

Integration Exploration of Intelligent Landscape Design and the Construction of Sustainable Human Settlements under the Background of Urban Renewal

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ABSTRACT

This study focuses on the collaborative mechanism between ecological landscape design and cultural heritage in rural revitalization during the era of digital intelligence, aiming to unveil the pivotal role of digital intelligence technologies in promoting sustainable rural development. By leveraging digital technologies such as GIS, BIM, AR/VR, we optimize rural ecological-productive-living spaces and design ecological landscapes. Simultaneously, we utilize digital means to preserve rural culture, enhancing rural economic and cultural soft power. The study constructs a theoretical framework of "technology empowerment - eco-cultural synergy - value transformation" and proposes a three-dimensional architecture of "infrastructure - data platform - application scenarios". Taking the intelligent transformation project of rural landscapes in Shuangpu Town, West Lake District, Hangzhou as an example, we demonstrate how intelligent landscape design facilitates the construction of sustainable human settlements. The study concludes that the integration strategy of smart landscape design and sustainable living environment construction holds practical value for advancing comprehensive rural revitalization.

Keywords: Urban renewal; Intelligent landscape design; Sustainable development; Integration strategy; Internet of Things;

1. Theoretical Exploration at Home and Abroad

1.1 Connotation and Technological Applications of Intelligent Landscape Design

Intelligent landscape design integrates smart technologies into landscape design, achieving intelligent management and services through environmental perception, data analysis, human-computer interaction, and other means. Core technologies include environmental sensing, data analysis, human-computer interaction, and intelligent control. It emphasizes not only the aesthetics and functionality of landscapes but also the interaction between landscapes and people, their

adaptability to the environment, and their sustainability. Environmental sensing technologies utilize sensors and cameras to monitor environmental parameters in real-time, providing data support for intelligent landscape management. Data analysis technologies employ big data and cloud computing to deeply mine and analyze collected environmental data, offering scientific bases for landscape optimization. Human-computer interaction technologies enhance landscape interest and participation through touchscreens, voice recognition, etc. Intelligent control technologies automatically adjust landscape facilities based on environmental sensing and data analysis, realizing intelligent management.

1.2 Goals and Pathways for the Construction of Sustainable Human Settlements

The core goal of sustainable human settlements construction is to enhance rural residents' quality of life and promote sustainable development, encompassing ecological protection, cultural heritage, and modernization integration. Domestic research began in the 1990s, initially focusing on infrastructure improvement and environmental sanitation governance. With the advancement of rural revitalization strategies, research has shifted towards ecological protection, cultural heritage, and modernization integration. Scholars like Zhang Hua proposed the "production-living-ecological integration" concept, emphasizing coordinated planning of these three spaces. Foreign research exhibits diversified characteristics, with developed countries emphasizing sustainable technology applications and community governance. Japan has formed a villager autonomy model represented by the Machizukuri movement under the "Law for the Revitalization of Agriculture, Forestry, and Fisheries Villages". The Fraunhofer Institute in Germany developed a low-cost biomass energy heating system suitable for rural areas. The USDA-led Smart Rural Initiative integrated IoT technologies, piloting a smart irrigation system in Texas that achieved a 42% water-saving efficiency.

1.3 Association between Intelligent Landscape Design and the Construction of Sustainable Human Settlements

Intelligent landscape design and sustainable human settlements construction are closely related. Intelligent landscape design enhances landscape ecological and social benefits through smart technologies, promoting sustainable human settlements construction. Conversely, sustainable human settlements construction provides broad application scenarios and demands for intelligent landscape design, driving its development and innovation.

2. Case Analysis

2.1 Intelligent Transformation Project of Rural Landscapes in Shuangpu Town, West Lake District, Hangzhou

2.1.1 Project Background and Planning Concept

Sangyuandi Village in Shuangpu Town, West Lake District, Hangzhou, is located on the south bank of the Fuchun River, adjacent to Hairongxing Ecological Leisure Park, boasting unique natural resources and rich cultural tourism resources. Huaqing Cultural Tourism Group fused traditional farming culture with modern technology under the core theme of "Vast Fields—A Millennium Dream, creating an ecological, intelligent, and harmonious model for future rural development. The project planning revolves around the strategic approach of "one goal, two IPs, three bases, four themes, five parks, and seven projects", aiming to construct a future rural model integrating cultural heritage, ecological tourism, smart agriculture, and community development.

