POPULATION DISTRIBUTION AND ITS CHANGE IN GUANGZHOU CITY

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ABSTRACT: Population density in Guangzhou City is characterized by a main single center and considerable differences throughout the 8 districts and 112 neighborhoods and towns. Historically, population density in Guangzhou City rose sharply, and population distribution was mainly influenced by the attraction of the port. After the founding of the People's Republic of China (PRC), a series of large-sized factories were built in suburban areas, which drew in a large amount of population from the areas outside of Guangzhou. A small part of this population lived in the suburban areas while most resided within the city centre. As the natural increase rate of population was very high, the population density of both the city centre and suburban areas rose, the former rose at higher rates. Since reform and the opening up to the outside world, Chinese economy has grown quickly, the total population of Guangzhou has also increased quickly. Meanwhile, changes in population density within the city is becoming more and more obvious. Population density in the city centre is falling and in city periphery is rising. From the analysis of the population density model, it is found that population distribution of Guangzhou is in the process of transition from an early stage to a mature stage. Population decline within the centre city of Guangzhou City, which reflects a prosperous economy of the city, is significantly different from the recession of in the western countries.

KEY WORD: population distribution, population distribution characteristics, change trend

I. POPULATION DISTRIBUTION CHARACTERISTICS

By the end of 1994, the population of Guangzhou City had increased to 3. 803 million, a population size ranked China's 6th next Shanghai, Beijing, Tianjin, Shenyang, and Wuhan. Population distribution in Guangzhou takes on the following characteristics:

1) The city's population distribution has only one main center with density steadily decreasing outwards. Towards the west and the south, density decreases at relatively higher rates due to the geographical limit of the Zhujiang (Pearl) River and the nearby limits of the city boundary in these directions. Towards the east and the north, population density decreases at

relatively low rates due to the presence of the most favorable land for urban development and the harbour in the eastern part of Guangzhou (Fig. 1).
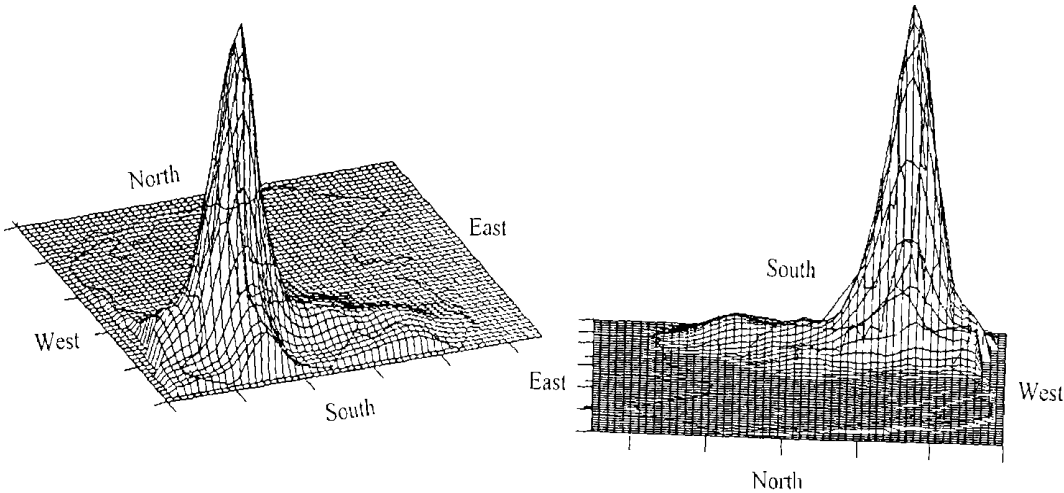

