

KNOWLEDGE DISCOVERY OF REMOTELY SENSED DATA FROM ECOLOGICAL VIEW

— A Case Study of Urban Spatial-temporal Relationship in the Pearl River Delta

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ABSTRACT: From the ecological viewpoint this paper discusses the urban spatial-temporal relationship. We take regional towns and cities as a complex man-land system of urban eco-community. This complex man-land system comprises two elements of “man” and “land”. Here, “man” means organization with self-determined consciousness, and “land” means the physical environment (niche) that “man” depends on. The complex man-land system has three basic components. They are individual, population and community. Therefore there are six types of spatial relationship for the complex man-land system. They are individual, population, community, man-man, land-land and man-land spatial relationships. Taking the Pearl (Zhujiang) River Delta as a case study, the authors found some evidence of the urban spatial relationship from the remote sensing data. Firstly, the concentration and diffusion of the cities spatial relationship was found in the remote sensing imagery. Most of the cities concentrate in the core area of the Pearl River Delta, but the diffusion situation is also significant. Secondly, the growth behavior and succession behavior of the urban spatial relationship was found in the remote sensing images comparison with different temporal data. Thirdly, the inheritance, break, or meeting emergency behavior was observed from the remote sensing data. Fourthly, the authors found many cases of symbiosis and competition in the remote sensing data of the Pearl River Delta. Fifthly, the autoconsciousness, stranglehold and invasion behavior of the urban spatial relationship was discovered from the remote sensing data.

KEY WORDS: complex man-land system of urban eco-community; spatial-temporal relationship; knowledge discovery; remote sensing; the Pearl River Delta

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1 INTRODUCTION

Recently ecological theories have been getting more attention and have been applied widely to the practice within the city planning circle of China. “The basic principles of ecology have become the theoretical basis of the sustainable development of the economy” (MA, 1990). The theory of urban ecology “is now not only being applied in urban fields as it did before but it has also founded its own theory system which includes comprehensive viewpoints of urban natural ecology, economic ecology and social ecology and put forward a

series of countermeasures to the “city problems” (HUANG and YANG, 2001a). Ecological studies in urban and rural planning have been very active since the 1990s in China. For example, ZHANG Yu-xing (1995) discussed the basic ecological theory about the urban space; DUAN Jing (1997) analyzed the relationship between the symbiosis behavior and competition behavior in the development of urban eco-community; ZHAO Cheng (1997) discussed the spatial competition mechanism of urban development; HUANG Guang-yu, CHEN Yong (1997, 1999) studied the conception of the ecological city, the technique of ecological city plan-

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ning and design and its application to the science park planning in Guangzhou as a case study; YU Kong-jian *et al.* (1997, 1998, 2001) not only studied the model of landscape ecology in urban and rural planning and regional planning but also applied the principles of landscape ecology and of the cell lives in the practice of the green-land system planning of Zhongshan and the science park planning of Zhongguancun; ZHANG Hui-yuan and NI Jing-ren (2001) discussed the accesses to control the landscape ecology of the cities, summarized the basic study contents of the urban ecology and urban environment and analyzed the ecological ideas of the new urbanism. HUANG Zhao-yi and YANG Dong-yuan (2001b) summarized the general situation about the study of the ecological city in and out of China and the methods of the ecological footprint, ideally pointing out the concept of the ecological city as that "a sustainable system which fairly occupies its share of carrying capacity in a global or regional ecosystem and a compound system with a harmonious nature, fair society and efficient economy based on the principles of ecology; most important of all, it is an ideal habitat with its own cultural feature in which nature coordinates with the man-made environment and man coordinates with man". This paper discussed the spatial relationship of the urban group based on the theories of ecology and the case studies of the development of the urban group in the region.

2 PERSPECTIVES OF THE SPATIAL-TEMPORAL RELATIONSHIP OF THE URBAN GROUP FROM AN ECOLOGICAL VIEW

2.1 Identification of the Concept of Urban Group

"Urban group" is usually called "urban agglomeration" or "cities and towns agglomeration" in China. Although in many cases these three concepts of the urban group are often referred to in a confused way, it is commonly considered as an aggregation of cities and towns in some region. ZHANG Jing-xiang gave a detailed description about the concept of the "urban group" as being "a group of neighboring cities and towns in a certain space which connect with each other closely in all respects of society, economy and ecology. As an integrity, there exists an affinity in their development. The variance of the closeness makes the urban group appear as different spatial sub-patterns of Desa-kota, Built-up Area or Metropolitan Interlocking Region etc." (ZHANG, 2000). This definition stresses the closeness of the association and the adjacency in the space of the cities and towns, it could be considered as a concept development

faced to the space configuration study in the urban and region field.

