved building identification.

4.2. Establishing a Multi-Tiered Age-Friendly Landscape Design System

Different types of landscapes provide varying levels of support for seniors at different spatial scales, such as communities, buildings, and entrances. By offering these supports at appropriate levels, seniors' ability to engage in physical activities, such as walking, is enhanced [11, 12]. The overarching goal of the multi-level landscape design

system is to create a seamless pedestrian experience at the community level, ensuring safe walkways and multiple opportunities for rest along the way. Key design principles include the use of non-reflective surface materials, two-sided rails along extended slopes, intermediate rest platforms along slopes, and adequate nighttime lighting to eliminate glare and provide consistent illumination. At the cluster level of buildings, it is crucial to facilitate social interaction among seniors. Seating areas should be arranged to encourage face-to-face interaction and include adjustable shade provided by trees or pergolas. Additionally, seniors should have access to fitness equipment tailored to their physical capabilities. At the entrance level of individual units, micro-spaces should be designed to meet the specific needs of senior residents. Essential elements include footrests at appropriate heights, comfortable and easy-to-grip handrails, clear and legible signage and bulletin boards, and unobstructed passageways with no height differences between entrances and exits. This multi-level landscape design fosters an environment that integrates elements promoting cognitive, physical, and social well-being for seniors.

As illustrated in Figure 1, this system transitions layer by layer from public to semi-public and then to private areas, seamlessly embedding supportive facilities into the daily activity patterns of the elderly.

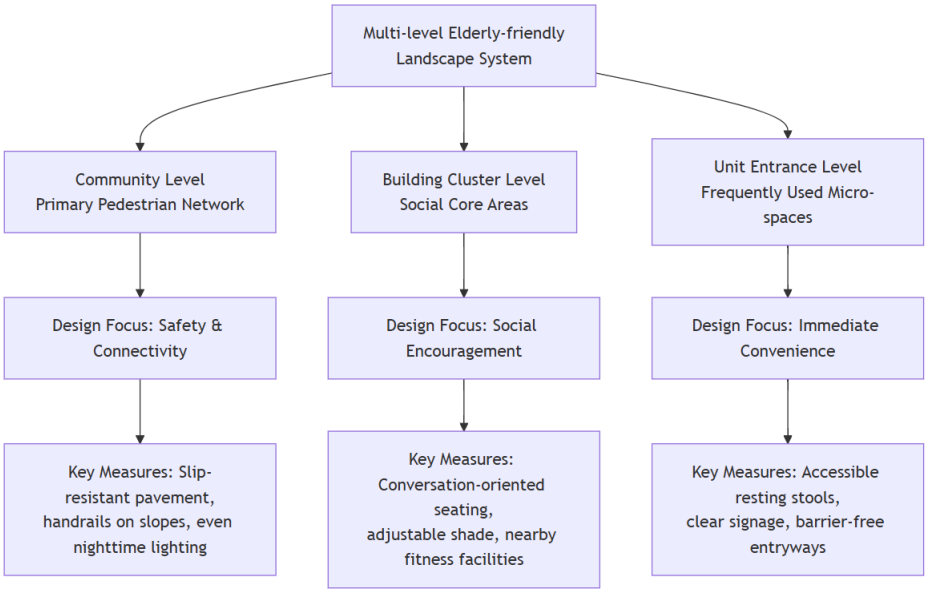

Figure 1. Framework and Key Components of a Multi-level Elderly-friendly Landscape Design System