Fig. 1 Distribution of population density in Guangzhou City

2) Within the 8 districts of the city, both population size and population density vary greatly with districts (Fig. 2).
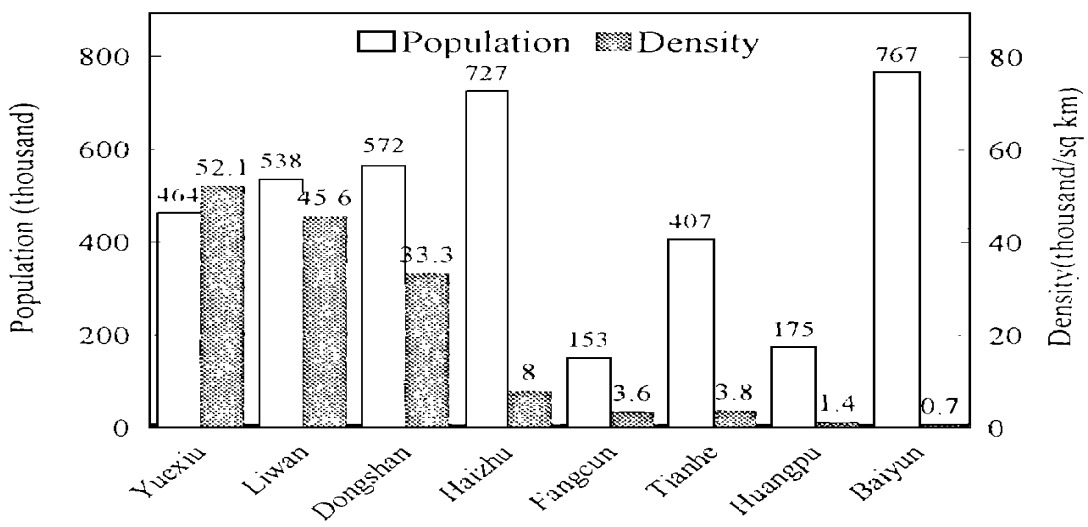

Fig. 2   Comparison of population and density among 8 districts in Guangzhou City

3) Furthermore, population density also varies considerably among the smaller administrative units called neighborhoods(Jie Dao in Chinese). In 1994, there were 91 neighbourhoods in Guangzhou City. The most dense neighbourhood in the city, housing 143 000 people per square kilometre, was Danan neighbourhood of the Yuexiu District. In contrast, the least dense neighbourhood in the city was Xiagang neighbourhood in the Huangpu District which contained

only 334 people per square kilometer, 478 times less than the former. There were 21 towns in Guangzhou in 1994, the most dense town was Changzhou Town at Huangpu District with 2029 people/km^2 and the least dense town was Taihe Town at Baiyun District with 336 people/km^2. The former is greater than the latter by 6 times.

4) The high density areas are located between Xiguan to Beijing Road, where almost all the neighbourhoods each has a density of 100 000 people/km^2 or higher .

The characteristic of population distribution outlined above are closely related to population development throughout history.

II. CHANGES IN POPULATION DISTRIBUTION THROUGHOUT HISTORY

Guangzhou, as a city, has a history of more than 2000 years, in which the urban development mainly result from the attraction of its harbour. Five thousand years ago, the city was largely surrounded by the sea. Because of tidal currents along the shore, sediments carried by the river flowing from the north were and continues to deposit at the river mouth, forming a continually enlarging delta that is used as farmland. During the Jin Dynasty, the width of the bay containing the river mouth was roughly 1500 m. The width of the bay then narrowed to 900 m by the Song Dynasty, to 700 m by the Ming Dynasty and subsequently to 500 m by the Qing Dynasty. As sediments accumulate towards the west and the south, the shoreline also migrates in these respective directions, affecting the city expansion and population movement. In 1911, the river bank was constructed and the quay was moved to Bai'etan (White Swan Pool). In addition to harbour attraction, the narrowing of the river also played a role in increasing activity and association between the north and south banks of the river. Development began along the Hongde Road in south of the river, followed by Fangcun District located at the west of the river. After the opening of Haizhu Bridge in 1933, population and land development progressed further southwards.

Aside from a slight population decrease during the Sui Dynasty, there has been steady increase throughout the 2000 years between the early Han Dynasty and Qing Dynasty (Zhang, 1988) (Table 1).

Table 1   Population density in Guangzhou region in different dynasties (household/km^2)

Dynasty	Han	Jin	Sui	Tang	Song	Yuan	Ming	Qing[*]
Density	0.15	0.8	0.5– 1	1– 2	3– 4	4– 5	10– 20	200

* Person/km^2

Population density within the central city during the 1920s was 24 000 people/km^2, increased to 30 000 people/km^2 during the 1930s and then decreased to 16 000 people/km^2 during the Japanese invasion of the early 1940s. By 1948, however, population density recovered to 42 000 people/km^2.

