

GIS and RS Application Study on Urban Dynamic Development

Anrong Dang, Huizhen Shi, and Qizhi Mao

Center for Science of Human Settlements
Tsinghua University, Beijing 100084

Abstract

Urban dynamic development has become an important issue to both officials and urban planners in China. As the capital of China, dynamic development of Beijing has been concerned a lot by both government and scholars. Based on geographic Information system (GIS) and remote sensing (RS), the authors have analyzed the quantitative and qualitative characteristics of dynamic development of Beijing. The conclusions are as follows: (1) The dynamic development speed has been accelerated in recent years. (2) The dynamic development scale has obvious difference in temporal-spatial distribution. (3) The dynamic development trend can be controlled by means of urban planning.

I. INTRODUCTION

Along with the economy developing and population increasing, urbanization has been accelerated very much in recent years in China. The urbanization rate was below 10.0% in 1949, when the People's Republic of China was established. While it is raised to 30.9% in 2000, and it will be increased to 60% in 2020. At the same time, urban dynamic development becomes an important issue to both officials and urban planners. As the capital of China, dynamic development of Beijing has been concerned a lot by both government and scholars.^[1-4] What kind of dynamic development has been happened in Beijing, and what will be the development trend? Based on geographic Information system (GIS) and remote sensing (RS), the authors have analyzed the quantitative and qualitative characteristics of dynamic development of Beijing.

II. STUDY FRAMEWORK

The framework of GIS and RS application study on urban dynamic development is described by means of workflow chart. According to the general process of urban dynamic development and the possibility of data acquirement, the framework of research method is worked out as shown in Figure 1 based on the characteristics and analysis method of GIS and RS^[5-9]. Four steps are included in the framework: data preparing, information processing, dynamic analyzing, and results outputting.

Data preparing

Data is a primary factor for the study of urban dynamic development. According to the necessity of researching and the possibility of data acquiring, some spatial-temporal database of case study urban, Beijing, was setup supported by GIS and RS. There are two major kinds of data sources, one is urban maps, while the other is Landsat TM/ETM image. Both vector data and raster data are included in the spatial database, such

as administrative divisions, latest planning map, Landsat image of different periods, and so on. All of the data are the basis for further processing and analyzing.

Information processing

Two types of information processing methods were used for two different kinds of data in this step. For the vector graphic data, digitizing and compiling was done, and the relative attribute data was added to establish integrated database of spatial-attribute. For the raster imagery data, the processing methods include geometric correction, image mosaic, classification, interpretation, and so on. During the processing, some filed works have been done in detail. The final results of imagery data processing were urban constructed area information and their distribution in different periods, such as in 1980's, in 1990's, and in 2000's.

Dynamic analyzing

Dynamic analyzing refers to urban dynamic development analysis, which was finished by means of GIS overlay analyzing and geo-statistical analyzing. Besides the data prepared in the first step and information acquired in the second step, some other information, such as urban planning information, developing orientation information are added to complete dynamic analyzing. Both spatial developing information and temporal changing results, which represent the urban dynamic development, were obtained in this step.

Results outputting

Many kinds of outputting methods were used to represent the research results, such as analysis map, statistical table, statistical chart, and analysis report. Each of them has the different effects and functions for urban dynamic development analyzing. While analysis map represents the spatial dis-

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in Geographic Information Science (CPGIS)

