# Characteristic analysis and study of spatial structure in village and small town

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**Abstract:** At present, the formation, evolution and simulation of spatial structure of village and small town are becoming the focus in the fields of geography, planning, remote sensing science, geographic information science and other related disciplines, which also receives the close attention of the management. In this study, we take Xianghe County of plain, Miyun County of mountainous area and Kunshan City of aqueous area for examples where characteristic analysis of village and small town spatial structure is carried out. The location and spatial scope models of village and small town based on grid are established, which is carried out with the help of GIS spatial analysis and modeling technology. In addition, according to Tyson polygon model, a new idea is brought forward that the spatial range of village and small town is determined by land-benefit instead of distance. The two models can provide reference for location and scope determination of village and small town because the factors are more comprehensive and more specified. This research can provide help for the planning of village and small town.

**Key words:** village and small town, spatial structure, characteristic analysis, GIS, grid
**CLC number:** P208 **Document code:** A

## 1 INTRODUCTION

Most of the settlements in village and small town are short of unified planning, or the planning is not sufficiently implemented in the past. Therefore, the settlements are messy and scattered. Furthermore, the infrastructure and service facilities are dated, and the living environment is poor in those areas. It is necessary to urgently carry out structural optimization and planning of rural settlements, enhance the infrastructure and service facilities, and improve people's living conditions, especially to strengthen the management and planning of settlements in rural areas and thus to meet people's desire for better living environment (Yang, 1993). At present, the main work lies in coordinating the relationship among the rural villages, production, living and the environment, exploring the proper size of settlements and the transformation ways in different regions, studying the reasonable structure of rural settlement system, and making these towns as the core in the multi-level economy (Jin, 1988). Based on the extraction of spatial elements in the village and small town, the spatial structure features of the corresponding targets are analyzed, the structural composition and the space allocation relationship of different elements are studied, the interaction among nature, organisms and social elements in humankind are constructed. This research can provide technical support for quantitative analysis of village and small town and serve for the town planning.

## 2 RESEARCH AREA AND DATA SOURCE

LANDSAT/TM image data are used in this research. Three representative areas, Xianghe County of plain area, Miyun County of mountainous area and Kunshan City of aqueous area, are taken as examples based on different terrain and the classification analysis of the settlements.

Xianghe County is located in the region of 39°36′—39°51′N, 116°52′—117°11′E, between Beijing and Tianjin. It covers a total area of 458km$^2$ and has a population of 310,000. Xianghe County lies adjacent to Beijing on the southwest and governs 7 towns and 2 townships. This county is located in the south of the Yanshan Mountains and the transition zone from the Chaobai River flood plain fan to the edge of the alluvial plain. The stratum belongs to the large zone of North China Region, which is covered by the fourth stratum. Its topography is flat and brown and damp soils make up of primary soils in this county. It has a continental warm climate, four clear seasons, and a long development history (Zhang *et al*., 2004).

Miyun County is located in north-east of Beijing, south of

**Received**: 2008-06-12; **Accepted**: 2008-11-05
**Foundation**: Supported by National Key Technologies R&D Program (No. 2006BAJ05A01, 2006BAJ09B03, 2006BAJ09B06).
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the Yanshan Mountains, north of North China Plain, which belongs to handover areas between plain and mountain. Miyun County covers an area from 116°39′33"E to 117°30′25″E (69km) and from 40°13′7″N, to 40°47′57″N (64km). The east and north part of this county borders on Xinglong, Chengde, Luanping County in Hebei Province respectively. The west is adjacent to Huairou District. The south adjoins Shunyi and Pinggu District. There is a distance of 65km from the county to Dongzhimen in Beijing. The total area is 2226.5km$^2$, 13.5 percent of Beijing. The county takes the form of a triangle and it is the county owning the largest land area in Beijing (Dai *et al*., 2002).

Kunshan City is located in the southeast of Jiangsu Province. Its longitude is ranging from 120°09′04″ to 120°48′21″ and the latitude is from 31°06′34" to 31°32′36″ (Long *et al*., 2007). It lies between Shanghai and Suzhou and has a superior geographical location. It is linked with Changshu and Taicang in Jiangsu Province from north to northeast, bordering on Jiading and Qingpu in Shanghai from south to southeast. The west is adjacent to Wujiang City and Suzhou City. The biggest distance of straight line is 33km from east to west, and 48km from south to north. It has a total area of 927km$^2$ and a total population of 650,000 (Liu, 2005).

## 3 CHARACTERISTIC ANALYSIS OF SPATIAL STRUCTURE IN VILLAGE AND SMALL TOWN

Spatial distribution describes the characteristics of spatial variable and spatial object from a global view. The qualitative description of spatial distribution is discrete on the surface. The spatial distribution is quantitatively measured with density, average, extremum, deviation and so on. In this paper the feature parameters of spatial distribution in small town and village is extracted including rural areas, densities and distances between rural.

The present situation of village and small town is the portraiture and comprehensive reflection of spatial development in the history. It shows the geographical foundation and reality phase of the spatial development, which indicates the natural trend of future development to a certain extent. The distribution characteristics are extracted from comprehensive analysis of many villages and small towns in a wider space. The basic parameters which reflect distribution characteristics can be obtained from image interpretation and GIS. According to the requirements of precision, the size of the grid is set by 30m in all layers. The changes of village and small town are analyzed using data processing and analysis in this study, which will provide a basis and reference for the plan of village and small town. The spatial data and attribute data are used and the vector data of village and small town with the scale of 1:50000 are chosen. The following characteristics analyses of the settlement sizes and rural land scale are carried out.

### 3.1 The characteristics analysis of settlement area

The situations of rural settlements are analyzed, using the proportion of rural settlements. The average area denotes the rural land scale. The intensity of settlement is analyzed by DV (density of village and small town).

*3.1.1 PR (percentage of residential land)*

$$\mathrm{PR}=\frac{\mathrm{RL_{area}}}{\mathrm{TL_{area}}}\times 100\% \tag{1}$$

where PR denotes the proportion of residential land(%), $\mathrm{RL_{area}}$ denotes residential area (km$^2$) and $\mathrm{TL_{area}}$ denotes the total land area (km$^2$) in the formula(Masahisa, 1999). Distribution density is the number of distributed object within the distributed region and its expression form can be diverse. Formula(1) reflects the proportion of region area within the total area. When the total area keeps unchanged, the larger the residential area is, the larger the density is.

*3.1.2 MAV (mean area of village and small town)*

$$\mathrm{MAV}=\frac{\sum_{i=1}^{n}A_i}{n} \tag{2}$$

where $A_i$ denotes *i* residential area, and *n* denotes the number of rural settlements in the formula (Tian, 2002).

