

Sustainable Community Transformation and Planning Based on Community Layout and Low Impact Development Concept

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Abstract. The Sustainable Cities and Communities emphasized in the United Nations Sustainable Development Goals are cities and residential communities that prioritize inclusivity, safety, and resilience against disaster risks. China's urbanization process has embarked on a trajectory of rapid development, characterized by substantial advancements in urban construction and continuous enhancements to the urban landscape and environment. Confronted with an immense urban population scale, the sustainable transformation of traditional communities has emerged as the primary focus for establishing resilient communities. This paper compares the disparities between communities established by the traditional community model and sustainable community concept, scrutinizes the limitations of traditional community models, and proposes strategies for the sustainable transformation of traditional communities through adopting low impact development concepts in rainwater management. For the "block" layout, this paper proposes enhancing the connectivity of green spaces and promoting diversity. For the "central" layout, it is recommended to optimize access roads, including pedestrian and vehicle routes, by integrating green spaces. In the case of an "intensive" layout, emphasis should be placed on improving resource utilization efficiency through multi-functional approaches. For the planning of new sustainable communities, this paper puts forward suggestions from the micro and macro planning levels.

Keywords: Low Impact Design; Sustainable Community; Urban Planning; Community Planning.

1. Introduction

The concept of *community* in China refers to a fixed geographical area where individuals consider their living environment as the primary entity, engage in social activities, and establish social norms. It functions as an administrative unit at the same level as administrative villages, with apartment complexes serving as its fundamental building blocks [1]. The transformation of the community, therefore, entails the transformation of individual apartment complexes. The primary focus in the design of traditional residential areas is to optimize resident capacity, with limited attention given to the planning and design of corresponding supporting landscape facilities [2]. With the advancement of the economy, the majority of urban environments created by traditional community models exhibit limited supporting facilities and lack adequate infrastructure to address the escalating risks posed by natural disasters. Consequently, residents' lives and properties are continuously jeopardized. [3].

In 2015, the United Nations proposed Sustainable Development Goals (SDG), with sustainable cities and communities being identified as one of the crucial targets for transformation [4]. Compared to traditional communities, sustainable communities prioritize multi-functional considerations encompassing inclusive community infrastructure, ecologically friendly environments, socially harmonious atmospheres, safe living conditions, and resilience against natural disaster risks - all of which represent the core objectives pursued by sustainable communities [4].

In the context of Sponge City, which share similarities with urban resilience in sustainable communities, low impact development is a rainwater management approach widely adopted by numerous countries. It is based on simulating natural hydrological conditions to achieve pollution control and recycling of runoff generated by rainfall and floods through small-scale source control. The utilization of rainwater purification and disposal technology presents significant advantages in addressing urban surface runoff treatment, rainwater collection, rainwater purification, rainwater infiltration, and water recycling. Implementing low impact development not only facilitates the accumulation of rainwater resources to a certain extent and contributes to water conservation in urban

areas but also enhances the aesthetic appeal of the urban environment [5]. Moreover, it improves flood detention capacity and disaster reduction capabilities within cities, thus becoming an integral component of the urban landscape [5].

Hence, this study analyses and compares the planning and layout of traditional and sustainable communities using the low impact development model. Furthermore, it explores the potential application of low impact development in facilitating the sustainable transformation and planning enhancement of traditional communities while offering corresponding recommendations for future reference.

2. Traditional Apartment Complex Layout

With the continuous advancement of social progress and housing system reform in China, people's demands for residential environment concepts, life philosophies, and daily behaviors are inevitably subject to constant updates, reflecting the intricacies of keeping up with the times and accommodating diverse needs.

In terms of current apartment complex development in China, three main forms of residential building distribution layout in traditional apartment complex planning can be identified: "block", "central", and "intensive" layout, and each showcases distinct characteristics.

