Spatial-Temporal Land Use Patterns and Master Planning in Wuhan, China

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by

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ABSTRACT

Urban planning in China has long been based upon the "blueprint" process and has been influenced by the national political and economic policies. Urban planning was very much a design and engineering exercise with the state as the single stakeholder. The dominance of ideology, state control and economic planning on urban planning and development was reduced after the economic reforms in 1978. The shift from a planned economy to a market economy is challenging Chinese urban planning. These macro political and economical changes require that urban planning methods and techniques incorporate process oriented planning. These, for China, new planning approaches require the need to understand the complicated urban land development processes.

Geographic Information System and Remote Sensing provided the advance techniques and methods for studying urban land development and assist urban planning. Wuhan with 7 million total inhabitants (urban population of 4 million) is a mega-city, which has undergone a series of physical as well as socio-economic changes over the last 50 years. By using GIS spatial analysis function, this research firstly describe the Wuhan urban expansion processes from 1949 to 2000 and land use changes in the inner city of Wuhan from 1986 to 2000. Three different development stages were identified and each stage has its own characteristics. Wuhan has grown rapidly in both first phase (1949 to 1965) and third phase (1990 to 2000) while steady urban expansion in the second phases (1965 to 1980s). Significant urban redevelopment took place in the inner city of Wuhan after the transformation from a planned economy to a market economy in the early 1990s.

The master planning processes and its implementation in Wuhan has been analysed in this research. The analysis shows that master planning over the last 50 year in Wuhan has adopted the "blueprint" style, which strong influence of the policies of the central government. Different planning philosophies and leading ideas have been responding to the concurrent national policies and political circumstances. By comparing two master plans (1954 and 1988) with actual development (1965 and 2000), it can be concluded that for both different periods actual urban development differs considerable from the proposed development as expressed in the master plans. This research ends up with some concluding remarks and recommendations for future development of Wuhan. An important conclusion is that urban planning practice should adapt to respond to the political, economic and social changes in modern China.

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To my dearest Qingming and Liangliang

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1. Introduction

1.1. Problem Statement

Since the open-door policy and economic reform were introduced in the end of the 1970's, Chinese cities started a period of rapid urban expansion and redevelopment. The introduction of the land lease policy in the late 1980's and shifting from a planned economy to a market economy in the early 1990's accelerated urban development.

There are mainly two types of urban development: expansion on the urban-rural fringe and redevelopment in existing urban areas (sometimes referred to as urban renewal). The urban morphology and land use pattern of Chinese cities has changed dramatically through both processes over the past 50 years but especially over the past two decades.

The urban expansion process consists: besides continued expansion at urban-rural fringe also on the development of satellite towns around the core of urban area. Urban renewal processes can also be found in two major forms: using open space in existing urban areas and annotation or conversion by demolishing existing constructions and use that space for new development. Both forms are resulting in increasing building density, floor space ratio and residential development in higher population density.

China is in a rapid urbanization process, especially due to rural-urban migration. The growing urban population and wishes for better a living environment have put enormous pressure on the demand for urban land. At the same time, rapid economic growth has caused the loss of valuable land resources. This does not only lead to environmental degradation and reduction of green land coverage, but also jeopardizes long-term economic and environmental sustainability. The reduction of agricultural land has caused political and economical problems as well. Therefore, urban planners have to play an important role in making a good balance between the need to maintain the amount of arable land and the need to accommodate the demand for urban development.

Urban planning in China has long been impacted by the social and economical policies of the central government introduced in different time periods since the founding of the People's Republic of China in 1949. A blueprint style, which was imported from the Soviet Union, has influenced Chinese urban planning for 50 years. The blueprint style of urban planning seems to work quite well with the centrally planned economy. Transformation from a planned economy to a market economy is challenging this type of traditional urban planning process in China. This traditional urban planning approach could not meet the needs of the new economical and political climate and could not respond adequately to the interesting of various private and public urban development actors.

In order to formulate acceptable and workable strategies to solve the land problem and develop new planning approaches for future urban development, we need to know how cities are developing and what are the impacts of the urban planning processes on the urban morphology and land use patterns. What was the impact of the various master plans, developed under different social-political circumstances, and how did these plans influence the spatial pattern of the city is one on the major questions addressed in this study.

1.2. Research aim and main objective

The aim of this research is to contribute to improve urban planning practices in China.

The main objectives of this research are first to analyse how urban expansion and land use change processes took place in Wuhan - China in different periods and under different social economic circumstances. A second main objective is to examine how the municipality of Wuhan adopted their planning approaches. Studying the urban development processes and the corresponding role of the urban planning bureau will help in understanding urban development in the past that might benefit future development.

1.3. Research objectivies

- To produce land use maps and to describe the land use patterns of Wuhan (from 1949 to 2000) and Hankou in 1986, 1993 and 2000.
- To analyse the changes of spatial-temporal land use patterns of Wuhan (from 1949 to 2000) and Hankou between 1986 and 2000.
- To analyse and compare spatial forms of Wuhan master plans developed under different periods using qualitative and quantitative techniques.
- To compare and identify the differences between urban master plans and land use maps and analyse the effectiveness of urban planning.

1.4. Research Questions

- How did urban expansion and urban redevelopment take place between 1949 and 2000?
- How did the land use structure change under a planned economy and under a market economy?
- What are the characteristics of the urban master plans and what were the development policies and leading ideas behind these master plans?
- What was the effectiveness of the urban master plans regarding the structuring of the spatial-functional urban patterns?

1.5. Research Methodology

- Use of remote sensing imagery in preparing land use maps of different periods

Visual interpretation of SPOT and IKONOS images is the main technique in obtaining primary land use data. Erdas Imagine 8.4 is used for image geo-referencing. ArcView GIS 3.2a is applied in data processing and land use analysis.

- Digitising the existing maps

ArcView GIS 3.2a is used in digitising the existing master plan maps and land use maps and inputting related attribute for each map.

- Spatial analysis in GIS in terms of urban morphology and land-use pattern

The raster data processing function of ArcView such as tabulate area, map calculator and Arc/Info workstation is used to analyse the urban morphology, land use structures and change analysis as well as mapping. Microsoft Excel is applied for descriptive statistical analysis, such as charts and tables.

- Time-framed comparison in relation to different urban master planning activities comparison between master plans and realities.

The qualitative and quantitative technique is used in comparing the differences between master plans and development realities with overlay analysis functions provided in ArcView GIS.

- Literature study and expert interviews

By studying the literature on urban planning theory and the changes in urban planning practises in China and interviewing local urban planning experts on the objectives and social economic contest of the different master plans we are able to analyse the problems of urban planning in Wuhan.

1.6. Workflow

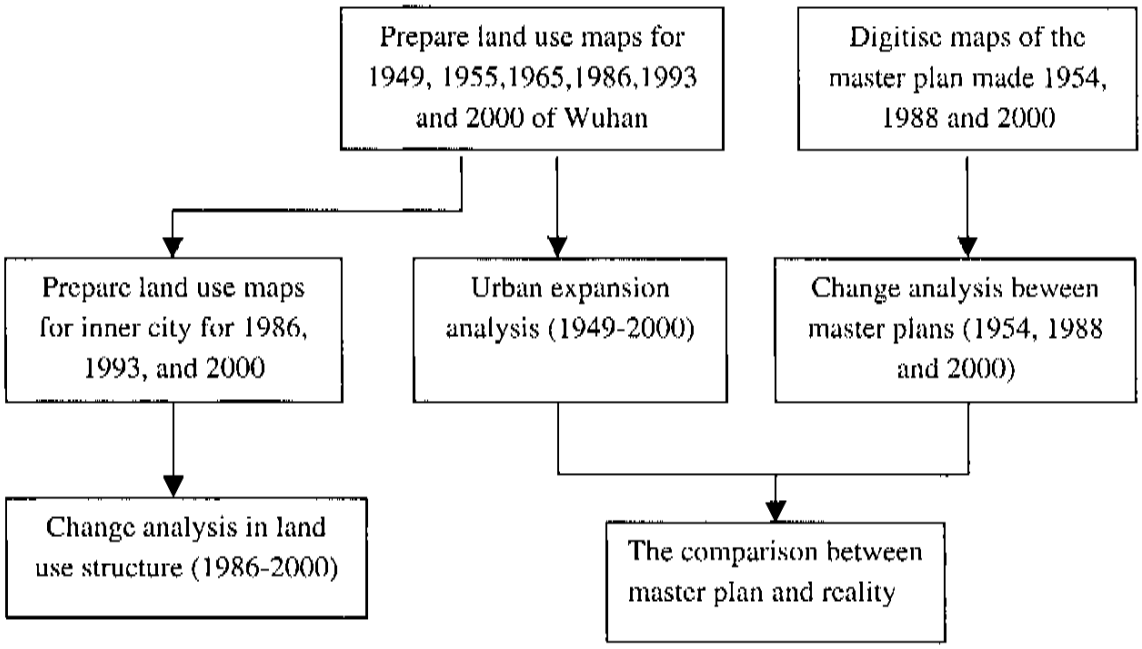


Figure 1.1 Workflow of the research

1.7. Structure of the thesis

The thesis focus on spatial-temporal analysis of land use of Wuhan in different periods, analysis urban master planning activities under different social – economic circumstance that related to the spatial - temporal patterns in Wuhan city. This thesis is structured into five chapters.

Chapter 1 states the research problems, objectives and questions as well as research methodology and a workflow.

Chapter 2 presents a literature review about planning theories and the general situation of urban planning practice and related urban planning theories and methods after the founding of the People's Republic of China in 1949.

Chapter 3 describes the case study area – Wuhan city and data collection. Some techniques about GIS and remote sensing analysis are discussed. And the case study of land use change analysis is included in this chapter.

Chapter 4 presents urban master planning activities of Wuhan city from 1949 to the present. Several comparisons between master plans in different periods as well as between master plan and development reality are discussed.

Chapter 5 gives the conclusions about Wuhan urban development and master planning practice. Several recommendations are provided as well in this chapter.

2. Planning Theory and Planning Practice in China

2.1. Planning theory

Planning theory has been part of planning task and planning curricula for decades. It has evolved, and definitions of its scope, intent, and substance have changed. Instead of attempting to develop consensus on a single approach to planning theory, many writers have advocated the delineation of different types of planning theory. For example, Andreas Faludi (1973) speaks of theory in, of, and for planning. Theories *in* planning include ideas developed in other disciplines that may be used by planners and planning theorists. They are those that come from outside the planning field and help us to explain or direct planning efforts in a particular direction using these theories. Theories *of* planning are those ideas concerning planning processes that pertain to the ways planners and planning works. How planners make decisions, how planning organizations function and how these fit together are the issues discussed here. The rational planning model is related to these kinds of theories. Theories *for* planning have to do with the role of planning in society. They unify, uphold, and justify planning values in the form of a conceptual foundation for the field and profession. Planning ethics is concerned primarily with these sorts of theories.

2.1.1. Definition of planning

A description of planning is given in the book of "Encyclopaedia of planning" and described as follows:

"Planning can mean different things to different people. In its broadest sense it may be said to be the practice of trying to so organize resource that a desired objective is achieved (usually sometime in the future). For some that means simple trying to anticipate the nature trends of society and is known as 'Trend' planning. For others it means defining goals or objectives and then devising policies for achieving those goals, which may mean revising or diverting trends". (Ashworth, 1973, p. 74-75)

However, planning in general is defined as "a process for determining future appropriate action to achieve a goal or a series of goals through a sequence of actions" (Paris, 1982, p. 11). It is a process most adult human beings undertake in their daily lives. Most people do not realize it, but they are fairly good planners with respect to their individual lives. Nevertheless, it is useful to reiterate that planning is not an application of principles or rules to a given situation; rather, it is a process of conscious choice of alternative actions to achieve a goal or goals.

2.1.2. Elements of planning

Conyers and Hills defined planning in another term, which is more or less similar to the previous one: "planning is a continuous process which involves decisions, or choice, about alternative ways of using available resources, with the aim of achieving particular goals at some time in the future" (Conyers and Hills, 1984, p.3). This definition attempts to convey the most important elements of the concept of planning. These elements are: to plan means to choose; planning as a means of allocating resources; planning as a means of achieving goals; planning for the future.

1. To plan means to choose

Planning means choosing between many desirable activities because not everything can be done at once. Planning involves make choices between alternative courses of action. Thus 'to plan means to choose' is one of the most important elements of planning.

2. Planning as a means of allocating resources

Another important element of planning is that it is concerned with the allocation of resources. The term 'resources' refers to anything, which is considered by those making decisions to be of potential use in achieving a particular objective. This definition includes not only natural resources such as land, water, minerals and so on, but also human resources, capital resources such as roads, buildings and equipment.

3. Planning as a means of achieving goals

It is not enough to say that planning involves making decisions about the use of resources. Because the 'best' use of any particular set of resources will depend very much on what one is trying to achieve. In other words, planning involves making decisions about alternative ways of achieving particular goals.

4. Planning for the future

There is one other important element of planning incorporated in most definitions, which is the time element. This concern with the future manifests itself in two main ways. One manifestation is that an important part of planning involves forecasting, or making predictions about what is likely to happen in the future. The other manifestation of planning's concern with the future is its role in scheduling future activities.

2.1.3. Types of planning activity

Since the concept of planning covers a very wide range of activities, it is good to discus the classification of different type of planning activity.

One way of classifying different planning activities is 'goal-oriented' classification. There are:

1. Town and country planning, which is concerned with the allocation of land between different functions or activities;

2. Anti-cyclical planning, which is designed to maintain stability in a national economy and to counteract the alternate booms and depressions, which have dominated recent economic history in most developed nations.

3. Development planning, which is concerned with increasing the rate of economic and social progress.

Another way of classifying different types of planning is to consider the scope of the activities. According this way, planning activities can be divided into:

1. Socio-economic planning
2. Natural resource planning
3. Architectural and engineering planning

According to spatial level of planning activities, we may distinguish categories such as:

1. National planning, which usually undertaken by central government agencies;
2. Provincial or Regional planning
3. Local or urban planning

It is also possible to classify planning activities according to operational level. They can be:

1. Project planning, which refer to an identified physical object such as a road, dam, school, hospital or housing complex and so on. Its boundaries are relatively clearly defined and it can be undertaken in isolation.

2. Sectoral planning, which means planning for a particular part of sector of a country's city's development. It could be prepared for sectors such as agriculture, education, transport and so on.

3. Integrated area planning, which involves planning for all sectors or types of activity within a particular geographical area.

2.1.4. Urban planning

Urban planning is generally understood as an activity to prepare development plans to regulate and control the use of land in the cities. Its main objective has generally been the improvement of living conditions of the urban area and the welfare of urban dwellers.

Urban development plans, which traditionally were in the form of coloured maps, can be in the form of written statements accompanied by diagrams and illustrations. Its form and content has shifted from just the allocation of land use to providing strategies affecting both the physical environment as well as the welfare of the community.

2.1.5. Rational planning approach

Rational planning had originated in the USA in the 1940s and 1950s, based on cybernetics, systems analysis and operational research. The task of planner is to identify all possible alternatives or courses of action, to evaluate the consequences of each against pre-stated purpose, and to select the most appropriate result. According to Faludi's point of view, planning is a rational process of thought and action, which ultimately aims (as science does) at promoting human growth. This statement is based on some crucial assumptions. Such as the city is not a place of chaos but of order; quantifiable information can be employed; human being is rational and undertakes rational action; individual or micro-behaviour can be extended to planning institutions. The basic contention of Faludi is that planning agencies can be modelled after the working of the human mind.

Proponents of the rational planning model realize that the model may not be fully applicable in the real world. The key problem is that an individual has a limited capacity to handle information. An individual may not able to take all action rationally. Planning agencies have not the 'extra-rational' capabilities too since that is the sum total of a group of individuals. Through rational planning was highly influential on urban planning practice research in the 1970s, it was never supported by a similar consensus to that achieved by the design method during the early decades of century.

2.2. Methods and techniques of urban planning

Effective and successful planning depends not only on the integration of various professional inputs and the overall approach that is adopted, but also the techniques that planners use.

2.2.1. Process of urban planning

The process of planning the human environment requires the ability to analyses and comprehend the existing situation in the context of its social, economic and political, as well as its physical, circumstances; forecast and likely changes that are apparent from prevailing trends; understand the extent to which these changes will affect other aspects of the environment; judge their desirability; decide upon the best strategy and tactics to guide and strategy and tactics. Thus, the planning process is an extremely complex and comprehensive operation.
John Ratcliffe (1974) summarized the process of planning as a perpetual series of steps as follows:

1. Preliminary study

In this stage, some analysis and survey of the planning area should be done. Including: data collection and analysis; identify problems; etc.