4.3. Co-Design Methods to Enhance Elderly Participation

A collaborative design process structured to allow older adults the opportunity to participate in the decision-making process includes creating low-threshold and easily understood ways to receive feedback and negotiate with designers. Techniques used to accomplish this include physical models, samples of materials, and clear, visually labeled schematic drawings rather than formalized or professional drawings typically used by designers. The use of these tools enables the older adult population to understand the intentions behind renovations and communicate their preferences effectively [13, 14]. Additionally, designers can create opportunities for older adults to conduct site visits for small-scale inspections and discussions about aspects they find unsatisfactory in their everyday use of the site or unsafe issues regarding particular spaces. The community needs to establish several opportunities for public consultation and briefings for the older adult population about preliminary design proposals. This approach allows the community to collect clear feedback through oral question-and-answer formats and simple voting. For all major design decisions, such as the placement of seating, the type of handrail to use, and the selection of plant varieties, the community should include

representatives from the older adult population in discussions to achieve consensus through informed dialogue. During the implementation phase, the community can continue to build on this embedded and issue-focused involvement by establishing temporary feedback boxes and providing weekly updates on progress through community meetings. The older adult population can share their experiences with designers, who can then incorporate these insights into the design forms, resulting in a design that closely meets the true needs of older adults in built environments.

4.4. Developing Scientific Design Evaluation and Feedback Mechanisms

The aging-friendly landscape renovation program includes a scientific design evaluation and feedback mechanism as an essential component to create a closed-loop management system that will not only be accepted by engineers but also account for the full lifecycle of the project. The baseline assessment involves gathering detailed measurements and conducting interviews on-site to document the current state and inventory of all existing physical assets within the community in terms of accessibility, brightness, and placement of resting areas. Additionally, during the construction phase, there will be a stage called field inspection and adjustment. In this stage, designers and representatives from the community will conduct joint inspections to determine if specific installations align with the habits of older adults when using the finished project and assess whether timely and minor changes are needed at key points in the construction process. Following project completion, the core phase of post-occupancy evaluation will take place. This phase will involve conducting organized site visits in the community with older adults and their caregivers, as well as designers, across all seasons. As part of this evaluation, a combination of observational assessments of behaviors and structured interviews will be used to evaluate the pathway functionality, comfort level, and changes in the spatial vibrancy of the facilities. Figure 2 illustrates the design evaluation and feedback closed-loop management process.

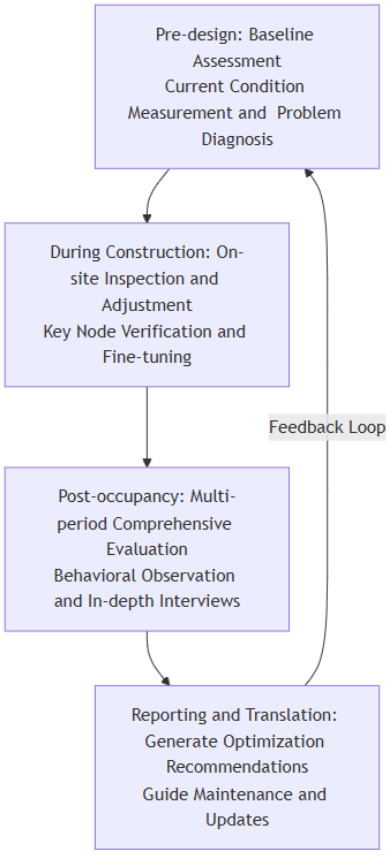

Figure 2. Design evaluation and feedback closed-loop management process diagram

4.5. Integrating Smart Technologies to Improve Landscape Service Efficiency

To enhance the efficiency of landscape services through technology, organizations should prioritize applications that reduce operational costs while addressing safety and convenience concerns, particularly for elderly individuals. For instance, smart lighting systems can be installed in main walking and activity areas, utilizing body detection to provide adequate lighting at night and adjust for glare. Additionally, smart emergency help buttons can be placed in resting areas such as corridors, seating zones, and benches, enabling users to send alerts with precise location information to the community property center. Environmental monitoring sensors can gather real-time data on air quality, noise levels, temperature, and humidity in public spaces, displaying warnings of exceeded standards on community screens or notifying management personnel [15]. Landscape facility maintenance and management can benefit from a QR code repair system, allowing elderly residents to report issues like loose seating or damaged floor tiles by scanning the QR code near the facility and submitting photos of the problem and location with a single click. These low betweenness centrality technological measures collectively create an implicit and efficient support network, significantly improving environmental safety warning capabilities and response times without disrupting the established behavioral habits of elderly individuals.