Generally, the population of Guangzhou City increased at relatively higher rates after the founding of the People's Republic of China. The population increased from 1. 506 million in 1950, to 3. 017 million by 1980 and during this period there were several booms and busts due to national economic and policy changes.

1. Economic Recovery Period and the First Five-Year Plan Period(1953– 1957)

During this period, as much of the country was in ruins after the war, a large-scale economic reconstruction plan was launched. Although Guangdong Province is located along the coast, it was not a key area of industrial development for the government. Nonetheless, because of the rise in economic power on the national level, Guangzhou City's population increased rapidly (Table 2). The population increase was mainly concentrated within built-up areas, leading to a significant increase in population density within the inner city.

Table 2 Population increase rates of Guangzhou in different periods (%)

Period	Agriculture	Non- agriculture	Total
Economic recovery	2. 2	5. 1	4. 3
First Five-Year Plan	1. 9	7. 0	5. 7
Second Five-Year Plan	0. 9	2. 6	2. 2
1963– 1965	5. 5	1. 1	2. 0
Third Five-Year Plan	2. 5	– 1. 1	– 0. 3
Fourth Five-Year Plan	3. 2	0. 7	1. 4
1976– 1979	0. 3	3. 0	2. 3
1950– 1979	2. 2	2. 5	2. 4

Source: Guangzhou Statistic Bureau, 1980. Statistics of Guangzhou National Economy(1949—1979)

2. The Second Five-Year Plan Period (1958– 1962)

Guangzhou entered into a phase of high industrial development, many large-sized plants were built in the areas surrounding the city, including iron and steel plants, cotton mills, nitrogenous fertilizer factories and so on. In the Huangpu District where harbour with favourable construction, medium-and large-sized enterprises such as shipbuilding and iron and steel industries were established. In the first two years of the Second Five-Year period, the total population was continually increasing. Although it was industrial development that lead to a population increase in the industrialized areas which were located at some distances from the old city, the population increase was mostly concentrated in the urban area. As a result, the population density increase in the surrounding areas also corresponded with population density increase

within the urban area (Table 3). Three-year natural disasters after 1958 brought tremendous difficulty upon the lives of the people in the city, by 1960, many residents moved back to rural areas, causing a total population drop in the city. However, because of the opening of Zhujiang Bridge linking the central area with the west of the Zhujiang River in 1960, the population of the Fangcun District gradually increased again.

Table 3 Population density in Guangzhou region (1953– 1982)

Year	Population density (person/km^2)				Studied area(km^2)
	Central area	Outer area	Near suburb	Outer suburb	
1953	76400	7800	800	400	28
1964	92600	16300	1500	700	42
1979	87600	20100	2100	1000	47
1982	91600	23300	2200	1100	51

Source: Hu Huaying, 1993. City·Space·Development. Guangzhou: Zhongshan University Press. 56. (in Chinese)

3. The Periods of the Third Five-Year Plan and the Fourth Five-Year Plan (1966– 1975)

One of the impacts of "the Cultural Revolution" on Guangzhou City was that its economy stagnated during that time. Especially the policy that young people went to the countryside to receive reeducation from the poor and lower-middle peasants made mechanical change in population become negative. But because the natural rate of population increase was relatively high, the total population of the city was in stable condition (Table 2).

The People's Bridge linking the north area of the river to the south area of the river was opened in 1967 and Haizhu Bridge was widened in 1975, providing advantages for people residence at south area of the river. During the Fourth Five-Year Plan period, Huangpu harbour was expanded and reconstructed to become Guangzhou City's new area for heavy industrial and chemical industry development. Attracted by the river port, Guangzhou's industrial sectors gradually moved eastward, resulting in a steady population increase in the Huangpu District.

4. After 1976

In 1979, reform policies allowed officials and their families as well as young people to return to the city, bringing a steady mechanical growth of population. Moreover, together with the high natural population increase rate of the city, this massive return to the city resulted in a major increase in the total population within the city. So between 1979 and 1982, whether within the central area, in the surrounding suburbs or in rural areas, population density was increasing.

