# STUDY ON ZONING OF URBAN MORPHOLOGY BASED ON GIS

*A case study of Xindu*

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**Abstract.** The traditional studies of urban morphology mainly focus on material aspects such as urban construction, urban environment. The writers of the paper, however, point out that the nature behind material aspects should be load capacity of urban land-use, which can be reflected through some economic and technological indexes, such as floor area ratio(FAR), building density and building height, and generally they are relative. The paper forms a new morphology zoning method after having studied the relation of the above indexes based on the digital methods of GIS. This rout of thought may have some reference value for controlling the expanse of urban land-use, optimizing the allocation of resources and urban morphology and supervising the implementation of urban planning. In the paper, the author proposed the concept of "zhubei" to describe and evaluate urban morphology. We can further analyze "zhubei" regards urban planning analysis and management, for example, the slope analysis, aspect analysis, view analysis, area and volume analysis etc. Therefore, we can describe current urban morphology and evaluate its rationality by relevant conclusions just like describing vegetation.

**Keywords.** urban morphology: zoning: GIS; digital; planning; zhubei.

## 1. Preface

The research results of urban morphology are very rich both at China and abroad. As an interdisciplinary subject, urban morphology has been widely recognized to have close relationship with urban planning and urban design. However, the definition, the contents and the method of it haven't reached a consensus in the academic field for a long time. Related closely to urban

planning, research into urban morphology is based chiefly on the method of architecture. And it mainly concerns about the urban construction, whether in aspects of theoretical research or urban construction. Generally, the studies have been done on some aspects, but it lacks the controls of both the capacity of construction land and economic technical indexes as well.

By taking Xindu district of Chengdu as the research object, this paper will expand the urban-related spatial data and evaluate the present urban morphology, depending on the GIS platform and making the secondary development. On the GIS platform, it will adopt the analytical method of relevant factors, buffer zone and superposed re-classification with combination of traditional method of urban morphology. And the above mentioned methods are used to form urban morphology district which helps to implement the urban planning. The urban morphology in this paper refers to the economical and technical index, which play a major role behind the morphology of urban physical space, including floor area ratio£¬building density, average building height and so on.

We introduce the concept of "Zhubei" by borrowing the concept of vegetation. It is a set of various buildings and also the concept of urban morphology, with corresponding indexes such as floor area ratio£¬building density and building height. It describes the distribution of building capacity in urban space vividly. It is like the vegetation which has three-dimensional properties and distributes spatially with obvious geographical characteristics. We consider that the introduction of "Zhubei" here can build a better description of the characteristics of urban space distribution so as to provide a means of quantitative analysis for the urban morphology and city style. Like the vegetation study, the "Zhubei" study can gradually form a systematic and scientific theory and method.

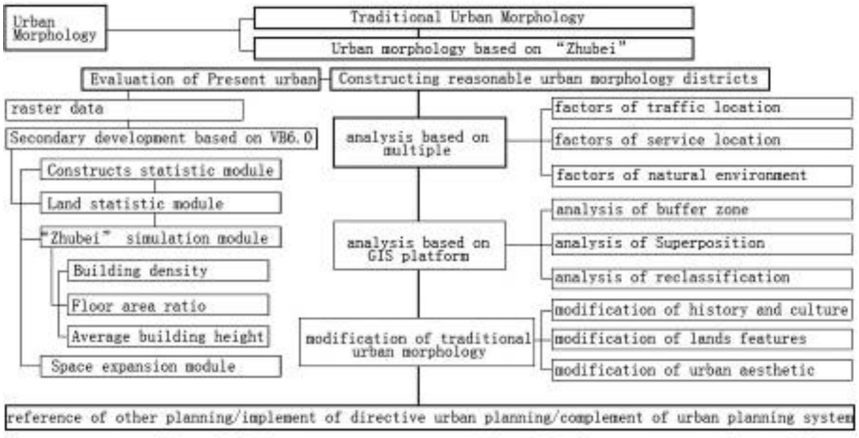


*Figure 1.* Research framework.

