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SMART CITY APPLICATIONS AND THE ROLE OF LANDSCAPE DESIGN IN MASS HOUSING: THE FUTURE OF URBAN LIFE

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Abstract

The rapid technological advancements of the 21st century have significantly transformed urban governance. Smart city frameworks have introduced innovative solutions in urban planning, mobility, energy management, and sustainability. Beyond technological infrastructure, smart cities also require ecological integration, inclusive design, and sustainable landscape strategies. This study investigates the role of landscape architecture in smart city applications within the context of mass housing developments. Through a comparative case study analysis of the Schoonschip Project in Amsterdam and the Kepez-Santral Urban Transformation Project in Antalya, the research explores how different ecological and technological strategies contribute to environmental performance, livability, and social cohesion. The findings reveal that landscape design plays a central role in the success of smart city initiatives by facilitating rainwater management, climate regulation, and inclusive public space creation. While Schoonschip exemplifies micro-scale, water-based smart systems, Kepez-Santral demonstrates the macro-scale integration of green infrastructure in rapidly urbanizing regions. The study concludes that hybrid approaches combining circular resource management with large-scale ecological planning are essential for the future of mass housing in Türkiye.

Keywords: Smart cities, Smart urban planning, Mass housing, Sustainable landscape design, Green infrastructure

AKILLI ŞEHİR UYGULAMALARI VE TOPLU KONUTLARDA PEYZAJ TASARIMININ ROLÜ: KENT YAŞAMININ GELECEĞİ

Özet

21. Yüzyılda hızlı teknolojik gelişmeler, kentsel yönetim biçimlerini önemli ölçüde dönüştürmüştür. Akıllı şehir çerçeveleri; kentsel planlama, ulaşım, enerji yönetimi ve sürdürülebilirlik alanlarında yenilikçi çözümler sunmaktadır. Ancak akıllı şehirler yalnızca teknolojik altyapıyla sınırlı kalmamalı; ekolojik bütünlük, kapsayıcı tasarım ve sürdürülebilir peyzaj stratejilerini de içermelidir. Bu çalışma, toplu konut gelişmeleri bağlamında akıllı şehir uygulamalarında peyzaj mimarlığının rolünü araştırmaktadır. Amsterdam'daki Schoonschip Projesi ile Antalya'daki Kepez-Santral Kentsel Dönüşüm Projesi'nin karşılaştırmalı vaka çalışması yoluyla analiz edildiği araştırmada, farklı ekolojik ve teknolojik stratejilerin çevresel performans, yaşanabilirlik ve toplumsal bütünleşmeye katkısı ele alınmıştır. Bulgular, yağmur suyu yönetimi, iklim düzenlemesi ve kapsayıcı kamusal alanların oluşturulması gibi unsurlarda peyzaj tasarımının akıllı şehir projelerinin başarısında merkezi bir rol oynadığını ortaya koymaktadır. Schoonschip mikro ölçekte, su temelli akıllı sistemleriyle öne çıkarken; Kepez-Santral, hızla kentleşen bölgelerde yeşil altyapının makro düzeyde entegrasyonuna örnek teşkil etmektedir. Çalışma, Türkiye'deki geleceğin toplu konut projeleri için döngüsel kaynak yönetimiyle büyük ölçekli ekolojik planlamayı birleştiren hibrit yaklaşımların gerekliliğini vurgulamaktadır.

Anahtar sözcükler: *Akıllı kentler, Akıllı kentsel planlama, Toplu konut, Sürdürülebilir Peyzaj tasarımı, Yeşil altyapı*

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1. Introduction

The increase in population has led to the rapid growth and development of today's cities. At this stage, with the increase in resource use, new, contemporary cities emerge using technological innovations to ensure environmental sustainability. The concept of a smart city arises from this; data analytics, the Internet of Things (IoT), Web3, artificial intelligence (AI), 5G communication technologies, and smart infrastructures are restructuring the city administration by increasing sustainability and general livability. These projects now require not only the provision of adequate housing infrastructure but also the creation of supportive social and ecological environments.