*3.1.3 DV (density of village and small town)*

$$\mathrm{DV}=\frac{n}{S} \tag{3}$$

where *n* denotes the number of rural settlements, and *S* denotes the area of study area in the formula (Tian, 2002).

Taking the situation of 1991 for an instance, the characteristics analysis of settlement area for plain, mountainous area and aqueous area are analyzed and the results are listed in Table 1. According to Table 1, proportion of rural settlement area is the largest in plain area. The proportion of aqueous area is larger than mountainous area. From the density of rural settlements, the density of plain is the highest. And the density of mountainous area is the lowest, which denotes that the north is low and the south is high. The size of the rural settlements is greater in plain area than in the mountainous area. The size of the rural settlements in Xianghe County of plain area is 1.48 times of that in Miyun County of mountainous area. The average scale of the rural settlements in Kunshan City of aqueous area is 1.04 times of that in Miyun County of mountainous area. The number of villages and land scale are smaller because the elevation is higher and traffic is inconvenient in the northern mountains. Miyun Town is located in the south of Miyun County, where terrain is relatively flat and the transportation is convenient. Therefore, the density and land scale of villages and small towns is larger in the south of Miyun County. Rural settlements are relatively close in the plain areas and the distribution is much denser. Similarly, the distribution of rural settlements is sparse in the mountainous area because rural settlements are more scattered in mountainous area and it is dense in the aqueous area.

**Table 1 Characteristics analysis of the area in village and small town**

| Type | Percentage/% | Density/(number/km$^2$) | Mean area /km$^2$ |
|---|---|---|---|
| Plain area | 14.71 | 0.4363 | 0.337 |
| Mountainous area | 2.77 | 0.1230 | 0.228 |
| Aqueous area | 8.44 | 0.3548 | 0.238 |

## 3.2 The land scale of settlements in county

The land scale of the rural settlements is not only impacted by the natural conditions such as terrain, climate and so on, and it is also restricted by economic conditions. The land scale also reflects the differences of living habits. It is of great significance to carry out active research of rural settlements for exploring the living conditions of residents in rural areas and exploring the future trend of urbanization. Taking remote sensing image and socio-economic data in 1991 as an example, the grading scale and percentage of settlements are analyzed respectively in Xianghe County, Miyun County and Kunshan City.

From Fig. 1—Fig. 3, we can see that the percentage of residential land shows inverse proportion to the distance. The nearer from the township, the greater the percentage of village land for settlements is. The grading scales of rural settlements show zonal differences in Xianghe County. Suyang Town in the middle is the highest. Qukou Town in the northeast takes the second place. The grading scales of southwest and southeast are the smallest. The regional differences of the percentage are

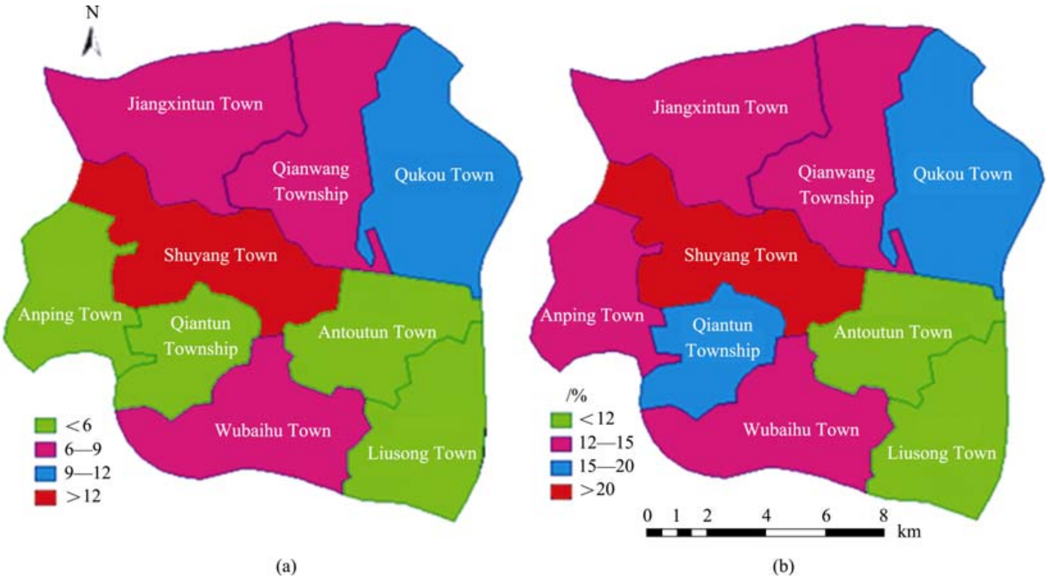


Fig. 1 The grading scale and the percentage of residential land in Xianghe County
(a) The grading scale of residential land; (b) The percentage of residential land

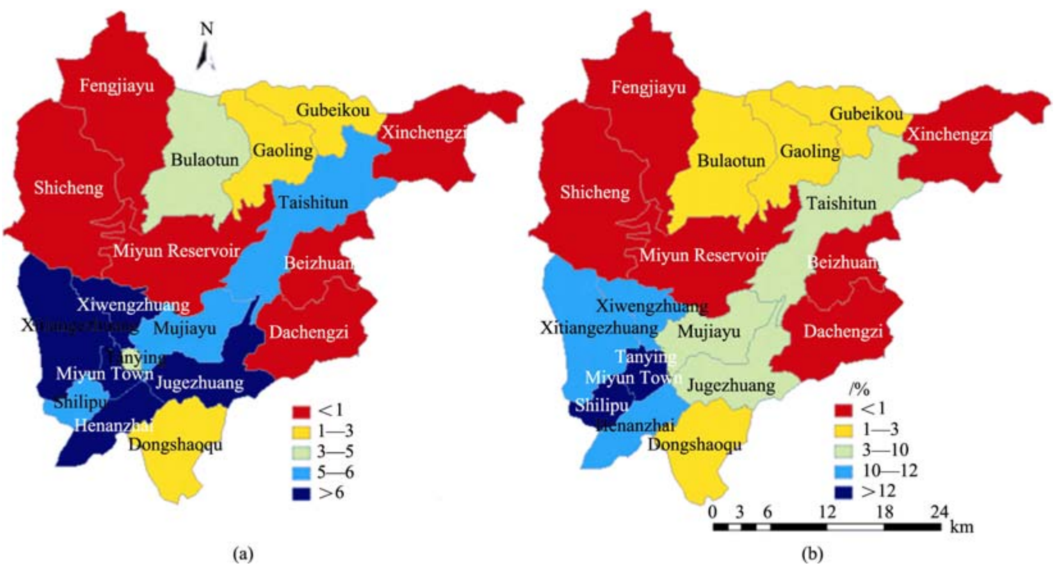


Fig. 2 The Grading scale and the percentage of residential land in Miyun County
(a) The grading scale of residential land; (b) The percentage of residential land

