Research on Site Coverage Distribution of Beijing Based on Geographic Information System

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ABSTRACT Site coverage is an important index to learn spatial development pattern of the city. In this paper, with the help of spatial analysis functions of GIS, buffer and sector analysis are imposed in pursuit of finding possible spatial distribution rules of Beijing taken flagpole in Tian'anmen square as center. The results of sector analysis indicate that the building densities in such superior geographical condition areas as southeast and south are higher. Building densities of northern and western areas are low because of their bad terrain. The results of buffer analysis indicate the density of city center is the highest and have a negative relation with the augment of distance. That is to say, the average building density of center areas (buffer 1, 2 and 3, about 7.5km away) is about 26%. The average building density of transition region of city and countryside (buffer 10~20, about 25~50km away from center) is about 9%. The average building density of exurbs (after buffer 20~50km away from center) can't reach to 3%.

1. Foreword

Building density, also known as building coefficient, refers to land within a certain range, than the building's entire basement area and land area, can directly reflect a degree of built-up areas [1]. Due to the expansion of urban development, not only in population growth, economic development, but also in the development and changes in the structure of urban space. So with the same population density, building density is also an important indicator of urban space research development model. In this paper, the use of GIS software, spatial analysis, the amount of calculation and query capabilities for building density throughout the City of Beijing for analysis sector direction and the annular belt, in a quantitative way to study the building density of the spatial variation analysis in space in Beijing development characteristics, scope and space to find changes in the characteristics of the urban fringe.

2. Regional Overview

Beijing, this historic world famous ancient city located in the northwest edge of the North China Plain, north and northwest of Yanshan towering, Western Hills, southeast of the Yongding River and the Chaobai River alluvial plain. Its downtown location 39 degrees north latitude, 116 degrees east longitude, Hebei Province and its neighbor Tianjin, Beijing city's land area 16,355 km^2. Wherein the plain area 6,338 km^2, accounting for 38.6%. Mountainous area 10072km2, accounting for 61.4%. Urban area 87.1 km^2. The total population of 1492.7 million. Urban area of 87.1 square kilometers. The city a total of 16 municipal districts, two counties. City districts have Dongcheng, Xicheng, Xuanwu, Chongwen, Haidian District, Chaoyang District, Fengtai District, Shijingshan District, Mentougou, Fangshan District, Tongzhou District, Shunyi District, Changping District, Daxing District, Huairou District, Pinggu. County Yanqing and Miyun County. Urban planning scope: Dingfuzhuang east, west Shijingshan, Nanyuan south, north to Qinghe, a radius of 1040 km^2. Range substantially in downtown areas inside and outside the Fourth Ring Road, an area of nearly 300 km^2 [2].

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3. Data sources and analytical methods

This study uses a vector space data after 2004 by the Beijing Municipal digitized aerial photography obtained, a scale of 1:50,000. The main basis of spatial data including Beijing municipal boundaries map, Beijing sub-county map, building the base maps.

Beijing building density variation analysis is in mapinfoV7.0 software support, with its secondary development tools Mapbasic programming, the buffer zone and the fan page of analysis. Then Tiananmen Square flagpole center (assuming it is Beijing's downtown), respectively, in Beijing to do the building density sector and analysis on the ring.

(1) Fan direction analysis sector analysis is based on the direction of the flagpole as the center for eight uniform radiation boundary intersects with Beijing, and then use the overlay, merge, erase and other fan-shaped region in the study area [3], the points in the direction of Beijing to Region (Figure 1).

(2) Analysis of the annular ring analysis to the flagpole as the center, equidistant do with 2500m buffer, do the endless belt 52, and then with the Beijing boundary map by superposition, merge, erase and other operations, forming a ring inside the study area region [4] (shown in Figure 2, numbered sequentially from the center to the outside of 1 to 52).

Each annular region, an area of the building sector and all are on mapinfo platform, by the amount of self automatically obtained from the graph.

4. Statistical results

The test building density calculated using statistical area within the building area/statistical region area [5]. Beijing Experimental entire total area of 16,355 km^2, total construction area of 878.73 km^2, average building density is 5.37%.