In these transformations, the role of landscape architecture increases even more, and it further increases ecological resilience with the environmental impacts of sustainable, well-designed green infrastructure beyond aesthetics in landscape designs within the scope of the city. Although urban designs are concepts that include spatial designs, each has its own components, emotions and aesthetics (Uzunali and Acar, 2023).

The ability of the urban landscape to adapt to the changing human culture is extremely important for its continuity (Zeybek, 2019). A smart city is an urban area that leverages information and communication technology (ICT) to improve the quality of life of its residents while promoting sustainability and efficient resource use. This concept encompasses innovative activities aimed at improving urban infrastructure, public services, and environmental sustainability through the integration of advanced technologies, especially artificial intelligence (AI) (Waheeb and Wheib, 2025; Suryawanshi et al., 2025; Ruíz-Vanoye et al., 2024).

The integration of smart city concepts with green infrastructure, especially blue-green infrastructure (BGI), is crucial for sustainable urban development. BGI improves the livability of cities by helping to reduce excess heat generated by urban flooding and construction (Pradyumna and Hegde, 2024). It combines water management and vegetation to increase urban resilience and biodiversity, while smart technologies, including machine learning, optimize these systems for better decision-making and resource management. This integration not only addresses environmental challenges but also aims to optimize the conditions of urban life.

Web 3.0 and artificial intelligence (AI) are important technologies that work integrated into the smart urbanization process. Web 3.0 technology provides data security while providing a centralized internet infrastructure. Artificial intelligence technology, on the contrary, connects them to a system for big data analysis and automated decision-making, which can raise concerns about data security. With Web 3.0, the Internet of Things has become possible. The Internet of Things (IoT) is an ecosystem of technologies that enables physical devices to collect and share data by connecting to the internet. IoT sensors in smart cities have a wide range of uses, from smart lighting that increases energy efficiency to sensor-supported systems that reduce traffic density. Management systems can be developed by combining the data obtained. For this, data must be processed, analyzed, and interpreted. Artificial neural networks (ANN) are the most important technologies in the field of data management of smart cities. With big data analysis and machine learning, it analyzes the behavior of users and produces solutions to adapt to environmental conditions, and these systems are used for solutions in many areas such as energy consumption optimizations and environmental analysis. (Chen and Xiao, 2024).

In this context, the purpose of the study and the research questions determined according to the relevant literature are given below:

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1. What role do smart city applications play in mass housing projects?
2. How do green infrastructure and sustainable landscape design make a difference in smart city applications?
3. How do the landscape design strategies implemented in these projects affect the quality of urban life?
4. What innovative approaches can be adopted for landscape design in mass housing projects in Türkiye?

2. Material and Methods

2.1. Material

The material of the research consists of two selected mass housing projects, the Schoonschip Project in Amsterdam, the Netherlands, and the Kepez-Santral Urban Transformation Project in Antalya, Türkiye. These projects were selected because they are related to smart city strategies and sustainable landscape design. Project websites and peer-reviewed academic publications related to both projects were used as primary information sources in the study. To examine how smart city applications are integrated with landscape architecture in mass housing projects and in this context, the landscape design approaches in both projects were evaluated in the context of sustainability applications and smart city technologies.

2.2. Methods

The study adopts a qualitative, comparative case study approach to examine the integration of smart city applications with landscape architecture in mass housing projects. As defined by the Landscape Architecture Foundation (1999), the case study method allows for an in-depth study of implemented projects through contextual analysis and provides insights into the planning, design and implementation processes.

The data collection process was carried out through a review of publicly available sources, including official project websites and peer-reviewed academic publications. The two selected cases Schoonschip in Amsterdam and Kepez-Santral in Antalya are examined within the scope of the established criteria regarding smart city strategies, green infrastructure, ecological resilience, spatial inclusiveness and sustainability-oriented landscape design.

