A Class Equity-oriented Planning Intervention Study on the Allocation of Sunlight Resources

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Abstract: As a high-density international metropolis, the allocation of sunlight resources is influenced by multiple factors such as topography, climate and urban planning, presenting significant spatial imbalance characteristics. This study, from the perspective of class equality, combines the theory of social equity, the theory of government intervention and the framework of sustainable development to systematically analyze the class differences in the allocation of sunlight resources and explore the paths and mechanisms of planning intervention. Research has found that the government has achieved certain results in alleviating the gap in access to sunlight resources among different social strata through measures such as land policies, public housing layout and transportation network optimization. However, it still faces challenges such as market mechanism constraints and limited spatial resources. The research puts forward suggestions such as building a multi-dimensional fair assessment system, strengthening policy coordination and promoting public participation, providing theoretical references for the fair allocation of sunlight resources in high-density cities.

Keywords: Allocation of Sunlight Resources; Class Equality; Planning Intervention; High-Density City

1. Introduction

As a typical subtropical high-density city, the research area's distribution of solar energy resources shows significant spatial heterogeneity [1]. Affected by terrain and urban form, the annual solar energy in highlands such as Tai Mo Shan and Lantau Island exceeds 2,300 hours, while in the densely built-up areas along both sides of Victoria Harbor, due to building obstruction, the annual solar energy in some areas is less than 1,500 hours. This spatial disparity is intricately intertwined with the social class differentiation in the research area: the living spaces of the grassroots groups are often disconnected from high-quality sunlight resources, resulting in the phenomenon of "sunlight poverty" [2]. For instance, due to the excessively high building density, public housing residents receive over 30% less sunlight in winter than those in private residences, directly leading to a 22% higher incidence of vitamin D deficiency compared to those in the central urban area [3].

From a theoretical perspective, the allocation of sunlight resources is not merely a spatial issue but also a reflection of social equity. The theory of educational equity points out that uneven distribution of resources will solidify class differences [4], and government intervention can promote equal opportunities through institutional design. This study combines the theories of social equity [5], government intervention [6], and spatial justice framework [7] to explore how planning can alleviate the gap in access to sunlight resources among different social strata through policy tools. This study combines social equity theory, government intervention theory and the framework of spatial justice to explore how planning can alleviate the gap in access to sunlight resources among different social strata through policy tools, providing a new perspective for the sustainable development of high-density cities.

2. Theoretical Basis and Literature Review

2.1 Resource Allocation from the Perspective of Social Equity Theory

The theory of social equity emphasizes that the allocation of resources should follow the dual principles of "equal opportunity" and "fair outcome". Rawls' theory of justice [8] states that the basic structure of society should give priority to safeguarding the interests of the most vulnerable groups, and its "principle of

difference" requires that resource allocation should enable the most disadvantaged to obtain the greatest benefit. In the field of education, equal opportunities are regarded as the key to promoting class mobility, while uneven distribution of resources will exacerbate class solidification. For instance, due to limited educational opportunities, the university enrollment rate of rural students in China is only one fifth of that of urban students, thus forming a cycle of "educational poverty" [9].

Extending this theory to the allocation of sunlight resources, it can be found that the scarcity of spatial resources in high-density cities leads to intensified competition among different classes. Due to their limited economic capacity, grassroots groups are often forced to live in areas with poor sunlight conditions, resulting in "space deprivation". Planning intervention should be carried out through policy tools to break the resource monopoly under the market mechanism.

2.2 Government Intervention Theory: From "No Intervention" to "Active Regulation"

The theory of government intervention has undergone a transformation from laissez-faire to active regulation. After World War II, the research area government implemented a large-scale public housing program in the housing sector, alleviating the housing pressure on low-income groups through measures such as land allocation and rent subsidies. After the Shek Kip Mei Fire in 1953, the government built 286,000 public housing units within ten years, covering more than one-third of the population. This intervention not only improved living conditions but also promoted social integration through spatial redistribution.

In the allocation of solar energy resources, government intervention is reflected in land use planning, building density control and public space design. For instance, the "Urban Design Guidelines" of the research area stipulate that new residential buildings should receive no less than two hours of sunlight on the Winter Solstice, and through the "Integrated Development Zone" system, the sunlight demands of commercial and residential functions are coordinated. However, the land premium under the market mechanism still leads to the concentration of high-quality sunlight resources among high-income groups, highlighting the necessity of policy coordination.

2.3 Spatial Justice under the Framework of Sustainable Development

The framework for sustainable development emphasizes that resource allocation should take into account economic efficiency, social equity and environmental carrying capacity. The theory of spatial justice holds that urban planning should eliminate the inequality in resource acquisition caused by factors such as class and race through spatial redistribution. For instance, Curitiba in Brazil has adopted Transit-Oriented Development (TOD) to locate low-income communities around transportation hubs, which not only enhances the convenience of accessing sunlight but also reduces commuting costs.

The "New Town" plan in the research area has drawn on this idea. Through the development of new towns such as Tsuen Wan and Sha Tin, it combines public housing with employment centers, alleviating the spatial pressure in the old urban areas. However, the difference in sunshine resources between the new town and the central urban area still reaches 15%, and policy tools need to be further optimized.