Since the founding of the People's Republic of China until the reform and opening up to the outside world, the total rate of change in population density of Guangzhou City is positive both in urban and rural areas, but that of the urban area was higher than the rural area.

IV. POPULATION DISTRIBUTION CHANGES SINCE THE REFORM AND OPENING UP TO THE OUTSIDE WORLD

1. The Differences in Population Increase at Different Times

Generally, Guangzhou's total population since the reform and opening up to the outside world increased at relatively high rates, but lower than those of the 1950s, it was the second highest rate since the founding of the People's Republic of China. From decade to decade, increase in population number was 917 500 in the 1950s; 131 800 in the 1960s; 503 700 in the 1970s and 543 500 in the 1980s. Similarly, the net increase in population during the 1980s was lower than that of the 1950s but higher than that of the 1960s and the 1970s (Fig. 3).

2. Variations in Population Increase Within 8 Districts

The average rate of population increase per year in Tianhe, Dongshan, Huangpu and Haizhu districts between 1980 and 1994 were 4.48%, 2.60%, 2.32% and 2.12% respectively. These were higher than the average annual rate of increase, 1.67% of Guangzhou City. Because Tianhe, Dongshan and Haizhu districts are near the city center, and Huangpu District has a harbour, these four districts had high rates of population increase.

Population increase rates of Baiyun and Fangcun districts are 1.86% and 1.48% per year respectively; they are lower than the average population increase rate of Guangzhou City. This is due to little attraction in these districts ——Fangcun District is located to the west of the river where transportation is less convenient and most of Baiyun District is relatively far away from the central area.

The years of 1989 and 1987 were the turning years for Liwan and Yuexiu districts respectively. Population within these respective areas increased slowly prior to these years and decreased after them. These two districts are the oldest in Guangzhou City, and also the main business districts in the city (Fig. 4).

3. Population Density Models

Clark, Tanner and Newling (Newling, 1969; Cadwallader, 1985) have analyzed patterns of population density changes in the western cities, classified their courses of change into three main stages (Fig. 5).

1) Youth stage (Fig. 5a to 5b). During this stage, population density is the highest within the city center and decreases outwards with distance and population increases at higher rates within the inner city than in the outer. Population density decreasing with distance from the city center is represented by the following equation:
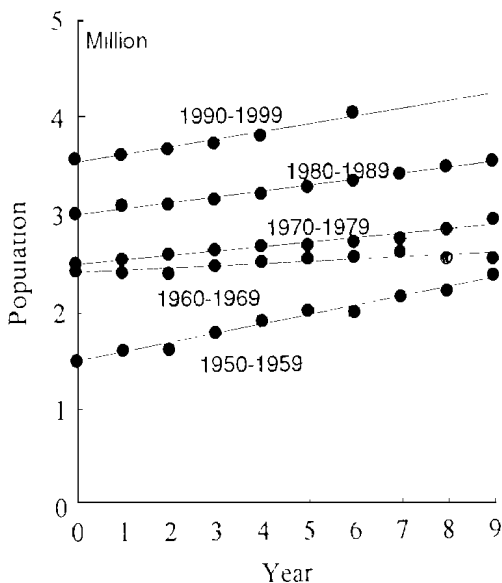
Fig. 3 Population growth in every decade
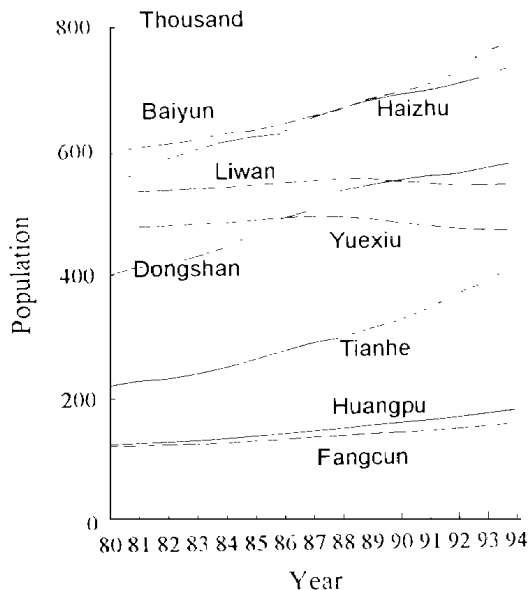since 1950 in Guangzhou City