2. Formulation of goals

Goal setting is an important aspect of the process in order to provide frames of reference in the making of day-to-day decisions. It can be thought of as the attachment of weights to different market failures and ultimately to different groups in society because different market failures will affect different groups in particular ways (Webster, 1993). Although it tends to be rather nebulous and often being framed as vague generalization, they do have the effect of setting the stage.

3. Identification of objectives

It follows that broad and general goals must be supplemented by relatively detail statements of the objectives, which must be attained, in order to move toward the goals. The reason is: goal-statements are somewhat vague. People may find it very difficult to form a clear picture of what is involved in reaching a goal. Identification of objectives is the more precise ways in which the goals might be achieved.

4. Preparation of alternative strategies

This stage means that the planners have to prepare some different 'courses of action' to achieving the goals and objectives mentioned in previous steps. Planners can make use of a very wide variety of approaches and techniques, ranging from professional judgment and intuitive thinking to highly formal, systematic, mathematical methods.

5. Evaluation

All the complete courses of action are compared and measured. This step include: measurement of levels of achievement of objectives; appraisal of the evidence produced; setting down of finding in a logical framework; making of recommendation to decision takers.

6. Implementation

The chosen plan should be put into practice. It is easy to think of implementation as a purely administrative activity not a management one requiring scientific support, but the reality is not as simple as this. The gap between planning and implementation is one of the major shortcomings of planning especially in the Third World. Conyers and Hills (1984) summarised the factors that affecting plan implementation are: nature of the planning process; organization of planning and implementation; content of plans; and management of the implementation process. And they also provided the various techniques and management approaches which can be utilized in this stage of the planning process.

7. Monitoring and reviews

Once a plan is operational there is a continuous need to examine the way in which it is working. This 'monitoring' stage reviews the performance of the policy regard its effectiveness and observes the consequences of the adopted plan.

However, the planning process is generally regarded as a cyclical process, which include the sequence of stages above mentioned.

2.2.2. Information needs and data collection for urban planning

As we know, urban planning must be based on knowledge. Knowledge depends upon information and information on the processing of data. In order to understand the society in which planning is to operate, to identify its problems and needs, to have more comprehension of its interacting elements and its effects on each other, urban planners have to hold wide range information and have the capabilities of using tools and techniques to analyse those information.

The categories of data needed for planning activities can be described as follows:

1. Physical characteristics: the nature, scale and form of the environment are the canvas on which the plan is painted. A topography map and some thematic maps such as geology, climate, minerals, land use, and location of rich agricultural land are required in the planning process. This kind of data can be attained for survey agency and local government. You can also get this kind of data by using remotely sensed imagery.

2. Utilities: A map of existing sewerage, water, gas, refuse, and electricity facilities should be maintained together with a note of their age, condition and capacity. It is surprising what influence of availability of utilities has in shaping planning policy and determining the scale of development.

3. Population: An urban planner's term of reference is principally directed towards people and their needs. An appreciation of the size, density, characteristics and distribution of the population is always the starting point in the preparation of all plans. Without an idea of the existing and likely future needs of the community in terms of family size, age and structure, the planner is deprived of any premise. A major producer of data for population studies is central government, and the outstanding basic source is the census of population, which usually undertaken every ten year.

4. Employment: The study of population leads naturally on to the need for jobs, demand for labours, and the consequent level of the unemployment in a local, regional and national context. The level of employment is commonly used as a measure for assessing both economic performance and social condition. Because of this it has important political connotations and thus merits considerable attention throughout the planning process. The nature of employment opportunity, and the magnitude of potential growth or decline, dictates, to a large extent, the future size of population for a particular area, and is therefore essential information in calculating community requirements if terms of housing, shopping, and other facilities. The worker, the employer, and the area are the three aspects in study of employment. The principal sources

of information are supplied by central government. This sort of data can also be found in census and yearbooks.

5. Housing: It is housing that gives shelter, security, privacy, investment, and personal identity. The urban planner is occupied with the task of ascertaining the size, condition, age, tenure, distribution, density, rate of growth and occupancy rates of the existing stock of housing. From this he can again plot future need and determine policy in respect of rehabilitation, redevelopment and overspill schemes. A large-scale topographic map and aerial photos can provide the information of housing. Field survey is needed too.

6. Shopping: Shops are a part of the social patterns of the community. To ensure the most appropriate location for retail facilities the planner is obliged to assess the needs and potential of his local authority area. This entails establishing the regional hierarchy of centres, gauging any deficiencies in the existing pattern and catering for future proposals. It also involves an understanding of shopping habits and trends, which might suggest a change in the hierarchy or a shift in emphasis. Information relating to existing shopping provision and usage can be obtained by the land use planner in part for published information, and in part from specially conducted surveys incorporating observation of land use and questions to shoppers and shopkeepers.

7. Education: Although often separately dealt with in local authority management, the provision and location of educational facilities is largely dependent upon population survey, and an analysis of the trends, changes, and implication in their social context.

8. Leisure and recreation: With the growth in available leisure time and the upsurge in demand for recreation, this area has rapidly become a major of the planning process. In order to get the information of recreation facilities demands, an interview survey is the popular method.

2.2.3. Models in planning

Modelling plays an important role in the planning process. Models are idealized representations of real-world situations. The situation concerned may, for example, be a national economy, a sector of that economy, a city or even an individual household. But model is simpler than the reality that it is intended to represent. This simplification involves representing only certain relevant and important aspects of the situation that the model relates to.

Models have a great many uses. Basically, they can help us to gain an understanding of the way in which man-made or natural system operate and thereby help us to explain why things are the way there are.

There are various general categories of models. One of the most frequently quoted classifications is that of Ackoff (1968), who distinguishes between: a, analogue models; b, iconic models; c, symbolic models.

In the case of analogue models the relevant properties of the real world situation are retained but with a scale transformation. An example of this is a plan of a house. Iconic models involve a change in the properties used to represent the real situation and usually a transformation of scale too. This means that we need a legend to explain the properties that are being used – as on a map. Symbolic models, as their name suggests, represent the real world in terms of symbols, most commonly through the use of mathematical formulae. This type of model is familiar to many planners and widely used in planning process.

Mathematical models in planning are used primarily to describe and predict the behaviour of the various systems with which planners deal. There are four basic elements in the structure of mathematical models. There are:
i, variables—can assume different values over space and time such as population, land use density etc.
ii, parameters—are values or constants which serve to adjust the general model structure to the real world situations;
iii, structural relations—are mathematical statements expressing the relationships between variables and parameters;
iv, an algorithm—indicates the various steps that have to be followed to actually calculate the model and derive a solution.

Global models
These are models that generally deal with the implications of patterns of development at the world level or with reference to particular regions of the world. They focus not only on economic issues but also on social and environmental concerns.

Economic models
These kinds of models are mainly used in economic development planning.

Widely used models in Urban and regional planning: gravity model and ratio model
Models that describe and predict changes in the structural and functional characteristics of cities and regions have been extensively used in the field of physical planning since mid-1960s. Ayeni (1979) in his book "concept and techniques in urban analysis" mentioned some variety of spatial interaction and allocation models, which have been developed and used in physical planning over the past 20 years.

One famous model is the so called 'gravity model', which is based on an analogy with the concept of gravity in physics. It is used to predict levels of interaction between different towns and cities or between different locations or areas within a particular city. It has a number of potential applications. For example, it can be used to predict the level of demand for retail services in different zones of a city and the shopping centres at which residents will shop. A simple formula of gravity model can be describe as: $G = P_1 * P_2 / d$, Where: G is the gravity; P_1 is the population of city2; P_2 is the population of city2; d is the distance of two cities.

Another well-known model in urban planning is the 'ratio model', which is used for population forecasting. This approach is often used to obtain regional population estimates from national data. Ratio model may also be used to forecast the size of particular groups within the population as a whole. Form example, the planner may be interested in finding out how the size of the school-age population

will change. Once he has calculated the ratio between school-age children and total population from historical data he can then project this forward to see how the number of children in that age group will change as total population changes. However, he has to assume that this ratio remains the same over the forecast period.

Although mathematical models play an important role in certain areas of planning activity, there are some limitations and problems associated with their use. The key problem is that models depend on the acquisition, storage and handing of large quantities of data. Getting and assembling data is a labour-intensive and time-consume task.

2.2.4. Use of information technology (GIS and RS) in urban planning

Rapid development of information and communication technology over the last few decades has had a significant impact on the planning processes. Among the technological advancements, Geographic information systems (GIS) are perhaps the one that has been most attractive to planners. With their powerful capacity for spatial data management, spatial analysis, and visualization, GIS provides planners with new tools to implement their work more efficiently.

GIS are widespread in management and planning, affecting the very organization and operation of the planning process itself though current GIS are not rooted in the sort of functions. The literature on the urban application of GIS is scattered in journals, proceedings, and books of various disciplines. Issues related to the practical application of GIS in urban planning and various decision-making processes by government agencies and industries can be referred to Masser (1991 and 2001), Webster (1994), Sui (1994), Brail and Klosterman (2001).

GIS can be employed for nearly all research and analysis about urban planning that involves land based spatial analysis and modelling. Especially for area monitoring, regional potential and feasibility and analyses and site selection studies, the GIS offer good functionality.

With the proper mathematic model, GIS can also provide the forecasting of urban population, analysis of urban population density, the trend of urban development.

With the strong analysis function of GIS, Urban planner can examine the urban traffic situation including railway, road and even air traffic and etc.

The visualization function of GIS can simulate the urban planning and urban development processes.

Remote Sensing (RS) is a technique of collecting data from a distance without touching the objects. Broadly defined, remote sensing is not limited to digital, satellite-based sensor systems, but encompassed the realm of photogrammetry and hence conventional analogue sensors, including aerial photography. Viewed from this perspective, remote sensing has been used routinely to provide information on urban areas for analysis and planning purposes since last decades. For instance, analogue ortho-photographs have long been used for urban planning. Now the satellite image owns its position in

the application of urban planning processes since it has the advantages of easily to get it, less expansive in contracting of aero-photos, easy of time sequence comparison and etc.

Remote sensing has been widely used in resource inventory, land use change monitoring and many other applications. In urban planning application, first of all, remote sensing can be regarded as an important data source for urban expansion monitoring and land use structure analysis. With the interpretation (visual or computer automatic) of remote sensed imagery, urban planners can get the land use date, which play an important role in urban planning processes. Secondly, remote sensing can be applied to monitoring the urban environmental including air and water pollution, green space investigation. Remote sensing can also be used in the urban traffic analysis.

Due to the limitation on course spatial resolution, further detailed land use information could hardly be derived based on such course resolution imagery. However, this situation has been changed by launching of high-resolution satellite imagery sensor, IKONOS in 1999. With 4 meter spatial resolution of multi-spectral imagery and 1 meter spatial resolution of panchromatic imagery, enormous amounts of information can be derived based on these high-resolution satellite imagery for urban studies.

2.3. Social economic development planning and physical planning

In the previous section of this chapter, we discussed the basic knowledge of planning of western countries. In order to understand the nature of urban planning in China, it is necessary to review two most important planning types including social economic development planning and physical planning that is very much concerning with urban planning in developing countries.

In most countries of the Third World economic development planning is a post-war phenomenon. The origins and rapid growth of economic development planning in developing nations can be attributed to several factors. The most obvious factor was the desire to achieve development. In the Soviet Union, which is generally regarded as the first country to practise systematic economic development planning, the first five-year plan was adopted in 1929. Prior to the Second World War the impact of the Soviet Union's planning experience on developing countries was limited, partly because the majority of these countries were at that time under colonial rule. After the war the Soviet planning model spread to the countries of Eastern Europe and to China. Five Year Plan, which is designed for national economic development, has been launched in many Asia countries such as India, Philippines and China. This kind plan focuses on the national economic aspect. Its aim is to increase the rate of growth and productive capacity. It is a blueprint for the future. This particular approach to planning was designed especially for use in countries with a high degree of state control over the economy, and many developing nations considered that a considerable amount of state control was necessary-and in many case also desirable, as a means of bringing about the type of development required. Consequently, the degree of direct influence which the Soviet approach has had on planning in individual countries is to extent development on the degree of state control considered desirable in a particular country, those with a one-party system of government lending themselves particularly well to this approach.

Physical planning is one of several terms used to describe a variety of planning activities, which are concerned directly or indirectly with controlling and managing the use of land. As the other terms of – for example, 'land use planning', 'spatial planning'; it ranges in scope from the detailed design of the layout of individual sites in either urban or rural area to the spatial distribution of activities between different regions of a country. Physical planning was designed to control the detailed use of land in urban and rural areas. This included determining the distribution of land between different function such as agriculture, industry, commercial development, housing and recreation. The methodology of physical planning bore some resemblance to the approaches to economic development planning. There was a preoccupation with blueprint plans, normally known in physical planning as 'master plan'. The procedure for the preparation of master plans was 'survey-analysis-plan'. It is the summations of the plan-make operation as well. First, the existing situation in the area to be planned would be surveyed, the survey data would then be analysed to establish whether any remedial actions were required. Secondly, required actions would be embodied in a fixed plan to be realized over a certain number of years. This simple approach dominates physical planning processes. Its essential ingredient was the preparation of a detailed statement of land use patterns representing some desired future end - state - a blueprint for the future (Conyers and Hills, 1984). The master planning approach is still widely used in physical planning and play an important role in urban planning in developing countries as well as in China.

2.4. Urban planning in post-1949 China

Although the western theory and method of modern urban planning was partly introduced in China in the 1930s and 1940s, there has been no systematic urban planning practice responding to urban development until 1950 in China. Urban planning began in China after the communist took over in early 1950s. It can be argued that urban planning practices in China have undergone several stages of development as a result of changing political circumstances in China over the past two decades. According to the point of view of Anthony Gar-On Yeh and Fulong Wu (1999), urban planning practice in China can be divided to four periods -- (1) physical planning evolved from industrial site planning in the 1950s; (2) turbulent urban planning during the political turmoil (1960 – 1978); (3) recovery and establishment of the urban planning system (1978 – 1989); (4) the new urban planning system since the 1989 City Planning Act in a transitional economy (1989 – present).

2.4.1. Industrial site planning in the 1950s

In this period, China adopted the Soviet model of industrial-oriented economic development. Chinese government created a unique urban system through the implementation of national urban policies, centralized planning and an ideological commitment. The policy concentrated on the development of heavy industry in major industrial bases and key-point cities. Urban planning at this time was focused on the coordination of the industrial projects. With the help of soviet experts in economic planning and city design, a comprehensive city planning approach based on the norms of Soviet planning practice was carried out in a number of key Chinese cities. This comprehensive urban planning was particularly to support national industrial construction. The characteristics of planning during the period emphasized on formalistic street patterns and grand designs for public buildings and monuments,

which were built around huge public squares. The main task of urban planner was site selection of factories, functional division of urban land use and design of residential districts.

2.4.2. Urban planning abandoned from 1960 to 1978

From 1960 to 1978, since a series of political catastrophes and economic disasters created chaos in China, urban planning was blamed for its promotion of unrealistic vision and abandoned. City growth were halted and even set back during this period. Urban planning bureaus were dismissed. Planning institutions and organizations ceased to exist. Planners were sent to the countryside or forcibly transferred to other jobs. Planning documents and information were discarded or lost. Western planning concepts were totally prohibited while Soviet planning principles were criticized. Buildings were encouraged to be constructed on any available vacant site. Cities grew spontaneously without professional planning guidance during these years.

2.4.3. Establishment of the urban planning system (1978 to 1989)

Urban planning re-established after the adoption of economic reforms in 1978. The Third Plenary session of the 11th National Congress of the Chinese Communist Party held in December 1978 opened a new era of economic and political reforms. It was announced that the open-door policy and economic development has again made the cities favoured location for growth. With the development of large-scale urban development programmers, the importance of urban planning has been recognized.

As a result, urban planning institutions were re-established in many cities. A nationwide effort to restore and revise urban master plans followed. And 78% of municipalities and 38% of county governments began drawing up their independent master plans. At the same time, urban planners began to learn from the experience of western countries. Some concepts and ideas such as Ebnezer Howard's Garden City and Sir Patrick Abercrombie's London Plan are known. Many planning terms like 'new town', 'green belt', 'anti-magnetic poles', 'growth poles', 'megalopolis', are widely used in urban planning, although some of them are not used exactly and properly. New techniques such as applied mathematics; computer-aided design, remote sensing and GIS have been introduced into the routine work of planners. Healthy development of urban planning is evident across the nation.