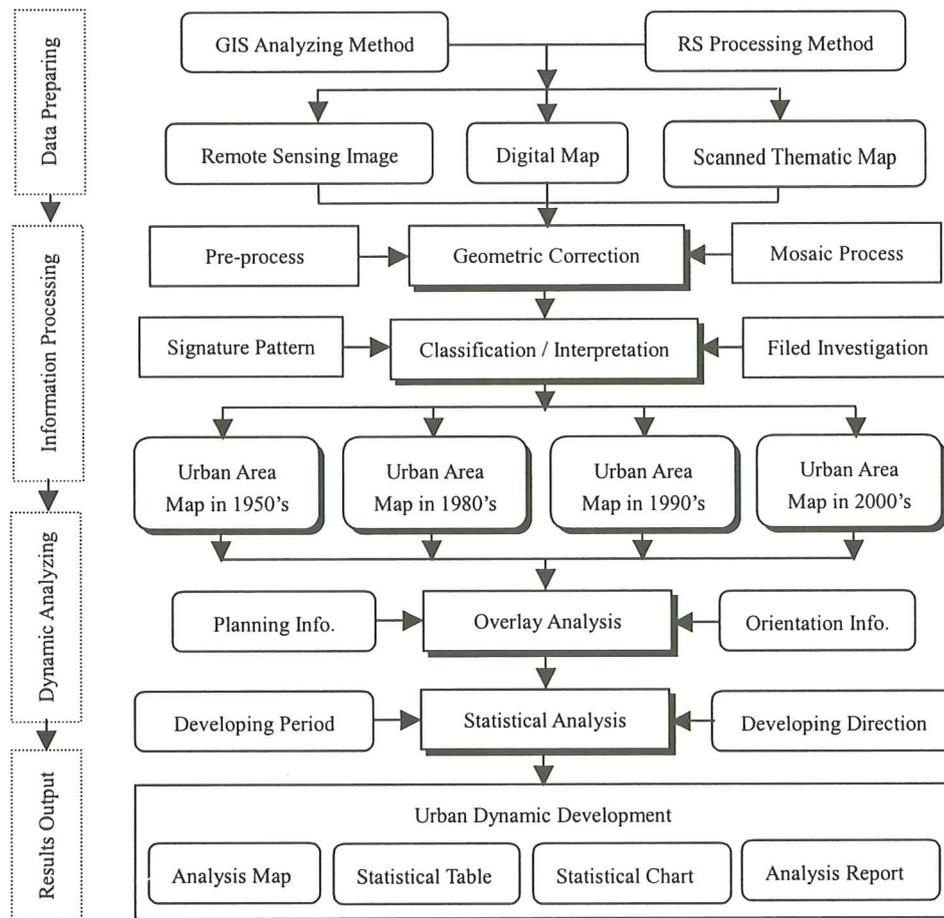


Figure1. Flow chart of study on urban dynamic development

tribution, statistical table and chart represent the quantitative characteristics, and analysis report is generally the qualitative description.

III. DYNAMIC ANALYSIS

Three aspects of urban dynamic analysis have been done based on GIS and RS. One is temporal dynamic analysis, the other is spatial dynamic analysis, and the third is planning compared analysis. All of them have been done by means of overlay analysis and statistical analysis.

Temporal dynamic analysis

As the capital of China, Beijing has been experienced several different developing stages from 1950s to 2000s. Its dynamic changing of construction area can be divided into two periods -- one is from 1951 to 1983, and the other is from 1984 to 2000. The dynamic analysis of the first period (1951-1983) was done based on aero-photos^[10], while that of the second period (1984-2000) was done based on satellite images (our study, 2001). And the results are shown in Figure 2, Figure 3 and Table 1. It should be realized that the difference of temporal

dynamic study between two periods is not only the information source, but also the study region. Shown as the Figure 2 and Figure 3, the study region of the second period is more broad than that of the first period.

Two characteristics of temporal dynamic development of Beijing can be worked out by comparing Figure2, Figure3, and Table 1. (1) The changing of absolute constructed area of Beijing in the second period (from 435.04 km² to 860.41 km²) is much more than that of the first period (from 111.90 km² to 370.98 km²). (2) The average development speed (constructed area increase per year) of Beijing in the second period (26.59 km²/year) is also much more than that of the first period (8.09 km²/year). That is to say, both construction area and development speed were increased rapidly.

Spatial dynamic analysis

Taking the center of Tian-anmen building as the center of Beijing city, the spatial dynamic analysis was done by dividing spatial development orientation into eight sections, such as north, northeast, east, southeast, south, southwest, west, and northwest. Each spatial development orientation has its own ID number that is listed in Table 2. The quantitative sta-