Fig. 4　Population growth of 8 districts
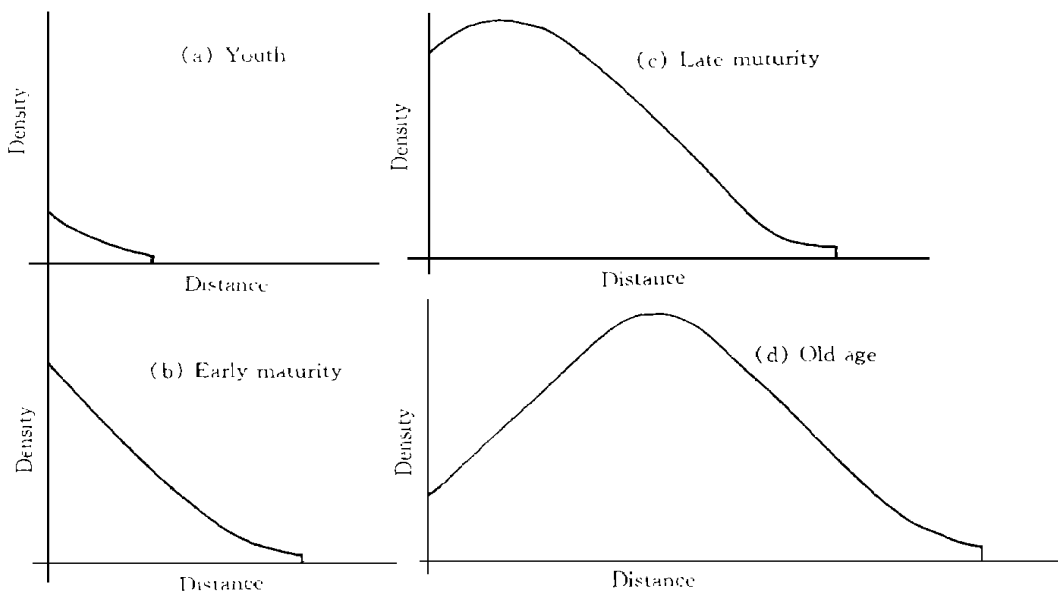of Guangzhou City (1980– 1994)

Fig. 5　Pattern for population density change in the western cities

$$d_x = d_0 e^{-bx} \Rightarrow \ln d_x = \ln d_0 - bx \qquad (1)$$

where d_x represents population density at distance ' x ' from the central business district (CBD), d_0 is density at the CBD, and b is a constant, the rate of change of density with distance. The higher this constant b is, the quicker the population density decreases away from

CBD.

2) Maturity stage (Fig. 5b to 5c). During the stage of maturation, population increase within the city centre slowed down and in the outer city quickened. Correspondingly, population density in the outer city gradually surpasses that of the inner city. The curve of population density changing with distance can then be represented by the following equation:

$$d_x = d_0 e^{-cx^2} \Rightarrow \ln d_x = \ln d_0 - cx^2 \qquad (2)$$

where c is another constant and the other variables are as above.

3) Old age stage. Progressing onwards into the old age stage, (Fig. 5c to 5d) the population migrates outwards from the city centre due to commercialization and the growth of service industry within the city centre. As a result, the point of maximum density also migrates outwards, creating a population density "notch" in the city centre (Berry, 1963). This density curve is represented by the following equation:

$$d_x = d_0 e^{bx - cx^2} \Rightarrow \ln d_x = \ln d_0 + bx - cx^2 \qquad (3)$$

where constants b and c are again the rates of population density decrease and the other variables are as above. Equation (1) and (2) are special cases of equation (3) when c is zero and b is zero respectively.

To adopt this model for Guangzhou City, we have chosen the city centre to be located around the intersection of Zhongshan Five Road and Beijing Road, using equation (3) to represent Guangzhou City's population density changing with distance from the city centre (Table 4).