Here we take the urban group as a complex "man-land" ecosystem which comprises individual, population and community called in ecology, with "man" as the object and "land" as the subject. "Man" and "land" are two elements of the "man-land" ecosystem, the "man" means the organization with self-determined consciousness possessing social and economic features, and the "land" means the physical environment (niche) that "man" depends on. Of the three types of organization, family is the elementary unit. The other two types, collectivity (enterprises) and government have different self-determined consciousness based on their differences of scale, class and work division. In a period of society conversion of contemporary China, the self-determination consciousness of the family increases, but the converse trend is true of the collectivity and the government. Therefore the individual of the complex man-land system in the urban eco-community means organization with self-determined consciousness and its niche, approximately equals to the eco-community in the smallest unit which coincides with the concept of the smallest "ecological city" recognized by the international science circle; the population means the sub-man-land system composed of the individuals with the same function, for the example, port group is a sub-ecosystem of the urban group which comprises the organizations to perform the transportation function and the port districts for this function; finally, the community is the complex man-land system of urban group which comprises the sub-man-land system with different functions. Summarily, the urban group is a complex man-land system of the urban eco-community with two elements of "man" and "land", its basic spatial patterns include individual, population and community.

Based primarily on the demand for space planning, the study of the ecological city in the present planning circle shows a trend emphasizing the theoretical and practical analysis of the "land" — the object of the ecological space, and ignoring that of the "man" — the subject of the ecological system. Actually, the formation and evolution of the spatial-temporal relation of the urban group is the result of the common influence between the two elements of the man-land system.

2.2 Types of the Spatial Relationships of the Complex Man-land System of the Eco-community

According to the formentioned concepts and spatial

patterns, the spatial relationship of the urban group could be divided into that of the individual, the population and the community. The individual is the elementary unit of the urban group. Its spatial relationship is affected by the contents of the self-determined consciousness of the organization and the scale of the niche. For example, the "unit" formed in the long history of China is the base of the social organization system, so it is also the key element to coordinate the urban spatial relationship. A "unit" is a sub-man-land system based on the common economic benefits and administrative guarantee. The most elementary "unit" is approximately equal to the individual of the complex system of the urban eco-community, for example, a chemistry plant or a block of offices is such an "individual", its spatial relationship depends on how it relates with its neighborhood "units" and superior "units". The spatial relationship of the population is affected by the contents of the self-determined consciousness of the collectivity, which is composed of the individuals with the same function, and includes its relations with the individuals, the other populations and the communities. The spatial relationship of the ten types of land use that needs to be coordinated in urban comprehensive planning could be regarded as that of ten types of population, so it is the same with the urban planning on the same administrative class. Finally, the spatial relationship of the community is affected by the contents of the self-determined consciousness of the city itself, which is composed of the individuals and the populations with different functions, and includes its relations with the individuals, the populations and the other communities. The purpose of space planning for urban group is to coordinate the spatial relationships among the individuals, the populations and the communities for the optimization of the spatial structure and the common benefits of the urban group. For the present urban planning system in China, the individual planning includes detailed and control planning, detailed and constructional planning; the population planning includes the comprehensive planning and sub-district planning of the big cities and all kinds of subject planning; the community planning includes the general planning of land use, the regional planning, the urban system planning, the concept planning, the strategic planning of the urban development, the compendium of urban planning and the regional subject planning etc. The planning at different levels should stress on the coordination of the spatial relationship correspondingly and optimize the common benefits of the urban group.