The analysis follows a thematic content analysis framework focusing on three main dimensions:

Technological integration: The extent to which smart systems (e.g. energy management, mobility solutions) are embedded in projects.

Sustainability and ecological performance: The role of landscape design in promoting environmental quality, water management and climate sensitivity.

Social and spatial impact: The contribution of public open spaces and inclusive design to community well-being and urban livability.

Through cross-case comparison, the study identifies recurring patterns, design principles and challenges associated with the implementation of smart urban strategies in landscape-based public housing projects. This methodological approach supports a critical understanding of how landscape architecture can shape future-proof, resilient urban environments.

These methods were designed in alignment with the main research questions posed in the study. Each analytical dimension, technological integration, ecological performance, and spatial impact corresponds to one or more of the research questions. This structure enables a coherent evaluation of how smart city principles intersect with sustainable landscape design in mass housing projects, particularly within the contexts of the Schoonschip and Kepez-Santral cases.

3. Findings

The Schoonschip Project, one of the mass housing areas designated as the research area, is located on the Johan van Hasselt Canal in the northern region of Amsterdam, the capital of the

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Netherlands. It is one of Amsterdam's pioneering initiatives towards sustainable living solutions on water (Figure 1).

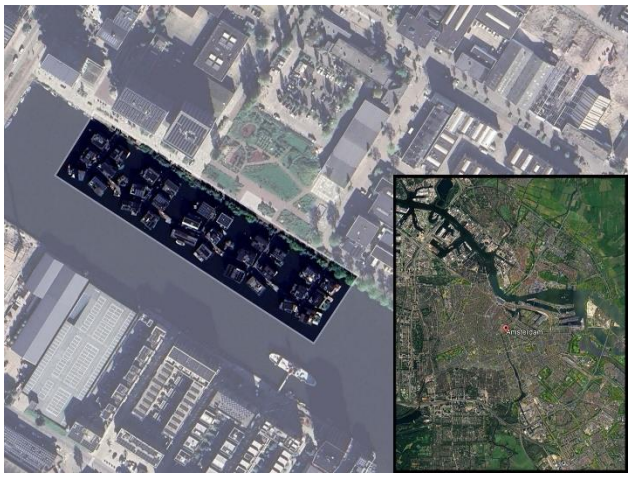

Figure 1. Schoonschip Project location (Google Earth, 2025)

Schoonschip is a public housing project located in the northern area of Amsterdam and consists of sustainable, floating housing. The project emphasizes the use of renewable energy, smart water management, and ecological landscape design. It is particularly notable for its innovative architectural approach, which integrates renewable energy systems, promotes the efficient use of water resources, and supports the creation of ecological habitats, and is also designed to minimize the carbon footprint and offers an environmentally friendly living space as an alternative to dense construction in the city (Chen, 2022) (Figure 2).

Figure 2. Schoonschip Project (schoonschipamsterdam.org, 2020)

Schoonschip is considered an innovative project due to its integration of floating housing units with decentralized renewable energy systems, closed-loop water management strategies, and landscape interventions that reconnect urban form with natural hydrological processes. It consists of a harmonious sequence of water bodies that enhances the spatial character of the landscape by emphasizing the relationship between boezem and polder waters. At the same time, it allows water forms to be integrated into the urban fabric both functionally and aesthetically. The design promotes biodiversity by combining existing ecosystems and paving the way for new nature developments, in line with the principles of a holistic smart city that values both social and ecological processes, as well as encouraging community participation through flexible and open designs, conducive to a variety of uses within the landscape (Bobbink, 2016).

Schoonschip uses solar panels, heat pumps, and smart energy management systems to meet the region's energy needs entirely from renewable sources. In addition, water collection and treatment systems contribute to sustainable water management by ensuring the reuse of rainwater and greywater. The project also plays a key role within the scope of sustainability with green roofs that support biodiversity, materials that do not harm the aquatic ecosystem, and landscape designs in harmony with nature (Malnoury, 2023).