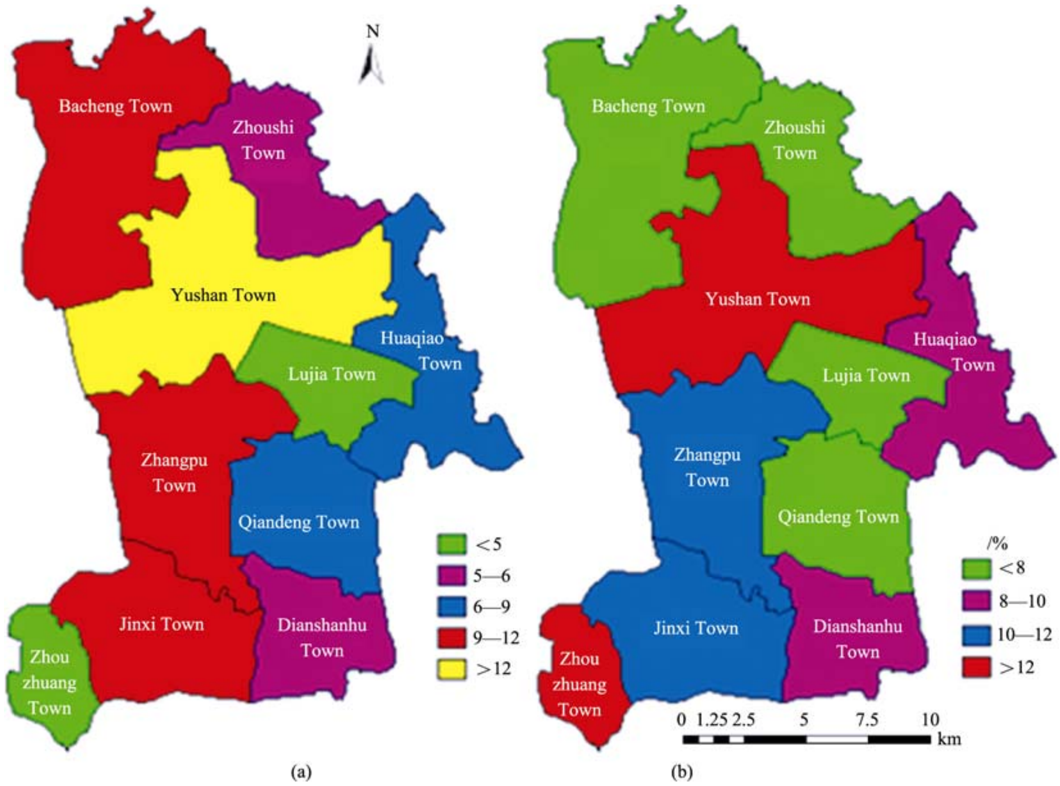


Fig. 3 The grading scale and the percentage of residential land in Kunshan City
(a) The grading scale of residential land; (b) The percentage of residential land

clear for residen tial land in Xianghe County. Suyang Town in the middle is the highest. Qukou Town and Qiantun Township follow Suyang Town. The village and small town in the north-east is the smallest. Fig. 2 shows the uneven spatial distribution of towns in Miyun County. The grading scales of rural settlements show zonal difference in Miyun County. The south is the highest and the north is the smallest. The regional differences of the percentage are clear for residential land in Miyun County. Miyun Town and Shilipu are the highest. The Town close to Miyun Town follows. The northwest and northeast are the smallest. The grading scales of rural settlements show zonal differences in Kunshan City. Yushan Town in the middle is the highest. Bacheng, Zhangpu and Jinxi Town follow Yushan Town. The east is smaller. Zhouzhuang Town is the smallest. The regional differences of the percentage are clear for residential land in Kunshan City. Yushan in the middle and Zhouzhuang Town are the highest. Zhangpu and Jinxi Town follow Yushan and Zhouzhuang Town. The north and the middle is the smallest.

## 4 THE LOCATION AND SPATIAL SCOPE MODEL OF VILLAGE AND SMALL TOWN BASED ON GRID

### 4.1 The location of village and small town

The village and small town is the area where the residents rest and engage in production. A good living environment is the basic requirement. Generally, people are long-term residents and there will always be very little relocation after the settlement is set up. Therefore, the choices have great impact on living and production, which must be taken seriously. The site selection is very important for the development of village and small town. If the site selection is improper, there will not be enough room for the village to develop in the future, or perhaps traffic will be inconvenient, or water will be inadequate, or it is more vulnerable to floods and other disasters. The site selection should try to meet the requirements below: ①The land should be chosen near the production and operating area as far as possible and it is better to be chosen at wild hills, thin field and slope which less account for or not account for farmland, woodland and artificial pasture (Jin, 1989). ②The water for production and living should be adequate, and its quality must be good (Jin, 1989). ③The terrain should be high and heliotropic. The groundwater level needs to be low and thus the area near the water is the best choice (Jin, 1989). ④Geological conditions is good and the traffic needs accessible (Ministry of Housing and Urban-rural Development of People's Republic of China, 1982). ⑤It is important to avoid the area which is passed through by railways, highways and transmission lines of high-voltage. The inappropriate area such as mountain torrents, tuyere and so on should also be avoided (Jin, 1989). ⑥Avoiding the area of underground resources and important historical sites (Ministry of Housing and Urban-rural Development of People's Republic of China, 1982). ⑦Avoiding the area with high incidence of endemic diseases (Jin, 1989). According to the above mentioned rules, the selection model is established combined with the specific traffic conditions, terrain, rivers distribution, socio-economic conditions and status of development. The model is shown as following:

$$V_{\text{feasiable}}(x,y)=f(X_{\text{economy}},X_{\text{terrain}},X_{\text{road}},X_{\text{river}}) \quad (4)$$

where $V_{\text{feasiable}}(x, y)$ denotes the point which is appropriate to build villages. $X_{\text{economy}}$ denotes the economic benefits of the point, $X_{\text{terrain}}$ denotes the topographical features, $X_{\text{road}}$ denotes the distance from the highway, and $X_{\text{river}}$ denotes the distance from the river in the formula. The conditions of this model include that the higher economic benefits, the more inappropriate building villages, and it is not suitable to building village in the area with a slope more than 25° or 20m far away from the road or 30m far away from the river. The technical flow chart of the location selection is shown in Fig. 4.