## 2. Study Areas, Data Collections and Arrangements

The planning area in Xindu district of Chengdu was chosen to be the study object, including the old and new urban districts. It covers an area of 32.6hm2 with about 200,000 populations. (Xindu Annals 2007). In terms of the map(1:2000)of the urban terrain in 2007 and the satellite photograph with the 0.61m resolution, each kind of construction, urban lands, rivers and the green lands can be transformed into raster data.( *.bmp file). In order to distinguish the different constructions and areas in the picture, the four colours are used to show them according to the four-color principle. The RGB value of construction elements are in green series (105, 105, 0; 155,155, 0;205, 205,0;255, 255, 0); while land elements are in red (255,0, 0;255, 40,40;255, 80, 80;255, 120, 120).

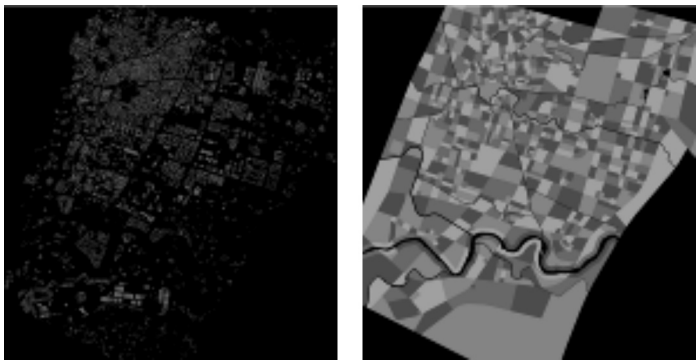

*Figure 2.* Construction elements and land elements.

## 3. Introduce a new Spatial Analysis

At present, the urban basic data and urban planning are mainly in the format of DWG and JPG. And the software such as AutoCAD and Photoshop are mainly applied to drawing. But they lack analytic functions. Though ArcGIS has many analytic functions, it can't be used flexibly and the most designers find it hard to master the secondary development. In view of the above reasons and the easy secondary development of raster data, software VB 6.0 will be applied to develop the related programs according to the requirement of space analysis, data structure and the theory of wave front method. And it will contain file modules of reading BMP and writing BMP, statistics modules of construct and land, and "Zhubei" index module, including the index calculation of building density, floor area ratio and average height of buildings as well as space expansion module of these indexes.

Construct statistics module is applied to add up the entrance number of each building, and the overall numbers, the base areas, the floors and structure styles of constructs. Part of the procedure is as follows:

```
For I = 1 To H
    For J = 1 To W
        L = RGB(HouseArray(I, J, 1), HouseArray(I, J, 2), HouseArray(I, J, 3))
          If L = jz1 Or L = jz2 Or L = jz3 Or L = jz4 And mm(I, J) <> 1 Then
             Nhouse = Nhouse + 1
             Istart = I
             Jstart = J
             A = Int(Nhouse / 256): B = Nhouse - 256 * A: C = 255
             HouseArray(Istart, Jstart, 1) = A: HouseArray(Istart, Jstart, 2) =
B: HouseArray(Istart, Jstart, 3) = C
             For I2 = 1 To 1000(Other omitted)
```

Land statistics module is used to count up the land areas and quantity of lands, total land areas, and various land areas as well as the number of the building lands and to build the relationship between construct and land to prepare for the related calculation of indexes in the future. Part of the procedure is as follows:

```
For I = 1 To H
    For J = 1 To W
      L = RGB(LandblockArray(I, J, 1), LandblockArray(I, J, 2),
LandblockArray(I, J, 3))
    If L = dk1 Or L = dk2 Or L = dk3 Or L = dk4 And mm(I, J) <> 1 Then
        Nland = Nland + 1(Other omitted)
```

"Zhubei" index module includes the calculation modules of building density, floor area ratio and buildings average height. Part of the procedure is as follows:

```
For I = 1 To Nland
    For I8 = 1 To Nhouse
        If House(I8, 7) = I Then
           ID = ID + 1
           LandBlock(I, 3) = ID
           LandBlock(I, 4) = LandBlock(I, 4) + House(I8, 5)
           LandBlock(I, 5) = LandBlock(I, 5) + House(I8, 6)
           BH1(I, 1) = Fp(I, 1) * 3
           BD1(I, 1) = Int(LandBlock(I, 4) * 1000 / LandBlock(I, 2))
           FAR1(I, 1) = Int(LandBlock(I, 5) * 1000 / LandBlock(I, 2))
           (Other omitted)
```