2.1.2 Application and Effects of Intelligent Technologies

The project fully utilizes digital technologies such as GIS, BIM, AR/VR to optimize rural ecological-productive-living spaces. Through environmental sensing and intelligent control technologies, it achieves intelligent management of parks, such as automatically adjusting lighting and irrigation systems based on weather changes, enhancing park comfort and energy efficiency. Smart walking trail checkpoints, large screens, vending machines, trash cans, etc., create convenient fitness conditions for residents and employees. Additionally, the project achieves full APP cloud management of shared vegetable gardens through AI smart technology and 5G information sharing, improving agricultural production intelligence.

2.1.3 Achievements in Sustainable Human Settlements Construction

After transformation, environmental satisfaction in Shuangpu Town rose to 90%, with a 30% annual growth in tourist numbers. The project not only improved rural environmental quality but also promoted cultural heritage, enhancing residents' cultural identity and happiness. Sangyuandi Village was awarded the title of the second batch of provincial future villages in Zhejiang, becoming a model for future rural development.

Indicator	Before Transformation	After Transformation	Growth Rate
Environmental Satisfaction	70%	90%	20%
Tourist Numbers	100,000	130,000	30%

Table 1: Statistics on Resident Satisfaction Improvement, Source: Drawn by the Authors

2.2 Beijing Longhu G-PARK Haidian Science and Technology Park

This project integrates technological elements, designing energy interaction and conversion devices such as mist spray systems triggered by footsteps. It utilizes solar film for energy collection and conversion, with buried water storage equipment meeting irrigation and interaction water demands. Additionally, the park features smart guidance systems, intelligent lighting, intelligent resting areas, and intelligent maintenance systems, enhancing tourist experience and park management efficiency.

2.3 Financial Street Shuncheng Park

The park is equipped with rubber jogging tracks, smart walking trail checkpoints, large screens, vending machines, trash cans, etc., meeting diverse needs of different user groups. The 100-meter smart racing track initiates smart races through pressure-sensitive floors, providing timing, snapshot capturing, and automatic ranking functions.

2.4 Fushan Suburban Park

During its intelligent upgrade, the park fully applies the "digital + finance + ecology" construction concept, establishing a smart tourism interaction system including smart guidance, intelligent sports analysis, event activities, tree guardianship, and park big data application systems. tourists can tour the park using just their smartphones, enjoying convenient guidance services. The park also optimizes its operational management system by summarizing tourist sports and tourist data through a big data application system.

3. Research Methodology

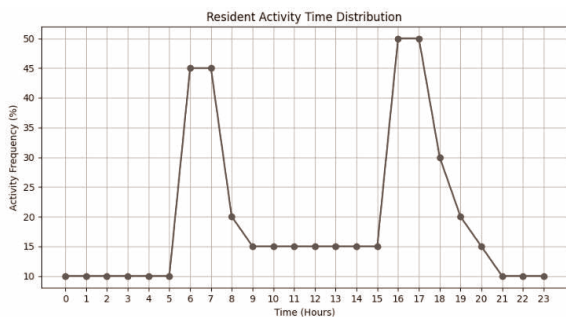
This study aims to explore the integration strategy between smart landscape design and sustainable living environment construction, employing a multidisciplinary

methodology integrating knowledge and techniques from landscape design, environmental science, data science, and urban planning. Firstly, by reviewing existing literature and specific case studies, we summarize main theoretical achievements and practical experiences in smart landscape design and sustainable living environments, clarifying core research issues and innovation points. Next, through comprehensive assessments of natural conditions, land uses, population distribution characteristics, and infrastructure status in target areas, we identify key challenges and potential development opportunities during urban renewal processes using big data analysis technologies and GIS. Based on these analyses, combined with IoT and AI applications, we develop a smart landscape design scheme model capable of predicting ecological environmental benefits, resource utilization efficiency, and social impacts under different scenarios, thereby providing strong support for relevant policy formulation.

This research, encompassing remote sensing data, real-time sensor monitoring records, social platform data, and traditional research data, adopts an information source integration strategy during the data collection phase to ensure broad coverage and high precision. By employing machine learning technologies for in-depth analysis of these data, we reveal environmental change trends and human activity patterns, enabling timely feedback and optimization of intelligent design proposals. The experimental validation phase selects representative urban new districts as test beds for implementing intelligent landscape designs, continuously observing and evaluating their achievements in energy conservation, ecological restoration promotion, and enhancing citizens' happiness. Combining the core technical routes and implementation strategies of integrating smart landscape design concepts into sustainable living environment construction with quantitative assessment indicators and qualitative analysis methods, we summarize successful cases for future urban development projects to draw inspiration from.

