



Article The Research on the Spatial Governance Tools and Mechanism of Megacity Suburbs Based on Spatial Evolution: A Case of Beijing

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Abstract: The research on the spatial governance of the suburbs of megacities is of great significance for coordinating the spatial relationship between the central urban area and the suburbs of megacities, and implementing the regional functional layout of megacities. It is helpful to formulate scientific spatial governance strategies, and coordinate suburban space and central urban areas to achieve coordinated and sustainable development. This paper uses spatial form indicators to study suburban space governance from the spatial evolution characteristics of suburban construction land, constructs the relationship between different spatial evolution characteristics and the utility of spatial governance tools in the suburbs of megacities, and discusses the mechanism of suburban spatial governance tools. The study found that the spatial governance of megacities runs through the whole process of spatial evolution. Together with the three stages of space evolution, "space shaping, space restoration, space reconstruction", we present three spatial governance mechanism types: "extensive development with positive guidance as the theme", "exploratory adjustment with transformation practice as the theme", "fine governance with management and control intervention as the theme". In addition, the study also found that direct and indirect suburban space governance tools have different action paths and usage characteristics, and there is a synergistic mechanism between the two types of tools.

Keywords: suburbs of megacities; spatial evolution; spatial governance; governance tool

1. Introduction

With the continuous agglomeration of population in megacities, the space in the central urban area is gradually becoming saturated, and functions and spaces begin to expand outwards. The outer suburban areas serve as the urban–rural transition area, and comprise the second half of urbanization, with the main function of serving the central city. In addition to undertaking various traditional functions such as food security and ecological conservation, the suburbs also bear the brunt of the overflowing urban functions of the central city. The form of suburban space is also constantly changing under the influence of various factors [1]. All of these are related to the regional background of megacities in order to be properly resolved [2,3]. If the suburba are allowed to develop, it will exacerbate the fragmentation of the suburban material space, the segregation of social spaces, and the imbalance of spatial development rights. It is not only easy to produce a "slum zone" or "public security problem" area of megacities in many developing countries, but also easy to produce the disorderly sprawl of cities that has appeared in the process of urbanization in early developed countries.

Henri Lefebvre, one of the founders of space theory, proposed that space arises from social practice and is the product of social relations. Space is not only affected by various social relations, but also reacts to social relations [4]. Spatial governance is the embodiment of the relationship between power, space and institutions. According to different spatial



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Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https:// creativecommons.org/licenses/by/ 4.0/). scales, there are certain differences in the approaches and main purposes of spatial governance. At the national level, governance is the process of using state power to mobilize all parties to participate in the production of urban space and promote national construction and urban development. At the regional level, spatial governance refers to the effective, equitable and sustainable use of land space through resource allocation, as well as the relatively balanced development of various regions [5]. The spatial governance at the suburban level focuses more on solving the problem of the uneven development of suburban spaces under the influence of central urban areas using different governance tools. It is the process of realizing a balance between urban space production and multiple interests, with many complex effects such as benefit and fairness, partial and comprehensive, individual and group.

Under the influence of globalization and central urban areas, urban suburbs, especially megacity suburbs, show strong economic development vitality, and spatial forms and spatial interests change drastically. Since 2013, the Chinese government has made a major decision to "promote the modernization of the national governance system and governance capacity". Handling and coordinating the spatial relationship between the central urban area and the suburbs of megacities plays a vital role in guiding the development of regional functional layouts in megacities and strengthening the implementation of spatial governance strategies, such as regional integrated development. To reasonably coordinate the spatial relationship between the central urban area and the suburbs of megacities, we must first grasp the spatial evolution characteristics of the suburbs and the mechanism of spatial governance. It is necessary to use various spatial governance tools to coordinate the government, market, society and other subjects to participate in the allocation of various resources in the suburbs, so as to achieve the optimization of spatial structure and balanced development.