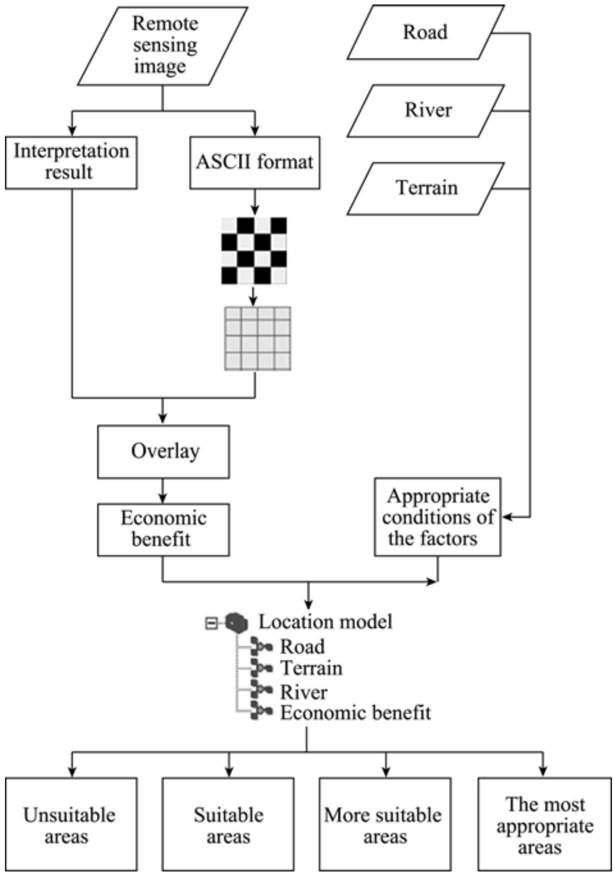


Fig. 4 Flow chart of village and small town location

In this study, TM data of Miyun County in 2001 is selected (Fig. 5(a)). From remote sensing image, the land use types are divided into 7 categories which include water, woodland, industrial and mining land, dry land, paddy field, roads and villages (Fig. 5 (b)). Most settlements are located in relatively flat terrain in this area which has a large imbalance, low density and is far from one to another. A part of settlements present the shape of ribbon and arc along the foot. And there is a small piece of woodland in the peripheral area. According to remote sensing image and field survey, the overall plan of this region is reasonable, but the traffic is not convenient and the topography is fluctuating in some area. The 30m × 30m grid is chosen in this study. Traffic, terrain, river and economic benefits are the factors impacting location but there exist several differences between impacts of the factors on the location. The weights of factors are given in order to better reflect these differences. The weights of factors denote the impact of location, so the reasonableness of determining weight is of great importance to location selection. In this study, the weights of factors are determined by using the expert evaluation method. The weight of the distance from water is 0.2. The weight of the distance from road is 0.5. The weight of the slope is 0.2. The weight of land-use types is 0.1. The location map is obtained by technical route (Fig. 5 (c)) which divides the region into unsuitable areas, suitable areas, more suitable areas and the most appropriate areas. This model may serve as scientific reference for village and small town location.

## 4.2 The spatial scope of village and small town

Thiessen polygon model determines its ownership using different distances from spatial points to two surrounding villages. This study makes an improvement to bring out the determination of spatial scope by the concept of land benefit instead of using the distance.

The villages are planned according to thiessen polygon model. $P=\{p_1, p_2, \cdots, p_n\}$ denotes the set of villages, $n$ denotes the number of villages. Suppose $p$ is a certain free point of rural region, and $E(p, p_i)$ means the land benefit from free point $p(x, y)$ to planning village $p_i(x_i, y_i)$. The scope of the village $p_i$ is shown as following:

$$V_i=\{p\in \mathrm{R}|E(p,p_i)\geqslant E(p,p_j),\ j=1,2,\cdots,m,\ j\neq i\} \quad (5)$$

$$E(p,p_i)=O-C(p,p_i) \quad (6)$$

where $O$ denotes the output value and $C$ denotes the cost in the formula. The output value is the economic output of farmland, woodland, pastures and industries from different land use. The costs denote the consumption of transport time and energy when lands are used. The factors impacting cost include the distance to villages, roads conditions and so on.

The paper re-defines the basic principles of the spatial structure optimization for village and small town and analyzes village and small town planning through GIS spatial analysis and modeling techniques. This research can provide scientific basis for the planning of village and small town.

# 5 CONCLUSIONS

(1) The characteristics of spatial structure are analyzed. The vector data with the scale of 1:50000 are chosen for the analysis of spatial structure characteristics from both settlement area characteristics and the settlement scale in the county region.

(2) The models of village and small town location and spatial scope are established based on grid, which include the two

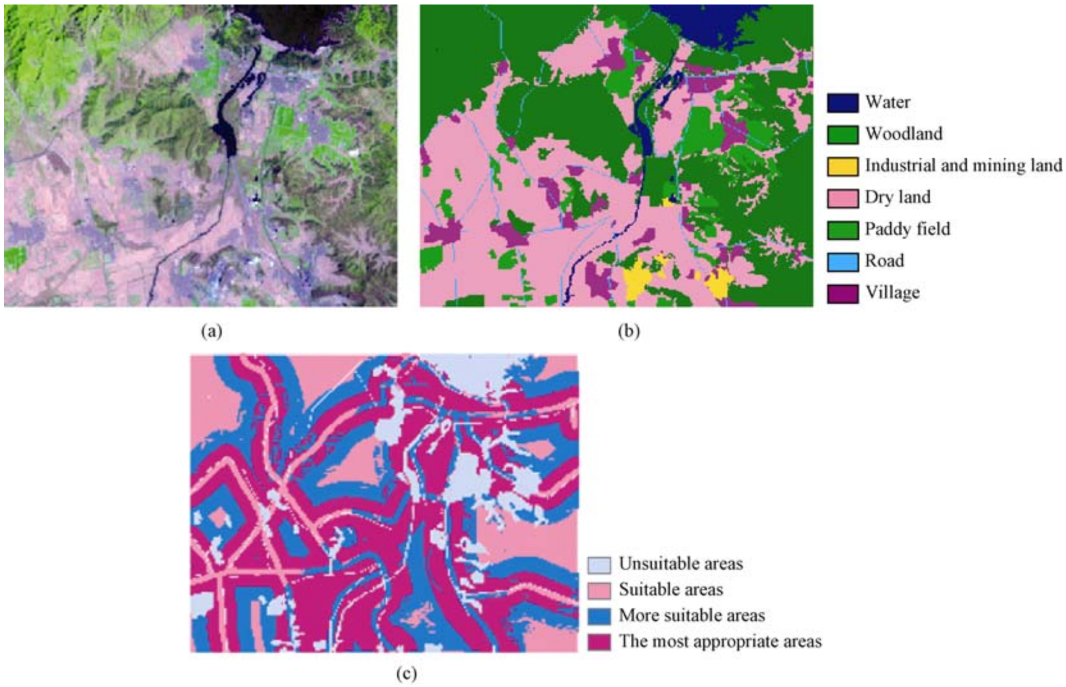


Fig. 5 The original image, the results of interpretation and village and small town site
(a) Original image; (b) Image of interpretation; (c) Village and small town location