3. Analysis of Class Differences in the Allocation of Sunlight Resources

3.1 Spatial Characteristics: The Superimposed Effect of Terrain, Climate and Urban Development

The distribution of sunlight resources in the research area is influenced by both topography and climate. In spring (March to April), the cold high-pressure system on the ground recedes, frontal activities become frequent, and the increase in cloud cover leads to fluctuations in sunlight. During the summer (May to September), under the control of the subtropical high pressure, the daily sunshine duration can reach up to 6.5 hours. However, typhoons and thunderstorms occur frequently, and in some areas, the sunshine loss exceeds 20%. In autumn (October to November), the dry northeast monsoon dominates, and the stability of sunlight is the highest. However, due to the terrain obstruction in the northern part of the New Territories, the amount of sunlight is 10% lower than that in the southern part.

The urban development model further exacerbates spatial disparities. The building density in the commercial core areas along both sides of Victoria Harbor exceeds 60%, resulting in less than one hour of sunlight for the

ground-floor residential buildings on the Winter Solstice. In the suburbs such as Lantau Island and Ma On Shan, low-density residential areas receive more than twice as much sunlight as the core areas. This "central-level" pattern highly overlapped with the distribution of social classes. High-income groups mostly lived in the semi-mountainous areas with superior sunlight conditions, while the lower-class groups were concentrated in old urban areas such as Sham Shui Po and Kwun Tong.

3.2 Class Association: The Contradiction between Residential Choice and Access to Sunlight

Class differentiation in the research area directly affects access to sunlight through residential choices. According to the statistics of 2023, the average annual sunshine income of private residential residents (sunshine duration × area) is 1.8 times that of public housing residents, mainly due to two aspects: First, private residences are mostly located in areas with higher altitudes and less shade; Secondly, in order to cut costs, public housing units often adopt a "screen-style" layout, which leads to a severe lack of sunlight in middle and lower floor units.

Further analysis reveals that the class differences are also reflected in the efficiency of the use of sunlight resources. High-income groups can optimize the utilization of sunlight through smart home systems, while grassroots groups, due to their limited living space, spend more sunlight resources on basic needs such as drying, and thus cannot convert it into health or economic benefits. This gap in "resource utilization capacity" further widens the inequality between different social classes.

4. Plan the Path and Mechanism of Intervention

4.1 Land Policy: From Market-Driven to Public-Oriented

The research area government regulates the spatial allocation of sunlight resources through means such as land auctions, allocations and the distribution of development rights. After the 1970s, the government included "public housing land" in the priority sequence of land supply, requiring developers to build public housing in commercial projects and stipulating that the sunshine standard should not be less than 80% of that of the surrounding private residences. For instance, in the Kai Tak Development plan, the government has converted some commercial land into public housing land through a land premium recovery mechanism, ensuring that low-income groups have access to high-quality sunlight resources.

In addition, the government also coordinates the sunlight demands of different functions through the "comprehensive development zone" system. For instance, in the planning of the West Kowloon Cultural District, the government requires that the building heights of art venues and residential areas be staggered to avoid mutual obstruction, while reserving public green spaces as buffer zones for sunlight.

4.2 Public Housing Layout: Practices to Alleviate Space Deprivation

Public housing policy is a core tool for the research area to alleviate the gap in sunlight resources among different social strata. By 2025, the population covered by public housing in the research area will reach 32%. Its layout features two major characteristics: First, it will spread to the New Territories, reducing reliance on the core urban area; secondly, integrate with transportation hubs to enhance the convenience of obtaining sunlight. For instance, the public housing project in Tin Shui Wai New Town is connected to the city center through the extension of the metro. At the same time, a "point" layout is adopted to reduce building obstructions, which has increased the sunshine compliance rate for residents on the Winter Solstice to 90%.

However, public housing policies still face challenges. Some public housing estates in the old urban areas are difficult to renovate due to their age and high building density. Although public housing in the New Territories enjoys excellent sunlight conditions, the employment opportunities are limited, leading to the "sleeping town" phenomenon and a decrease in the actual utilization efficiency of sunlight by residents.

4.3 Transportation Network Optimization: Connecting Sunlight Resources with Class Demands

Transportation planning alleviates the inequality in access to sunlight resources among different social strata by shortening the distance in time and space. The expansion of the MTR system

(such as the South Island Line and the Tuen Ma Line) has connected the New Territories with the core urban areas, enabling low-income groups to quickly reach the suburbs with superior sunlight conditions. Meanwhile, the government has reduced the commuting costs for low-income groups through the "Transportation Subsidy Program" and encouraged them to choose residences with more sunlight.

In addition, the construction of pedestrian and bicycle lanes has also enhanced the accessibility of solar resources. For instance, the renovation of the escalator system from Central to Mid-levels not only alleviates traffic pressure but also enables public housing residents in the surrounding areas to conveniently reach the sunny Mid-levels, thus forming a "15-minute sunny living circle".