Space expansion module makes space extension of the related indexes to form a three-dimensional mimetic diagram similar to urban terrain map. The space expansion of "Zhubei" index essentially makes a global interpolation calculation of the Eigen value of the isolated special objects which distributes in Point-Line-Surface Structure, making Eigen value in the situation of continuous distribution in geography space so that it will be easier to make qualitative and quantitative analysis and evaluation.

As the problem is about the outward distance- attenuation expansion of space object Eigen value, the factors that passive point attracts initiative expansion point can be left out of account. At the same time, the point at which the space object expands itself should be included in the scope (ie. when d=0, the value cannot tend to 8) and it should distribute symmetrically. Therefore, we consider that the use of standard normal distribution (Gauss distribution) in statistics is more reasonable.

Through VB secondary development, the author makes a related expansion of urban "Zhubei" indexes, using Gauss fuzzy approach. It will not only show the overall outline of city morphology very well, meanwhile, with the space expansion of economical and social data, it can also study various social problems in the city.

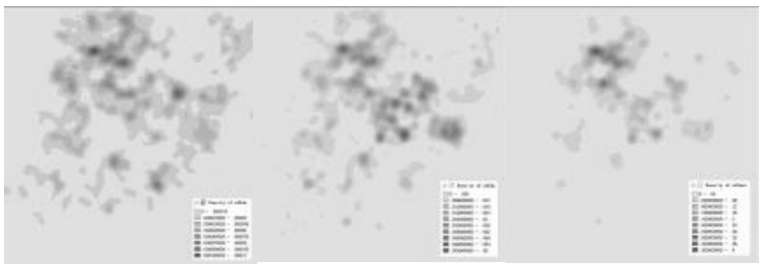

*Figure 3.* The density of building density, build height and floor area ratio.

## 4. Evaluate Present Urban Morphology

To represent the indexes of the urban morphology based on "Zhubei", we use 3 indexes which are the ratio between total construct areas of evaluation unit and the total areas of the corresponding land (Floor area ratio), the ratio between the total construct's land areas of evaluation unit and the total land areas, and average construct height of evaluation unit.

According to the analysis, it is easy to find that the floor area ratio of the old urban district in Xindu is about 1.5 and lower than 2.0, which indicates that the development degree is not high. Its building density mostly decreases gradually from the inner city to the outside in the form of layer distribution.

The building density of the new district is lower than that of old one for the constructs in the new one were built after 2000 with many high-rise buildings and wide roads.

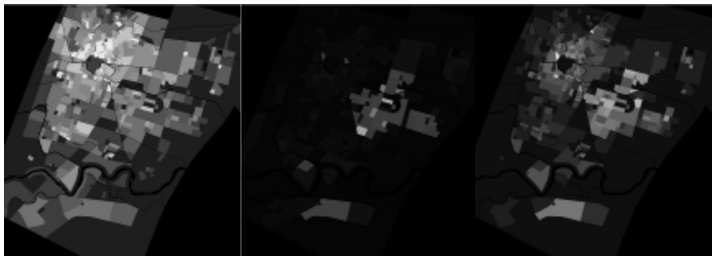

*Figure 4.* The present building density, building height and floor area ratio.

The current buildings are mainly located in the old district. With the development of city and the intensification of development, the amount of buildings increases in the new district focusing on the high-rise and living constructs, forming a different urban texture. However, most constructs in old districts are multi-story buildings and low-rise ones with poor quality and narrow roads. In recent years, with the rapid economic development of Xindu district, the development of new zone as well as the reduction of the old city reformation , most of the new residential areas are built in the new zone, part of commercial facilities increase gradually and the population density is becoming bigger and bigger. In the next few years, with the industrial structure adjustment and the city government's relocation in the new district, the population density in Xindu district will be more intensified.