For developed countries, research on and practical experience in spatial organization and governance models of megacities have been around for decades. However, since there is no successful model to follow in the practice of spatial governance in megacities in developing countries [6], relevant research only focuses on the main issues of spatial governance [7], the governance background, or a discussion of the mechanism. Most of the research scales are urban areas [8] or urban fringe areas [9], and there are not many studies related to spatial governance in the suburbs of megacities. The existing research on the suburban governance of megacities only involves the main modes of suburban governance [10], the formulation of suburban governance frameworks [11,12], and the understanding of the driving force of suburban diversification [13]. It is not considered that the development of megacities is a continuous process, and there is insufficient research on the temporal evolution relationship of the suburban spatial structure and spatial governance mechanism in the entire period, from the rapid development period to the stable development period of megacities. In particular, there is a lack of research on the governance effectiveness of various plans and policies that determine and affect suburban space, as well as evolutionary research on the mechanisms of action of various subjects and institutions that participate in and carry out spatial behavior.

Therefore, this study selects Beijing, which has entered the late stage of urbanization and has relatively stable urban spatial patterns, as the research object. This paper sorts out the characteristics of suburban space evolution in different periods from the perspective of time and space, studies the main mechanism of suburban spatial governance in different stages, and summarizes the types, characteristics and functions of governance tools for suburban spatial governance in megacities, in order to provide a reference for the adjustment of spatial planning strategies and the formulation of spatial governance strategies for newly upgraded megacities and developing megacities.

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2. Materials and Methods

2.1. Overview of the Study Area

This paper takes the suburbs of the megacity Beijing as the research object. As the capital of China, Beijing is an international megacity that had a permanent population of 21.89 million in 2020, a total area of 16,410 square kilometers, and 16 districts under its jurisdiction. In a broad sense, the central urban area is located in the "six urban districts", and the remaining ten districts and counties are suburban areas. Under the comprehensive control of the concept of sustainable development of megacities as "determining people by water, and determining the city by people", the overall expansion rate of the central urban area has dropped significantly. The peripheral suburban areas have also shown a diversified development trend through transformation and development measures such as "improving quality and efficiency".

The topography of Beijing suburbs covers plains, shallow mountains, and mountainous areas. In terms of location distribution, the suburbs of Beijing present relatively common characteristics of circles and layers. In terms of dominant functions, they cover most of the common urban functions. They are the first choice for studying the suburbs of a megacity. Accordingly, this paper selects ten suburban counties in Beijing as the research objects. The ten suburban counties had a permanent population of 10.9 million in 2020, accounting for 49.9% of the city's population, with a total area of 15,030 square kilometers, accounting for 91.6% of the city's total area.

2.2. Research Time Period and Data Acquisition

The main time axis of this study is from 2000 to 2020. The main characteristic years are 2000, 2005, 2010, 2015 and 2020. The time stages of the study of suburban space evolution are divided into four stages: 2000–2005, 2005–2010, 2010–2015, and 2015–2020.

The names of administrative divisions are based on the 2020 statistical division codes published by the National Bureau of Statistics of China, and the boundaries of administrative divisions are based on the 2020 version of the basic geographic base map of Beijing's administrative divisions issued by the Beijing Municipal Commission of Planning and Natural Resources.

In addition, this paper uses the Landsat series of multispectral satellite remote sensing images with a resolution of 30 m. After screening and processing, the land use data are extracted by manual visual interpretation and supervised classification. The classification accuracy is about 85% after manual correction, which may meet the research needs.

2.3. Main Research Methods

Suburban spatial form mainly refers to the spatial form formed by material entities, which is embodied in the evolution of the plane form of construction land, and is the external manifestation of suburban functional activities. The measurement indicators that reflect the spatial form include expansion strength, dispersion coefficient, shape index, compactness, etc. [14–16]. This study intends to take Beijing as an example, using several representative indicators for analysis, and preliminarily outline the characteristics of the evolution of the spatial form of the suburbs of the megacity.

(1) Land expansion strength

The expansion intensity of construction land, as an index reflecting the speed of urban expansion, can be used to analyze and describe the expansion status of urban built-up land, and compare the trend of urban expansion in different periods. The expansion intensity index can be expressed as a percentage of the total land area by which the study area expands during the study period.

(2) Compactness

The compactness index is mainly measured via the spatial geometric properties of the distribution of construction land, and is an important indicator to reflect the spatial aggregation of construction land in suburban areas. The compactness is equal to the ratio of the total area of all patches in a certain area to the total perimeter multiplied by the coefficient, and the index is between 0 and 1. The larger the indicator is, the higher the compactness of the area is, and vice versa.