2.4.4. Planning in transition (1989 to present)

However, since 1978 there has been more emphasis on technology and professionalism in urban planning than ideological commitments. The adoption of 1989 City Planning Act was a milestone in the history of urban planning in China. Based on the implementation of an Urban Planning Regulation promulgated by the State Council in 1984, The City Planning Act was enacted by the National People's Congress on 26 December 1989 and has been effective since 1 April 1990. The Act consists of six chapters and 46 articles. Chapter 1 (articles 1-10) describes general rules. Chapter 2 (articles 11-12) discusses the formulation of city plans. Chapter 3 (articles 23-27) deals with development in new areas and the redevelopment of existing urban areas. Chapter 4 (articles 28-38) specifies the imple-

mentation of plans. Chapter 5 (articles 39-43) lays down the legal responsibilities and chapter 6 (articles 44-46) is the supplement (Appendix 2 states the first two chapters of the Act, which was downloaded from website www.china-construction.org).

In order to interpret the Act correctly, the Explanatory Notes of the City Planning Act has been published by Ministry of Construction in 1990. Although the explanatory notes do not have legal status, it still provides guidance to local government in the preparation of urban plans. As a product of the transitional period, the Act inherits the traditional principle and philosophy of urban planning, the way of which the urban planning was prepared under the centrally planned economy.

The significance of the Act is that it authorizes the local government to prepare a system of plans to undertake development control. The Act also formalizes various levels of plan formulation introduced by local authorities to cope with problems emerging from economic reforms. Regional development, infrastructure construction, urban renewal, conservation, environmental protection and sustainable development have become priorities in urban planning. A system, which is suitable for the Chinese characteristic has been established (See Figure 2.1).

The key points of the Act are as follows: (1) urban planning can be divided into two major stages as master plan and detailed plan; in these two stages, there are several sub-levels; (1) preparation of urban plans should obey various principles specified by the Urban Planning Act, and meet the standards and technical norms defined by the government; (3) preparation of urban plans should be integrated with urban social and economic development plans; it is required to fully understand natural and environmental conditions, to emphasize urban design and historical conservation, and to coordinate the unity of economic benefits, social benefits and environmental benefits; (4) urban planning should consider broadly the opinions of residents and relevant institutions; the power of preparation and approval of urban plans should obey the regulations by the Urban Planning Act.

The deepening of economic reform through a new such as land lease policy, and the shifting from a planned economy to a market economy, has particular impacts on urban planning practice because the policy of speeding up housing provision and land development. A new urban planning practices and approaches such as urban district planning, detailed development control plan, proposal of zoning ordinance and other land leasing plans were approved through the circular of the Ministry of Construction or the State Council.

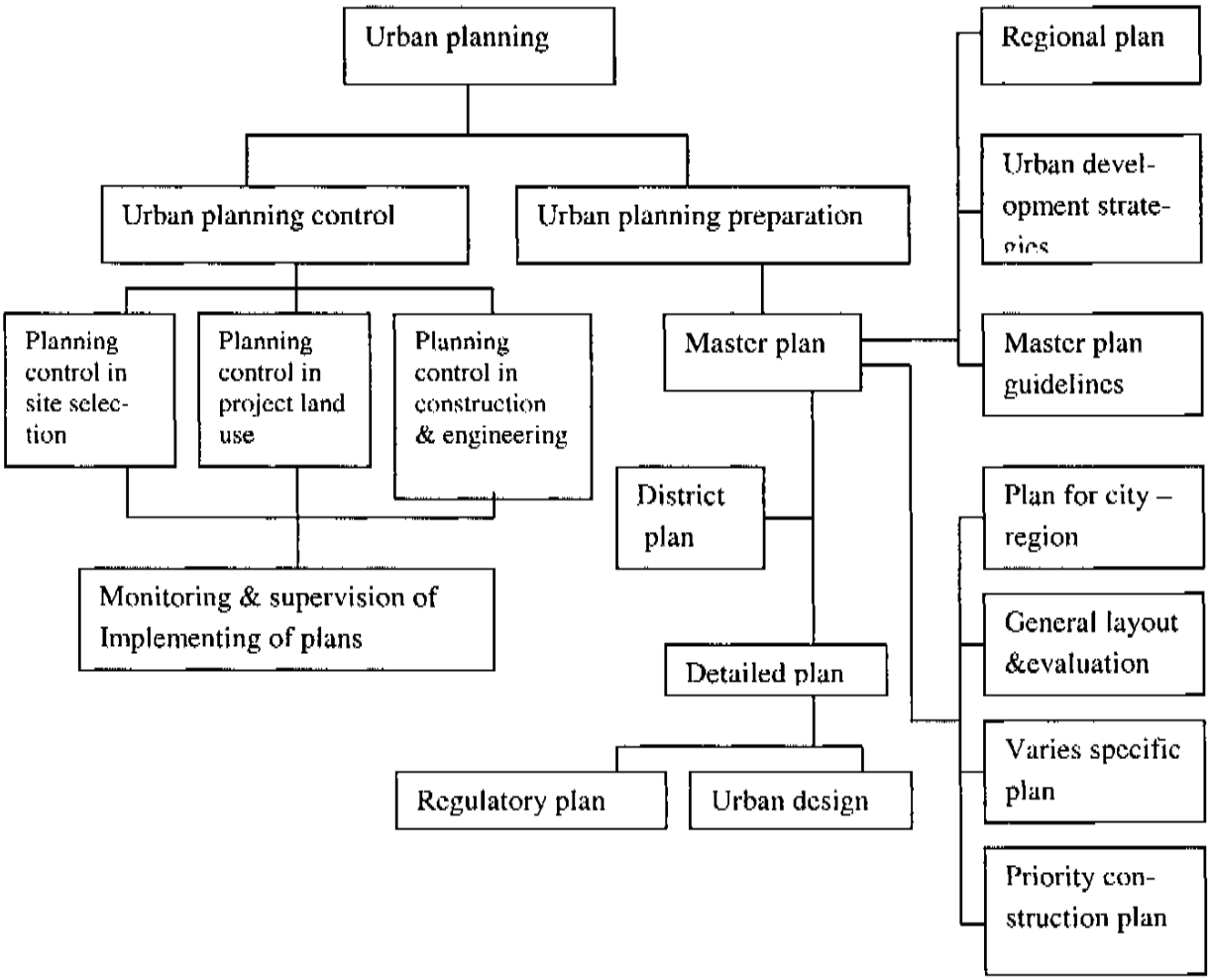


Figure 2.1 Urban planning system in China (source: Zou, 1995)

2.4.5. Master planning processes

Master planning plays a very important role in the urban planning of China. According to the City Planning Act, "the urban master plan should include the designated function of a city, the development goal and target planning size of the city, the standards, norms and criteria for the main constructions in the city and the land use structure, functional and land use differentiation and the general layout for various types of construction, comprehensive transport system, water space and green space system, sectoral planning and planning for short-term construction (the Explanatory Notes of the City Planning Act, chapter 2, article 13,14, and 15)

The content of the master plan is specified as follows:

1. Arranging the urban system, transportation system, infrastructure, ecological environment and landscape resources within the administrative area of the city and counties;

2. Projecting target population size and area of land uses within the planning period; delineating the boundary of urban planning district;

3. Specifying future urban expansions and the land use structure; deciding the location of the city or town centre;

4. Preparing the structure and layout of the urban transportation system and road system plan to decide urban road hierarchy, the system of main roads, main square, car park and cross sections.

5. Preparing plans of urban water supply, drainage, flood-prevention, electricity supply, gas, heating, sanitation, environmental protection and coordinating these sectoral plans;

6. Arranging development of water system (river and lake system).

7. Arranging green system plan;

8. Preparing disaster prevention plan, air defence and earthquake plan;

9. Preparing environmental protection plan, conservation plan of scenery sites, cultural relics and traditional streets; delineating conservation boundary and control area; suggesting countermeasures of environmental protection;

10. Preparing special protection plans if the city is on the list of cultural and historic cities;

11. Deciding the principle methods and approaches of urban renewal and land use adjustment; suggesting the requirements and measures to control population density within the old city;

12. Planning rural settlements, rural industrial land uses and vegetable, pasture land, forest and orchard, non-staple agricultural products base; delineating the green space and separation belt;

13. Studying the general technical and economic feasibility; suggesting implementation procedures and approaches;

14. Preparing short-term plans; deciding the goal and content of the construction in the short term and the measures of implementation.

Technical issues:

1. The planning document includes the text and the appendix, planning notice and basic data of planning should be put in the appendix.

2. The major maps include the existing map of the city, urban system plan of the city-region, the urban master plan, transportation and road plan maps of sectoral plans and map of short-term planning.

3. The map scale of large and medium cities is from 1:10000 to 1:25000 and for small cities, from 1:5000 to 1:10000. The urban system plan is 1:50000 to 1:100000.

The following figure shows the procedure of master planning:

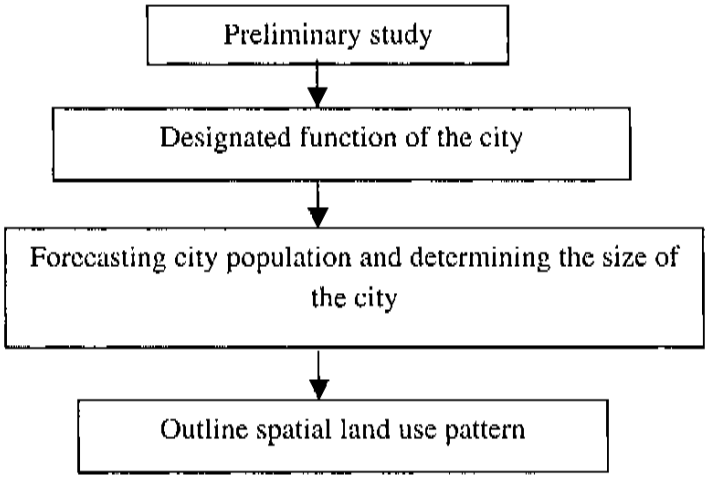


Figure 2.2 Procedure of master planning

Four major stages are included in the procedure of master planning: preliminary study; determining functionality of the city; forecasting city population and city size and spatial land function allocation.

Preliminary study includes several aspects such as nature and social data collection and analysis, current land use analysis, land suitability assessment etc. The approaches of the preliminary study can be field survey, discussion in the seminar and expert's consultancy.

Designated function of the city is a number of indications in reflecting the status and dominant a role it plays in various aspects of national economic development. For instance, the designated Wuhan is a capital city of Hubei province, one of China's key industrial cities and a harbour city. Xi'an is dominantly a historical tourist city due to the fact that it had been an ancient capital city for many centuries and existing of many famous historical sites.

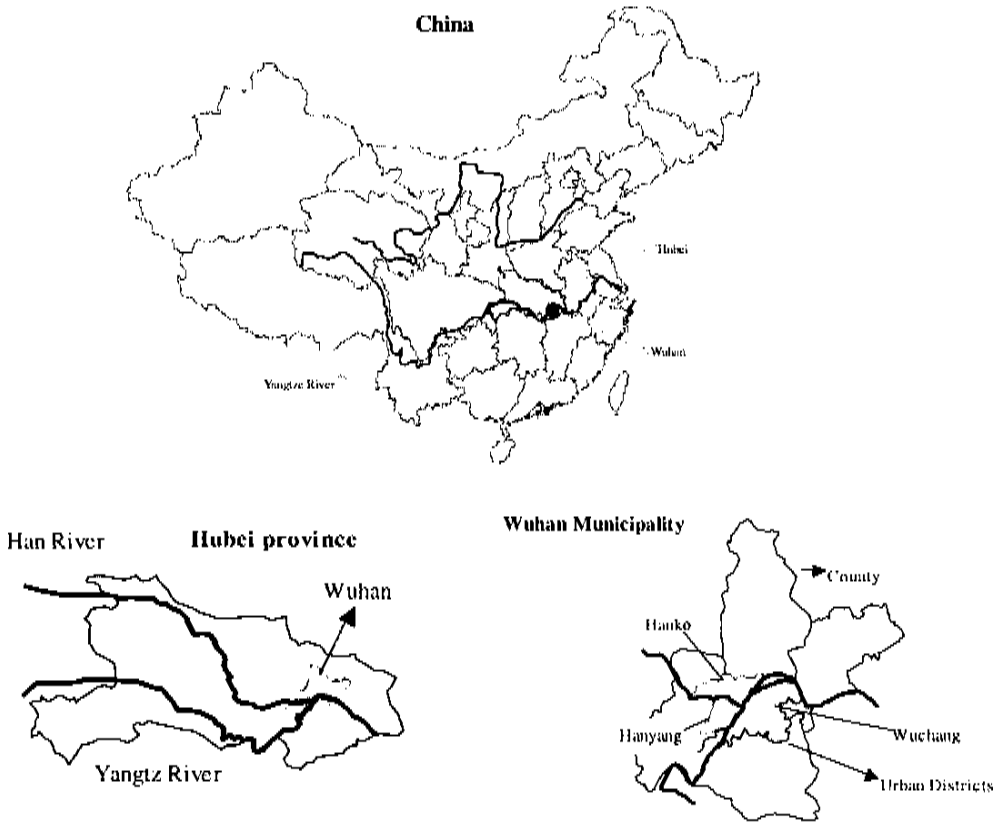
Population forecasting plays an importance role in the processes of decision-making. The size of the city include the total population that the city will reach in terms of planning horizontal as well as the amount of land that will be used for the urban development.

Urban spatial outline is to propose a form of urban spatial pattern including road network and other infrastructure and structural distribution of various type of land uses by taking into account of social, economic environmental as well as engineering and architectural factors. The core issue is to organize all kind of land uses properly in urban space with sound scientific and reasonable bases. In principle, urban spatial outline should be as compact as possible and accessibility is another key issue here. This stage is the core of urban master planning.

3. Land Use Wuhan

3.1. A description of Wuhan city

The Wuhan municipality is situated in the central part of China with about 4 million urban inhabitants and a total municipal population of 7 million people. The municipality has around 1600 square kilometres built-up areas and another 6400 square kilometres of non built-up areas. As the Yangtze River and the Beijing-Guangzhou railway line cross here, Wuhan has been a focal point for water, railway and other traffic. Its topography is dominated by relatively flat land between 22-27 meters above sea level. Wuhan has a nickname "Water City" because many lakes can be found in and around the city.



Map 3.1 Location map of Wuhan

The City is subdivided into three parts (Wuchang, Hankou and Hanyang) and separated by two rivers (Yangtze River and Han River). Wuhan is a multi-centre city and is the capital of the Hubei province. The urban development of these three parts has each unique characteristic. Hankou has been a historic commercial town for more than 300 years. The proportion of commercial land use type is higher than those of Wuchang and Hanyang. Hanyang has lots of historic attractions. A number of heavy industry sites are locating in Hanyang. After the foundation of Wuhan city in 1949, Wuchang was supposed to develop into a town for regional cultural and higher education facilities. More than 20 universities and colleges have been built in this part.

Wuhan is the largest economic, financial, technical, cultural, education and transportation centre in central China. The driving force of the urban development from 1950s to 1970s was mainly industrialization. With the policy of reforming and opening up to outside world, the driving force had been shift to real estate development, new technology development, and urban renewal and infrastructure development etc during past two decades. The land use pattern of the city centre has changed rapidly. Urban sprawl has led to encroachment on valuable agricultural land as well. The Urban planners of Wuhan need to understand how urban expansion and land use change took place in different periods that will help decision-makers in finding better solutions to cope with future development problem in Wuhan.

3.2. Data source and collection

In order to obtain spatial - temporal land use information of case study area, several different data sources were used. Table 3.1 lists the various data sources of Wuhan city.

Table 3.1 Data sources for land use mapping of Wuhan

Source (year)	Scale/Resolution	Coverage
Aerial Photographs (1955)	25,000	100%
Aerial Photographs (1965)	8,000	70%
Aerial Photographs (1986)	6,000	City centre, Hankou
SPOT (Sept. 1986)	Pan/MS, 10/20m	100%
SPOT (Nov. 2000)	Pan/MS, 10/20m	100%
IKONOS (Nov. 2000)	Pan/MS 1/4m	City centre, Hankou
Land use map (1993)	AutoCAD format	100%
Topographic maps (1993)	1:10,000	100%
Planning maps (1954, 1982, 1988 and 1996)	Scanned from a published official report	100%

SPOT images (1986 and 2000) and IKONOS (2000) image were purchased by ITC-SUS project. Planning departments of various districts of Wuhan produced the land use maps of 1993 with Auto-CAD format. Topographic maps from 1993 were used for geo-referencing of remote sensing images. Wuhan master planning maps are used for analysis of proposed land use patterns and comparison between planning of reality, which is described in chapter 4.