It is in the Mediterranean Region of Türkiye, which is another area examined by the study, in the Kepez district of Antalya province. The area, which includes the Kepez and Santral neighborhoods, is located northwest of the center of Antalya (Figure 3).

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Figure 3. Antalya Kepez-Santral Urban Transformation Project location (Google Earth, 2025)

The Kepez-Santral Urban Transformation Project is one of the largest urban transformation projects in Türkiye and has been designed in accordance with sustainable and smart city principles. At the same time, it aimed to ensure environmental sustainability, improve the quality of urban life, and create modern mass housing areas. Green infrastructure solutions are distinguished from existing constructions with energy-efficient building designs and smart city technologies.

When the transformation project is examined, an area has been created where city residents can live together without breaking away from nature, with large parks, green corridors, and pedestrian-friendly recreation areas. Within the scope of sustainability, the resource use of the region has been brought under control thanks to solar energy panels, smart irrigation systems, and water management applications. In addition, plant selections make significant contributions to sustainability thanks to landscape designs that ensure the preservation of ecological balance and green areas that improve the urban microclimate (Mansuroğlu et al., 2018) (Figure 4).

Figure 4. Antalya Kepez-Power Plant Urban Transformation Project (ankahaber.net, 2024)

3.1. What Role Do Smart City Applications Play in Mass Housing Projects?

Smart city applications increase sustainability and quality of life by combining innovative technologies and problem-oriented solutions in mass housing projects. A sustainable quality of life can be targeted by adapting innovative technologies to cities. The Schoonschip project uses smart city technologies on a small scale with high impact. Solar panels in every household create a circular system by optimizing water and waste management while providing energy efficiency with smart grid systems. In the Kepez-Santral project, it shows large-scale effects with smart technologies. With the sensors in the buildings, it saves water and energy and controls the use of resources. While using technology in a community-oriented and alternating manner, Schoonschip focused on large-scale infrastructure solutions in the Kepez power plant project. Both projects use smart city technologies efficiently at different scales.

3.2. How Do Green Infrastructure and Sustainable Landscape Design Make a Difference in Smart City Applications?

In the Schoonschip project, the system is based on water, and with the green roofs and floating gardens in the buildings, it also supports biodiversity while using rainwater, thus reducing the risk of flooding and flooding, while reducing the heat island effect. While providing efficiency

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in resources with water source heat pumps and wastewater management, it also reduces its carbon footprint to low levels. In the Kepez-Santral project, thanks to the green corridors and large parks in the terrestrial context, it contributes to the ecological balance with the plant selections used while increasing the air quality. It limits water consumption with smart irrigation systems. While Schoonschip aims to increase environmental benefit by integrating green infrastructure with the water ecosystem, it creates green areas with a more traditional approach in the Kepez-Santral project, but the circular approach of the Schoonschip project is more innovative.

3.3. How Do the Landscape Design Strategies Implemented in These Projects Affect the Quality of Urban Life?

Thanks to the green roofs and smart scaffolds that are commonly used in the Schoonschip project, the interaction between residents increases and strengthens harmony with nature. While it provides economic and psychological benefits for residents with food production in roof gardens, it increases thermal comfort and quality of life with well-insulated structures on the water. While the recreation and socialization needs of the population are met with the large-scale green areas, walking paths, and social areas in the Kepez-Santral project, it also reduces air pollution with sustainable, nature-friendly landscape designs and encourages the physical activities of individuals. Schoonschip emphasizes individual well-being while adopting a community-oriented lifestyle, while in the Kepez-Santral project, it focused on designs whose landscape appeals to the crowded population.