Because the man-land relationship comprises two el-

ements of "man" and "land", the spatial relationship could be divided into three types: man-man relationship, land-land relationship and man-land relationship. The man-man relationship is formed when different organizations occupy different niches in the city according to their different social and economic status. In the era of the planned economy, the spatial relationship of organizations also possessed the characteristic of "plan", and a spatial relationship of the "dualistic structure of the city and the country" was formed on the basis of the organization system of "two classes and one stratum" (the working class, the farming class and the clerisy). According to recent research by the Chinese Academy of Social Sciences, a new rudimentary social structure of ten strata has been formed in present China, it means that the spatial relationship is turning from a dualistic social structure to a multielementary social structure. Land-land spatial relationships often appear as location relationships and its basic principles have been penetrated into more thoroughly by the location theories than that of any other spatial relationship. The man-land spatial relationship is the emphasis of the ecology study and the theoretical study of the man-land relationship, it appears as the mutual relationship between the organizations and the natural environmental background that they depend on, usually measured by such indexes as ecological carrying capacity, population density and ecological footprint etc. In the planning practice of present China, the comprehension and application about the land-land spatial relationship has gained increasing attention, but the other two types of relationship are still ignored by many planners. With the impending tide of large-scale urbanization in the new century, fragment strata and the sustainable development of the ecological environment will become the new problems that need to be dealt with, therefore planners must improve their knowledge of sociology and ecology so that they can do better work in the man-man spatial planning and man-land spatial planning at different scales.

2.3 Types of Spatial-temporal Relations of the Complex Man-land System of the Urban Eco-community

The behavior patterns of the spatial relations of the urban group have a lot of attributes from ecology. Some fundamental biological behavior such as concentration and diffusion behavior, growth and succession behavior, inheritance and break (or meeting emergency) behavior, symbiosis and competition behavior, autoconsciousness (or stranglehold) and invasion behavior are also very typical in the spatial relations of the urban group. A-

mong these behaviors, the concentration and diffusion behavior is most pervasive. Man, being highly social creatures is the object of the urban eco-community, and concentration is the basic spatial behavior pattern of the organization. Since the primeval era, people began to flock together in order to defend themselves and carry out productive activities collectively; urbanization brought about by the industrial revolution made people flow into the cities, but the city problems caused by this overconcentration compelled the urban space to disperse. This process of concentration and diffusion in urban development takes this "push" and "pull" as its mechanism and the "man" of the man-land system as the behavior object. The growth and succession behavior of the spatial relations of the urban group is similar to the concentration and diffusion behavior, but it especially emphasizes the ecological process. Theoretically expressed by the "Growth Pole" theory, the spatial growth of the urban group is a continuous process where the urban area sprawls outwards from a central district to a periphery district. The succession behavior of the urban group stresses its functional rise in the development, it is a qualitative change for the urban group which contrasts with the growth behavior as a quantitative change. The functional rise of the urban group is achieved through the continual structural evolution of individual, population and community, including both of the functional change of land use in a single city and the functional division in the urban system. For early cities, the political and military functions were most important. Since the Industry Revolution, the economic function has become the main function of cities. In the information society of the 21st century, the ecological function and knowledge innovation function of cities have been getting increasing attention. Inheriting the old city and developing new districts are all the inheritance and break behaviors of the spatial relations of the urban group. The spatial growth of cities always preserves its inheritance to the cultural characteristics in their long history except for some special affairs such as natural environmental deterioration etc., and the cities with more profound historic heritage can also recover earlier from social crisis. New cities will grow up in a break manner in the districts with more comprehensive advantages when there are very good development opportunities, or old cities will change their development direction greatly because of some accidents, these are instinctive behavior of meeting emergency. The "break" development of new cities and the meeting emergency behavior of old cities will promote the succession of the urban group directly, enhance the status of the urban