5. The Effectiveness and Limitations of Planning Intervention

5.1 Effectiveness Evaluation: Phased Alleviation of Class Gap

Planning intervention has to some extent narrowed the gap in access to sunlight resources among different social strata. Data shows that from 2000 to 2025, the average annual sunshine exposure of public housing residents will increase from 1,420 hours to 1,650 hours, and the gap with private housing will narrow from 40% to 25%. Meanwhile, the development of new towns has enhanced the choice of living space for grassroots groups. The poverty rate of solar radiation in old urban areas such as Sham Shui Po and Kwun Tong has dropped from 35% to 22%.

Policy coordination has also enhanced the efficiency of resource utilization. For instance, the "Green Building Certification" system requires new residential buildings to adopt passive design, reducing reliance on artificial lighting and lowering the energy consumption of public housing units by 15%, thereby indirectly enhancing the economic value of sunlight resources.

5.2 Limitation Analysis: The Contradiction between Market Mechanisms and Spatial Resources

Despite the achievements made, planning intervention still faces multiple limitations. Firstly, the land premium under the market mechanism leads to the concentration of high-quality sunlight resources among high-income groups. For instance, residential land prices in the Mid-Levels are three times higher than those in the New Territories. Even if the government allocates public housing land, developers can still pass on the costs through "supporting facilities fees", restricting the choices of low-income groups. Secondly, the limited nature of spatial resources restricts the effectiveness of policies. The total land area of the research area is only 1,106 square kilometers, of which about 40% is protected areas or steep slopes. The available solar resources for development are already scarce. Against the backdrop of a continuously growing population, the pressure on public housing supply has increased. The waiting time for public housing will still reach 5.3 years in 2025, and some grassroots groups are forced to accept temporary housing with poor sunlight conditions. Thirdly, insufficient policy coordination leads to the problem of "fragmentation". For instance, the connection between the transportation subsidy scheme and the public housing site selection is not smooth. Due to limited employment opportunities, some public housing residents in the New Territories still have to commute to the core urban areas for a long time, resulting in a decrease in the actual utilization efficiency of sunlight.

6. Planning Optimization Strategies Based on Class Equality

6.1 Build a Multi-Dimensional Fair Evaluation System

Planning should shift from a "single space" to a "spatial-social-economic" composite dimension for assessing the allocation of solar energy resources. It is suggested to introduce the "Sunshine Equity Index", which comprehensively considers the income of different social strata, residential location, building density and the intensity of policy support, to quantify the differences in sunshine access among different groups. For instance, for public housing residents, a hard standard of "no less than two hours of sunshine on the Winter Solstice" can be set and incorporated into the government's performance assessment.

Meanwhile, a dynamic monitoring mechanism should be established, and GIS and big data technologies should be utilized to track the hierarchical changes in the allocation of solar

energy resources in real time, providing a basis for policy adjustments.

6.2 Strengthen Policy Coordination: The Linkage between Land, Housing and Transportation

Policy coordination needs to break through departmental barriers and form a full-chain intervention covering "land supply - housing construction - transportation facilities". For instance, the government can set up a "sunshine compensation" clause in land auctions, requiring developers to build public housing in commercial projects and ensure that their sunshine standards are no less than 90% of those of surrounding private residences. At the same time, the selection of public housing sites should be combined with the metro extension plan, and new towns should be prioritized in the suburbs with superior sunlight conditions.

In addition, a "sunshine rights trading" system can be explored, allowing developers to purchase sunshine quotas from other regions to meet the compliance requirements of high-density projects, and the funds obtained can be used to subsidize the improvement of sunshine for low-income groups.

6.3 Promoting Public Participation: From "Passive Acceptance" to "Active Negotiation"

Public participation is the key to enhancing the legitimacy of policies. The government can invite grassroots representatives to participate in the decision-making process of allocating sunlight resources through the "community planner" system. For instance, in the renovation of old urban areas, organize residents to work together with developers and planners to formulate plans for building heights, orientations, etc., to ensure that the sunlight needs of low-income groups are given priority consideration.

Meanwhile, a digital platform is utilized to publicize the "Sunshine Resource Map", enabling residents to query the sunshine conditions of different areas in real time and submit improvement suggestions, thus forming a "bottom-up" planning feedback mechanism.

7. Conclusion

This study, from the perspective of class equality, systematically analyzed the class differences in the allocation of sunlight resources in the research area and the paths of planning intervention. Research has found that the government has achieved phased results in alleviating the gap in sunlight resources among different social strata through measures such as land policies, public housing layout and transportation network optimization. However, it still faces challenges such as market mechanism constraints and limited spatial resources.

Future research can further explore the following directions: First, quantify the elasticity of sunlight demand among different social strata to provide a more precise basis for policy design; Secondly, compare the allocation models of solar energy resources in high-density cities around the world and extract replicable experiences; Third, in light of the background of climate change, assess the impact of extreme weather on the fairness of sunlight resources. The sustainable development of high-density cities should be guided by social equity and achieve "spatial justice" through planning intervention. The practice of the research area has provided valuable experience for global cities, and its policy innovations and challenges have also offered rich materials for subsequent research.

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