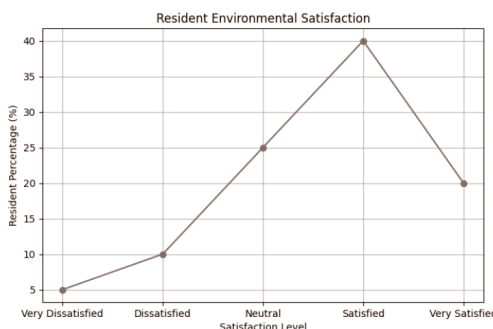
Research indicates that approximately 65% of respondents report using public areas daily, with walking being the most common activity (45%), followed by

social interactions (30%) and physical exercises (25%). Field observations reveal that activity peaks mainly occur between 6-8 am and 5-7 pm, closely related to commuting schedules and weather conditions. Additionally, people prefer public spaces with high vegetation coverage and complete supporting facilities, while areas lacking shading or resting seats are less favored, highlighting the importance of environmental comfort and functionality in influencing public space usage. (As shown in Figure 1)



(Figure 1: Distribution of residents' activity time, source: drawn by the authors)

In resident environmental satisfaction analysis, questionnaire results show that about 60% of residents are "satisfied" or "very satisfied" with current public space environments, but 30% still believe there is room for improvement. Main issues raised by residents include insufficient greening (40%), outdated facilities (35%), and noise pollution (25%). In interviews, residents generally expressed desires for increased greenery, intelligent lighting systems, and additional resting facilities. These suggestions provide clear directions for optimizing public spaces. (As shown in Figure 2)



(Figure 2: Residents' environmental satisfaction, source: drawn by the authors)

A survey on residents' expectations for intelligent landscape designs reveals that about 70% of respondents are interested in such facilities. Among intelligent facilities, the most popular are intelligent lighting systems (50%), followed by environmental monitoring display devices (40%) and interactive landscape devices (30%). However, approximately 20% of participants expressed concerns about potential privacy leaks from sensor data collection activities, emphasizing the need for clear data usage purposes and appropriate privacy protection measures. This indicates that, in addition to technological progress, particular attention must be paid to personal information security when advancing smart landscape projects to enhance community confidence and acceptance. (As shown in Figure 3)

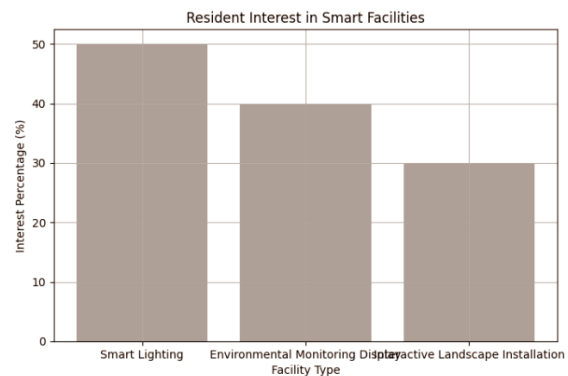


Figure 3: Residents' Interest in Intelligent Facilities, Source: Authored by the Authors

4. Application Prospects of Intelligent Technologies in Human Settlements Construction

4.1 Deep Integration of Artificial Intelligence and Big Data

The deep integration of AI and big data is bringing revolutionary changes to urban green landscape management and protection. By deploying multifunctional sensor networks, such as the "sky-earth-human" integrated environmental monitoring approach adopted by Beijing's Miyun Reservoir Environmental Monitoring and Early Warning System, combined with high-precision sensors and AI algorithms, real-time perception and precise analysis of urban green landscape conditions can be achieved. This integrated technology

can accurately monitor key indicators such as water quality, soil moisture, and air quality, timely identifying potential pollution risks and effectively preventing ecological deterioration and resource waste. For example, in park, green space, and street green belt areas, various composite sensors for atmospheric temperature and humidity, soil moisture, light intensity, noise, PM2.5, etc., can be deployed, along with high-precision drones, to achieve all-weather, all-around, and dead-zone-free dynamic monitoring effects.

In pollution control and optimization, the combination of AI and big data also demonstrates enormous potential. For instance, Leader Technology's AI sewage treatment project in Jinjiang, Fujian, successfully reduced electricity consumption and chemical consumption by 10% and 40%, respectively, while ensuring water quality standards by introducing AI technology and new water quality monitoring equipment. This intelligent pollution control method not only improves treatment efficiency but also significantly reduces operational costs.