4.1. Regional analysis of the sector
4.1.1. Building density distribution area is small size and sector relations

Statistics showed that (Figure 3), the highest area of the corresponding 3, 4, 5 three fan-shaped area smaller build-

ing density, about 10%, which is twice the average building density of the whole Beijing. The larger 1, 6, 7, 8 four regional density is low, less than the average building density in Beijing. And the smallest of the four regions, building density is not the biggest, most area, the density is not the smallest. Therefore, an area with no law sector between building density at all. But throughout the district, the area where a large fan-shaped area contains much of the mountains, so they are smaller than general building density to flat original lower main fan zone.
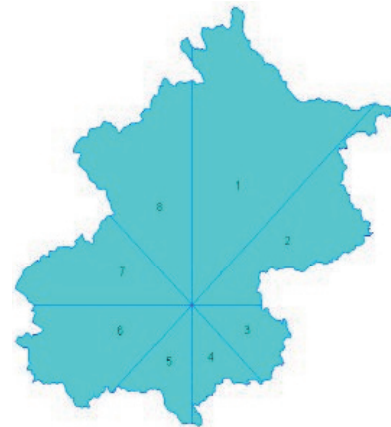

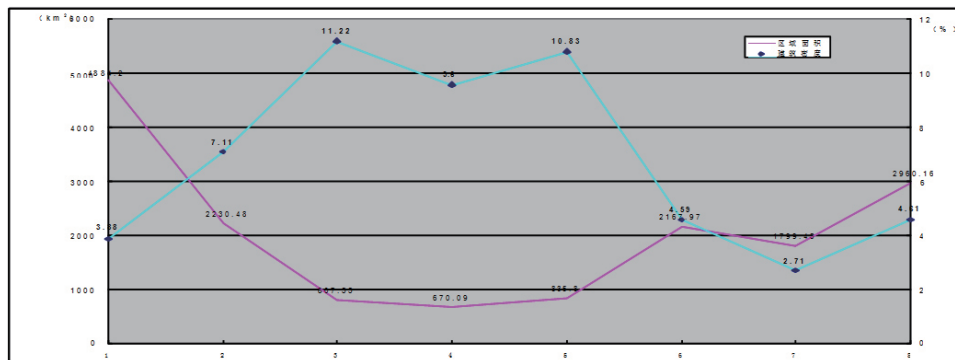**Figure 1.** Sector analysis.

Figure 2. Ring analysis.

Figure 3. Results of sector analysis.

4.1.2. Building density affected by topography, hilly plains building density less than

Geographically speaking, the high density of 3, 4, and 5 sector located south and southeast of Beijing, Beijing belongs to the plains. West while the lower density of 1, 6, 7, 8 sectors are located in Beijing, the north and northeast, covering half round mountain bend, so-called "Beijing dome." Plains occupy advantageous natural and geographical conditions, flat, fertile land, irrigation facilities, good basic conditions for agricultural production, and has relaxed a dense road network, such as the eastern highway, railway leading to Tianjin Port, Qinhuangdao Port, Tangshan Port and Huang Ye Hong Kong and other sea south have major railways, major highways leading to the majority of the hinterland and the southeast coastal economically developed areas, developed commercial activities, Beijing is the most economically active areas of highest growth potential, ease of gathering population and development [6], and therefore a higher building density. Instead, hilly land use difficult, only to forestry, animal husbandry, fruit-based, plus the landscape due to restrictions resulting in its inaccessibility, slow economic development and thus little room for development. Northwest at Sheung Shui more consideration ecological and environmental protection, land development and construction have also been limit. Therefore low building density sector 1, 6, 7, 8. In these four areas, the sector 7 almost entirely suburban mountainous areas, and 96% of the area is mountainous Mentougou in this area to mining and agriculture dominated this area must be sparsely populated, so building density is the lowest.

4.1.3. Building density that affect large urban planning

Prior to 2004, the Beijing Urban Planning and Development Link and the center of the city is focused on the external radioactive transport links as the main development axes, and to invest more in the east and north. For example, Shunyi, Tongzhou District in eastern region is the center of the city population to undertake major regional functions ease and a new industry gathering, the regional focus on the development of Beijing secondary industry, as well as the northern part of the Olympic Sports Center, the Asian Games Village and the high-tech Haidian district as the center construction of the park [7] have had a significant impact on the building density in these regions. Beijing places in the western principles of ecological priority limit construction zone delineation, strictly control the development and construction of shallow mountain area. Building density spatial variation is largely influenced by urban planning.

4.1.4. Building density quite different in different regions

The results from the statistical point of view, in accordance with the sector number, building density curve increases sharply at first, slightly tends to level 3 after Slow, then quickly lower region 5, has a certain rebound in eight. In addition to building density sector 6 and 8 than similar building density among various other sectors are quite different. This is the combined result of the geographical conditions of different regions, historical factors, economic development, different infrastructure caused.