Mr. Cheng jianquan, staff member of SUS and also a PhD candidate of ITC, provided some intermediate data such as the land use data of 1955, and 1965 and geo-referenced satellite images (SPOT images 1986 and 2000).

3.3. Land use classification schemes in China

Land use is the function of land determined by natural conditions and human intervention. Urban land use data play an important role in urban planning and management. It is fundamental for understanding the function of a city. Before data processing of land use information, the land use classification schemes have to be defined and uniformed. The selection of a land use classification scheme depends on various factors such as available data, local planning system, the purpose of application, etc. The National Land Use Standard Classification (NLUSC) has been promoted in China since 1992. It includes 10 major classes, 46 groups and 73 subgroups (see the Appendix 1). The ten major classes include residential, commercial and public facility (which include both institutional and commercial land use), industrial, warehouse, transportation, roads and squares, utility, green space, special use (military, jail and land use for foreigners), and water bodies. The local land use classification was not uniformed nationally and underwent many modifications.

Changes of land use classification can be found from the different (1954, 1982, 1988 and 1996) master plans of Wuhan (WUPAB, 1999). According to the master plan of 1954, the main urban land uses are industrial, warehouse, residential, universities/schools, clinics, commercial and green areas. In 1982 they were industrial, residential, warehouse, institutional, commercial/trade centre, special use and green areas. In the master plan of 1988 the land use classification included institutional, commercial, residential, industrial, warehouse, special use and green. More detailed land use classes can be found in the master plan of 1996. They are: low-density residential, mixed commercial and residential, commercial, financial and trade, governmental offices, education and research, hospitals and recreational/green areas, industrial, warehouse, transportation, railway, infrastructure, special use, waters. These modifications indicate a shift of urban development from industry-oriented to tertiary-oriented as more detailed sub-classes related to tertiary section are added into the new scheme.

3.4. Land use data collection techniques

Land use information can be obtained from two major sources i] field surveys, ii| remotely sensed imagery.

Almost all field surveys need topographic maps. Field surveys are flexible in terms of frequency, scale and are more accurate than RS data. But they are time-consuming, labour-intensive and often difficult to standardize.

Remote sensing (including aerial photography) can offer a number of advantages including speed and cost-effectiveness, the ease of time sequence comparisons and the ability to overcome site access problems (Kivell, 1993).

There are two approaches of urban land use classification from remote sensed images: (1) visual image interpretation, (2) digital image analysis.

3.4.1. Visual image interpretation

Visual image interpretation is based on human being's ability to relate colours and size as well as patterns in an image to real world features. Some features such as size, tone, shape, texture, patterns compose of the basic elements of visual interpretation. It is still a reliable solution for the creation of a land use map. While the use of aerial photographs for land use mapping is practice for many decades there is also ample experience in the use of satellite images of low (Landsat, Thematic Mapper) and medium resolution (SPOT). Little experience is available of the high-resolution images (IKONOS).

1. Aerial photographs

The use of aerial photography for land use surveys and urban analysis has been well established since the 1940s in Western Country. In China, high accuracy aerial photographs originally have been used for topographic mapping since the 1950s. In the late 1970s and early 1980s, aerial photos have been widely used for thematic mapping such urban land use, city traffic investigation and urban environmental investigation etc. Photo interpretation techniques were introduced in urban planning bureaus and other related agencies.

However, using aerial photography for urban land use mapping is costly compared with satellite images. It was slow and costly technique and non-digital form limited further analysis though it can be converted to digital form by scanning. The major problems of aerial photography are the frequency of making (every 5-10years), scale (sometimes only very small scale e.g. 1:40,000 not very useful for urban studies) and its accessibility for researchers.

2. Low resolution satellite LANDSAT images

New methods of gathering land use information were introduced with the launching of the first LANDSAT satellite in 1972. But the imagery was, and still is, limited by the poor level of spatial resolution of the sensor. It is not good enough to the urban land use classification since only few land types can be identified on these images.

3. Medium resolution satellite SPOT images

Advances have been made with the imagery from the French SPOT satellite, which is capable of resolution down to 10 meters in the panchromatic mode and 20 metres in multi-spectral mode. SPOT images are regarded as an ideal source to produce land cover maps at the urban – rural fringe, but within the urban areas only a few land classes such as large industrial, high density areas, sport complexes, water bodies, green areas) can be distinguished by human beings. In nowadays, SPOT imagery is widely used to monitor for urban expansion.

4. High resolution satellite IKONOS images

IKONOS is the world's first commercial high-resolution earth imaging satellite launched in September 1999. It provides 1-meter panchromatic and 4-meter multi-spectral images. IKONOS images are opening up a new application field of remote sensing especially in urban studies. More detailed information and land related evidences can be found in these images even a car is discernible in a 1-meter resolution satellite image. This information is helpful in inferring land use functions. A 1-meter IKONOS image is regarding the spatial resolution comparable to an aerial photograph with a scale of approximately 1:10,000.

5. The use of local knowledge and auxiliary materials

Local knowledge and auxiliary materials are two elements that play an importance role in visual interpretation beside some technical issues. They are used when some land use types are look similar in terms of features.

Figure 3.3 IKONOS image, 1-meter pan, Hankou -Wuhan

3.4.2. Digital image analysis

1. Supervised classification

Supervised classification procedures are the essential analytical tools used for the extraction of quantitative information from remotely sensed image data. In supervised classification, the operator defines the spectral characteristics of the classes by identifying sample areas (training areas). It is requires that the operator be familiar with the area of interest. The operator needs to know where to find the classes of interest in the area covered by the image.

2. Unsupervised classification

If the operator does not have sufficient knowledge or the defined classes of interest, an unsupervised classification can be applied. In an unsupervised classification approach, clustering algorithms are used to partition the feature space into a number of clusters. Several methods of unsupervised classification system exist, their main purpose being to produce spectral groupings based on certain similarities.

3. Image fusion

Image fusion is the combination of different digital images in order to create a new image by using a certain algorithm. Fused image takes the advantages of both higher spatial resolution and spectral information for effective visual interpretation of images. Image fusion techniques can be grouped into three types depending on the stage at which fusion process takes place. These three groups are pixel, feature, and decision-level fusion techniques.

4. Problems remain in automatic classification

Digital images acquired by satellite sensors are frequently processed using supervised, multi-spectral classification algorithms in order to derive thematic maps, in some cases these can be a reasonable substitute for conventional land use maps. Unfortunately, the relationship between many types of land use associated with urban areas and their spectral properties in satellite sensor images is complex and indirect. Many researches have initiated automatic solutions for land use classification based on digital imagery, but there are many aspects, which remained unsolved such as image understanding and pattern recognition. Furthermore, using computer automatic or semi- automatic classification approach can recognize few land use functions. It cannot fulfil the demands of land use analysis especially in the application of urban planning.

3.5. Land use change in Wuhan

In the process of urbanization, increasing urban population and urban activities are stimulating the urban expansion. As many cities in China are surrounded with agriculture land, urban expansion results in its loss, which is in China with its limited amount of arable land problematic. Studying on the how urban expansion can help urban planner to analyse the patterns of urban development and urban morphology.

3.5.1. Data processing

To analyse city expansion, the data of built up area is needed. SPOT images are regarded as an ideal source to monitor urban expansion. Build up area is easily extracted from SPOT image by both visual interpretation and supervised classification approach.

In the research, built up area in 1949 was extracted from an official map. Build up area in 1986 and 2000 was obtained from SPOT images by visual interpretation. By converting and integrating exist land use map in 1993 it was possible to get the built up area of 1993. All data have been converted to ArcView grid for spatial analysis and mapping.

3.5.2. Land use change analysis

Based on maps of built-up area from 1949 to 2000, we have a clear view of the urban expansion of Wuhan (see Map 3.2). The core of the urban area has been concentrically developed at the junction of Yangtze River and Han River. The urban area extended mainly along the axis of the two rivers.

In order to characterize the expansion quantitatively, a geometric centre was defined at the junction of the two rivers, namely Yangtze River and Han River. A number of buffer zones have created with 2-kilometer interval from the centre (see Map 3.3). Built-up density is defined as the proportion of built-up areas divided by total area of each zone.

The built-up densities and distribution for different periods are illustrated in Figure 3.4. The urban edge has been extended from 12 kilometres in 1949 to 24 kilometres in 2000. And the city size in 2000 is 10 times larger in compared to 1949.

Changes in built-up density for each zone can be found in figure 3.5. Built-up densities have increased in all zones. However high increasing ratios can be found in both periods of 1949 to 1965 and 1993 to 2000 in contrast to moderate increasing ratios in the period of 1965 to 1993 which referred to the period of Cultural Revolution and early stage of the economic reform (see figure 3.6). Increasing ratios increase from zone 1 to zone 8 spatially as well, which indicated that urban expansion is the major development of the city.

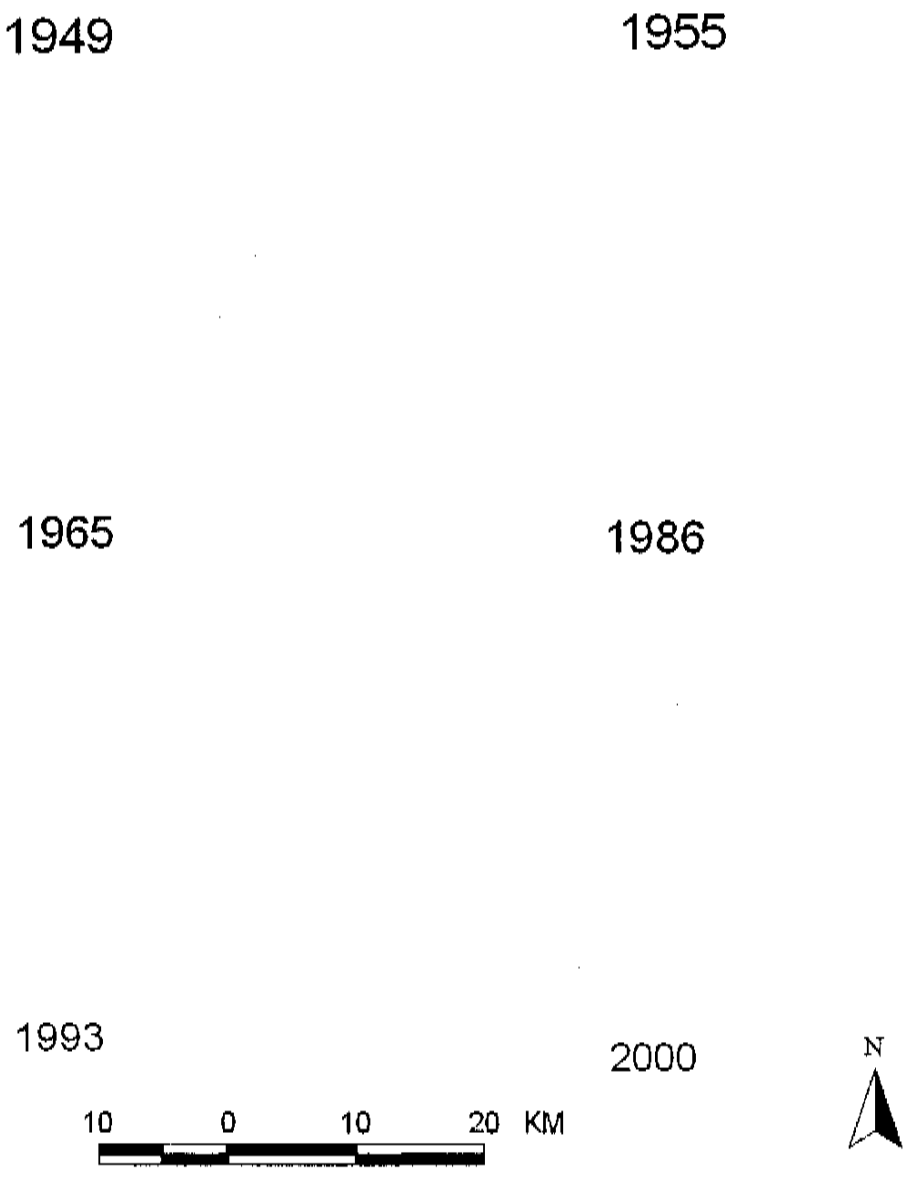
Based on the above analysis, it can be concluded that the urban development process of Wuhan can be divided into three stages in Wuhan:

The first stage was the 1950s, the transition from capitalism to socialism. This stage brought rapid industrialization that leads to the first development wave from 1953 to 1965 since a number of key industrial project were initiated and implemented in Wuhan by central government. In this period the central government was the main investor for city development.

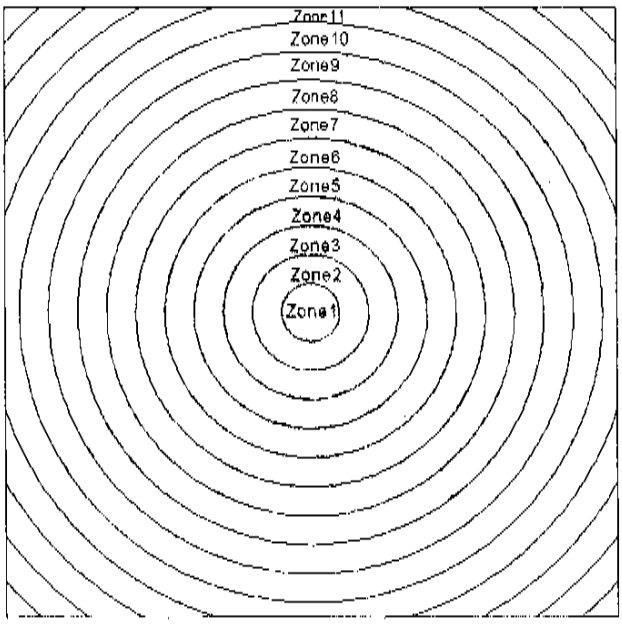
The second stage covers the period of Cultural Revolution and the early stage of the economic reform. In this stage, urban expansion was relatively slow. It is because that the political factor stemmed the urban development from 1960 to 1978. And in the early stage of economic reform, the municipality of Wuhan had to put many efforts to recover "everything", which have been "destroyed" during the 10 years chaos of the Cultural Revolution. In addition, Wuhan was not yet been selected as 'open door' city (a number of open cities mainly situated in coastal region such as Shenzhen, Guangzhou, Xiamen, and etc. in early stage of reform), which can take a series of favourable and flexible policies such as tax concession to attract various investments in the early stage of reform.

The third stage started alone with the land reform in the early 1990s and transferring from a planned economy to a socialist market economy. This policy makes potential and possibilities of urban development turn into reality. The investment from foreign, domestic, central/local government and collectives are the driving forces of this development wave. Various economic entities co-existed for urban development of Wuhan. Some Economic Development Zone, High Technology Development Zone have been established in Wuhan city.

In conclusion, nation social-economic processes shaped urban growth pattern in Wuhan. The interpretation or analysis the urban development pattern over the last 50 years should consider the following factors: investment structure, industrial structure, housing policy, land use policy and urban master planning (Cheng et al, 2001).