(3) Extended mode

The expansion mode of suburban space can be divided into three categories: enclave expansion, edge expansion and filling expansion [17]. The expansion modes in different periods can be determined by the common edge measure method [18]. That is, the expansion type of the new construction land in a certain period is represented by calculating the ratio R between the common edge length Lc of the map spot of the new construction land in a certain period. If R = 0, the newly added construction land is an enclave expansion; if 0 < R < 0.5, the newly added construction land is an edge expansion; if $0.5 \le R \le 1$, the newly added construction land is an edge expansion types of suburban space in different periods, different stages of suburban urban space expansion can be established.

2.4. Research Technology Route

Through the processing of remote sensing images of different characteristic years, the land-use polygons of Beijing suburbs in different periods can be extracted, and the stages of the evolution of suburban spatial form can be divided by spatial morphological indicators such as land expansion intensity, compactness, and expansion mode. Combined with the evolution of the theme of suburban space governance in different periods, the relationship between the evolution characteristics of different suburban forms and the utility of different suburban space governance tools is established, and then the action mechanism of the suburban space governance tools in megacities is obtained (see Figure 1).



Figure 1. The technology roadmap.

3. Results

3.1. The Evolution Stage of Suburban Spatial Form

Through the calculation, the spatial expansion pattern of suburban construction land in different periods from 2000 to 2020 (see Figure 2) and spatial evolution characteristics (see Figure 3) can be obtained. Based on the three index characteristics of expansion intensity, compactness and expansion mode of suburban construction land, the expansion process of Beijing suburban space form can be divided into three stages.



Figure 2. Spatial expansion patterns of suburban built-up land in different periods from 2000–2020.



Figure 3. Evolution map of spatial expansion pattern of suburban construction land.

3.1.1. Space Shaping Stage

In this stage, the expansion intensity of suburban construction land appears as an incremental expansion of medium and high speed (Table 1), and the compact degree is a decentralized expansion of low compactness. In terms of expansion mode, edge expansion and filling expansion account for a relatively high proportion, and these are mainly distributed in the ring central city area.

Year	Construction Land Area (km ²)	Construction Land Per Capita (m ²)	Average Area of Growth (km²)	Annual Average Expansion Intensity	Expansion Speed
2000	1383	354	-	-	-
2005	1720	390	67	4.9%	medium speed
2010	2424	410	141	8.2%	high speed
2015	2491	367	13	0.6%	low speed
2020	2384	298	-21	-0.9%	decelerate

Table 1. Scale and expansion intensity of suburban construction land from 2000 to 2020.

3.1.2. Space Restoration Stage

From 2010 to 2015 was the stage of spatial restoration involving slowly gathering contiguous pieces. Compared with the substantial expansion of suburban construction land in the previous stage, the per capita construction land in this stage dropped significantly, and the utilization rate of construction land increased. In terms of expansion intensity, it also turned to slow expansion at a low speed, the compactness index increased, the proportion of infill expansion mode reached the largest peak, and the increase in enclave-type construction land was the smallest. The outward expansion of the spatial form of the suburban construction land was terminated, showing the spatial restoration feature of contiguous spread from the central urban area inward.

3.1.3. Spatial Reconstruction Stage

The period from 2015 to 2020 was the spatial reconstruction stage of the relatively decentralized development of multi-centers with controllable reductions. After the suburban construction land has undergone the space shaping stage of substantial outward expansion and the space restoration stage of interior filling, the total amount of suburban construction land reached the upper limit of the stage, and it began to enter a new stage of spatial reconstruction. The main manifestation is that the scale and expansion intensity of construction land experienced a significant negative growth, the expansion trend changed from increasing to decreasing, and the compactness of construction land in most districts and counties dropped significantly. In the spatial expansion model, the proportion of edge-type and enclave-type (isolated) growth land both reached the highest, and the suburban space showed a trend of decentralized expansion as a whole. At the same time, in terms of space, the newly added construction land patches in this period showed a multi-center distribution situation that was separated from the central urban area, and the spatial structure of suburban construction land changed from a circle extension to a center plus multi-point structure.