4.2. The results annular region

Statistics Results are shown in Figure 4 the annular region. The resulting overall result is: the central city that is 1, 2, 3 annular region from the central area of approximately 7.5 km, average building density is about 26%; the urban fringe about 10 to 20 annular region, from the center about 25~50 km, the average building density of about 9%; annular region 20 after the outer suburbs, away from the central area of more than 50km, average building density less than 3%.

4.2.1. Building density from the center to the periphery becomes smaller

The highest density of the central annular region 1, 2, 3, followed by ring-shaped area. These three annular region mainly Dongcheng, Xicheng, Chongwen and Xuanwu four Old Town, here is the main center of the city and the city, convenient transportation, among the most prosperous of the lot in Beijing, the most densely populated area, Beijing is the political, cultural, commercial and entertainment center. In this region fully reflects the combined effect of the city, thus building the highest density. Ring 3 and 4, 5
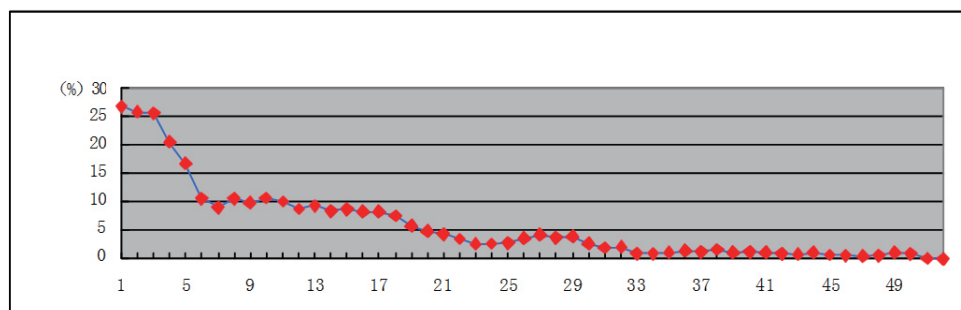

Figure 4. Results of ring analysis.

and there is a significant turning point segment, this part is mainly Chaoyang, Haidian, Fengtai, Shijingshan four suburban area covers tricyclic regional areas of Victoria. Because of the old city has reached saturation, and peri-urban areas is still in the development stage, and in recent years begun to focus on the planning department of ecological environment construction and urban green planning rather than blindly pursuing high building density, building density fluctuations in the region. With increasing distance from the city center, the radiation reduces the effectiveness of the city, building density change urban and suburban regions tend to relatively flat.

4.2.2. Obvious boundaries of the old city and the new city center in 15-20 km away

Old Town called Dongcheng, Xicheng, Chongwen and Xuanwu, new city means Chaoyang, Haidian, Fengtai and Shijingshan district. As can be seen from the graph, clear the old city and the new city boundaries appear in the annulus 6-8, about 15-20 km away from the center point. Metro is the development and construction in recent years, the most active areas, located in Beijing edge of the old city, although the location of these new city is less than the old city, but due to relatively close distance from the city center, and has convenient transportation, excellent infrastructure, good living environment, while adding mediation policy, people's ideas have changed, more and more residents and businesses have been moved here. Metro has an important role in economic and social development in Beijing, Beijing is the focus of development and hot spots.

4.2.3. Beijing urban and broad transition zone

Urban fringe is the most rapid urbanization in rural areas, is the end of the city, the first Country. From the point of view of Beijing Urban and Rural annular analytical curve relatively wide transition zone. This is because the size and city size, urban population, the urban-rural economic development zone was correlated [8]. Building density on the curve of the annular area of about 9% belong to the transition zone of Beijing's urban and rural areas, away from the center is about 25-50 km.

4.2.4. Urban and transitional zone of different sizes in different directions

Based on the above analysis of a single endless belt, in order to more precisely the spatial distribution of the urban fringe, the paper again centered on Tiananmen Square flagpole, the annular area is divided into eight partitions. After statistical analysis, the eight directions along which building density. The changes, in order to better analyze the characteristics of the urban fringe of Beijing, shown in Figure 5.