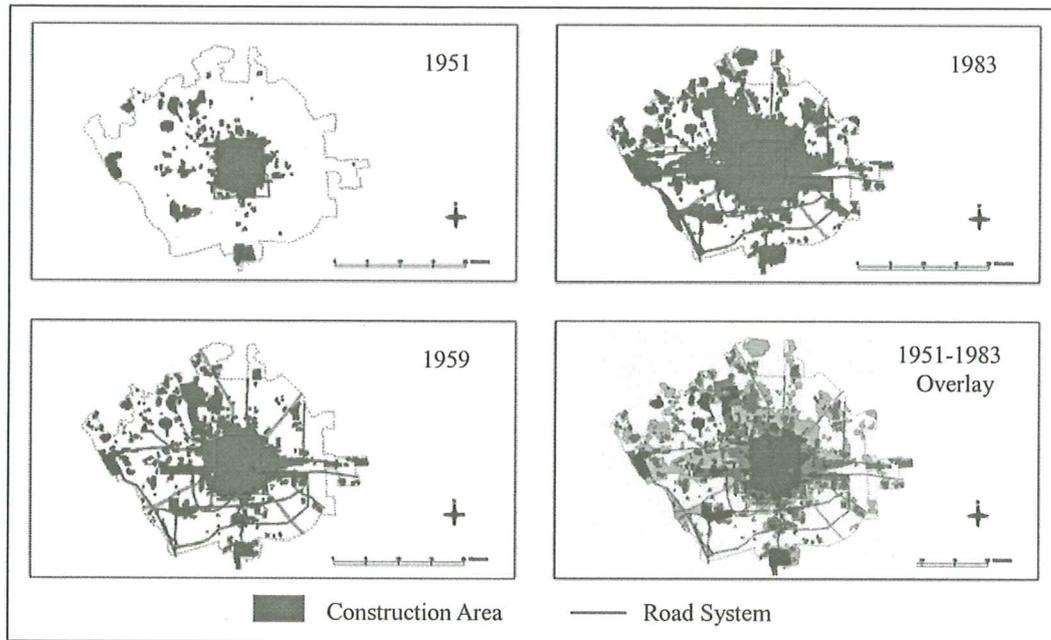


Figure 2. Dynamic changing of urban construction area from 1951 to 1983 (Refer to reference [10])