aspects of location and the determination of spatial scope. The model of location is established by selecting the parameters including traffic conditions, terrain, rivers distribution, economic benefit and block use. According to thiessen polygon model, the model of spatial scope is improved. And a new idea is brought out to determine the spatial scope of villages using the concept of land benefit. The model takes comprehensive and specified factors into consideration, thus it can serve as reference for location and spatial scope determination of village and small town. This study contributes to the planning of village and small town.

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# 村镇空间结构特征分析

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摘 要： 以平原村镇香河县、山地村镇密云县和水乡村镇昆山市为研究区，分析了村镇空间结构的特征。建立基于网格的村镇选址及空间范围模型，采用 GIS 空间分析和建模技术实现；此外，空间范围模型根据泰森多边形模型的思想，提出用土地效益的概念代替距离来确定村镇的空间范围。由于考虑因素更全面，更具体，这两个模型可以更好地为村镇的选址与空间范围的确定提供参考。此研究为村镇规划工作提供帮助。

关键词： 村镇，空间结构，特征分析，GIS，网格

中图分类号： P208　　　文献标识码： A

## 1 引 言

随着社会经济发展，人民生活水平日益提高，城市化步伐的加快和全面建设小康社会的推进，迫切需要对村镇居民点进行结构优化和规划，加强生产生活基础设施、服务设施的建设，改善人们的居住环境，尤其是要加强对农村居民点的治理和规划，以满足人们对居住环境迫切需要改善的需求。当前主要的工作是协调农村聚落与生产、生活、环境之间的关系，探讨不同地区聚落的适宜规模与改造途径，研究农村聚落体系的合理结构，将集镇组建为农村地区多层次的经济发展核心(金其铭，1988)。在村镇空间要素提取的基础上，对相应的村镇目标地物的空间结构进行分析，研究不同要素的结构组成及其空间配置关系，分析自然、生物与人类社会要素之间的相互作用关系，从而为村镇定量化分析提供技术支撑，为村镇规划服务。

## 2 研究区与数据源

研究采用的遥感数据主要为Landsat/TM遥感数据。在聚落分类分析的基础上，按地形不同，选取了具有代表性的 3 个研究区，分别是平原村镇香河县、山地村镇密云县和水乡村镇昆山市。

香河县地处京津之间，位于北纬 39°36′—39°51′，东经 116°52′—117°11′，总土地面积为 458km$^2$，人口 31 万人，现辖 7 镇 2 乡，西南部与北京相邻。该县域位于燕山山脉南麓，潮白河洪积平原扇缘向冲积平原过渡的交接地带，地层属华北地层大区，为第四纪地层覆盖，地势平坦，土壤以褐土和潮土为主，为大陆性暖温带气候，四季分明，人工开发利用历史悠久(张丽珍等，2004)。

密云县位于北京市东北部、燕山山脉南麓、华北平原北缘，是平原与山区交接地带。东经 116°39′33″—117°30′25″，东西长 69km；北纬 40°13′7″—40°47′57″，南北宽约 64km。东部、北部分别与河北省兴隆、承德、滦平 3 县接壤，西部与北京市怀柔区为邻，南部与北京市顺义区和平谷区毗连，县城距北京东直门 65km，总面积 2226.5km$^2$，占北京市总面积的 13.5%，县城呈三角形，是北京市土地面积最大的区县(戴尔阜等，2002)。

昆山市位于江苏省东南部，东经 120°09′04″—120°48′21″，北纬 31°06′34″—31°32′36″(Long 等，2007)，地理位置优越，上海与苏州之间。北至东北

收稿日期：2008-06-12；修订日期：2008-11-05

基金项目：国家科技支撑计划课题(编号：2006BAJ05A01、2006BAJ09B03、2006BAJ09B06)。

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与江苏常熟、太仓两市相连，南至东南与上海嘉定、青浦两区接壤，西与吴江市、苏州市区交界。境内东西最大直线距离为 33km，南北 48km。昆山市总面积 927km$^2$，总人口 65 万人(刘琼, 2005)。

## 3 村镇空间结构的特征分析

村镇空间分布定性描述是面域上的空间分布，且是离散的，从定量角度来度量村镇空间分布常用分布密度、平均值、极值、离差等。本研究提取了村镇的空间分布特征参数，主要包括村镇面积、密度以及村镇间距离。

村镇现状是历史村镇空间发展的写照和村镇空间发展条件的综合反映。它表明村镇空间发展的地理基础和现实阶段，在一定程度上预示着今后发展的自然趋势。村镇分布特征从较广空间的众多村镇综合分析提取，反映村镇分布特征的基本参数可从影像判读结合 GIS 技术获得。考虑所需精度的要求，以上各个图层的栅格大小统一设置为 30m。运用数据处理和分析功能，对村镇的变化进行分析，为村镇规划提供依据与参考。数据采用空间数据和属性数据，选择 1:5 万村镇矢量数据，对村镇居民点用地面积、用地规模特征进行了分析。

### 3.1 村镇居民点用地面积特征分析

利用农村居民点用地比重分析农村居民点用地情况，农村居民点平均面积表示农村规模，利用农村居民点密度 DV 分析村镇居民点的密集程度。

#### 3.1.1 村镇居民点用地比重 PR(percentage of residential land)

$$PR=\frac{RL_{area}}{TL_{area}}\times 100\% \quad (1)$$

式中，PR 为村镇居民点用地比重(%)，$RL_{area}$ 为村镇居民点用地面积(km$^2$)，$TL_{area}$ 为总土地面积(km$^2$) (Masahisa, 1999)。分布密度是单位分布区域内的分布对象的数量，其表达形式可以是多样的。式(1)反映村镇面积在区域总面积中所占比重，在区域总面积不变的情况下，其村镇总面积随之扩大，村镇密度大。