2.1. "Block" Layout

The residential buildings in the "block" layout exhibit a high degree of consistency in terms of scale, shape, orientation, and other relevant aspects. Rather than emphasizing the building hierarchy, these buildings are arranged in rows, clusters, and groups based on optimal sunlight exposure intervals. This results in the formation of a closely-knit apartment complex that lacks adequate space divisions and variety. This residential building distribution layout exhibits distinct grid characteristics, with roads following either a grid or tree-like configuration.

In residential areas where the "block" layout and its derivative layouts are the primary distribution modes of residential buildings, although there are dedicated green spaces for residential buildings, these green spaces remain relatively independent. The road network resulting from the "block" layout exacerbates the perceived distance between green spaces, diminishing their interconnectedness. Scattered and isolated distribution of green spaces makes it difficult to meet residents' needs for viewing and activities, fostering a sense of separation among neighbors and reducing environmental affinity. Furthermore, the dense road network contributes to spatial monotony, leading to an overall decline in residential quality and resident satisfaction.

2.2. "Central" Layout

The "central" layout is distinguished by multiple concentric circles of varying sizes that emphasize their centers, typically featuring natural vistas with special significance or locations capable of providing high-value functions or embellishments as focal points, radiating outward to establish primary and secondary spatial relationships. In the "central" layout, residential buildings and road networks are both circular concentric circles nested within each other, with secondary roads connecting the residential buildings while being separated from the main circular road.

The "central" layout is commonly utilized in mountainous regions, where the natural topography of the ring road network is considered to establish a centripetal spatial arrangement. This residential design prioritizes optimal sunlight exposure, ventilation conditions, and expansive vistas by aligning with contour lines along the ring road network or vertically orienting residences along contour lines for a slightly radiating effect at the expense of narrower sightlines.

In contrast to the "block" layout, the "central" layout exhibits coherency and a larger spatial extent. However, when integrated with the ring road network, this arrangement tends to excessively centralize resources, thereby diminishing resident-resource accessibility. For instance, if the public green space for outdoor activities is situated on one side of the ring road network or high elevation,

residents residing on the opposite side or low elevation would need to traverse a greater distance compared to their counterparts, resulting in inconvenience, particularly for elderly individuals who heavily rely on such spaces for neighborhood engagement.

Furthermore, the planning of circulation often integrates vehicle traffic and pedestrian traffic, thereby significantly augmenting the risks associated with residents' travel. Simultaneously, the convergence of traffic exacerbates issues such as surface water accumulation and drainage overflow caused by rainfall, profoundly impacting the quality of residents' transportation and daily life.

2.3. "Intensive" Layout

The residential areas with an "intensive" layout are constrained by limited available land, often resulting in a compromise on green spaces to accommodate housing needs. To maintain the floor area ratio, residential and public facilities are typically arranged compactly, with efforts made to utilize underground space or construct taller buildings. Consequently, the layout becomes dense and lacks sufficient landscape elements. The introduction of high-rise residential buildings due to increased floor area ratios further exacerbates the scarcity of green areas and other public resources, thereby diminishing residents' quality of life. For instance, there is a dearth of public green spaces for neighborhood interactions and gathering spots, as well as essential measures for rainfall management and flood control. Failure to appropriately manage and harness surface runoff may lead to damage to underground infrastructure and adversely affect travel convenience and overall living quality, similar to the "central" layout.

3. Application of Low Impact Development in Sustainable Transformation of Traditional Apartment Complex Layout

The development of sustainable communities has emerged as a crucial focus in urban planning, with particular emphasis on the sustainable transformation of traditional communities. This paper introduces the concept of low impact development and integrates it with the layout characteristics inherent to traditional communities, proposing corresponding plans for achieving sustainable communities, utilize the landscape and garden area for functional transformation, aiming to fulfill people's diverse needs in terms of leisure, ecology, scenery, and physical fitness. By fully optimizing the available resources, adopt the ecological design principle emphasizing the appropriate placement of vegetation to achieve a sustainable community transformation.