Map 3.2 Urban expansions from 1949 to 2000



Map 3.3 Zones

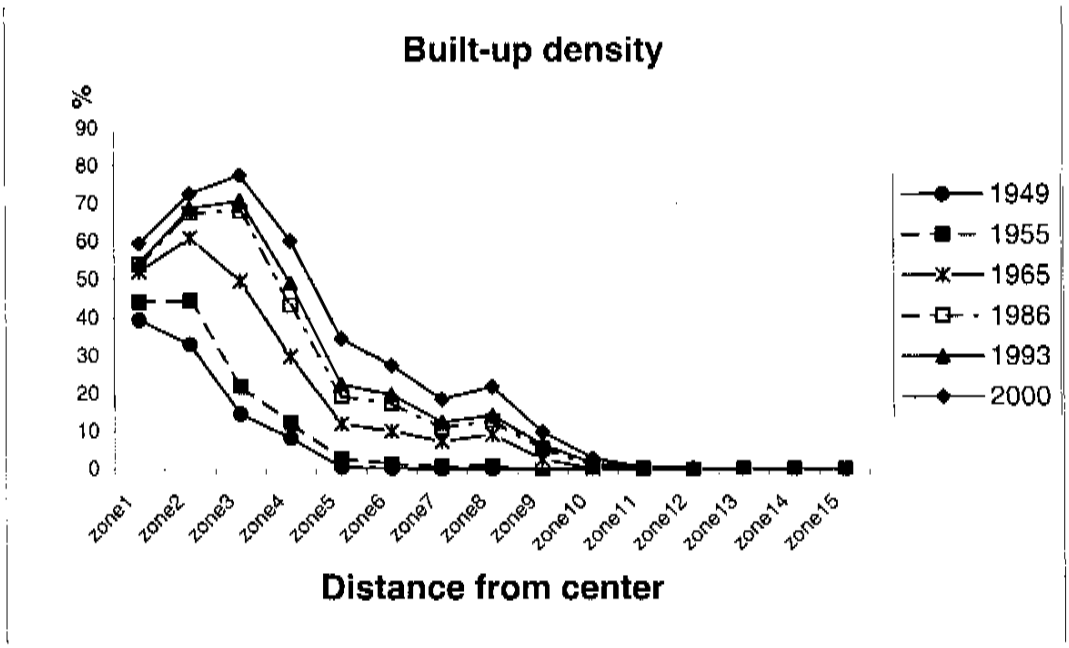


Figure 3.4 Built-up densities (1)

3.6. Land use change in Hankou

Urban development can be divided into urban expansion in which non build-up land or agricultural land is converted into urban land use and urban redevelopment when land use change from one urban function to another. This section discusses the detailed land use structure and changes in the inner city of Wuhan.

3.6.1. Data preparation and mapping

In this research, the ten major classes of The National Land Use Standard Classification (NLUSC) were applied for mapping the land use structure for different years. Since the vacant land or under construction site is not indicated in the NLUSC, these kinds of land was integrated with roads in this research. The three land use classes of Residential, Commercial and Industrial were involved in land use change analysis. ArcView GIS 3.2a is applied for land use coding and mapping.

Visual interpreting aerial photos and IKONOS image and digitising in GIS software obtain land use data of 1986 and 2000 in Hankou area (data used for analysis does not cover the whole area). Before interpretation, geo-reference for digital image is needed. Erdas Image software provides the convenient tool for geo-referencing. The original image has been rectified using more then 30 easy recognized points systematically chosen and evenly distributed over the images to guarantee enough points in the centre and corners of the images. A geographic map of 1993 was used to get the coordinate of the selected points. A second order polynomial model was chosen for the image rectification and resampled using the nearest-neighbour algorithm in Erdas Image. The projection system of WGS84 North with zone 50 was selected for Wuhan.

Since the land use data in 1993 came from different planning departments and with AutoCAD data format, a conversion from AutoCAD to ArcView and data integration has been processed.

3.6.2. Land use change analysis

Map 3.4 shows the spatial structure of urban land use in the inner city of Wuhan in 1986, 1993 and 2000.

The amount of areas for each land use classes and its percentage of total area are shown in Table 3.2. It can be concluded that residential land uses, although reducing, is still the dominant land use type in the city centre. The changing tendency can be found that both residential and industrial have been decreased while public facilities increased from 1986 to 2000 according to figures 3.8.

Table 3.3 illustrates the changes of land use type. It implies that the transformation from residential to public facility that includes commercial and institutional dominant the changes of urban land use in city centre.

Map 3.5 states the spatial distributions of the land use change from one type to another. It can also be inferred that city redevelopment was dominated by the transfer from residential to commercial and public facility.

Table 3.2 Land use structure in 1986, 1993 and 2000 (unit: Hectare)

Land use	1986		1993		2000	
Residential	992	48%	936	46%	874	43%
Industrial	188	9%	138	7%	126	6%
Public facility	361	18%	439	20%	491	24%
Warehouse	23	1%	21	1%	13	1%
Transportation	21	1%	23	1%	5	-
Utilities	31	2%	27	1%	26	1%
Special use	30	1%	32	2%	30	1%
Green space	125	6%	114	6%	130	6%
Water, others	50	2%	42	2%	26	1%
Road, Uncons	235	12%	284	14%	335	16%
Total	2056	100%	2056	100%	2056	100%

Table 3.3 Land use change from 1986 to 2000 (unit: Hectare)

Classification	Residential	Industrial	Public facility
Residential	-	13	126
Industrial	33	-	35
Public facility	35	6	-

Land use change in the inner city refers to urban redevelopment. The national land policy has been impacting on urban redevelopment process. Before economic reform, urban land belonged to the public. The state managed it in a fragmented way. The actual occupant – mostly state work units such as enterprises, administrative bodies, public institutions and etc. decided the use of the land. Enterprises had to build living quarters for the workers. So quite often the residence was adjacent to the production area, which caused mixed uses of incompatible function.

In the mid-80s, China has lawfully approved that the right of use of the state-owned land may be transferred. It means that land use right are separated from land ownership, where the dominant land ownership is government land and land users can lease land from the government. Consequently, land markets were established. Land reform not only propelled urban new development in which some Economic and Technological Development Zones were initiated, but also involved the city redevelopment in which the real estate plays an important role.

Since 1992, the real estate industry, which was adapted to attract more domestic and foreign private investment, became a leading industry and a main driving force of Wuhan urban development. Land use function has been changed dramatically especially in the old city centre. A large amount of residential used lands (high densities but low-rise citizens houses) have been demolished and rebuilt as high-rise buildings with commercial use or mix commercial and residential functions.

Figure 3.9 shows the Wuhan real estate development from 1990 to 1997). It implies that the rapidest increase of real estate development in the period of 1992 to 1995.

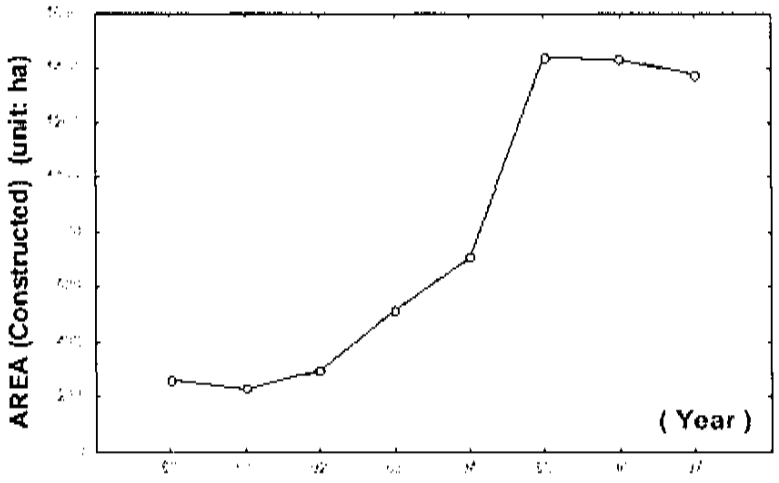


Figure 3.8 Real estate developments in Wuhan (source: Cheng 2001)

4. Master Planning in Wuhan

4.1. Review of master planning in Wuhan

After the founding of the People's Republic of China in 1949, Wuhan was selected as one of the key industrial construction regions in China. Master plans for the city were developed and revised seven times between 1949 and 1996. In 1953 under the first Five-Year Plan, *a draft of an urban plan for Wuhan* was developed by the Wuhan urban construction commission to meet the demands of the national economic development. In 1954, as some key development projects were initiated in Wuhan, *the urban master plan*, which was supervised by experts from the former Soviet Union, was revised. The plan was approved by the Hubei provincial government and registered by the state planning commission. Two years later, in 1956 the central government requested local governments to develop their 12-year national social economic development plan and, *a 12-year plan of Wuhan urban development* was developed based on experience of planning implementation in previous periods.

In 1958 when the second Five-Year plan (1958-1962) and Great Leap Forward development began, Wuhan City proposed an ambitious industrial development scheme with 200 development projects. *Wuhan urban development plan* was revised in 1959 under such circumstances.

In the periods between 1960 to 1976, urban planning had been interrupted due to serious natural disasters in the early 1960s and the culture revolution campaign. City growth and urban planning were halted and even setback during this period.

After the Third Plenary Session of the Eleven Central Committee of the Chinese Communist Party in 1978, the urban construction and development of Wuhan entered a new period. In 1979 *the Wuhan Urban Master Plan* was revised, and approved by the State Council in 1982.

According to "The implementation scheme of Wuhan economic reform" approved by the State council, revision of *Wuhan urban master plan* started in 1985 and was finished in 1988. This revision concluded the experiences of urban construction and economic development in recent years with economic reform and the opening to the outside world policy, and adjusted the goal and scale of urban development according to the new situation of being a central city of China under economic reform.

In the 1990's Wuhan was authorized as an open city and open port, Wuhan entered an important development period. In order to meet the new challenges and opportunities towards the coming 21st century, the *Wuhan urban master plan for the period 1996 to 2020* was made between 1993 and 1996 and approved by the State Council in February 1999.

4.2. Site planning approach in the 1950s

4.2.1. To recover the national economy

After an 8-years war with Japan (1937 - 1945) and a 3-year civil war (1946 - 1949), Chinese economy had been seriously damaged. Therefore the main objective of national plan was economy recovering. Very few new development projects were initiated between 1950 and 1952. Urban construction was dominated by limited urban renewal for improving the infrastructure during this period. The focus was on redevelopment in the inner city and not much urban expansion took place in this initial stage of the P.R. of China.

4.2.2. The first National Five-Year Plan and master planning in 1954

In the 1950s, China was following a Soviet style central government with a controlled social economic system. A social economic development plan called the First Five-Year Plan, modelled on Soviet Union based ideas and concepts (or Marxist doctrine), with state control of the industrial sector, was launched. Various ministries of the central government had their own nation-wide development plans. When a development project was planned by a ministry, the local government had to help in finding a suitable site, but was not involved in the decision-making process regarding type and size of such a project. Therefore, the local government was in a rather passive position in population forecasting and demand for urban land during the development of the master plans. This is the main reason why master planning in this period adopted the site-planning approach.

In the beginning of the first Five-Year Plan, a number of large-scale industries were planned or initiated by the central government in Wuhan such as the Wuhan Iron and Steel factory and the First Yangtze River Bridge. Along with these large development projects, a number of local industrial development projects were initiated as well as infra-structural projects. The main objective of the master plan was to find and allocate suitable sites for these development projects. The Wuhan Iron and Steel factory was planned to be built in Wuhan due to easy accessibility and low transport costs by using the Yangtze River as waterway to transport raw materials and the steel products. Some other industrial development projects were planned to be located in Wuhan such as heavy machinery manufactories, boiler manufactory and rail carriage manufactory etc. in order to use the products of the Iron and Steel factory locally.

- Population forecast

Based on census data, the urban population of in 1954 of Wuhan was 1.5 millions. According to type and scale of planned projects, the total urban population was estimated as 1.8 millions in 1960 and 2.0 millions in 1972.

- Land allocation

According to the forecasted population, the total amount of land for these developments was calculated as 20352 hectare (12% for industrial use).

- Site selection

The following aspects were taken into account for site selection:
Land availability, accessibility, water supply, flood prevention, distance to city, impact of potential pollution and existing industrial areas. For instance, the site selected for the Wuhan Iron and Steel factory was mainly based on the following factors: Close to river harbour and easy railway connection, enough space for development and space for future expansion, sufficient water supply, minimize pollution to existing urban areas (down-stream of the Yangtze River, down or side of major wind direction from built-up areas) etc.

The master plan and actual sites selected are shown in Figure 4.1.

- Comments

1. Since a number of industrial development projects were determined by the central government, the master plan was focused on related population forecast and site selection. Urban planning was treated as a type of urban design in infrastructure development according to the blueprint planning style of development plan under planned economy.

2. The factors involved in site selection were reasonable at that time. However, due to the slogan of "production first", a number of residential areas and public facilities were behind the timetable. Workers and other residents had to suffer for a quite long time with relatively low living standard. Planned green spaces had not been implemented as indicated in the master plan.

3. Urban spatial patterns

These key development projects resulted in massive population increasing, contributed to the city's economy and employment. A large amount of surrounding land had been converted into industrial and residential use, accompany with these development projects, hence the urban spatial pattern had been changed a great deal (see Fig. 4.1). Those kind of approach resulted in the discontinuously or sprawl urban patterns. Most planned projects were completed and a number of industrial zones were formed around factories such as the Wuhan Iron and Steel Plant, the Qingshan power plant and the Wuhan Boiler plant in 1965. Most of the newly built up areas were built up by following the master plan made in 1954.

4. Land use structure

The characteristics of the urban design were based on formalistic street patterns and grand designs for public buildings and monuments, which were built around large public squares. Residential were planned as a "neighbourhood unit". A small amount of commercial uses were arranged within a certain maximum radius from the residential buildings while a large amount industrial uses were surrounding the urban – rural fringe.

We can conclude that when development projects were initiated and funded by the central government under the National Social-economic Development Plan. The site planning approach and following plan implementation worked well to guide urban development. Master planning is a tool that can be implemented under state controlled systems. The problems were a low level of investment in urban infrastructure and welfare, inadequacy of housing, public facility, sewage networks and electricity supply. The industrial output was regarded as the major indicator of development in the 1950s other than the living quality of residents. The increasing demand for improved living standard was realized by the communist party of china in the early 1980s and received increased attention.

The highly centralized industrial-planning system was criticized as being unable to address these demands.

4.2.3. The Great Leap Forward, construction plan of 1959

Up to 1956, according to the command of the state about "local government has to develop the 12-year plan of national economy and social development". The Wuhan construction committee developed a 12-year plan for Wuhan, which designed the functionality of Wuhan as the base of heave industry and important industry city of the region of middle China, a pivot of railway and water traffic, a centre of scientific research and high education, a political centre of the Huber province.

In 1958 when the second Five Year Plan (1958-1962) and Great Leap Forward (1958-1960) campaign began, Wuhan proposed ambitious industrial development with some 200 projects. Due to the shortage of construction capital the projects were finally reduced to 12 industrial zones (Cheng et al, 2001). The plan of urban development of Wuhan in 1959 designed Wuhan to be not only an industry base of Iron and Steel, mechanical, chemical, but also a base of science and technical developments. High education played an important role to support industrial and economic development of the region. The plan also specified that some small satellite town could be established in the adjacent region to meet the needs of industry while the size of urban area should be controlled.

Unfortunately, the maps of the plan were lost during the Cultural Revolution.

4.3. Urban development without planning

The failure of the great leap forward and the withdrawal of Soviet assistance from China in 1960 changed the emphasis from the development of industry to the development of agriculture. Form 1960

to 1965 was the period of recovery and consolidation. With the introducing of national development policy, in which the reduction of the differences between the urban and countryside, urban development took a two-prong approach: ruralize the cities and urbanized the countryside. The future planning goal was to make the "rural cities" similar to the "urban countryside" in both form and function (Ma and Hanten, 1982).

At the same time, the urban planning was blamed as well for its promotion of unrealistic vision. In 1960, the National Economic Planning Meeting announced the abandonment of urban planning (Yeh, 1998). From 1966 to 1976, the Cultural Revolution made that China entered a disastrous period. Urban planning was totally abandoned. The situation of Wuhan was not in the exception.

Since war was assumed to break out in any time, the central government focused on the construction in the inner part of China (so called "third line development") such as Sichuan province. Wuhan, as a city of primarily heavy industry, was considered a target for bombing in case a war broke out. Therefore investments from the central government had been reduced drastically. Urban new development in Wuhan almost halted. A limited investment for urban redevelopment was shifted to military for defence purpose. The residential housing projects were small and based on individual units.

In addition, the limited urban construction was guided by non-professional municipal mangers since the trained planners had been sent to work in the countryside or forcibly transferred to other jobs.

However, the underground space had been changed a lot due to the massive construction of underground shelters to prevent air strike by the former Soviet Union in late 1960s and early 1970s. Many under ground space have been used as storages or even for commercial uses nowadays.

Worth to be mentioned is that the government of Wuhan put some efforts to develop a new master plan to guide the urban construction from 1973 to 1985. This master plan in considered the basis for the master plan of 1982, which will discussion in next section. However the master plan of 1973 was interrupted and had not been sent forward for approval.