#### 3.1.2 村镇居民点平均面积 MAV(mean area of village and small town)

$$MAV=\frac{\sum_{i=1}^{n}A_i}{n} \quad (2)$$

式中，$A_i$ 为 $i$ 农村居民点面积，$n$ 为农村居民点数量(田光进, 2002)。

#### 3.1.3 村镇居民点密度 DV(density of village and small town)

$$DV=\frac{n}{S} \quad (3)$$

式中，$n$ 为村镇居民点数量，$S$ 为研究区面积(田光进, 2002)。

以 1991 年为例，分析平原村镇、山地村镇和水乡村镇的用地面积特征，分析结果如表 1。从表 1 可以看出，平原地区的农村居民点面积比重最大，水乡村镇大于山区农村居民点面积比重。从农村居民点密度来看，平原村镇的村镇分布密度最高，而山地村镇分布密度最低，并呈现出北部低，南部高的格局。平原地区的农村居民点规模大于山区。平原村镇香河县农村居民点规模是山地村镇密云县的 1.48 倍，水乡村镇昆山市农村居民点平均规模为山区的 1.04 倍。由于密云县北部大多是山，海拔较高，交通不方便，村庄数量少且规模较小，而密云镇坐落在密云县南部，地势较平坦，交通便利。因此，密云县南部村镇密度大且规模较大。平原地区农村居民点相对较近，分布较为稠密；山区的农村居民点分布较远，分布较为稀疏。水乡地区的居民点分布密集。

表 1 村镇用地面积特征分析

| 村镇类型 | 居民点用地比重/% | 居民点密度/(个/km$^2$) | 居民点平均面积/km$^2$ |
|---|---|---|---|
| 平原村镇 | 14.71 | 0.4363 | 0.337 |
| 山地村镇 | 2.77 | 0.1230 | 0.228 |
| 水乡村镇 | 8.44 | 0.3548 | 0.238 |

### 3.2 县域内居民点用地规模

农村居民点规模既受到地形、气候等自然条件的影响及经济条件的制约，也反映了居民居住习惯的差异,积极开展农村居民点的研究对于探讨农村居民的居住环境，探索村镇城市化的未来趋向具有重要意义。以 1991 年遥感图像和社会经济数据为例，分析香河县、密云县和昆山市域内居民点用地等级规模和各区域居民点用地所占百分比。

由图 1—图 3 可以看出，居民点用地所占百分比和村镇的距离基本上呈反比，离镇区越近，村庄居民点用地百分比越大。香河县农村居民点用地等级规模呈现地带性差异，位于中部的淑阳镇最高，位于东北部的渠口镇次之，西南部和东南部村镇用地等级规模最小。香河县居民点用地所占百分比区域差异明显，位于中部的淑阳镇最高，渠口镇和钳屯

乡次之，位于东北部的村镇最小。图 2 显示了密云县城镇分布不平衡，密云县农村居民点用地等级规模呈现地带性差异，位于南部的村镇最高，位于北部的村镇最小。密云县居民点用地所占百分比区域差异明显，密云镇、十里堡最高，紧挨密云镇的村镇次之，位于西北部和东北部的村镇最小。昆山市农村居民点用地等级规模呈现地带性差异，位于中部的玉山镇最高，位于西部的巴城镇、张浦镇和锦溪镇次之，东部更小，周庄镇最小。昆山市居民点用地所占百分比区域差异明显，位于中部的玉山镇和周庄镇最高，而张浦镇和锦溪镇次之，位于北部和中部的村镇最小。

## 4 基于网格的村镇选址及空间范围模型

### 4.1 村镇选址

村镇是居民用以休息的地方，也是从事生产的地方，良好的生活居住环境是基本的要求，聚落建立以后，一般将长期居住，很少搬迁，所以用地选择的好坏，对居民的生活和生产有很大的影响，必