3.2. The Theme and Utility of Suburban Spatial Governance in Different Stages

3.2.1. Space Shaping Stage: Spatial Governance with Positive Guidance as the Theme

From 2000 to 2010 was the space shaping stage of rapid suburban expansion, with the largest increase in construction land, which was mainly distributed in the surrounding suburban areas. In addition to being close to the city center in terms of location and benefiting from the two processes of urban suburbanization and suburban urbanization in terms of development background, these growth areas are also affected by urban planning, economic policies, housing policies and other aspects. However, due to the immaturity of economic policy control in this period, the suburban space in this period showed extensive development under the positive guidance of planning spatial governance.

On the one hand, major events and the implementation of urban planning directly promote the development of suburban spaces. In 2001, China's accession to the WTO, Beijing's successful bid for the Olympic Games and other major events injected new vitality into Beijing's development [19], and accelerated the construction of economic and technological development zones and higher education parks. The approved "Beijing Urban Master Plan (2004–2020)" proposed to strengthen the construction of peripheral new

cities, which has played a major role in promoting the spatial expansion of the suburbs in terms of land index allocation and spatial layout guidelines.

On the other hand, policies such as housing and the economy indirectly promote the spatial expansion of the suburbs. The system of paid land use enables housing policies to have the function of economic regulation. The intervention of the capital market has led to a rapid increase in the market demand and development scale of suburban housing, and the focus of residential construction has begun to expand from the central city to the suburbs. Indirectly, the expansion pattern of suburban construction land shows sprawling growth around the central urban area. At the same time, with the support of economic policies such as investment attraction and tax relief, the suburban area began to construct parks to develop manufacturing and high-tech industries. It also indirectly caused the circle-type diffusion growth of industrial construction land, and further promoted the rapid expansion of residential land in the suburbs through job–housing connections.

3.2.2. Space Restoration Stage: Spatial Governance with Transformation Practice as the Theme

From 2010 to 2015 was a stage of spatial restoration of the slow agglomeration and contiguous suburbs. Compared with the previous period, the increase in construction land was significantly reduced here, mainly in the northern mountainous areas, and by a small amount in the southern suburbs. Affected by the lack of policy regulation under the paid land use system, the suburban sprawl trend was obvious in the previous stage. Many planning goals of the "Beijing Urban Master Plan (2004–2020)" have been achieved or abandoned ahead of time, and the green space in the planning has also been greatly eroded [20]. The contradiction between population, construction land and resources, and environment is becoming increasingly acute, and the problems of land regulation and planning management are gradually being exposed. In order to repair and correct the development problems of the previous stage, this stage has witnessed a series of exploratory adjustments under the transformation practice of guiding policy-based spatial governance.

This stage is mainly dominated by indirect mechanisms, such as strict population policies and housing policies, resulting in a sharp rise in housing prices, which indirectly boosts the low-quality sprawl of suburban space. In suburban areas, the advantages of the relatively low cost of living, loose population management, and the proximity to central urban areas have attracted a large number of migrants to live there. Population agglomeration has motivated the suburban areas located in the central city, new city and the periphery of the industrial park to use spare land to develop and construct rental housing, showing a slow agglomeration and contiguous expansion in the suburban circle. For suburban areas far from the central city, especially the mountain front areas with better landscapes in the north, some developers have illegally developed residential projects or leased apartments through illegal land use conversion procedures, attracting mid- to high-end foreign residents to rent. As a result, the management of non-construction land is out of control, which is manifested in the disorderly spread and expansion of land in the outer suburbs.