As can be seen from the statistical curve eight different directions, building density curve shape. (1) Eight broadly consistent with the direction of the central region the highest density increases with distance, the overall trend of building density is reduced, which also verified this article endless belt the results of the analysis. (2) The location presents certain urban fringe areas and directivity characteristics. Within four regions in eastern fringe about 22.5 km from the center starting place. The past several west than in the east, northwest and north west in both directions from the beginning about 17.5 km from the center point. This is due to the trend in recent years, the development of Beijing's eastern reasons. (3) The width of the fringe in two directions except the northeast and northwest are about 30 km. Northeast fringe of the widest range of about 47 km. The northwest section minimum, only about 10km. (4) Building density urban fringe are about 10% volatility. (5) Figure 5(a-h) characteristics different from before, that is, there are times peak, reflecting There are satellite towns.

Spatial distribution of differences between the urban fringe different direction by the direction of economic development, infrastructure condition factor, caused by natural conditions.

Beijing urban fringe is mainly in the outer suburbs of Changping, Shunyi, Mentougou, Huairou, Fangshan and other satellite towns near urban areas. Since the development of the city center is relatively saturated, the Government to strengthen the infrastructure of these satellite towns, more and more starts to move towards the development of these areas around Beijing. And these areas are small plain at Beijing, geographical conditions are relatively favorable, with Beijing loop construction, it is relatively convenient transportation [9], the economic development of these areas have good momentum, it is suitable as a back-up of the Beijing area development resources to ease the tension in Beijing urban land.

4.2.5. Low building density in northern remote areas

After the endless belt 33 from Beijing to remote areas, building density is less than 1%, here is located in the northwest of Beijing, the north and northeast, the Beijing mountainous areas, including the northern part of Yanqing, Huairou and Miyun County. These areas limit due to poor infrastructure natural and geographical conditions, the environment and development prospects of investment far less than other regions, it is not suitable for development of the city, but mainly for the development of industry, mining and agriculture, mainly rural-based.

The overall results show that ring the city center building the highest density, followed by suburban district, close to the city and the location good building density outer suburbs Secondly, while far from the city center, is a mountainous region of the outer suburbs lowest building density. Ring analysis results to a certain extent confirmed radiation effect on the surrounding area of the city. In fact, this result also reflects the spatial distribution of land use and development level of Beijing.
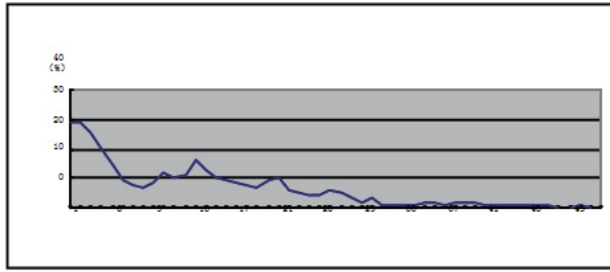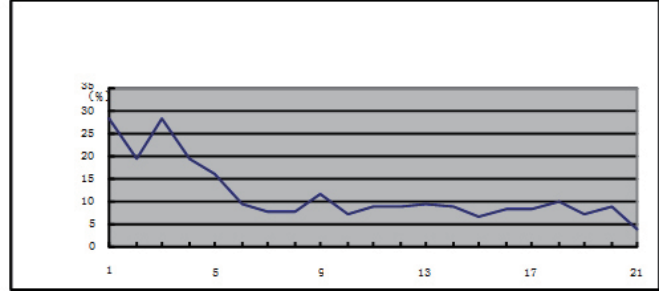
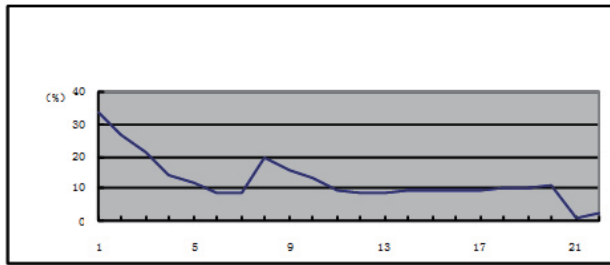(a) Building density curve on NE direction
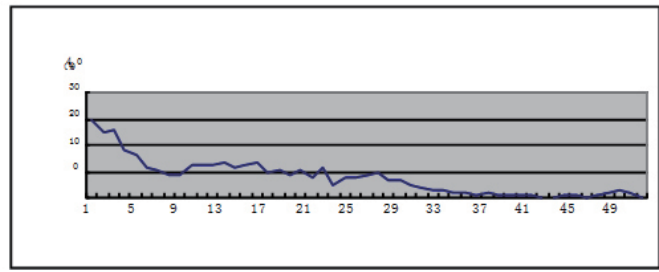
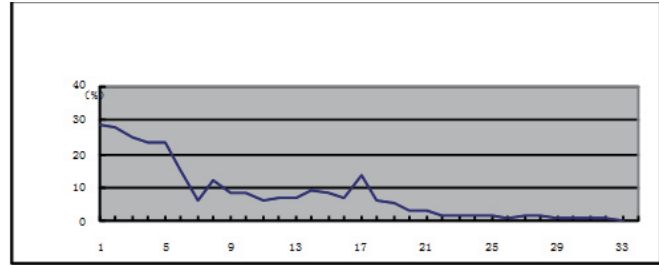(b) Building density curve on EN direction
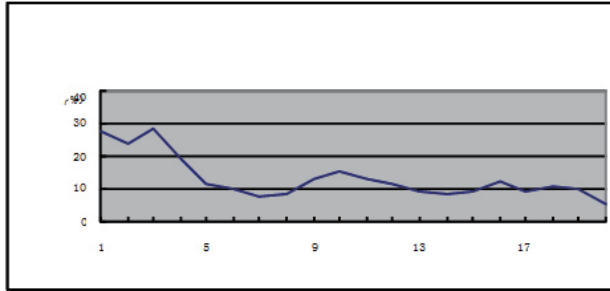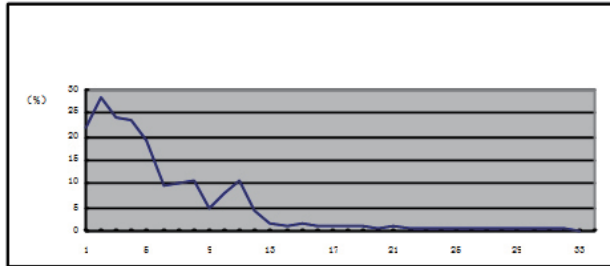
(c) Building density curve on ES direction