5. Practical Implementation Pathways and Assurance Recommendations for Optimized Design Strategies

5.1. Establishing Policy Support and Multi-Stakeholder Collaboration Mechanisms

The establishment of policy support and multi-party collaboration mechanisms first requires local governments to issue clear implementation rules for aging-friendly renovation projects, which should include specific subsidy standards and application processes for community public space accessibility renovation, lighting upgrades, and rehabilitation landscape construction [9, 16]. The street supervisory department needs to play a core coordinating role, regularly organizing functional departments such as planning, housing and construction, civil affairs, and community neighborhood committees, property service enterprises, and resident representatives to hold project joint meetings, jointly review design plans, and clarify cooperation responsibilities during the construction period. The collaborative platform can introduce a technical support group composed of university teams or professional social organizations to provide full assistance to the community from demand research to solution demonstration. The government-established list of qualified suppliers and designers can help communities quickly match reliable construction forces, ensuring effective control over the design and engineering quality of renovation projects. This institutionalized and normalized cross-departmental collaboration model provides stable policy support and organizational guarantees for the continuous improvement of the landscape environment in old communities.

5.2. Cultivating Community-Driven Momentum and Sustainable Operation Models

Local communities can empower themselves by transforming passive environmental users into active managers of shared spaces. Community workers should actively identify and support senior citizens who are passionate about contributing to environmental initiatives. These individuals can be encouraged to form environmental discussion groups or gardening clubs and take an active role in proposing and overseeing the maintenance of public areas. To ensure the long-term sustainability of these organizations, a maintenance fund should be established during the planning phase of renovation projects [17]. This fund can be supported through partial government funding, revenue generated from public areas, and voluntary contributions from residents. Property management companies should adopt environmentally friendly practices and offer volunteer or public welfare positions to both young and older individuals with the appropriate skills and motivation. Additionally, organizations should continue hosting community gardening classes and Health and Wellness seminars in public gardens. These initiatives foster a

strong emotional connection between community members and their environment, creating a mutually supportive cycle that enhances both the environment and the community.

5.3. Building Dynamic Evaluation and Adaptive Maintenance Systems

To implement a dynamic evaluation and adaptive maintenance program effectively, clear processes must be established for regularly assessing and updating how the community utilizes the landscape within the neighborhood [18]. The program should involve regular inspections conducted four times per year by a volunteer group comprising both neighbors and community volunteers to evaluate the condition of pedestrian pathways, lighting, and the health and safety of recreational facilities within the neighborhood. In addition to these regular inspections, a comprehensive review will be conducted annually by qualified professionals and neighborhood members. This review will include physical measurements taken during inspections, follow-up interviews with residents who use the facilities, and photographic comparisons between the current and previous year to identify trends in usage. All issues identified during the evaluation process, such as areas where pavement has settled below the intended level, peeling paint on seating surfaces, or insufficient shade from trees in certain areas, must be prioritized based on their urgency for maintenance, repair, replacement, or optimization. Corresponding timeframes and funding sources should also be assigned to address these issues effectively.

6. Conclusion

This paper comprehensively reviews the relevant research findings in the field of community landscape design from an aging-friendly perspective, identifying four key design dimensions: physiological adaptability, humanistic care, community suitability, and long-term maintenance. It clarifies the core connotations and intrinsic connections of each dimension, providing clear directional guidance for optimizing landscape design. Addressing research gaps such as fragmented findings, the lack of unified and actionable integration frameworks, and insufficient alignment between theory and practice, this paper integrates the four key dimensions to establish a comprehensive optimization framework for community landscape design from an aging-friendly perspective. This enhances the theoretical system in the field and offers systematic support for practical implementation. Future research could focus on the differentiated needs of elderly communities across various regions and types, refining the framework's content and design strategies through specific practical cases. Additionally, it could explore the deep integration of long-term maintenance mechanisms with landscape design while continuously monitoring the evolving needs of the elderly population to optimize the design framework. This will promote the in-depth implementation of aging-friendly concepts in community landscapes and provide support for the continuous improvement of elderly care service systems.

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