group in the ecosystem, and improve the development of urban group together with the inheritance behavior. Planners now pay more attention to the symbiosis and competition behavior of spatial relations of the urban group. Symbiosis means the phenomenon that the spatial concentration of behavior objects with self-determined consciousness will bring common public benefits, but competition is a kind of behavior that the behavior objects struggle for resources and space for their own benefits. The competition space can be divided into superior space and inferior space according to the difference of the strength of competition objects. Symbiosis and competition accompany each other, transform to each other and appear alternately. Urban group planning needs to grasp the essentials of their relations, find out the primary contradiction and optimize the benefits of the development of the urban group. For example, DUAN Jing(1997) put forward the principles of symbiosis by means of planning management, infrastructure regionization, transport planning, resources development cooperation and function division etc. Though there is quite a lot of similarities between the autoeciousness and invasion behavior and the symbiosis and competition behavior, the difference of the status and behavior manner of the behavior objects between them is also very obvious. The autoeciousness behavior of the spatial relations of the urban group means that the inferior space relies on the superior space to develop itself, the most familiar example is that the inferior behavior object with self-determined consciousness makes use of the infrastructure founded by the superior object and the forces of the superior subject to develop itself. However, the development of the autoeciousness space is generally dropped behind that of the host space and gets the development opportunities only after the host space has almost exhausted its own development potency. Of course, it is also possible for the autoeciousness space to surpass and restrict the development of the host space, which is often called the "stranglehold". The invasion behavior of spatial relations of the urban group means that the superior behavior object or exterior behavior object seize the inherited spatial development resources of the invaded object and suppress its development, it may even change the situation of the spatial development completely.

3 PROCEDURE FOR KNOWLEDGE DISCOVERY OF SPATIAL-TEMPORAL RELATIONSHIP OF COMPLEX MAN-LAND SYSTEM OF ECO-COMMUNITY

The main procedure for the knowledge discovery of the

spatial-temporal relationship of the complex man-land system of the eco-community in remotely sensed images is shown in Fig. 1.

4 CASE STUDY

Based on the theoretical analysis, the authors took the

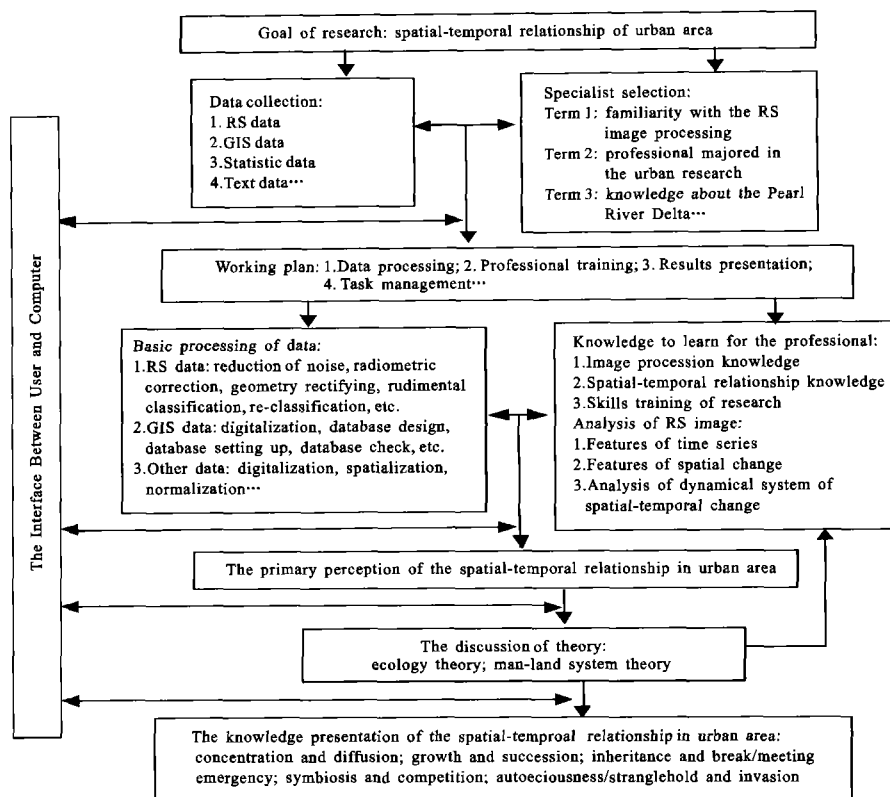


Fig. 1 Procedure of knowledge discovery of spatial-temporal relationship in urban area from remotely sensed images

Pearl River Delta (PRD) as a case study and found some knowledge of the spatial relationship of complex man-land system of urban eco-community from the remote sensing data.

4.1 Recent Situation of Concentration and Diffusion, Growth and Succession

For understanding the situation of the space growth of the urban group in the PRD in recent years, we chose the TM satellite images of the PRD in 1988 and 1998 and extracted the thematic information of the urban built-up land-cover as shown in Fig. 2.