## 5. Modelling of Urban Morphology Division

The ideal urban morphology needs scientific and rational indexes of city land. So it requires us to rely on the existing and planning resources to assess the urban construct land reasonably and to find the rational construct indexes of urban lands. According to the location theory, the major factors that influence enterprise site are traffic conditions and agglomeration economy while traffic and service locations, natural environment and financial reward are the main factors to influence family locations

### 5.1. SERVICE LOCATION

The service location conditions mainly refer to the convenient services that the commercial service centers provide to the target site. According to the urban

concentric circles theory, the nearer the distance between the district and the inner district is, the higher the floor area ratio is. Service location can be represented by the reciprocal of the distance between the district and the commercial centre.

With commercial centres of all levels in regulatory plan as the basis, the service condition districts for each centre are established respectively. Therefore, according to the influences in service district, the value can be assigned: the value of inner district is 4; 10 minutes (within 500m) walking distance and the inner community is 3; value parameter is 2 when 5 minutes (within 300m) walking distance; other districts' is 1. According to commercial centers of land-use map in the regulatory plan, the service sub-center for districts and small districts can be built respectively. Superimpose the two to model the urban morphology distribution model, and set 4 grades through re-classification.

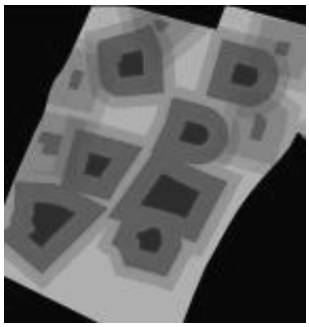

*Figure 5.* The service location distribution model.

## 5.2. TRAFFIC LOCATION

Traffic location includes rail transit location and main road location. Compared with common traffic modes, rail transit (light rail) is able to better drive the high-intensive land development so as to form a development peak zone within the scope of walking distance around stops. The calculated result, according to transportation accessibility, shows the following differential exists in land development intensity in each area, i.e., light rail + artery > light rail > artery > other areas. Therefore, we could assign a value to the indexes in terms of the transportation accessibility affected by light rail: the value of 10 is assigned to the coverage area of the distance between both sides of light rail line $D \leq 800$ meters, the value of 0 to other areas.

The higher the public transportation accessibility of a land is, the higher its floor area ratio is. As a result, there is a positive correlation between the index of artery traffic service of a land and its development intensity (floor area

ratio). In accordance with the rules about the service areas of public transportation stations in Code for Design on Urban Road Traffic Planning, we could assign a value to the indexes in terms of transportation accessibility affected by roads: the value of 10 is assigned to the area within the scope of 250 meters of both sides of artery (excluding the width of the road), the value of 0 to other area.

To sum up, according to the comprehensive traffic planning of District Planning of Xindu District of Chengdu, we could build a distribution model of urban morphology in terms of traffic conditions and determine four grades by reclassification.

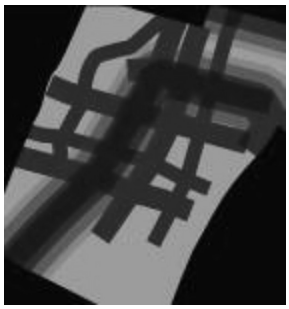

*Figure 6.* The Traffic location distribution model.

### 5.3. NATURAL ENVIRONMENT LOCATION

The experience of urban construction shows that the shorter the distance between a land and urban public green space is, the higher its floor area ratio is. The land facing to a green space could be directly affected by not only environment but also landscape. As a result, its floor area ratio is the highest in general. With the distance between a land and a green space being longer, the environmental effect from green space and the convenient degree of using green space for rest would be gradually lowered , so does the floor area ratio. Therefore, there is also a positive correlation between the index of environment and floor area ratio.

As the environment index, the reciprocal of the value of the distance between a land and an urban public green space is chosen as the research object. On the basis of the green space system determined in the regulatory plan, we could assign the value of 10 to the area near to public green space within the scope of 100 meters, the value of 6 to the area within the scope of walking distance in 10 minutes, the value of 1 to other areas; while as the non-development land, the public green space could be assigned the value of 0. According to the public green space and water in the regulatory plan, we could construct a distribution

model of intensity in terms of environmental conditions and determine four grades by reclassification.