4.4. Planning in early stage of economic reform

China initiated its political and economic reform and "open door" policy in 1978. Urban planning has recovered and became an important tool for urban development principally. A second round of master plan development (the first round was in the 1950s) started throughout the whole country. Lack of professional and experienced urban planners was the major problem though some planning institutes and high education programs about urban planning had been re-established at that time. Although some planners accepted some ideas from the western world they did not know how to use them properly. During this period, urban planning still adopted the Soviet Union's approach that was introduced by experts of Soviet Union.

4.4.1. Master planning in 1982

With the introduction of the policy of reform and open door to the outside world, Wuhan urban planning administration bureau was established in 1979. The Wuhan master planning was revised in 1980 based on the efforts in preparing the master plan of 1973 and was approved by the State Council in 1982.

The plan summarized the designated function of Wuhan as: "the political, economic, scientific and cultural centre of Hubei province, one of the most important nodes of China's transportation network, an important industrial base". The urban population should not be exceeded over 2.6 million in the short term and 2.8 million by the end of year 2000 in the urban area. The build-up area should not be exceeded over 185 km^2 in 1985 and 200 km^2 in 2000.

In order to avoid continued expansion of the central built-up area and control the size of the city, the plan suggested developing several satellite towns surrounding the municipality. Figure 4.2 illustrates the master plan.

- Comments

1. This master plan was intended to bring urban development under a proper planning guidance after two decades of development without proper planning guidance based on development experiences and lessons learned in the past. However, the plan was guided by planned economy and still in blueprint style.

2. Urban spatial patterns

A number of infrastructure projects were proposed such as the second Yangtze River Bridge, the Yangtze River container harbour and road network (see figure 4.2). These infrastructure projects would have impacts on urban spatial patterns.

3. Land use structure

Green space was emphasized in this plan especially in the east part and the green belt along roads. A small amount of commercial land use was planned alone main streets.

4.4.2. Master planning in 1988

Urban reform and rapid development had left the master plan approved in 1982 behind the reality. The revision work of the Wuhan urban master planning started in 1985 and was finished in 1988. See figure 4.3.

The plan summarized Wuhan with the following characters: "the political, economic, scientific and cultural centre of Hubei province, one of the most important nodes of China's transportation network and trade, an important industrial base for conventional manufactory and for high-tech industries, as well as regional centre for commercial, financial, science and technology, cultural and educational, information exchange in the central region of China".

The urban population should not be exceeded over 3.5 million by the end of year 2000 in the urban area. Some 650 km^2 of urban built-up areas and potential development areas were included in this version of the master plan. Based on the fact that Wuhan has been divided into three parts, Hankou, Wuchang and Hanyang, each part should play dominant roles in social economic development, say, Hankou should emphasize in commercial, trade, financial, communication and other services, Wuchang should emphasize in educational, research and high-tech industrial, Hanyang should play important role in tourism as well as industrial development and related facilities.

Both the East Lake High-tech Development Zone (ELHDZ) around the East Lake and the Wuhan Economic and Technological Development Zone (WETDZ) near Hanyang should play leading roles in city's economy. The newly allocated industrial areas included the Yangluo town due to the development of a major electrical power plant. Among these major development zones, two were selected in satellite towns, Zhuangkou for automobile manufactory and Yangluo for electrical power plant, while Guanshan was selected as continue expansion of existing built-up areas for high-tech industrial.

- Comments

1. This master plan was prepared under the pressure of rapid urban growth and the new situation due to the economic reform and the open door policy. However, the plan was guided by planned economy and still in blueprint style. Site planning approach was applied again in finding satellite towns for automobile manufactory and the electrical power plant. Economic growth and accessibility were emphasized in this version of the master plan. Not much attention had been paid to environmental issues.

2. The second ring road of Wuhan was planned in solving inter-city traffic problems and potential funding from the central government as part of the national highway network.

3. Urban spatial patterns

Spatial pattern would change again in both forms of continued urban expansion and new satellite towns. Other major changes were expected as well due to construction of the second Yangtze River Bridge and relocation of railway line from Beijing to Guangzhou within the built-up area.

4. Land use structure

This plan highlighted the green space especially the green belt alone the main road. However, limited public green space can be found in the old city. A number of commercial streets have been arranged in the inner city of Hankou.

4.5. Planning in transition

4.5.1. From a centrally planned to a market economy

The deepening of the economic reform has particular impacts on urban planning practice because the policy of speeding up housing provision and land development, and foreign investment is closely related to urban development, Wuhan was selected as one of the cities to experiment with the land lease systems in 1990. The previous master plan could not meet the needs of new period since the differences between plan and reality had been emerged especially in land use patterns of city centre.

In addition, the transformation of political economy in urban development and housing and land reforms as well as shifting the planned economy to market economy not only challenges conventional urban planning, but also provides the opportunity for urban planning to evolve towards a more realistic and active practice.

4.5.2. Impact of the City Planning Act

After the adoption of economic reforms in 1978, the central government of China began to recognize the need to improve the legal system of urban planning. Based on the implementation of Urban Planning Regulation promulgated by the State council in1984, the City Planning Act was enacted by the National People's Congress on 26 December 1989 and has been effective since April 1 1990.

The Act perceives the function of urban planning as to define the size and economic orientation and structure of a city, to realize the goal of economic and social development of the city, to prepare 'rational' city plans and carry out construction to meet the needs of development for socialist modernization.

The Act also states that urban planning consists of two tiers, i.e. the master plan and the detailed plan. According to the Act, master plan outlines the general land use pattern of the city while the detailed plan faces immediate development or is specified in the master plan.

4.5.3. Impact of land lease policy

In 1992, the Wuhan municipal government promulgated several reform policies including *the implementation scheme of state-owned land use system reform in Wuhan, implementation scheme of leasing and transferring urban land use right in Wuhan* and three other regulations. About 1000 land parcels

in urban districts (in total 1371 hectares) were leased in the period between 1992 and 1998, in which 80% of the leased land was located in the old city area while the remaining 20% located in newly developed areas. The municipality government received large sums of capital from land leasing, and invested these funds to develop the urban infrastructure such as road network, recreation place, green space etc. Land lease accelerated the urban redevelopment process and had changed land use pattern especially in old city area. It impacted on the urban planning as well because the use of leased land very much depends on the investors though there are certain controls by urban planning management.

4.5.4. The new urban master plan (1996-2020)

Wuhan has been selected as an open city and open harbour to the outside world as well as an experimental city for a comprehensive reform toward socialist market economy since 1990s. Implementation of the developing China Central-west strategy, the Three Gorges Dam project construction and speeding up economic development in regions along Yangtze River have significant impacts in city's economy and development. Wuhan was expected to be built as a modern internationalised city toward the 21st century. The preparation of new master plan was started in 1993 and end in 1996 (see figure 4.4). The planning horizon is from 1996 to 2020. This version of the master plan was prepared by following principles with following characters such as strategic thinking, looking steps forward, adjustable, sustainable and operational.

Important aspects of the master plan:

- Toward an integrated social economic development for both urban and surrounding rural areas.
- To make a good use of space and adjust of economic sectors and spatial distribution of population.
- To promote development of the service sector especially in central city.
- To enhance development in culture, protect historical heritages and natural landscapes.
- To improve ecological environment and toward sustainable development.
- To increase infrastructures, public facilities and utilities.

The total area of municipality had been divided into three parts, central city, surrounding satellite towns and rural areas. The central city will mainly be used for the third productivity including commercial and trade, financial and insurance, real estate, transportation and communication as well as for education, research, tourism and consultancy. The second productivity (new industrial projects and manufactories resettled from the central city) will be concentrated in the surrounding satellite towns. The rural areas will mainly be for agriculture and ecological development.

The functionality of Wuhan was designed as: Wuhan is the capital city of Hubei province and a major city of central part of China, an important national industrial based and a major node of transportation and telecommunication. The urban population should not be exceeded over 5 million by the end of year 2020. The urbanization level, which can be described as: the percentage of urban population or non-agriculture population divided by total population of municipality, was expected to be above 80 % in urban areas and 55 % to 60 % in rural areas by the year 2020.

- Comments

1. This version was prepared under the pressure of rapid urban growth and the new developments. However, the plan was constrained by planned economy and challenged by unpredictable nature of market economy during the transit period from planned economy to market economy.

2. Use was made of computers and related technologies in preparing the master plan. GIS systems were established as well for land suitability evaluation and digital mapping. AutoCAD software was used to outline the land use structure and mapping. However, legacy traditional planning making process, the final productions are still in blueprint style.

3. However, legacy traditional planning making process, the final productions are still in blueprint style.

4. Economic growth and accessibility were emphasized in this version of the master plan. A lot of efforts had been put in finding new area for future development. But not proportional a mount of efforts had been allocated in finding solutions to existing problems in the inner city area.

5. Urban spatial patterns

   Spatial pattern would be changed by urban expansion to fill vacant land in the central city area and relocation of the existing airport in Hankou. The second ring road might influence the urban development a lot in the future. Other major changes were expected as well due to construction of the third and fourth Yangtze River Bridges and three crossing river tunnels.

6. Land use structure

   In contrast of the location of land use type in the previous planning of 1980s, the large-scale public facilities are distributed in any part of the city in this plan. And some mixed land use function such as commercial and residential in one building were planned, which emerged already during the real estate development. Explanatory notes of City Planning Act specified the proportion of four land use types including residential, industrial, road and green space (20-32% for residential, 15-25% for industrial, 8-15% for road and 8-15% for public green space). Although, the green space occupy more than 25%, little proportion has been allocated in the inner city while most of them distributed around the city edges.

4.6. Spatial – temporal comparison between master plans

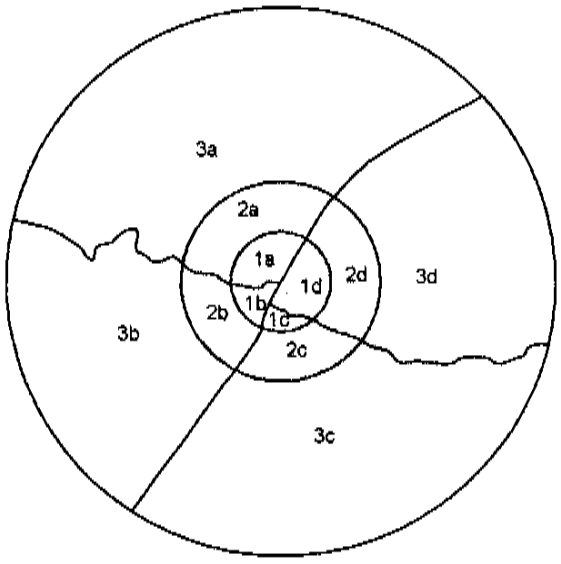
4.6.1. Introduction

The spatial pattern of urban land use has long been an interesting topic for many urban geographers and planners. As was mentioned in chapter 2, one of the elements of urban planning is that planning means allocating the land resource of cities. The most important part of urban master planning is to outline the spatial land use pattern of the city.

A description and qualitative analysis of master plans in difference periods of Wuhan have been discussed in previous sections. Different master planning under different circumstance have various land use patterns. The objective of this section is to analyse the spatial – temporal patterns of land use structure by means of quantitative analysis.

Three master plans (1954, 1988, 1996) have been digitised and coded in GIS system. The procedure of the analysis is as follows: first, scanning the master plan from the published office report. Secondly, geo-reference these maps to make them in a same coordinate system with Erdas Image software. Thirdly, digitising the maps and inputting the attribute data with land use information in ArcView GIS 3.2a system. Finally, converting them to raster format for spatial statistic.

Using a geometric centre (see chapter 3) was defined and three concentric rings have been created which embrace whole Wuhan. Three curve lines (two central lines of both Yangtze River and Han River and one is the main road of Wuchang) divide these zones into four sectors. Thus, 12 regions with the combination of rings and sectors can been created (see map 4.1). With the "tabulate area" operation (it is kinds of attribute overlay function) in ArcView, the area of various land use types of three maps within different regions can be worked out.



Map 4.1 Sectors

Table 4.1 Land use in different sectors according to different master plans (unit: Hectare)

Sectors	Total area	Residential						Commercial						Industrial					
		1954		1988		1996		1954		1988		1996		1954		1988		1996	
1a	1778	767	43%	754	42%	662	37%	41	2%	265	15%	362	20%	12	1%	24	1%	0	0%
1b	790	111	14%	114	14%	171	22%	20	2%	57	7%	65	8%	54	7%	90	11%	0	0%
1c	522	133	25%	190	36%	163	31%	11	2%	12	2%	40	8%	37	7%	42	8%	30	6%
1d	1937	493	25%	492	25%	392	20%	15	1%	11	1%	165	9%	21	1%	109	6%	69	4%
2a	4817	741	15%	1102	23%	1823	38%	3	0%	252	5%	361	8%	183	4%	848	18%	338	7%
2b	2965	118	4%	556	19%	741	25%	0	0%	10	0%	17	1%	122	4%	667	23%	310	10%
2c	3076	350	11%	653	21%	1272	41%	0	0%	2	0%	98	3%	381	12%	505	16%	359	12%
2d	4219	876	21%	702	17%	1335	32%	32	1%	109	3%	228	5%	266	6%	444	11%	171	4%
3a	43735	352	1%	926	2%	1718	4%	0	0%	25	0%	394	1%	543	1%	1937	4%	1741	4%
3b	25936	0	0%	993	4%	1982	8%	0	0%	63	0%	350	1%	205	1%	1052	4%	2177	8%
3c	35860	810	2%	1125	3%	1882	5%	10	0%	49	0%	244	1%	187	1%	854	2%	1639	5%
3d	26417	702	3%	2189	8%	1745	7%	6	0%	78	0%	88	0%	866	3%	3219	12%	3119	12%
Total		**5454**		**9794**		**13884**		**137**		**932**		**2412**		**2879**		**9792**		**9951**	

4.6.2. Findings based on comparison of the three master plans

The analysis involves three major land use classes: residential, commercial and industrial. Table 4.1 illustrates the area of each land use type and its density, which is defined as the proportion of the area of each land use type within each sector divided by the total area of the sectors.

1. Residential

The tendencies of residential areas vary in different versions of the master plan and vary in different spatial sectors. In general residential areas have decreased in the first circle. This implicated the intention of urban renewal projects that many low quality residential houses have been demolished and replaced with commercial use in the central part of city. One area in 2a was planned to be changed from industrial to residential. Residential areas increased rapidly within the second circle and the third circle in general. It implies the residential intent to move to outwards. Detail figures can be found in Table 4.1 and Figure 4.5.

However, if we take look at the actual area of the sector 3c and sector 3d in 1954, the figure shows that many residential areas were developed in this two sectors.

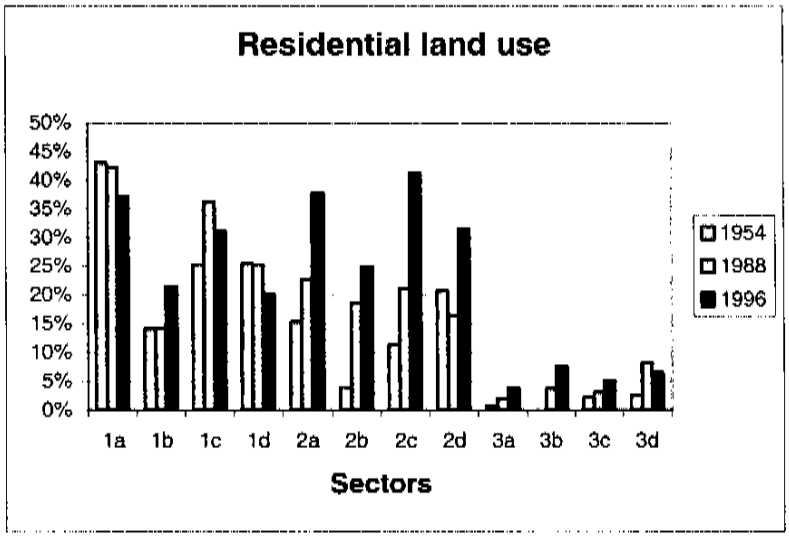


Figure 4.5 Residential land use according to different master plans

2. Commercial

Commercial areas increased in whole Wuhan in general. However, it increased significantly in the first circle in Hankou and Hanyang from 1954 to 1988 (see 1a, 1b in figure 4.6) while significantly increase can be found in the first circle of Wuchang from 1988 to 1996 (see 1c, 1d in figure4.6) due to construction of the first and the second Yangtze River Bridge in 1956 and 1994 respectively. This implicated the intention of urban renewal projects that many low quality residential houses will be

demolished and shift to commercial use in the central part of city. Commercial areas increased as well in the second circle and the third circle in general. The significant increase of commercial used land implies the service sector become the one of the driving forces of urban development.