Fig. 2 shows that the spatial concentration and diffusion of the urban group in the PRD have progressed greatly. In the central area of the PRD, where Guangzhou-Foshan and Hongkong-Shenzhen are the primary core cities, and Shunde-Jiangmen-Zhongshan, Macao-Zhuhai and Dongguan are the secondary core cities. There is a further trend in concentration of cities. In the outer ring of the PRD, where Zhaoqing,

Huizhou, Kaiping and Qingyuan are the core cities, the diffusion trend of cities is obvious. In general, the core-fringe spatial pattern of the PRD is relatively stable.

We can also find from Fig. 2 that there has been a great growth rate of urban space in the PRD, the building-cover area of the cities and towns has increased 1.69 times, from 556.8 km² to 1497.61 km² in the 10 years. A qualitative change of the spatial pattern has happened because of this great growth rate of urban space, it is a successive process evolving from the polarized spatial pattern in 1988 to the spatial pattern of the urban and rural integration in 1998.

4.2 Cases of Inheritance and Break/Meeting with Emergency Behavior

Both the inheritance from the historic heritage and the high-speed development of some central cities and towns are the presentation of the inheritance behavior of the spatial relationship of the urban group in the PRD. For

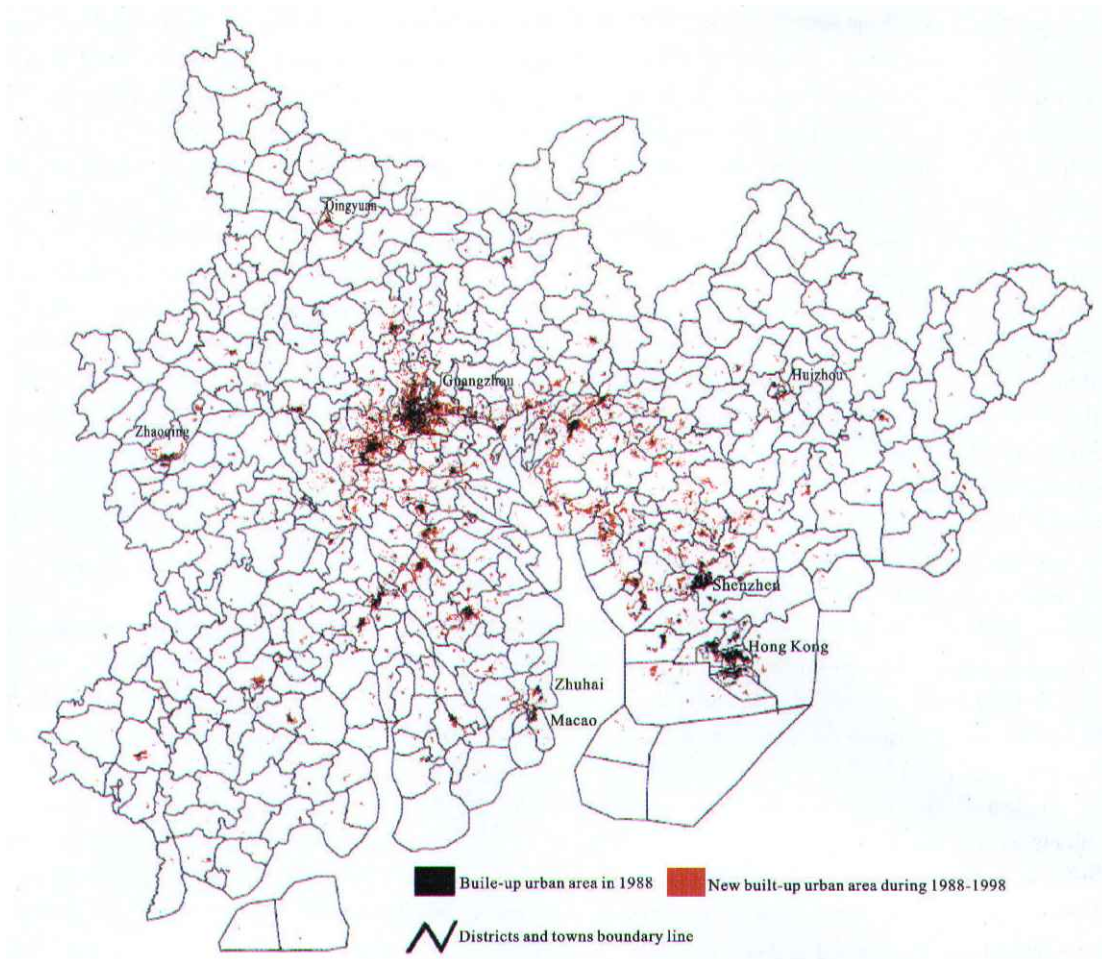


Fig 2 Thematic information of built-up urban area extracted from TM images of the Pearl River Delta

example, in such old-line cities and towns as Guangzhou, Foshan, Hong Kong, Macao, Zhaoqing, Huizhou, Guangcheng, Zhongshan(Xiangshan), Xi'nan, Ronggui(Rongqi-Guizhou), Xiaolan, Shilong, Chikan, Changsha and Xintang, the traditional market culture has been carried forward and many outstanding enterprises have boomed. Some famous enterprises such as Jianlibao Co. of Xi'nan, Kelong Co. and Gelanshi Co. of Ronggui, Lebaishi Co. of Xiaolan are internationally famous brands based on the native capitals and developed in the old-line towns with lower administrative class. Inheritance of the historic heritage has become one of the important characteristics of these cities and towns.

The newly developed towns can be looked upon as the cases of the meeting emergency behavior of the spatial relationship of the urban group in the PRD. These new booming towns in the PRD like Longgang, Songgang, Chang'an, Houjie, Fenggang, Dalingshan, Dalang, Changping, Tangxia and Hecheng not only have restructured the city system but also will possibly induce

the function succession of the urban group. In fact, the development of new towns has weakened the function of the central cities in the PRD while urban and rural integration has become characteristic of the region. The transformation of the development direction of Xinhua is another typical case of the meeting emergency behavior of spatial relationship of the urban group because of the exterior inducement. In the 1990s, the strategic development direction of Xinhua was along the Guang - Hua Highway(from Guangzhou to Huadu) and Jing - Guang Railway(from Beijing to Guangzhou) in western Xinhua, so the economic