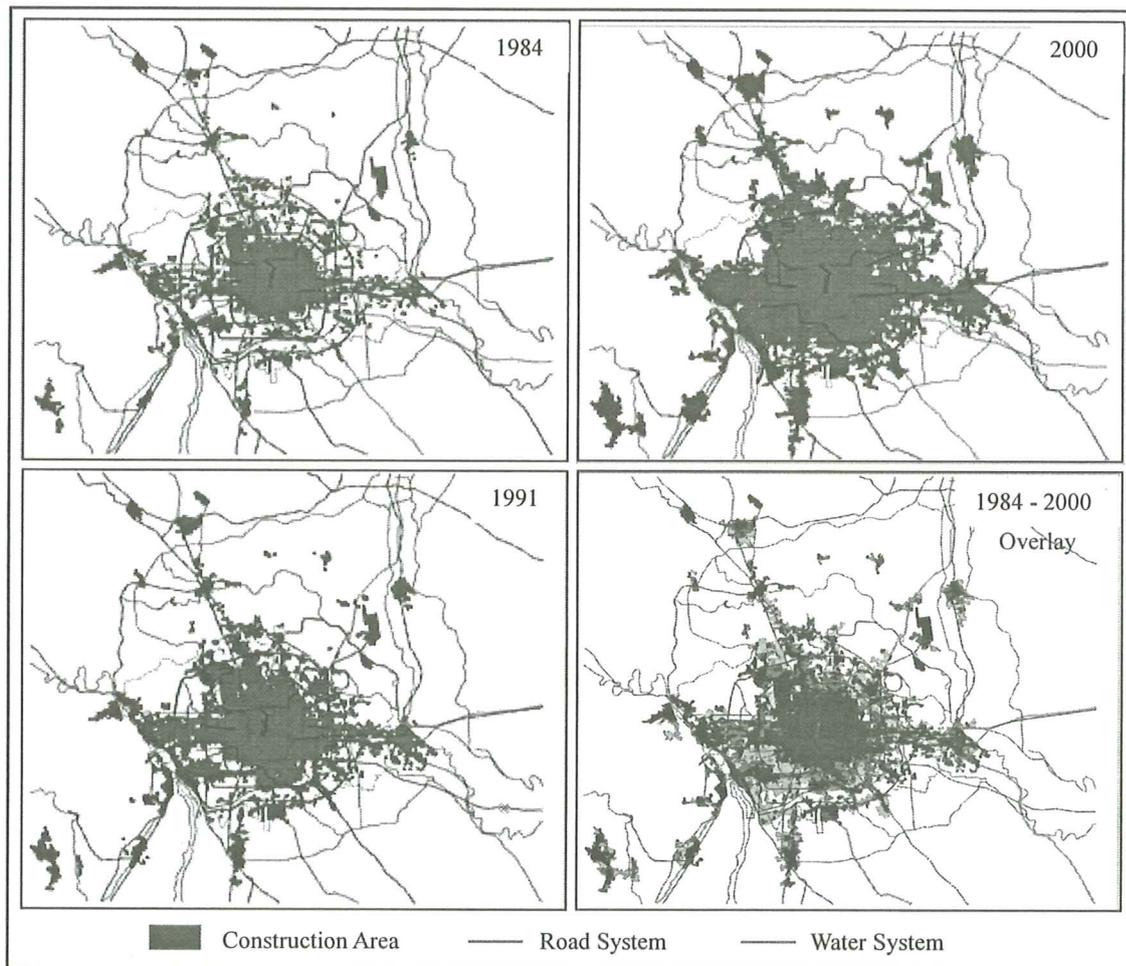


Figure 3. Dynamic changing of urban construction area from 1984 to 2000

Table 1. Temporal dynamic analysis of urban construction area

Year	1951	1959	1983	1951-1959	1959-1983	1951-1993
Area (km ²)	111.9	220.81	370.98	108.91 / 13.61	150.17 / 6.26	259.08 / 8.09
Year	1984	1991	2000	1984-1991	1991-2000	1984-2000
Area (km ²)	435.04	653.1	860.41	218.06 / 31.15	207.31 / 23.03	425.37 / 26.59

Note: (1) The data during the year 1951-1983 are cited from reference [10] based on aero-photos. (2) The data during the year 1884-12000 are obtained by our study based on satellite images. (3) "108.91 / 13.61" -- refers to "total increase in a period / average increase per year"

tistical analyzing of each spatial development orientation has been done based on the temporal dynamic analysis and GIS overlay analysis. The increase rates of urban constructed area are listed in Table 2, and the data are illustrated in Figure 4 by means of radar chart. In radar chart, each axis represents the spatial development orientation while the label number refers to the ID number in Table 2, and each octagon labeled with numbers represents the increase rates of urban constructed area, such as 2, 4, 6, and so forth. Obviously, the characteristics of spatial dynamic development of Beijing can be deduced from Table 2 and Figure 4. While the first characteristic is that the difference among different spatial development orientations is distinctness, the second characteristic is that the dominating spatial development orientation was varied from 1951 to 2000.

Shown as Table 2 and Figure 4, different spatial development orientation has different increase rate of urban construction area, and the dominating spatial development orientation was changed during the period of past 50 years. The dominating spatial development orientation was east from the year 1951 to 1959, but it was changed to northeast from 1959 to 1983. During 1984 to 1991, the dominating spatial development orientation was southeast, and it was also southeast from 1991 to 2000.

Planning compared analysis

Regarding as the best way to control and manage urban development, urban planning has been applied for a long period all over the world. How about the control function for urban construction of urban planning in Beijing, and what is the

relationship between planning and real development? Some of these kinds of questions will be answered through out the planning compared analysis.

Similarly, taking the center of Tian-anmen building as the center of Beijing city, real constructed area in the year 2000 and urban planning construction area in the year 2000 was divided into eight sections. Compared analyzing and computing have been done by means of GIS overlay analysis. As listed in Table 3 and illustrated in Figure 5, the results of planning compared analysis can be summarized as follows: (1) The total real constructed area is less than planning construction area, same as all of the development directions. (2) While the planning construction area was not occupied by real construction, some constructions were located outside the planning boundary, especially in the east development direction. (3) The non-constructed areas inside the planning construction area is bigger than the constructed area outside the planning contradiction area, from this point of view, urban development of Beijing is really under planning controlling.

IV. CONCLUSION

To sum up this study, some conclusions can be worked out: (1) The dynamic development speed of Beijing has been accelerated in recent years. (2) The dynamic development scale of Beijing has obvious difference in temporal-spatial distribution. (3) The dynamic development trend of Beijing can be controlled by means of urban planning and managing.

Table 2. Spatial dynamic analysis on increase rate of urban constructed area

ID No.	Orientation	1951-1959	1959-1983	1984-1991	1991-2000
1	North	8.18	2.71	6.18	3.09
2	Northeast	6.12	3.29	5.86	3.11
3	East	16.61	1.91	5.57	4.31
4	Southeast	8.99	2.45	9.51	5.81
5	South	5.38	1.28	7.27	3.98
6	Southwest	5.03	1.92	6.53	1.17
7	West	12.38	2.94	5.41	1.83
8	Northwest	9.16	1.34	4.27	2.73

Note: (1) The number in the first row, such as 1951-1959 refers to "from the year 1951 to the year 1959". (2) The increase rate of urban construction area was calculated by the formula " $A(1+R)^T = B$ ". Where: A is the constructed area in the beginning year, B is the constructed area in the end year, T is the number of the period from beginning to the end, and R is the increase rate of urban construction area (R%).