In addition, the development policy at this stage is mainly based on the transformation of industrial structure, which also plays an indirect role in improving the quality of suburban space development. For example, Huai-Rou District, located in the northern mountainous area, has developed high-tech, film and television culture, conferences and exhibitions, leisure tourism and other industries through the transformation of industrial structure, relying on the ecological landscape resources of Yanqi Lake. This has become a new avenue for Beijing's international communication functions, and has successfully achieved the transformation and upgrading of the outer suburban mountainous space. Under the effective drive of this model, ecology-based high-tech industries and leisure tourism have gradually gathered in the north, improving the output of the northern mountainous land and the development quality of the space. 3.2.3. Spatial Reconstruction Stage: Spatial Governance with Management and Control Intervention as the Theme

The period from 2015 to 2020 was the spatial reconstruction stage of suburban development from single-center agglomeration to multi-center decentralized development. The expansion intensity and the increase in construction land both showed negative values, and the trend of suburban sprawl was basically curbed. The areas where construction land has been reduced are mainly distributed in the suburban circles. The north and south ends of the central axis of the central urban area are the only areas where the construction land has increased in largely. With the improvement of urban governance capabilities and planning control capabilities, as well as the understanding of the development of the suburbs of megacities, this stage was characterized more refined governance, represented by the intervention and control of red line indicators.

The most prominent impact on suburban space is the growth boundary and other management and control policies, which directly promote the reduction in and improvement of suburban space. Beijing has introduced a series of industrial restrictions and land control policies. By clarifying the development direction of suburban industries, delineating ecological red lines and growth boundaries, etc., the suburban construction land has been renovated, vacated, optimized and upgraded. At the same time, the scale of construction land has been reduced and the infrastructure layout supplemented [21]. At the same time, the increase and decrease policies of collective industrial land "demolition of five to build one" also explain the phenomenon of more enclave-type (isolated) expansion patches during this period.

In addition, through the industrial structure policy, the industrial distribution structure in the suburbs has been optimized, low value-added industries have been moved out, and the reduction in and efficient use of construction land in the suburbs have been promoted. A large number of general low-end manufacturing, wholesale markets and logistics centers have been withdrawn one after another, vacating large areas of low-efficiency industrial land and corner construction land, and indirectly optimizing the use efficiency of suburban space. Most of the suburban areas are showing a trend of reduction and contraction as a whole, and the construction land indicators are concentrated in park projects and areas of major infrastructure, resulting in the growth areas of suburban space being concentrated around new city areas and major project areas. Reduction and multi-center scattered agglomeration became the characteristics of the development of suburban space during this period.

4. Discussion

4.1. The Basic Mechanism of Suburban Space Governance

By identifying the spatial governance mechanisms at different stages in the evolution of Beijing suburban space, they can be divided into two categories, direct and indirect, according to the different modes of action of the governance mechanisms. The two types of governance tools have different effects in different stages of suburban space evolution. The two types of tools complement each other, and jointly regulate the spatial development status of megacity suburbs through different combination modes.

Direct suburban space governance tools can be divided into forecasting policy tools, management and control policy tools, and planning policy tools, from the perspective of scope and effect. Direct suburban space governance tools directly arrange and manage the layout and utilization of suburban space. As part of statutory policies, they can directly guide suburban development and construction (Figure 4).

Among them, the predictive policy tools have certain flexibility and discretion in the implementation process, and their scope of action is the widest, but the effect feedback time is long, and it is suitable for the long-term guidance of suburban space development. Predictive tools play an important role in coordinating the spatial relationship between the suburbs of a megacity and the central urban area, and building a reasonable regional urban structure. Due to the characteristics of the rigid transmission of central authority [22],

management and control policy tools have the most precise scope of action. It can effectively avoid the negative eroding impact of the development of megacities on suburban ecological reserves and basic farmland, and protect the environment and food security of megacities.



Figure 4. The types and action mechanisms of direct tools used for suburban space governance.

The planned policy tools implemented by relying on the government's expropriation power are mainly manifested in the implementation of major events and major projects. This type of policy integrates the government-led, efficiency-first management model, and the welfare model aimed at rationally allocating public services and welfare resources. Among them, the implementation of major events has a relatively clear scope of action and short-term feedback, which can affect and improve the spatial form quality of specific suburban areas in a short time. The implementation of major projects has a larger scope of action and a longer duration of action, which can have a long-term impact on the region and coordinate the unbalanced state of the suburban space of megacities.

Indirect suburban space governance tools do not directly participate in the allocation of suburban space resources, but act on the government, market and society, and indirectly affect the development of suburban space with the help of the constraints and changes in the relationship between the three (Figure 5). Although the direct effect is not on the suburban space, it can indirectly have a profound impact on the resource allocation of the suburban space, and common approaches mainly include economic policy tools, population policy tools, housing policy tools, etc.