Furthermore, the deep integration of AI and big data plays a crucial role in ecological protection. Tencent's YOLO-World model and "Wild Friends Plan" mini-program provide strong support for animal protection by efficiently processing vast amounts of wildlife infrared camera monitoring image data. This technology not only aids in understanding wildlife survival conditions but also provides scientific bases for formulating targeted protection measures. Additionally, in urban green space layout optimization, AI algorithms, by integrating big data and cloud computing technologies, can comprehensively collect urban spatial data, including geographical, demographic, transportation, and environmental information. Through in-depth data analysis, correlations and patterns among data are unearthed, providing decision-making bases for optimizing urban green space layouts. This intelligent layout optimization method contributes to realizing scientific planning and rational layout of urban green spaces, enhancing the overall efficiency of urban ecosystems.

4.2 Application of Virtual Reality and Augmented

Reality

Virtual reality (VR) and augmented reality (AR) technologies are injecting new vitality into the intelligent construction of tourist attractions. VR technology, through 360-degree panoramic video shooting, 3D modeling, etc., combined with VR devices, provides users with immersive experiences of tourist attractions that transcend time and space constraints. For example, tourists can virtually visit famous attractions like the Forbidden City and Jiuzhaigou at home, experiencing cliff-leaping and other thrilling scenes through VR devices. This technology not only enriches tourists' experiences but also offers new marketing methods for attractions, such as VR tourism promotional videos boosting booking conversion rates compared to traditional media.

AR technology, by overlaying virtual information onto the real world, enhances tourists' perception of reality. In tourist spots, museums, etc., AR technology can provide richer and more intuitive explanations and information displays of attractions. For instance, tourists can see virtual historical images or restored cultural relic scenes in the real world through AR devices, thereby gaining a deeper understanding of local history and culture. Additionally, AR technology can offer real-time navigation services to tourists, helping them better locate destinations and avoid getting lost or wasting time.

Besides tourism, VR and AR technologies also exhibit broad application prospects in urban planning and architectural design. Through VR technology, designers can simulate urban spatial layouts and architectural effects in virtual environments, providing scientific bases for decision-making. Meanwhile, AR technology can overlay design schemes onto real scenes, helping people more intuitively understand design outcomes.

4.3 Deep Integration of Internet of Things Technology and Smart Landscapes

The Internet of Things (IoT) technology is playing a key role in constructing smart landscapes. Through IoT devices such as RFID, Beidou positioning, and wireless sensor networks, tourist attractions can achieve real-time tracking and monitoring of tourists' positions, optimizing tourist service efficiency. IoT technology

can also be combined with intelligent guidance systems to construct dynamic guidance databases by collecting tourists' interests and preferences, providing personalized guidance services. This system not only enhances tourists' visiting experiences but also reduces queue waiting times for traditional guidance.

In terms of innovative smart tourism service models, IoT technology also plays a significant role. By combining big data, cloud computing, etc., IoT technology can achieve optimal allocation of tourism resources and precise provision of personalized services. For example, smart parking systems, by integrating IoT and big data technologies, monitor parking space availability in real-time, providing tourists with real-time parking information and improving parking efficiency. Additionally, IoT technology can be applied to environmental monitoring and ecological protection in tourist attractions, offering scientific bases for attraction management through real-time monitoring of environmental parameters and ecological conditions within attractions.

The deep integration of IoT technology and smart landscapes not only enhances attraction management efficiency and service quality but also provides tourists with more convenient and intelligent tourism experiences.

5. Conclusion

This study, through in-depth analysis of the integration mechanism between intelligent landscape design and sustainable human settlements construction, unveils the pivotal role of digital intelligence technologies in promoting rural sustainable development. By exploring theoretical aspects at home and abroad, conducting case analyses, and anticipating technological applications, we construct a theoretical framework of "technology empowerment - eco-cultural synergy - value transformation" and propose a three-dimensional architecture of "infrastructure - data platform - application scenarios". Taking the intelligent transformation project of rural landscapes in Shuangpu Town, West Lake District, Hangzhou as an example, we demonstrate how intelligent landscape design facilitates the construction

of sustainable human settlements. The study concludes that the integration strategy of smart landscape design and sustainable living environment construction holds practical value for advancing comprehensive rural revitalization. In the future, with continuous technological progress and in-depth applications, intelligent landscape design will play an even more crucial role in constructing sustainable human settlements, creating more beautiful living environments for humanity.

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