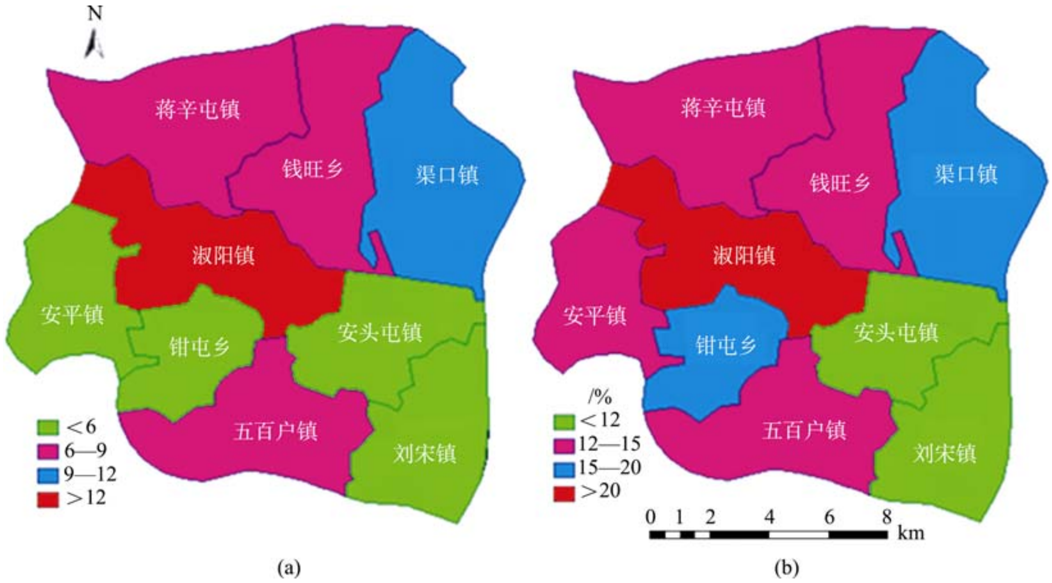


图 1 香河县居民点用地等级规模及居民点用地所占百分比
(a)居民点用地等级规模; (b)居民点用地所占百分比

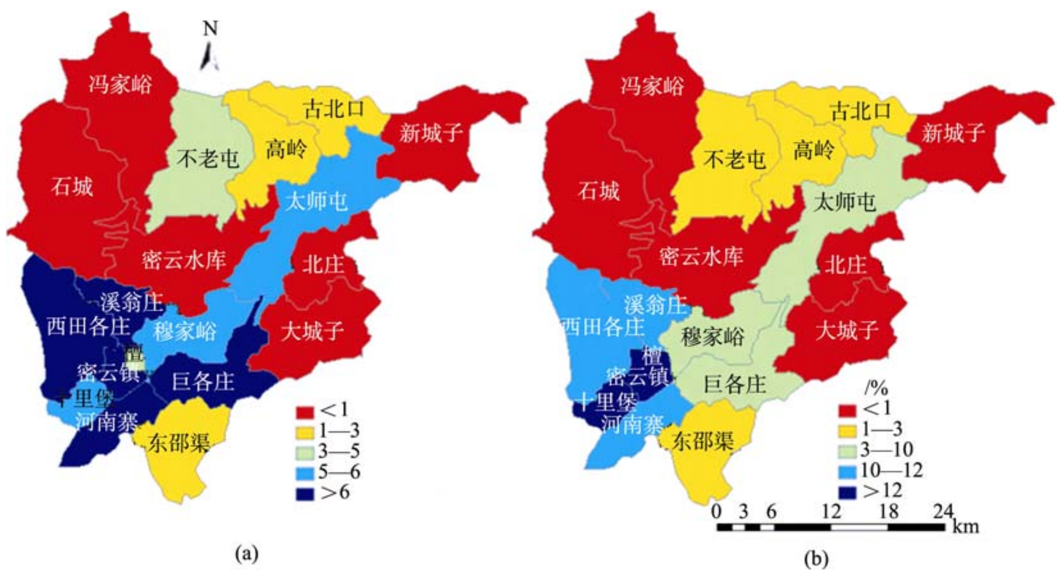


图 2 密云县居民点用地等级规模及居民点用地所占百分比
(a)居民点用地等级规模; (b)居民点用地所占百分比

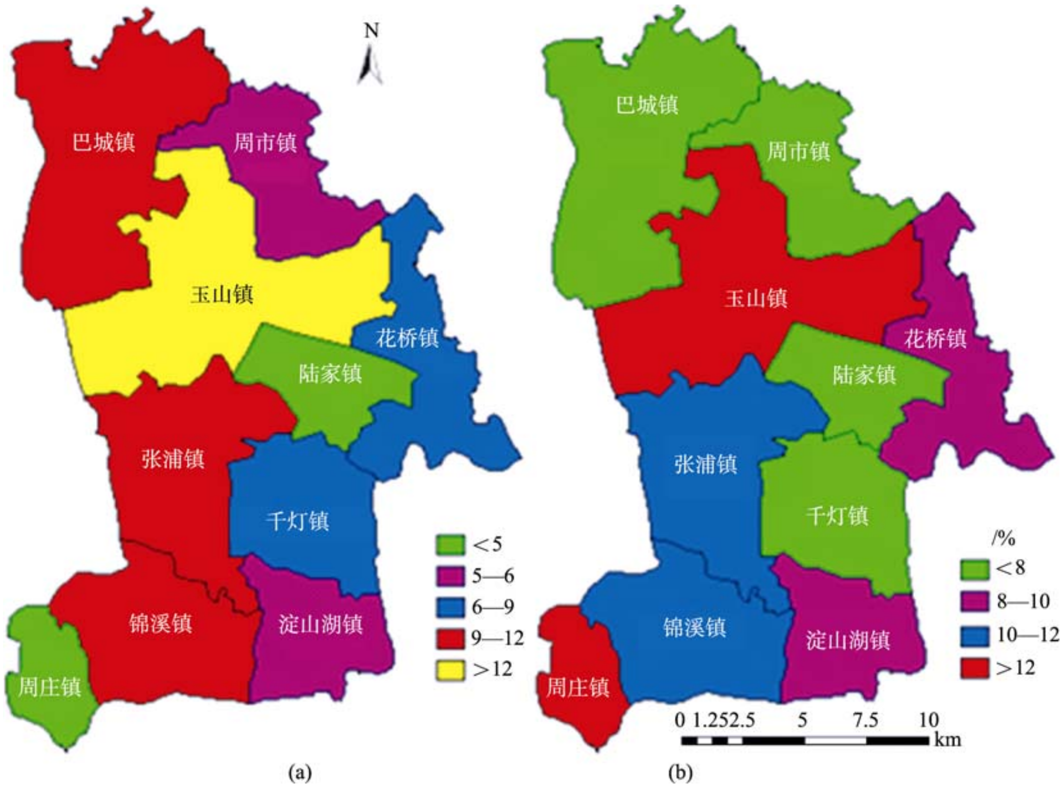


图 3 昆山市居民点用地等级规模及居民点用地所占百分比

(a)居民点用地等级规模; (b)居民点用地所占百分比

须慎重对待。用地选择是村镇建设重要的内容，用地选择不当，村庄今后没有发展余地，或交通不便，或水源不足，或易受洪水等灾害影响。村镇用地选择，应尽量达到：①村镇用地一般宜在生产作业区附近，尽可能选择在荒山、薄地和山坡地上，少占或不占耕地、林地、人工牧场(金其铭, 1989)；②生产、生活用水充足，水质良好(金其铭，1989)；③地势高爽、向阳、地下水位低，最好选择在靠近地面水的地段(金其铭，1989)；④地质条件好；交通方便(中华人民共和国住房和城乡建设部，1982)；⑤避免被铁路、公路和高压输电线路穿越，避开山洪、风口等不适宜建房的地区(金其铭，1989)；⑥避开已经控明有可供开采的地下资源或有重要历史遗迹的地方(中华人民共和国住房和城乡建设部，1982)；⑦避免地方病的高发区(金其铭，1989)。根据以上原则，结合具体的交通条件、地形、河流分布、社会经济条件和现状发展的基础，建立村镇选址模型，村镇选址模型如下：

$$V_{\text{feasiable}}(x,y)=f(X_{\text{economy}},X_{\text{terrain}},X_{\text{road}},X_{\text{river}}) \quad (4)$$

式中，$V_{\text{feasiable}}(x,y)$ 表示适宜建村庄的点，$X_{\text{economy}}$ 表示点的经济效益，$X_{\text{terrain}}$ 表示地形特点，$X_{\text{road}}$ 表示距离公路的情况，$X_{\text{river}}$ 表示距离河流的情况。此模型的条件是：经济效益越高的区域越不适宜建村庄，坡度 25°以上的，距公路 20m 或较远，距河流 30m 或较远的区域不适宜建村庄。村镇选址技术路线如图 4。