In addition, the commercial used land was almost equally distributed in every part of the city in the master plan of 1996 (see table 4.1). It implies that the tendency of Wuhan would be developed in a city with multi-centres. These centres are distributed near main roads and integrated functions such as shopping, new and high technology services, recreation, housing and other public facilities.

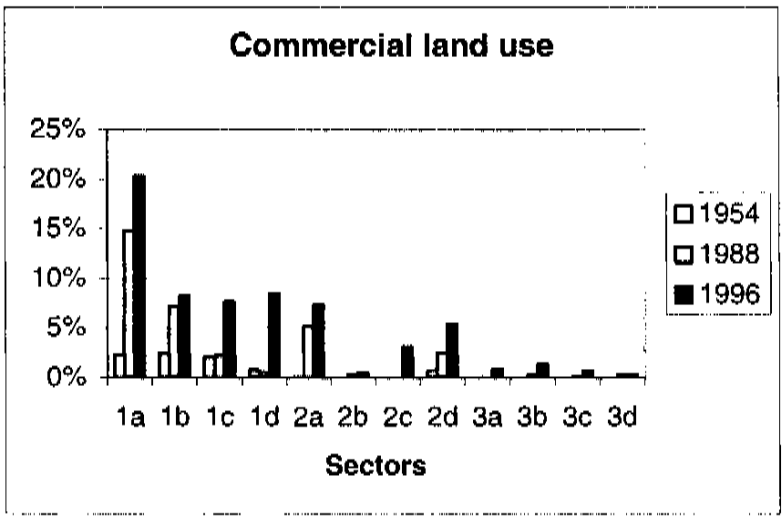


Figure 4.6 Commercial land use according to different master plans

3. Industrial

Industrial development is quite sensitive to political decision as the majority of industries are State owned enterprised. In general, a large proportion of industrial use was distributed within the third circle in the three master plans (see table 4.1). From Figure 4.7, it is obviously that industrial areas increased in the period between 1954 and 1988 and significantly decreased in the 1996 master plan in the first circle and the second circle. In addition, it can be noticed that industrial areas were planned to be removed completely in the first circle of Hankou and Hanyang (1a, 1b). This reflected the shifting from the industrialization phase to the post-industrialization phase of development. However, industrial areas increase in the third circle for new industrial as well as for industrial resettlement from the inner city area.

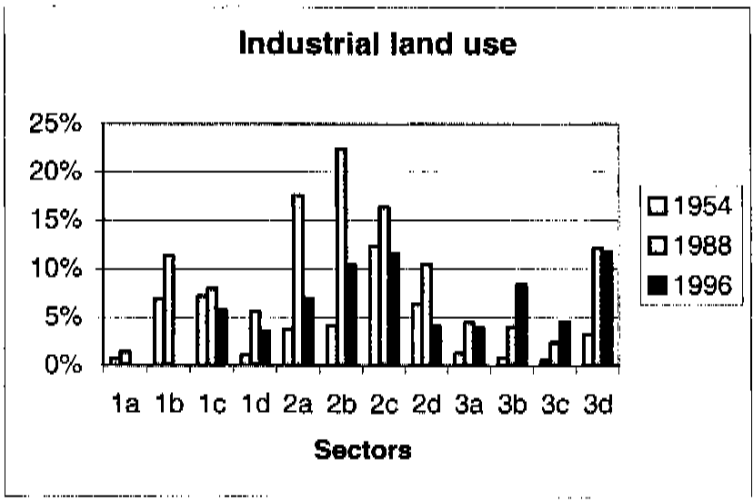


Figure 4.7 Industrial land use according to different master plans

4.6.3. Comparison between the two master plans - 1988 and 1996

The master plan of 1988 was under developed under the centrally planned political circumstance. The urban planners of Wuhan did not have enough experience about urban master planning under a market economy at that time though many planners had professional training in the university. Some western planning ideas and concepts such as "green belt", "garden city", and "growth pole" were introduced but could not be applied properly in planning activities.

The master planning of 1996 was under the different situation from that of previous one. It is under the circumstance of market economy and the pressure that various stakeholders play a role in urban development.

We are able to identify the differences of the different master plans by overlaying the plans. Map 4.2 shows the result of overlay of two planning maps by overlaying the plans. Some important differences are highlighted indicated on the map.

Some differences are due to the development of the second ring of Wuhan such as A1, A2, A3, A6 and A7 in map. A4 and A5 are late reflection of construction of the first ring of Wuhan since the second Yangtze River Bridge was completed in 1994. A8 can be seen as a backup for future expansion of Wuhan Economic Development Zone (mainly car industry).

Some areas had been changed other way around that were planned in 1988 for urban use be abandon in 1996 for various reasons. For instance, regions where accessibility will not be improved in short term such as B1. Areas that may have impact the city's overall interests such as B3 due to increasing concern of drinking water from the Han River. However, it is observed that B2 was built up in early 1990s and it had not been indicated in the later version of the master plan due to reason that the location is in a lower region and under threat of flooding (outside the dike of Hankou). Another area is indicated as B4 with similar concern.

1. Planning

With rapid development in social, economic, technical, environmental aspects, planners could hardly predict such changes precisely. Adjustments have been made to cope with changes in reality.

Planning quality could be impacted by lack of data and scientific analysis method in problem identification and sound analysis. Rapid urbanization presents planners with the problems of cities which are changing so rapidly that it is extremely difficult to operate the processes of data collection, plan preparation, and keep pace with the rate of change.

Urban planning in China was primarily focused on producing planning maps and little attention had been paid to the implementation.

2. Plan implementation

Different interpretation could cause differences in planning implementation due to the fact that only general ideas were illustrated in maps of a master plan and could hardly indicated the potential use each piece of land in detail.

Interest parties could have impacts in using a piece of land for their interests. Developer may try to convince authority to adjust the plan to meet their demands. Leaders may not like to stick to the plan when they try to attract investments to their city, and planning decisions might become ad hoc and not very transparent.

Development projects may not follow the requirements indicated in building permits. Quite often, it is difficult for planning authority to monitor illegal development due to lack of means to monitor in real time.

Public participation was not enforced in planning and implementation phases is another factor influenced the effectiveness of planning.

Monitoring or examining the adopted plans in terms of its effectiveness is necessary and useful. But lack of scientific analysis methods for evaluation quantitatively stems this stage of planning processes in the past. Fortunately, GIS provides a strong function of spatial analysis. By using spatial overlay operation of GIS, the comparison between plans and reality can be executed in terms of both visualization and quantitatively data. However, digital maps of both plan and reality are needed for this analysis.

The GIS overlay procedure is actually an inherent feature of the space-controlled measurement frameworks (Chrisman N. 1997). Once two maps are rendered in to the same grid system, the pixel becomes the base object for both. The computation of overlay results simply translated into Boolean (0 or 1) or arithmetic operation on a cell - by - cell basis.

4.7.2. Comparison of proposed build up between master plans and reality

In order to analyse the effectiveness of the different master plans of Wuhan, use have been made of the land use maps and the master plans. Two comparisons between plans and reality have been made by using the spatial analysis function of GIS. One is the comparison between master plan 1954 and reality in 1965, which refer to the typical planned economy period. As mentioned in previous section, urban planning was to support the key national industrial projects. Another one is the comparison between master plan in 1988 and reality in 2000, which refers to the transition period of shifting a planned economy to a market economy.

In this analysis, some green space around city edge and several lakes have been excluded in the overlay process as well as a satellite town that are located the north-east part of the city.

1. The comparison between master plan in 1954 and reality in 1965

According to the quantitative data, the total area of proposed build up area is 14739 hectares. 72% proposed constructions have been finished. About 5563 hectares proposed lands had not been built in 1965. And around 5502 hectare lands have been built up that the plan was not able to foresee.

The actual development in general was likely the continue expansion around exiting built-up areas where accessibility was good. Road network played an important role in changing the spatial pattern. For instance, the spatial pattern had been changed a great in Hanyang due to the construction of the first Yangtze River Bridge and the first Han River Bridge.

In contrast, areas such as 1, 2, 3 in map 4.3 had not been built up mainly because of the road construction was left behind the timetable.

A number of areas were built up not following the master plan because of new railway connection in north and northwest parts of Hankou.

A big difference located the northeast part (the Iron and Steel plant) can be found in the map (site number 4). The scale of industrial construction was larger than that of proposed.

Area 5 was planned to be an industrial area according to the previous version of the master plan, but it has not built up even up to now due to the major concern of the increasing importance of the drinking water source (Han River) be polluted while water quality of the Yangtze River decreased.

Site number 6 was built up that the plan was not proposed since it is closed to the Yangtze River and it was planed to be an industrial zone in the planning of 1959.

2. The comparison between master plan in 1988 and reality in 2000

Based on the quantitative data, the total area of proposed build up area around 35835 hectare, the already build up area in 2000 is about 30640 hectare. About 11789 hectares lands have not yet been built. On the other hand, about 6594 hectare lands had been constructed without planning.

There are two type of differences have been identified. One is proposed build up could not be implemented in reality until 2000. Another type is built up without planning.
Map 4.4 shows the deviation between proposed build up area and reality. A number of small areas of differences can be discarded due to the accuracy that produced by the overlay operation. Several major differences have been indicated with polygon or circle. The explanation of these differences one by one as follow:

- Site 1

This site was planned to become a river harbour for integrated transportation of sea-land cargo. There are two main reasons for the site remains unchanged. One reason is that the water depth is not stable for different seasons in this part of riverbank. Another reason seems that existing harbours around Wuhan still have potential capacity in cope with increasing shipping.

- Site 2

This site was planned to build a residential area. However, this site is been considered too far from the major part of city. Not much job opportunities could be found in nearby areas.

- Site 3

This site was planned as an industrial area. However, this site is considered too be isolated from the major part of city. On the hand, the municipality had shifted its interests from developing a conventional manufactory to high-tech industry, which could be found in a better location near the existing built-up areas.

- Site 4

This site is reserved for potential expansion of the iron and steel factory. And it has not yet been built in 2000.

- Site 5

This site was planned to become a high-tech industrial area (East Lake High Technology Development Zone) since there are several universities surround, which can provide the enough technique support. Major part of planned site has been built up according to the master plan. However, some areas have been built up other planned site due to increasing demand in high-tech industrial. Some of sites are located in Jiangxia District (Wuchang county) that is outside the administrative boundary of city districts. Building permits were issued by Jiangxia District.

- Site 6

It was intended to reserve a large area as a buffer zone between Wuchang district and industrial zone. However this piece of land has been used for urban development in late 90s after the second Yangtze River Bridge was built up.

- Site 7

The planned development of this area could not be implemented probably due to the traditional industrial is not the driving force of economic development of Wuhan and it is still far from the centre.

- Site 8

This site is a river shore of the Yangtze River, which was intended to be built as a harbour. However, This site is much valuable for other uses such commercial or recreational uses while existing harbours around Wuhan still have potential capacity in cope with increasing shipping. It was shifted to another land use type in the new master plan (1996).

- Site 9

The proposed residential area has not been implemented. The development was impacted replacement of old airport by a large housing development project in nearly area.

- Site 10

This site is the Wuhan Economic Technology Development Zone for a joint venture with France for the production of Citroen automobiles, a satellite town. The planned development has been partly implemented and it will be build up in nearly future. However, sites along the main road are more attractive than sites away from the main road based on the observation of urban development in this area.

- Site 11

This area is located in Dongxihu District (State-owned farming region located northwest part of Hankou) that is outside the administrative boundary of city districts. Building permits were issued by Dongxihu District for food industry with investments mainly from Taiwan, which the master plan cannot foresee.

- Site 12

This site was planned to build an industrial area. However, this site is reconsidered due to the fact that the municipality had shifted its interests from developing a conventional manufactory to high-tech industry.

In summary, two major reasons that stop the planning implementation can be found. One reason is that the proposed developments do not reflect changing interest of the local government, public or private sector. Wuhan is in a rapid urbanization and economical development process with corresponding changes in land use needs. Another reason can be concluded as a time delay. The municipality has to find a proper way to stimulate the development. However, some reasons probably still remain unknown. On the other hand, development out of control often happened mainly due to the real estate development in the 1990s. The municipality of Wuhan faces a heavy task in development control although those real estate developments have improved the live condition of Wuhan citizens. However invading the green space and water bodies causes the environmental problems and is harmful for sustainable development.

4.8. Concluding remarks

In this chapter, some efforts with combining qualitative and quantitative analysis approach have been put to analyse the situation of Wuhan urban master planning activities in different periods. GIS technology makes this analysis possible and more flexible. The analysis of urban spatial land use pattern has been highlighted due to use of GIS spatial analysis function.

Based on four master plans of Wuhan (1954, 1982, 1988 and 1996) and the differences, the following conclusions can be drawn:

4.8.1. Population growth in relation to master planning

The urban population increased rapidly accompanied by industrialization and urban expansion. Figure 4.8 indicates the urban population growth of Wuhan from 1949 to 1999. Two periods can be found with high urban population increasing, from 1949 to 1959and from 1978 to present due to large-scale industrial construction in the 1950s and economic reform and the opening door policy after 1978. Urban population increased only 0.2 millions between 1959 to 1977, with growth rate of 0.5 % in comparing to growth rate of 9 % in the previous period (1949 to 1957) and growth rate of 2.1 % in the following period (1978 to 1999). Urban population decline can be identified as well in the period of 1959 to 1962, which refer to the 3-year natural disasters and the political campaign so called "sending down" movement (Cannon and Jenkins, 1990). In general, urban population growth has strong associations with political situation and stage of development.

The two dash lines specify the forecasted population growths in the two years of 1954 and 1982 as parts of the master planning. You will fond the big gaps between actual population and the forecasted population in both cases. These phenomena implied that either increased fast than people expected or population forecasts were too conservative. Since forecasted urban population is a key figure in forecasting amount of urban land to be used, a dynamic balance has to be made between urban population and amount of land required and static blueprint style master planning can hardly meet the demand of a dynamic social economic development. Additional challenges have to be faced with transition from planned economy to market economy and fast increasing floating population (temporal population in urban areas).

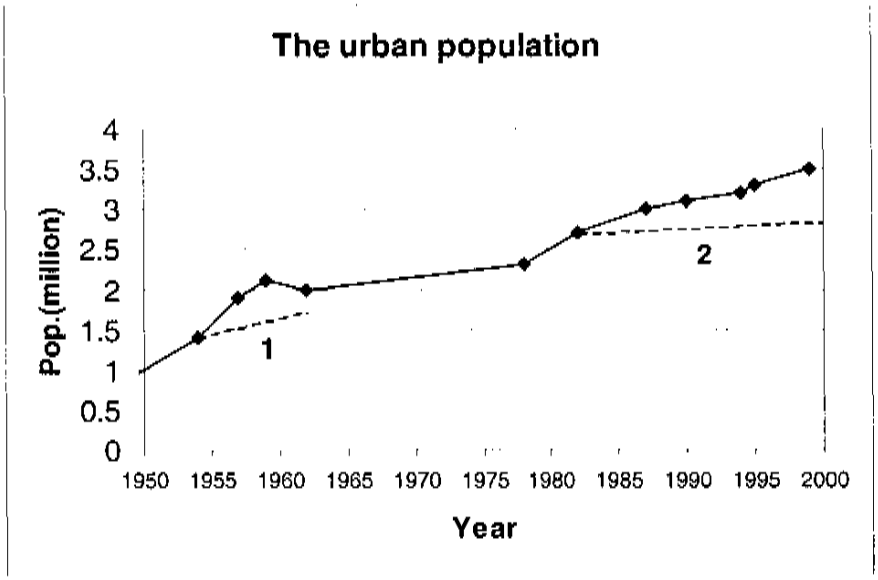


Figure 4.8 Population growth of Wuhan from 1949 to 1999

1 and 2 are the lines of forecasted population in 1954 and 1980
(Data source: population census of Wuhan)

4.8.2. Urban development and planning practice in Wuhan

1. All three master plans were basically static and blueprint style. When we compared the master plan made in 1954 and development reality in 1965, this type of comprehensive planning seems work properly under centralised planned economy and socialist system.

2. When social and economic development grows fast, the master plan would be left behind the development reality. The evidences could be found when we compared the master plan made in 1982 and 1988 with development reality in 2000. For instance, the total urban population by the year 2000 were forecasted as 2.8 millions and 3.5 millions when preparing 1982 and 1988 version of master plan respectively. However these figures had been exceeded 15 and 3 years earlier respectively. Similar phenomena could be found as well when we compared urban built-up area in reality and the planning maps.