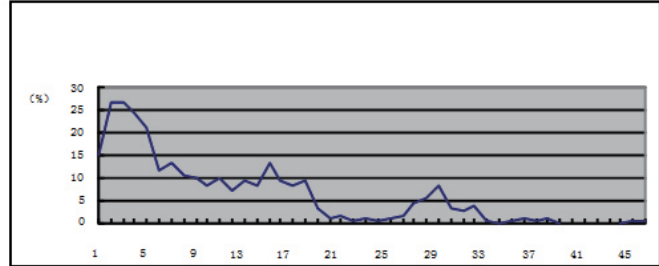(d) Building density curve on SE direction

(e) Building density curve on SW direction

(f) Building density curve on WS direction

(g) Building density curve on WN direction

(h) Building density curve on NW direction

Figure 5. Results of different directional analysis.

5. Conclusion

In this paper, the use of geographic information system software mapinfo Beijing made building density sector analysis and the ring, gives quantitative results. From a comprehensive analysis of the sector and the annular region, the closer from the city center located in the plains of eastern and higher in southern Beijing building density area in the region due to the convenient transportation, economic development is rapid, will attract more residents and businesses, thus building density is much higher than other areas, adjust policies and because a large part of the

factory moved to the south-east, this area is also building density than other for a reason. While building the highest density of the downtown area, but has no potential for development, the main building is reserved for ancient buildings, renovation of old buildings dominated. As for the surrounding suburban areas and suburban area, there are more development space and value, building density will continue to rise. Mainly due to the influence of the remote northwest of the topography, there is no room for development, but mainly concentrated in rural residential area, industrial and mining enterprises and scenic areas, and

therefore lower building density [10]. Building density level is affected by both the regional economy, terrain, traffic, fertile land and the extent of use types and other factors.

The test results of the analysis and some other scholars on population density tends to be consistent in Beijing [11]. Because the population density and building density has a high correlation, it showed positive correlation trend, high population density, building density area often high, otherwise low. Because of population growth in the aggregate and residential area, directly request the residential area to provide greater work and living space, a "population increase—population density increases—to expand settlements and build" model [12]. The results of this paper can basically reflect the spatial distribution of the current characteristics of Beijing building. The shortage is not the building floor area ratio indicators considered together, comparative analysis of multi-period has not been until the data has then further research to better analyze the characteristics of land use in Beijing, in order to provide economical and intensive use of land reference.

Conflicts of interest

These authors have no conflicts of interest to declare.

Authors' contributions

These authors contributed equally to this work.

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