3.4. What Innovative Approaches to Landscape Design Can Be Adopted in Mass Housing Projects in Türkiye?

When examined in two projects, innovative approaches can be developed for Türkiye's mass housing projects; the circular water system created by using the gray water used in the Schoonschip project in irrigation and collecting rainwater can be an effective solution to water scarcity in our country. At the same time, rooftop gardens and vertical greening can contribute to food sources while increasing thermal comfort. While the wide green corridors in the Kepez-Santral project can be enriched with local plant species and improve the urban texture, they can serve as a bridge between the city and nature thanks to the correct use of green areas. Efficiency can be increased with smart irrigation and monitoring systems, which are a part of smart cities, as well as the preservation of cultural identity can be ensured by combining traditional Turkish garden style with modern innovative techniques.

4. Conclusion and Discussion

This study sets out to examine how smart city principles are integrated into mass housing developments through sustainable landscape design. By analyzing the Schoonschip Project in Amsterdam and the Kepez-Santral Urban Transformation Project in Antalya, it addressed four central research questions concerning the role of smart technologies, the function of green infrastructure, impacts on urban quality of life, and innovative landscape strategies suitable for Türkiye.

The analysis confirmed that both projects, despite differing in scale and ecological focus (water-based versus land-based), demonstrate how landscape architecture is essential in realizing the core objectives of smart cities, namely sustainability, livability, and ecological resilience. This aligns with recent literature asserting that smart urban development must include nature-based solutions to enhance climate adaptation and social inclusion (Pradyumna and Hegde, 2024; Waheeb and Wheib, 2025).

In terms of the first research question, both projects illustrate that smart city applications play a pivotal role in improving resource efficiency and environmental performance in mass

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housing. Schoonschip's decentralized energy systems and circular water reuse mechanisms exemplify high-impact micro-scale smart technologies (Chen, 2022). Meanwhile, Kepez-Santral demonstrates how macro-scale smart systems such as smart irrigation and building-integrated sensors can address the needs of rapidly urbanizing regions while fostering social equity.

For the second question, the findings support that green infrastructure, when integrated with smart technologies, significantly enhances ecological performance. In Schoonschip, green roofs and floating gardens contribute to flood mitigation, biodiversity, and thermal regulation, while Kepez-Santral's wide green corridors and vegetation strategies mitigate heat island effects and improve air quality. These insights are consistent with Bobbink (2016), who emphasizes the importance of hydrological integration in urban landscapes.

Regarding the third question on urban life quality, the projects indicate that landscape design influences both individual well-being and community cohesion. In Schoonschip, shared open spaces, rooftop gardens, and energy autonomy strengthen social ties and local identity. In contrast, Kepez-Santral enhances accessibility, public health, and recreational opportunities at a larger scale fulfilling the need for inclusivity and livable public space in dense urban environments (Mansuroğlu et al., 2018).

Addressing the fourth question, the study suggests that a hybrid design approach could be highly effective in future Turkish housing projects. Türkiye's climatic diversity and seismic conditions require flexible, context-specific design strategies. Combining Schoonschip's circular ecological systems with Kepez-Santral's broad-scale green infrastructure can yield smart housing models that are both technologically advanced and socially grounded.

However, several challenges must be acknowledged. The implementation of smart systems, including Web 3.0, IoT, and AI, often requires substantial financial resources and robust data infrastructures. These requirements can be prohibitive, particularly for smaller municipalities. Additionally, concerns about data privacy and security remain unresolved, particularly in centralized data architectures (Chen and Xiao, 2024). Ensuring that technological innovation does not compromise user anonymity or civil liberties is a critical future task, especially as digital literacy increases and more citizens engage in participatory urban governance.

In conclusion, the integration of landscape architecture with smart city technologies is not only beneficial but essential for the creation of resilient, inclusive, and sustainable mass housing developments. Future planning efforts in Türkiye should prioritize hybrid models that blend ecological intelligence with digital innovation, thereby positioning landscape architects as strategic actors in smart urban transformation.

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