3.1. "Block" Layout Improve Strategies

Considering the issues with the "block" layout, this study proposes the following three suggestions:

(1) To address the problem of independent green spaces, it is recommended to investigate the feasibility and rationality of narrowing secondary roads. If feasible, replacing impermeable pavements with permeable grass pavements could connect small and dense green spaces into larger area, enhancing resilience against natural disasters [6]. The available space can be utilized for low impact development infrastructure designs such as grass swale or rainwater gardens, which enhance aesthetics and reduce physical and sensory distances between green spaces, eliminating the sense of isolation.

(2) To mitigate the monotony of spatial vision, it is recommended to judiciously select diverse plant species and incorporate low impact development species to enhance visual discrimination.

(3) Considering the limited availability of shared space, it is recommended to strategically incorporate grass swales with seepage pipes and rainwater gardens near existing green areas or adjusted pavements to enhance the diversity of green spaces. This approach not only enhances the community's water-saving and emission-reduction capabilities but also fosters a neighborly atmosphere that encourages interaction [7].

3.2. "Central" Layout Improve Strategies

To address the traffic problems caused by the "central" layout, this study proposes separating pedestrian and vehicle routes to improve traffic flow, safety, and inclusiveness. Specific recommendations include utilizing grass swales and wooden boardwalks to effectively utilize unused turf areas of green spaces and adding dedicated pedestrian paths for enhanced travel safety. The route should be conveniently laid directly on the central turf area, while incorporating a network of grass swales for improved rainwater treatment capacity and aesthetics compared to traditional stone slabs or permeable pavement [6, 7].

Additionally, if the environmental conditions allow, the wooden boardwalks can be expanded to create nodes, including benches and picnic tables. This would transform portions of the wooden walkway into multi-functional spaces that cater to residents' convenience while maintaining its primary purpose.

3.3. "Intensive" Layout Improve Strategies

Similar to the "central" layout, there is also potential for enhancement in the "intensive" layout. For instance, the primary road can be appropriately expanded by incorporating pedestrian walkways on either side or one side of the road surface with permeable pavement; if impermeable pavement is used, consideration should be given to substituting it with permeable pavement.

However, considering the spatial limitations, this study proposes the implementation of distinct boundaries to delineate pedestrian and vehicle roads, thereby enhancing their differentiation. For instance, utilizing contrasting materials for permeable pavements can establish a sense of boundary that psychologically constrains crossover between these two modes of transportation. If feasible, road widening can be considered to create nodes within a specific range. These nodes should also incorporate permeable pavement and be partially surrounded by rain gardens or grass swales. The presence of surrounding vegetation in these nodes fosters social interaction and enhances environmental comfort [7].

This study also proposes the integration of rooftop gardens as a means to effectively utilize roof resources, thereby suggesting their potential for enhancing sustainability. The incorporation of rainwater barrels and passive-irrigation tree pits within these gardens aims to optimize the utilization of both rainwater and land resources [8]. By acting as natural filters, rooftop gardens facilitate the purification of rainwater, while flexible discharge time in rainwater barrels serves as a buffer system. This purified rainwater not only satisfies residents' partial demand for domestic water but also contributes to further storage by irrigating green plants through tree pits.

4. Planning of New Communities

Sustainable communities represent the prevailing trend in urban planning, prioritizing attributes such as inclusivity, safety, and resilience, identified as shortcomings within current planning methodologies [4].

4.1. Micro Level of Apartment Complex Layout Planning

Low impact development can be incorporated in community landscape design to improve landscape aesthetics and practicality while achieving sustainability [7]. For example, rainwater gardens with unique plants, sunken green spaces, and grass swales can be alternately used to soften and beautify the rigid edges of landscapes, improving the overall integration and functionality of community landscape design. The original natural landform can also be transformed according to the concept of low impact development. For example, low-lying areas can be transformed into sunken green spaces, infiltration ponds, or retention ponds, reducing costs while improving landscape features [9].