and technological development zone of Xinhua is located in western Xinhua. However, since the relocation of the Baiyun Airport pitched on the eastern side of Xinhua, which is bordering with the Baiyun district of Guangzhou, the development direction of Xinhua has turned to the east. The satellite image of Xinhua in 2000 showed that the backbone roads network had been built and some land had been turned into built-up area in eastern Xinhua, at the same time, western Xinhua developed very slowly.

4.3 Cases of Symbiosis and Competition Behavior

A general trend of concentration of the urban group in the PRD can be figured out from Fig. 2. The common benefits brought by symbiosis is the basic motive force of this concentration. We can say that the symbiosis behavior is true of the urban group in the PRD in general. In addition to that, many twin-cities or twin-towns in the PRD are also the result of symbiosis behavior. For example, Hong Kong-Shenzhen, Guangzhou-Foshan and Macao-Zhuhai are typical twin-cities, Dagang-Lingshan, Lianhuashan-Shilou, Rongqi-Guizhou, Pingzhou-Sanshan, Shilong-Shijie, Guanghai-Nanwan, Sanpu-Changsha are typical twin-towns. Twin-cities or twin-towns are adjacent to each other so much that they usually develop finally as a new integrity, for instance, Rongqi and Guizhou has been united as Ronggui Town. The competition relation of the urban space almost exists between those spaces with the same function, especially between the development zones of the new towns. Though the conditions of natural resources and location are important in the competition, the comprehensive competence, including the administrative power of the behavior objects of the space competition, their organization abilities and economic strength may be more significant. Those competition spaces with stronger comprehensive competition become the superior spaces, which will obtain a faster speed of development. The Yunpu Industry Zones of Guangzhou, whose development was performed by the Administration Committee of the Economic and Technological Development Zone of Guangzhou and the government of Nangang Town, is a case of this situation. Given the same natural conditions, the Administration Committee of the Economic and Technological Development Zone of Guangzhou have completed most of the infrastructure construction and land conveyances on the area that it is responsible for. In reverse, the land developed by the government of Nangang Town only attracted several enterprises with most of land property having not been conveyed. This case indicated the important role of the behavior objects in the spatial competition. Compared with the government of Nangang Town, the Administration Committee of the Economic and Technological Development Zone of Guangzhou possesses stronger administrative power as a direct accreditation institution of the government of Guangzhou, and the committee has gained successful experiences and has made the service system more satisfactory. With unaltered natural development conditions, it is not curious that the towns in the PRD contested for the investment by depreciating their land,