Table 4 Population density model of Guangzhou City

Year	Model: $\ln d_x = \ln d_0 + bx - cx^2$	R^2
1982	$\ln d_x = 4.8411 - 0.47615_{4x} - 0.010896\ x^2$	0.57288
1994	$\ln d_x = 4.62297 - 0.20038_{3x} - 0.036673\ x^2$	0.63592

From the 1982 model, we can see that $b < 0$ and c is nearing zero, population distribution is similar to that represented by equation (1) (infant stage of city population density development). A comparison between the 1982 model and the 1994 model reveals that b has increased from -0.476154 to -0.200383 and nearing zero; c has increased from 0.010896 to 0.036673; and the distribution curve has evolved to resemble the curve represented by equation (2). Once $b = 0$ and the distribution curve is as that of equation (2), Guangzhou City will have reached the mature stage of city population density development. In relation to this model, the present state of Guangzhou City's population distribution can be classified as being at a stage of transition between equations (1) and (2) ——the population is gradually spreading outwards from the city centre where a "notch" in the distribution curve has yet to appear.

4. Trend Surface Analysis

The distance-density model is 2-dimensional. In order to depict accurately the spatial vari-

ation of population density, it is necessary to apply a 3-dimensional model to facilitate trend analysis. For each coordinate point ($x_i y_i$), there is an assigned population density d_i which consists of two components: one (d_i') represents the trend for density change and the other (ε_i) is residual density (Latham, 1970). The density trend is controlled by the population density of the entire city and the residual density is controlled by local and random factors.

$$d_i = d_i' + \varepsilon_i \tag{4}$$

For a city developing in a plain with no geographical barriers (e.g. hills, rivers, etc.), the density trend (d_i') becomes the dominant factor, leading to an ideal simulation of the model represented by equation (4). In contrast, for a city located in areas containing geographical barriers, the residual density (ε_i) becomes significant, resulting in a flawed simulation of the model.

Table 5   Coefficients (R^2) of the trend surface analysis of Guangzhou City

Year	Orders of trend surface			
	5	2	3	4
1982	0. 34892	0. 53805	0. 53957	0. 53428
1994	0. 40218	0. 57422	0. 57827	0. 58146

From Table 5, we see that R^2 for all orders of surface in 1994 is greater than those in 1982, implying that the overall goodness of fit is better in 1994 than in 1982. This shows that population density distribution is gradually becoming more and more regular and uniform. Before the reform and opening up to the outsidle world, industries were invested much more, housing construction less, the use of land was granted to land users at little or no cost. Consequently, land users used these properties as if they belonged to them, leading to an uneven population distribution within the same area of the city. Since the reform and opening up to the outside world, however, housing development has been given higher priority and many residential buildings have been constructed in areas surrounding the industrial areas, in the perimeters surrounding the city centre and within the city centre itself housing distribution became more even. Meanwhile, various policies were being reformed and loosened so that it became much more convenient for the urban population to move to other places for residence within the city. So the change of trend surface is that population distribution has become more regular.

V. CONCLUSIONS

1) In a general sense, landuse expansion and population distribution spreading in Guangzhou City historically result from the following reasons. The first is the attraction of the city's harbours. Since ancient times, as the shoreline continually migrated southwestwards, population growth and landuse development also progressed in the same direction. However, in modern times, as the tonnage of ships increased considerably and the southwest harbour was limited in its handling capacity, the more naturally suitable Huangpu District in the eastern part

of the city underwent construction of a deeper harbour, resulting in eastward population growth and land development. The second reason is the effect of transportation routes. When movement was limited within the city, population growth in the north areas of the river where there are no natural barriers was relatively higher than in other areas. However, since the improvement of transportation infrastructure, the south and west areas of the river have entered a phase of steady population growth. The third reason is the effect of the development of the manufacturing industry. With the split up of old industries and the emergence of new industries, a new set of needs arose in terms of land use. In 1974, within the Huangpu District, the expansion of the Huangpu harbour resulted in the concentrated development of industries closely related to shipping and the desirability of lower transportation costs. Such industries were shipbuilding, machinery manufacturing, petroleum processing, etc. As for plants such as steelmaking plants that use up large areas of land, their development was concentrated in the Fangcun District.