Among the numerous public facilities and spaces, many can be integrated with low impact development to achieve functional integration and optimize resource utilization. For instance,

investigate the potential of implementing cascading low impact development. By incorporating a series of rainwater gardens with varying elevations around a sunken green space characterized by significant terrain drop, passive irrigation of rain gardens can be achieved through repeated utilization of surface runoff at higher levels [8]. Vanke's Rainwater neighborhood has provided evidence of cascading low impact development infrastructures. This approach not only mitigates the perception of height difference within the sunken green space but also enhances spatial belongingness and intimacy through the strategic use of taller surrounding vegetation, thereby reinforcing the role and appeal of this public activity area [7].

Low impact development can also enhance the resilience of communities to natural factors. For instance, rainwater gardens planted with broad-leaved deciduous trees on the sunny side of residential buildings can effectively reduce indoor cooling costs and outdoor temperatures during summer through physical shade and evaporation [10]. Additionally, they allow sunlight to enter in winter, thereby reducing indoor heating costs [10]. Roof gardens serve a similar purpose by mitigating direct sunlight exposure on upper floors, thus improving livability during hot summers.

4.2. Macro Level of Apartment Complex Layout Planning

The concept of sustainable communities promotes active participation and seamless integration [4]. This can be further interpreted as fostering a strong sense of community, facilitating meaningful interactions, and promoting harmonious integration. Such communities align with the principles of sustainable communities and the notion of the Chinese complete residential community concept, promoting a better urban living environment.

To foster a community with collective consciousness, effective coordination among all components is essential. In constructing new sustainable communities, this study proposes that planners consider integrating and interacting with other elements, such as residential building settlements, transportation systems, and communal spaces, in their designs to achieve mutual benefits. For instance, in the design of low impact development infrastructures of apartment complexes, it is recommended to reserve access ports for grass swales of neighboring apartment complexes. This approach transforms the grass swales of each apartment complex into a community-scale aboveground network that reduces drainage system costs and alleviates associated pressures. Additionally, promoting rooftop gardens encourages residents to engage in vegetable and fruit cultivation as well as small-scale animal husbandry, thereby achieving partial food self-sufficiency while maximizing resource utilization. The surplus produce can be sold within the community, fostering social interactions within and across communities and cultivating a harmonious living environment.

5. Conclusion

This study critically examines the limitations of traditional community models and planning methods in achieving sustainable community development by employing theories and concepts from multiple disciplines. Subsequently, it explores the application of low impact development in constructing sustainable communities. Ultimately, this research offers valuable insights for enhancing planning practices.

The traditional apartment complexes, characterized by "block" layout, "central" layout, and "intensive" layout as the primary distribution forms of residential buildings, exhibit inadequate planning rationality and integrity. Consequently, there exists a substantial disparity between these traditional apartment complexes and the communities they form in various aspects concerning the concept of sustainable communities. Given the diverse distribution forms of residential buildings within each traditional apartment complex, it is imperative to undertake context-specific sustainable transformations. When establishing connections with the surrounding site, it is not advisable to adopt a rigid boundary treatment approach. The design of the boundary should be implemented in an appropriate manner based on the availability of green space in the vicinity, ensuring both stability

and seamless integration with the surroundings and guarantee the safety of residents, site functionality, and environmental harmony. In cases where there is ample green space nearby, a natural and gentle slope boundary should be considered; however, when green space is limited, flexible slope protection approaches such as metal railings, gabions, or fir piles should be employed according to site-specific conditions. This study integrates low impact development with sustainable transformation, aiming to explore and harness the derivative application potential of low impact development in diverse scenarios beyond rain and flood management. The objective is to address existing limitations, supplement deficiencies, and ultimately transition traditional communities into sustainable ones.

The traditional planning methods employed in traditional communities are not sustainable, as they tend to overlook crucial attributes of residential areas. By embracing the principles of low-impact development and incorporating them into the planning process, these deficiencies can be effectively addressed. The integration of low impact development facilities not only enhances landscape aesthetics and resource utilization efficiency at a micro level but also fosters harmonious public spaces. Moreover, on a macro scale, it facilitates collaboration between planning methodologies, reduces urban drainage costs, stimulates social activities within and across communities, and enables simultaneous implementation of advanced planning and design concepts.

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