4.8.3. Urban planning role in urban development

1. Master planning plays an important role in urban development. When we compare the urban structure and road network in 2000 with the master plan made in 1954, we could found that they are very similar. If we evaluate quality of a plan by using percentage of planned activities being realised, the master plan made in 1954 is better than the versions made in 1982 and 1988.

2. When development projects could be planned and funded according to the plan, accompany master plan would reach their objectives properly based on development reality in 1965 and plan made in 1954. When development projects could not be planned in advance or development funding was not only from the central or local government, related planning would not be able to implemented properly according to development reality in 2000 and master plans made in 1982 and 1988 due to shifting sources of investment from government funding along to investments from multi-sources, government, foreign investment and from private sector etc. and transition from planned economy to market economy.

5. Conclusions and Recommendations

This chapter presents the main findings of this research and gives some recommendations about urban planning. The most significant finding of this research is that a sound scientific analysis method for monitoring urban land use change and examining the effectiveness of urban planning with the combination of quantitative and qualitative analysis has been found by using GIS software.

5.1. Conclusions

Conclusions can be drawn from the procedural analysis: urban development that refers to the chapter 3, urban planning that refers to the chapter 4 and about the application of remote sensing and GIS technologies.

5.1.1. Urban development

During the last five decades, Chinese national development policy has undergone many changes. Urban development was affected not only by industrial development, but also by the specific strategies adopted for industrialization.

In Wuhan, different development stages have different impacts on urban spatial pattern with different characteristics:

1. Rapid urban expansion can often be found in early stage of development (industrialization). Under the planned economic system before 1978, urban development in Chinese Cities was much influenced by ideology, state control and economic planning. Urban land belonged to the state, while land was administratively allocated to industries more or less free, without charging land rents. Industrial and residential land uses were mixed due to each factory build its owe workers' housing adjacent to its factory.

2. Low urban growth ratio took place in the period of 1960s to end of 1970s due to the chaos the Cultural Revolution.

3. Housing development, commercial and public facilities as well as infrastructures are major driving forces in changing urban spatial pattern in late development stages.

4. The transition from planned economy to market economy and the establishment of a land market and real estate development has led to significant changes in land use structure, especially in inner city areas.

5.1.2. Urban planning

Urban planning, by Chinese definition, refers to the location and physical planning of urban activities, which include utilities, transportations, industries the other production activities, community facilities and housing. Over the last five decades, the policies of the central government have influenced the urban planning and urban development process as well. Different planning philosophies and leading ideas have been responding to the concurrent national policies and political circumstances. Some general conclusion can be drawn as follow:

1. In the early 1950s, high priority was given to the quick restoration of the economy soon after the civil war. In the middle 1950s, industrialization was the driving force of urban growth. Urban planning was an element or tool of central planning. The situation got worse in later 1950s and 1960s due to the Great Leap Forward campaign and several nation-wide natural disasters. Politics played the dominant role during the Cultural Revolution and planning could hardly survive in this periods. Urban planning became an important issue again in 1980 after two decades of development without proper guidance of a master plan. A number of planning and revision efforts were made in early the early 1980s, late 1980s and middle 1990s. However, these versions of master plan were still prepared in the way people were doing in 1950s (Blueprint style and under planned economy).

2. The political and economic reform not only profound impacts on its socio-economic development, but also significantly changed the environment in which urban planning operates. There is a notable shift of urban planning philosophy form socialist ideology to pragmatism. For instance, one of the main objectives of the new Wuhan master plan (1996) is to attract more private investments. Urban planning is now said to achieve a better-coordinated development so that development cost can be minimized.

3. Conventional urban master planning highly relied on national economic planning, for instance, the registration of state project, annual plans and resource allocation. It is most ineffective in dealing with external, non-state investments.

5.1.3. Remote sensing and GIS are important tools for urban research

Remote sensing has been served as an important data source for the thematic mapping. Recent development in high-resolution imagery is promising in urban researches. IKONOS as well as other remotely sensed imagery play an important role in this research. It can play a crucial role when other data are not available or out of date.

The rapid advances of GIS functionality make land use change studies more feasible than before. GIS can also provide the monitoring the effectiveness of urban planning. Fortunately, a GIS system has been established in Wuhan urban planning and land administration. A lot of effort has been spent in land suitability evaluation and spatial structure analysis and digital mapping. CAD (Computer Aided Design) was mainly applied to draw planning maps such as the outline of spatial land use pattern in the process of master plan making.

5.2. Recommendations

The transformation from planned economy to a market economy in China is challenging the traditional urban planning processes including its procedures, approaches, method and techniques that been used during the development of urban master planning.

5.2.1. Legal status

Urban planning legislation is an important political guarantee for the role of urban planning and basis for planning to play its authoritative role. Although the City Planning Act has been executed since 1991, as a product of planned economy, it cannot provide adequate guidance to development control. The urban planning legislation should turn 'what should be done' into 'what should not be done', which is the basic demand of a legal version and at same time, improves the capability of adaptation of planning and turn one possibility in many possibilities.

5.2.2. Communication and Participation

With the increase in the number of stake holders in land development and conflicts of interest, more public participation should be introduced into the plan-making processes. Compared with developers who can resort to powerful economic bargaining measure, the general public does not have resources or enough information to understand the real consequences of certain planning decision. The public should be fully informed and be able to participate in the planning process. Thus, planners have a responsibility to help the public to understand the plans and express their interests. Public debate might help in increasing communication and understanding between planners and general public and promoting public participation as well.

On the other hand, the involvement of new actors such as the private investor requires carefully evaluation on not only how to attract these investments but also to guide regarding location, environmental impact and establish transparent and reasonable land lease contracts (Cheng et al, 2001).

5.2.3. Sustainable development

The protection of the ecological environment and urban sustainable development is an important issue under the market economy. Urban design became an important issue in urban planning activity. Sustainable development needs a sustainable urban planning.

5.2.4. Enhance urban planning theories and tools

The theories and practice in the western world may offer experiences worthwhile to analyse for Chinese urbanization and decision-making processes. For instance, healthy urban planning, which promotes the idea that a city is much more than buildings, streets and open spaces, but a living, breathing organism, the health of which is closely linked to that of its citizens is introduced in European coun-

tries. However, the methods that are suitable for one society might not fit the situation of another society.

Planning Support Systems (PSS) offer a new perspective on computer-assisted planning. The heart of PSS should be a GIS that serve as a display and communication device, producing maps and charts. But it is not only a GIS. It includes the full range of planners' traditional tools for urban and regional economic and demographic analysis and forecasting, environmental modelling, transportation planning, and predicting future development and land use patterns.

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Appendix 1: National Standard Land Use Classification and code

(Major classes and groups)

Land use code			Land use classification
Classes	Group	Subgroup	
R			Residential
	R1		Good infrastructure and environment with lo rise building<=3 floors
		R11	Residential only with open space
		R12	Public service and facilities for local area
		R13	Only local access roads and parking
		R14	Green space
	R2		Good infrastructure and environment with buildings >3 floors
		R21	Residential only with open space
		R22	Public service and facilities for local area
		R23	Only local access roads and parking
		R24	Green space
	R3		Medium infrastructure and poor environment
		R31	Residential only with open space
		R32	Public service and facilities for local area
		R33	Only local access roads and parking
		R34	Green space
	R4		Poor infrastructure, poor environment and poor quality buildings
		R41	Dwelling
		R42	Public service and facilities for local area
		R43	Only local access roads and parking
		R44	Green space
C			Commercial and Public Facility
	C1		Government office
		C11	Office for municipal government
		C12	Office for up local government
	C2		Commercial and Financial
		C21	Commercial
		C22	Bank and Insurance
		C23	Consultancy
		C24	Service
		C25	Hotel
		C26	Markets

Land use code			Land use classification
Classes	Group	Subgroup	
C			Commercial and Public facility
	C3		Cultural and Recreation use
		C31	Newspaper agency and Press office
		C32	Cultural and arts group
		C33	Radio and TV station
		C34	Library and exhibition hall
		C35	Theatre and Cinema
		C36	Recreational building(eg dance hall)
	C4		Sport facility
		C41	Stadium
		C42	Sport training facility
	C5		Medical treatment and Health centre
		C51	Hospital
		C52	Epidemic prevention
		C53	Sanatoriums, rehabilitation centre
	C6		Institutional
		C61	University
		C62	Professional training centre
		C63	Adult education centre
		C64	Special school (eg or disabled or delinquents)
		C65	Research and design institute
	C7		Culture heritage and Historic site
	C9		Others
M			Industrial
	M1		Non pollution industrial
	M2		Light pollution industrial
	M3		Heave pollution industrial
W			Warehouse
	W1		Warehouse for normal material
	W2		Warehouse for dangerous material
	W3		Open storage site

Land use code			Land use classification
Classes	Group	Subgroup	
T			Transportation
	T1		Railway
	T2		Road
		T21	Highway
		T22	1,2,3 level road
		T23	Long distance bus Station
	T3		Pipeline (e.g. water, oil, gas) or conveyor belt
	T4		Harbour
		T41	Sea harbour
		T42	River harbour
	T5		Airport
S			Road and Square
	S1		Road
		S11	Main road
		S12	Road
		S13	Sub road
		S14	Other road
	S2		Square
		S21	Traffic Square
		S22	Gathering Square
	S3		Parking space
		S31	Automotive parking space
		S32	Non automotive parking space
U	U1		Utility facility
			Supplying facility
		U11	Water supplying facility
		U12	Power supplying facility
		U13	Gas supplying facility
		U14	Heating supplying facility
	U2		Traffic facility
		U21	Public traffic facility
		U22	Goods transportation
		U29	Other facility
	U3		Posts and Telecommunications
	U4		Environmental facility
		U41	Water treatment
		U42	Trash treatment
	U5		Construction and maintain facility
	U6		Funeral Facility
	U9		Others

Land use code			Land use classification
Classes	Group	Subgroup	
G			Green space
	G1		Public green space
		G11	Park
		G12	Street green belt
	G2		Productive or protective land
		G21	Productive land
		G22	Protective land
D			Special use
	D1		Military
	D2		Diplomatic (embassy or consulate)
	D3		Prison and security place
E			Water bodies and Other
	E1		Water bodies
	E2		Tillable field
		E21	Vegetable plot
		E22	Irrigated land
		E29	Others
	E3		Garden plot
	E4		Forest
	E5		Herbage land
	E6		Villages and small towns
		E61	Village
		E62	Village enterprise
		E63	Village road
		E69	Others
	E7		Bare land
	E8		Mining land

Appendix 2: The City Planning Act of the People's Republic of China (chapter 1 and 2)

Chapter One General Provisions

Article 1: This law is made to define urban scales and development direction, to realize the goal set for urban economic and social development, to work out reasonable city planning and to conduct urban construction so as to meet the needs of the construction of the socialist modernization.

Article 2: This law must be observed for drawing and implementing city planning as well as constructing within areas included in city planning.

Article 3: Cities as referred to in this law are cities directly under central government, municipalities and towns set up by the state according to administrative systems. City planning area, near suburbs, areas which needs to be programmed and controlled because of urban construction and development within urban administrative areas as well as the specific boundary of city planning areas shall be defined by the urban people's government while working on the general city planning.

Article 4: The policy of strictly control scales of large cities, reasonably develop medium and small sized cities to promote reasonable layout of the productive force and the population.
Large cities are those with a non-agricultural population of more than 500,000 in the urban districts and the near suburbs.
Medium-sized cities are those with a non-agricultural population of over 200,000 but less than 500,000 in the urban districts and the near suburbs.
Small cities are those with a non-agricultural population of less than 200,000 in the urban districts and the near suburbs.

Article 5: City planning must meet with the actual situation of our country, balancing relations between short-term constructions and long term development. Constructions conducted within city planning area must follow the principle of applicability and economy while implementing the policy of building up the country through thrift and hard work.

Article 6: Comprehensive arrangements with due consideration for all concerned shall be made in working out the city planning according to The Program of National Economy and Social Development as well as local natural environment, resource conditions, historical background and current characteristics.
Infrastructure projects fixed in the City Planning shall be included in The Program of National Economy and Social Development according to the procedures of national capital construction and implemented in stages as planned.

Article 7: The Urban master planning shall be harmonious with state land planning, regional planning, river drainage planning and general land application planning.

Article 8: Scientific and technical research on city planning and the spread of advanced techniques are encouraged by the state so as to enhance the level of scientific technique in city planning.

Article 9: Responsible city planning administrative departments of the State Council are in charge of city planning for all cities over our country.
Responsible city planning administrative departments of local government higher than the level of county are in charge of city planning for all cities within its jurisdiction.

Article 10 Every unit or individual has the obligation to observe city planning and is entitled to the right of reporting or complaining behaviours in violation of city planning to the authorities.

Chapter Two The Making of City Planning

Article 11: Responsible city planning administrative departments of the State Council and the people's governments of provinces, autonomous regions and cities directly under central government shall organize to work out town planning system for cities in the country, province and autonomous regions to give directions to the making of city planning.

Article 12: The people's government of the county level shall be responsible for working out city planning for towns.

Article 13: The making of city planning shall start from the reality, forecasting scientifically the prospective development of the city, which shall adapt the development scales of the city, various construction index fixed, development procedure to the level of national and local economic and technical development.

Article 14: Attentions shall be paid to the protection and improvement of urban ecological environment while working out the city planning so as to prevent pollution and other public harm. Urban afforestation and city outlook environment health construction shall be strengthened to protect historical relics, traditional urban appearances, local characteristics and natural scenes. And cares to be taken to protect national traditions and local characteristics in working out city planning in national autonomous regions.

Article 15: Such principles as benefiting production, bringing convenience to living, promoting circulation, prospering economy and promoting science & technology, culture and education shall be implemented while working out the city planning.
City planning shall comply with such requirements as against fire, explosion, earthquake, flood, mud rock flow and requirements concerning public security, traffic management and air defence construction of the people etc.. Measures against earthquake and flood shall be taken in the planning for places strong earthquakes and severe flood are likely.

Article 16: The principle of reasonable and thrifty use of land shall be adopted in making the city planning.

Article 17: Reconnaissance, measurement and other necessary basic materials shall be available in making city planning.

Article 18: The city planning is usually made in two stages, overall planning and detailed planning. For large and medium sized cities, sectional planning may be worked out on the basis of the overall planning to further control and determine land usage, scope and capacity at different sections and to accommodate constructions of various infrastructure and public facilities.

Article 19: Urban master planning shall include: the nature, development goal and scale of the city, main construction standards and fixed indexes, land use layout for urban construction, functional division and overall arrangement of various constructions, comprehensive urban traffic system and the system of rivers, lakes and green lands, various specialized planning, and the short term construction program.
Urban planning for places where city and county people's governments are located shall include the town system planning in the administrative areas of city or county.

Article 20: Detailed city planning shall include specific programming of various constructions within recent urban constructional areas on the basis of the overall planning or sectional planning. Detailed city planning shall include: specific scope of land use for various constructions at sections programmed, such controlling indexes as density and height of construction, block planning, comprehensive and vertical programming of engineering pipeline.

Article 21: City planning should be approved by different levels.
Urban Master planning for cities directly under central government shall be reported to the State Council for approval by the people's government of such cities.

Urban master planning for cities where the people's governments are located, cities with a population of over one million and other cities appointed by the State Council shall be reported to the State Council for approval after being checked and agreed by the people's governments of such provinces and autonomous regions.

Urban master planning for cities other than as stipulated in the second and third clause of this article and cities where the people's governments of county level are located shall be reported to municipal people's government for approval. Urban master planning for towns other than as stipulated in previous clause shall be reported to the people's government of county level for approval. Over city planning shall be approved by people's congress or its standing committee of some level before the municipal people's government and county people's government report it to a higher authority for approval.
Sectional city planning shall be approval by the municipal people's government.

Detailed city planning shall be approved by the municipal people's government; Detailed city planning with sectional planning shall be approved by the responsible administrative city planning department of municipal people's government except those important detailed city planning, which shall be approved by the municipal people's government.

Article 22: The municipal people's government may modify part of the Urban master planning according to urban economic and social development and report to the standing committee of the people's congress of the same level and the departments originally approved such planning to be filed. But such important change in the planning as concerning the nature, scale and development directions of the city as well as the overall layout shall be reported to the original approving department for approval after being checked and agreed by the people's congress or its standing committee of the same level.