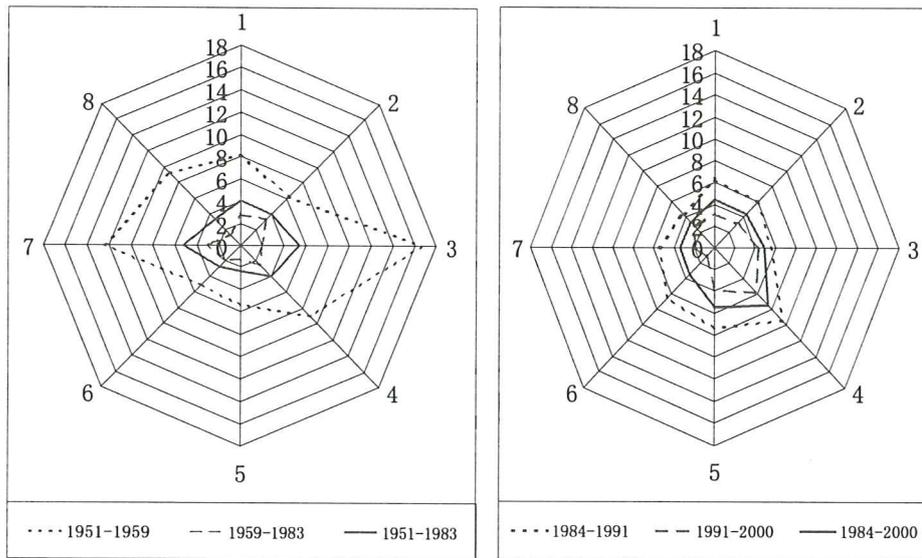


Figure 4. Spatial dynamic changing on increase rate of urban construction area

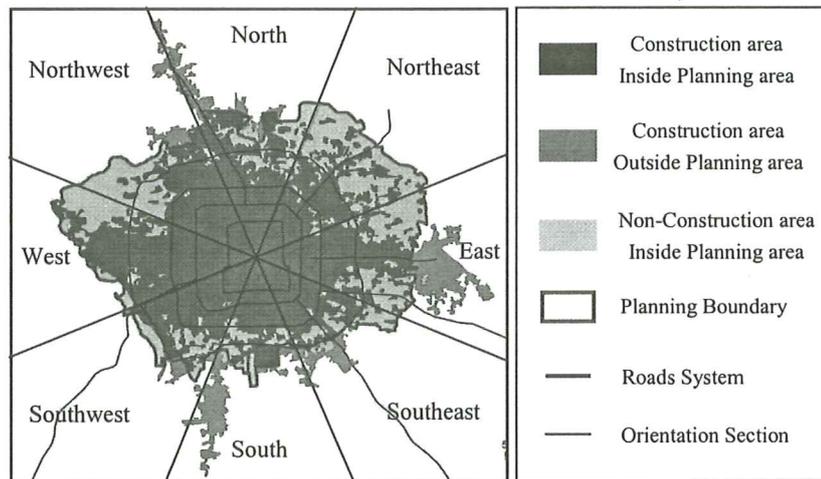


Figure 5. Compared analysis between planning and construction area

Table 3. Planning compared analysis of urban construction area (km²)

ID No.	Orientation	Planning 2000	Constructed 2000	Outside Constructed	Inside Non Constructed
1	North	127.95	116.31	24.54	36.18
2	Northeast	178.29	98.11	0	80.18
3	East	160.24	145.04	46.3	61.49
4	Southeast	83.11	78.03	19.13	24.21
5	South	67.83	84.3	35.32	18.86
6	Southwest	105.75	89.71	8.11	24.15
7	West	181.05	134.12	0.34	47.26
8	Northwest	146.38	114.79	19.73	51.31

Note: (1) Planning 2000” refers to the planning construction area in 2000 worked out by Beijing Planning Bureau. (2) Constructed 2000” refer to the real constructed area in 2000 obtained by our study based on satellite images.

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