Figure 5. Types and action mechanisms of indirect tools for suburban space governance.

Among them, economic policies act on various areas such as taxation, finance, industry, etc., and are more conducive to guiding the introduction of resources in the market, such as capital and industry, to the relatively weak suburbs in terms of implementation. This can change the uneven distribution of resources in megacities and drive the development of suburban space. In megacities, population policy not only controls the population size and attracts directional population agglomeration, but also produces the side effects of spatial isolation and spatial injustice, which indirectly affect the healthy development of suburban spaces. On the one hand, housing policy can stimulate the vitality of suburban collective construction land and ensure the diversified and healthy operation of the suburban land market; on the other hand, it can guarantee the basic housing rights of suburban residents, attract talent to settle down, and maintain the justice of suburban space.

4.2. The Synergy Mechanism of Suburban Space Governance Tools

Although direct and indirect suburban spatial governance tools are different in transmission mechanism, transmission subject, and usage characteristics, when used, they can individually or synergistically affect the spatial evolution of suburbs (Figure 6). At the same time, if a single tool is used outside of its expected direction, the feedback mechanism can be used to mobilize other governance tools to balance the imbalanced utility. For example, the use of economic policies can stimulate the market demand for land, but after reaching a certain level, there will be conflicts between economic goals and unsustainable land resources. At this time, feedback adjustment can be triggered, and the red line tool can be used to reasonably manage and control land resources, so as to guide the coordinated and sustainable development of economic society and suburban space at a reasonable level.



Figure 6. Synergy mechanism diagram of suburban space governance tools.

From the example of Beijing's suburban space evolution, it can be seen that in different stages, the direct and indirect suburban space governance tools show various ways of superimposing, coordinating and cancelling each other in terms of effect. Therefore, on the basis of fully understanding the effect mechanism of various tools on suburban space, different tools must be selected, and the synergistic mechanism between them should be used to rationally act on suburban space, so that suburban space can develop sustainably according to the established direction.

5. Conclusions

Through the quantitative analysis of the spatial evolution of Beijing, this paper finds that the evolution of Beijing's suburban space has altered it from rapid expansion to slow development, and again to reduced development. According to the main evolution characteristics, it can be divided into three stages: space shaping, space restoration, and space reconstruction.

In the research on the spatial governance mechanism of Beijing's suburban spatial evolution, it is found that the spatial governance mechanisms of megacity suburbs place different emphases on different spatial evolution stages. At the same time, the space governance mechanism and effect also follow three different stages of space evolution. They exhibit three different characteristics in turn: "extensive development with positive guidance as the theme", "exploratory adjustment with transformation practice as the theme", "Fine governance with management and control intervention as the theme", and each governance mechanism with different characteristics includes a variety of suburban space governance tools.

Based on the research on the spatial governance mechanism of Beijing suburbs, the spatial governance tools in the suburbs of megacities are divided into two categories—direct and indirect—and the application scenarios, conduction and effects of the main tools in the two categories are discussed. The synergistic mechanism between different suburban space governance tools is also preliminarily discussed. The study finds that the governance of suburban space in megacities is accompanied by the whole process of spatial evolution, and it is necessary to select an appropriate combination of governance tools at different status of suburban space.

Compared with previous studies on the evolution process of suburban space [23,24], the influencing factors and the mechanisms of action [25,26], this paper starts from the spatial evolution characteristics of construction land, and innovatively establishes the connection between the suburban spatial evolution and the use of governance tools in different periods. Then, the themes and utility of megacity suburban space governance in different development stages are obtained, and the types, characteristics and action mechanisms of megacity suburban space governance tools are summarized, filling the research gap on the evolution of megacity suburban space governance mechanisms and governance utility. At the same time, this paper still has some shortcomings. On the one hand, in the research scale of the suburban space governance mechanism, there is a lack of research on the micro-scale of internal communities and the macro-scale of external megacities; on the other hand, since megacities are built on the common living rules of citizens [27], more consideration should be given to the deep impact of human needs [28] on suburban space in the study of space governance.

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