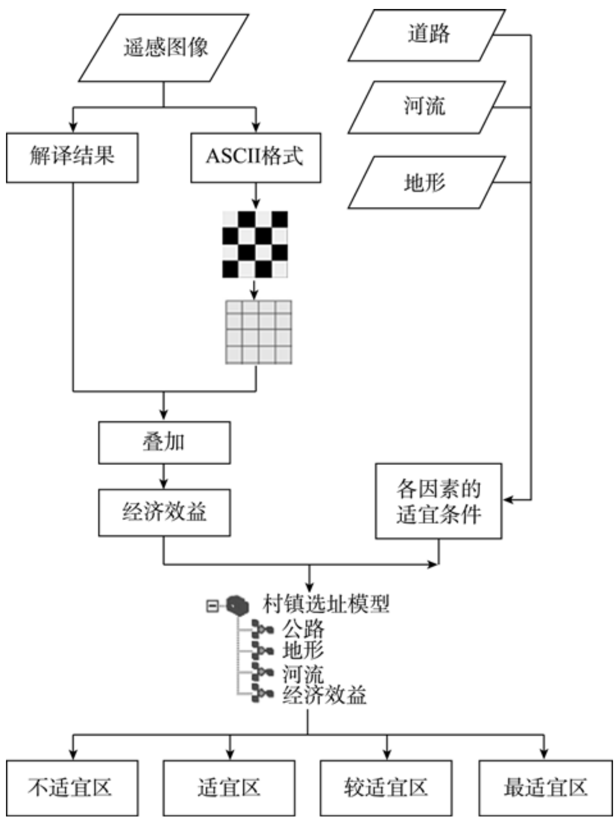


图 4 村镇选址技术流程图

本研究中选择区域为密云县2001年的TM数据(图 5(a))，由遥感影像分析得知，此区域的地块用途分为 7 类：水域、林地、工矿用地、旱地、水田、道路和村庄(图 5(b))，此区域居民点大多分布在地势较平坦的地方，不平衡性大、密度低，且相距较远，有一部分居民点沿山脚呈带状、弧状分布，外围有小片的林地。根据遥感图像和实地调查，发现此区域总体规划较合理，但有些村镇位置交通不便利或所处地形起伏等。本研究中的网格大小选择 30m×30m，选取交通、地形、河流和经济效益为影响村镇选址的因素，各因素对村镇选址的影响程度存在差异，为了更好地反映这种差异，需要给因子赋予权重，因子权重表示的是对村镇选址的影响程度，因子权重确定的合理性对村镇选址至关重要。采用专家打分法来确定因素的权重，距离水域权重为 0.2；距离道路权重为 0.5，坡度权重为 0.2，土地利用类型权重为 0.1。按照村镇选址技术路线得到村镇选址图(图 5(c))，区域被划分为不适宜区、适宜区、较适宜区和最适宜区，此模型可以为村镇选址工作提供科学依据。

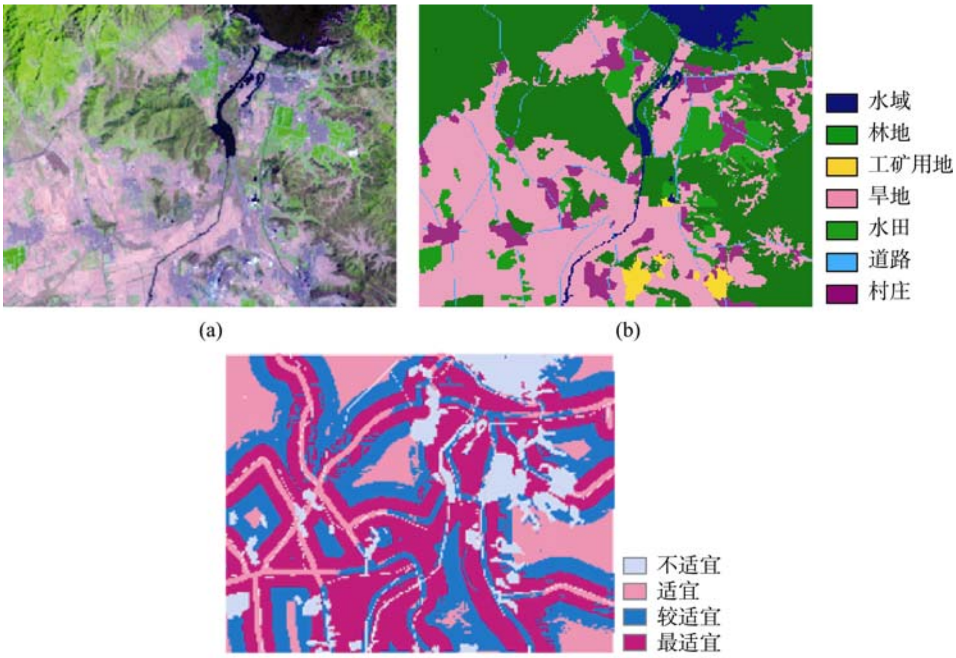


图 5 原始图像、解译结果与村镇选址
(a)原始图像；(b)解译图像；(c)村镇选址图

**4.2** 村镇空间范围

泰森多边形模型利用空间点到两个临近村庄的距离不同来确定它的归属，本研究对此做了改进，提出用土地效益的概念代替距离来确定村镇的空间范围。

根据泰森多边形模型的思想，对村庄进行规划，村庄集 $P=\{p_1, p_2, \cdots, p_n\}$，$n$ 为规划村庄数；设 $p$ 为乡村地域的某个自由点，用 $E(p, p_i)$ 表示自由点 $p(x, y)$到规划村庄 $p_i(x_i, y_i)$的土地效益，村庄 $p_i$ 的范围为：

$$V_i=\{p\in \mathrm{R}|E(p, p_i)\geqslant E(p, p_j), j=1,2,\cdots, m, j\neq i\} \quad (5)$$

$$E(p, p_i)=O-C(p, p_i) \quad (6)$$

式中，$O$ 为产出值，$C$ 为成本。产出值是耕地、林地、牧场、工矿等不同用途土地的经济产出量。成本表示对一块土地利用时运输时间、运输能源的消耗。影响成本的因素包括到村庄的距离、路况等。

研究重新界定了村镇空间结构优化的基本原则，通过 GIS 空间分析方法和建模技术进行村镇规划分析，为村镇规划提供科学的依据。

# 5 结 论

(1) 分析了村镇空间结构特征；选择 1∶5 万村镇矢量数据进行空间结构特征的分析。从居民点用地面积特征、县域内居民点用地规模两方面进行分析。

(2) 建立了基于网格的村镇选址及空间范围模型，包括村镇选址和空间范围的确定两个方面，选

取交通条件、地形、河流分布、经济效益和地块用途为参数，进行村镇选址模型的建立；根据泰森多边形模型的思想，改进了村镇空间范围模型，提出用土地效益的概念来确定村庄的空间范围。此模型考虑因素更全面，更具体，因此，对村镇的选址与空间范围的确定有很好的参考价值，研究有助于村镇规划工作的开展。

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