that's a common measure for the competitive spaces to reinforce their competence, enhance their status in the competition and provide the superior spaces. The expansive infrastructure construction in Dongguan is also the result of severe spatial competition. From the view of philosophy, the spatial symbiosis is relative and the spatial competition is absolute. Though the purpose of ideal urban planning is to optimize the benefits of symbiosis for the city planners, it is inevitable that they act for their own "masters" in the practice. So it is important for them to comprehend the coordination principles of the symbiosis and competition and "tell the truth to the powers".

4.4 Cases of Autoeciousness(Stranglehold) and Invasion Behavior

The relocation of the town government of Xi'an in Gaoming is a typical case of the autoeciousness behavior of the inferior behavior object to the superior behavior object. Before the relocation, the town government was located in the market town of Xi'an and being far away from the locus of the city government of Gaoming, and the town developed very slowly. In 1999 the town government moved to the neighboring development zone of Hejiang where the city government was located. Under its powerful influence, the town developed faster than before and showed a good development trend. The GDP of the town has increased about 20% annually in recent years. The small towns located in the big cities also take the autoeciousness-development as an important characteristic of the spatial development. When the development of the autoeciousness space progresses greatly and prevents that of the host space, the autoeciousness behavior will evolve to the strangle behavior. The strangle behavior of the spatial development of Nanhai to that of Foshan is a typical case of this situation. Nanhai is administratively subordinate to Foshan, its government was ever located in the building-area of Foshan and moved to Guicheng nearby for new development space. In recent years, the land provided for the development of Foshan in its interior city has almost been used up, but its exterior space was surrounded rapidly by Nanhai. Despite its higher administrative class, the economic development of Foshan was exceeded by that of Nanhai so much that its control function to Nanhai was weakened and so became the "object" that was strangled by Nanhai. The severe prevention to the development of the town district of Taiping caused by the industrial zone of Taiping of Conghua is a typical case of spatial invasion behavior. Though the town district of Taiping possessed

more favorable development conditions than the industrial zone of Taiping, which includes the border of the Baiyun district of Guangzhou, standing at the hinge of No. 105 national highway, shorter distance to Guangzhou, longer development history and flatter landform etc, the town district developed slowly in recently years. The authors found the information from the satellite image of 2000 that its development scale didn't reach the expected target of 50 000 people in 2000 confirmed by the general planning of the town district of Taiping (this planning completed in 1992 was certificated by the experts of the jury and the construction committee of Guangzhou and had obtained a first-rank planning appraisal in Guangdong), and the building-area scale of the industry zone of Taiping to the north of it has exceeded greatly its scale. Despite its more favorable natural conditions, the town district of Taiping actually became the inferior space because its administrative class and economic strength has been surpassed by the behavior object of the industrial zone of Taiping — the city government of Conghua, and couldn't reach its expected development target, because its development resources had been invaded severely in the competition of the neighboring superior space. The construction of the economic and technological development zone of Zengcheng is another case of spatial invasion behavior with the motivation to contest the development of resources of Dongguan. Located in the south of Zengcheng and nearing the relatively developed district of Shilong and Shijie in Dongguan, especially with the Guang-Shen Railway (from Guangzhou to Shenzhen), it is favorable for the economic and technological development zone of Zengcheng to attract investment.

5 CONCLUSION

The aforementioned theoretical and practical analysis indicates that the spatial development of the complex man-land system of the urban eco-community does bear obvious attributes of biology, and the ecological theories should be applied more widely in the urban planning.

The planners should analyze the essence of the two elements of "man" and "land" more thoroughly in the practice, and comprehend the situation of the spatial behavior of the complex man-land system of the urban eco-community correctly, so that the urban planning can be more faithfully and more truthfully fit the reality outcome of the urban development than before.

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