2) From the founding of the People's Republic of China to the implementation of the reform and opening up to the outside world, the population density growth trend is that population density increases in both the city center and the outer city, but that of the city center increases at higher rates(Fig. 6a). This growth pattern is closely related to the country's policy that emphasizes industrialization in cities while neglecting the development of infrastructure and public service facilities during the period. Under the directive philosophy reflected by slogans such as "produce first, live second" and "change our consumer-oriented city into a production-oriented city", industrialization first began in the rural areas while the increased population resided mainly within the urban area. Housing construction in the rural areas then followed and subsequently, commercial services. Population growth in the rural areas coincided with industrialization there. This pattern is different from the development of the western cities where housing is of high priority and becomes the first to expand into the suburbs.
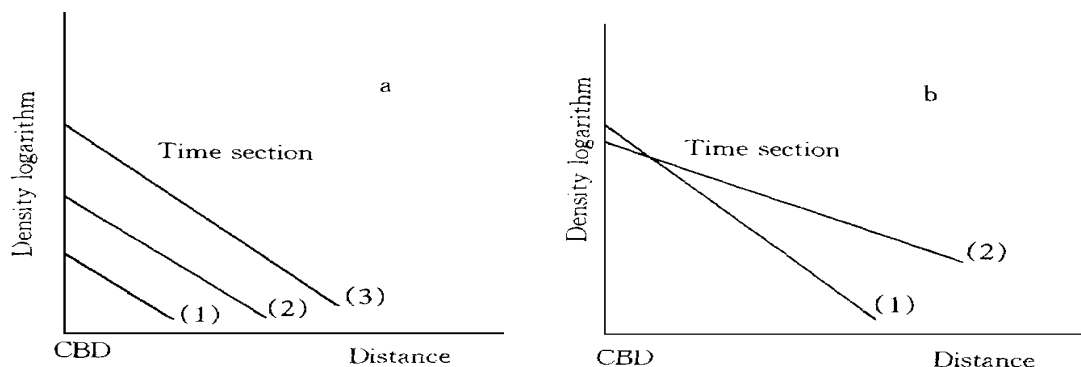

Fig. 6   The pattern of population density change in Guangzhou City

3) Since the reform and opening up to the outside world, while Guangzhou City's total population has been increasing relatively quickly, population distribution changes within the city have become obvious and important(Fig. 6b). As population density within the city centre

decreases and that of the city periphery increases, the population is becoming less centralized and is spreading outwards from the city centre. The appearance of such a phenomenon is closely related to the various guidelines and policies formulated since the reform and opening up to the outside world. Since then, there has been a change of emphasis on a city's industrial production to an emphasis on a city's central function and more attention was given to housing matters in the city periphery and various public service developments. Economic progresses lead to a newly increased population residing in the city periphery which also attracted many from the inner city; fast paced financial growth also guaranteed the capital need for building infrastructure and housing within the city; the repayable land use system resulted in a reorganization of various types of land use in the city according to the ability of the land user to pay rent, leading to a concentration of commercial land and office buildings within the city center and a spreading of the population outwards from the city center; real estate in the suburban and rural areas were thriving. Reforms in the housing and labour systems, redevelopment of the old city, etc. all provided desirable living conditions for the population migrating outwards into the suburbs.

4) In the suburbanization process of the western countries, residential areas are the first to expand into the suburbs. The presence of a residential population then gives rise to commercialism and a service industry in the suburbs. In contrast, in China before the reform and opening up to the outside world, industrialization was the premier development in the suburbs. It is only after the reform and opening up to the outside world that the expansion of residential areas into the city periphery has become increasingly important. Nonetheless, since this change of development priority, suburban development has not surpassed that of the past in terms of the amount of land used.

5) Since the reform and opening up to the outside world, although the population is spreading outwards from the city centre, the tertiary industry within the city center has been thriving, giving rise to a new sense of life and energy. Population decrease within the city center is evidence that the city is becoming more prosperous, which is a contrast from the decline of activity within the city centers of the western countries.

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