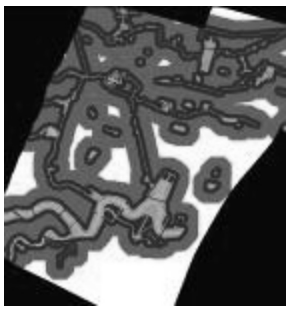

*Figure 7.* The Natural Environment location distribution model.

Referring to the relevant analytical results of other cities, we find that the influencing factors of service and transportation are 0.67 and 0.33 respectively. The service factor contains the 0.1 contributed by the public green space to the floor area ratio. Then we can get the order of the impacts of the three factors, that is, service location 0.57>traffic location0.33>environment location0.1.

### 5.4. BUILD UP URBAN MORPHOLOGY ZONING

According to the value assignments and their corresponding weights of service conditions, traffic conditions and environmental conditions, we could combine them to get the benchmark model of intensity zones of Xindu District. The index of benchmark intensity could be figured out according to the following formulas:

The benchmark intensity index =the intensity index based on service conditions * the weights of service location+ the intensity index based on traffic conditions * the weights of traffic location+ the intensity index based on environmental conditions * the weights of environment location.

According to the benchmark intensity index, we could divide Xindu District into four morphology zones, including high intensity (when the range is from 3.75 to 4.15, take 4.0), medium intensity (range from 2.65 to 3.45, take 3.0), medium and low intensity (range from 1.95 to 2.55, take 2.0), low intensity (range from 0.5 to 1.5, take 1.0). As the non-development land, the public green space is assigned the value of 0.

By simulation contrast between the current urban morphology and the ideal urban morphology, modifying it by using the traditional method of urban design and adding up urban land use, we get the district models of urban residence, commerce, industry and other extended urban morphology.

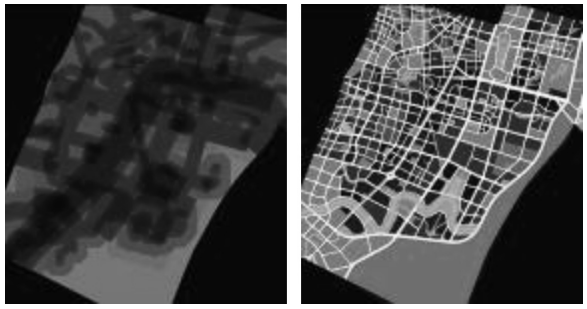

*Figure 8.* The Natural Environment location distribution model.

## 6. Conclusion and Discussions

Describing urban morphology based on Zhubei has a positive reference value for the macro urban planning and urban design. And the district concept of urban morphology is helpful to the management and implement of urban planning. As the complement of urban planning system, the districts method of urban morphology can be the reference for regulatory plan to ensure that the building resources distribute in the whole city, avoiding overloading constructs of some lands so that influence the environment. We evaluated present urban morphology with the medium measure, and set up the districts of urban morphology through factors analysis and relevant GIS analysis. To help draw up and carry out the urban planning, we will continue exploring how to take advantages of remote sensing data (space and satellite photograph) and how to make use of the description of urban morphology based on "Zhubei", " Renbei", "Qianbei"etc.

## References

Ai, J: 2001, Urban digitization and key technologies, Digital City Theory And Practice (on), "Chinese international digit urban construction technology seminar and the 21st century digit city forum" conference collection), Guangzhou, 497-501.

Yongchun, Y.: 2008, spatial distribution of land use intensity and drive of industry: a case study of Lanzhou, *City Planning Review*, 63-68.

Duan J.: 2003, Urban morphologic study and spatial strategic planning, *City Planning Review,* 45-48.

Yang, W. Z.: 2006, Method for weight distribution of evaluation factors on GIS, *Geospatial Information*, 39-41.

He Y.: 2006, Research on comprehensive application of DEM and GIS spatial overlay analysis technology in land quantitative evaluation, *Computer Engineering*, 251-253.