Evaluation of Suitability of Urban Human Settlement Environment Based on GIS -- Take Tianpeng Town Pengzhou City as an example

Hai Xiao1*, Rong Bai2, Yuan Zheng2, Xinyi Xia2

1 College of Architecture and Urban-Rural Planning, Sichuan Agricultural University, Dujiangyan, China
2 College of Architecture and Urban-Rural Planning, Sichuan Agricultural University, Dujiangyan, China
* Corresponding author’s e-mail: 41228@sicau.edu.cn

Abstract. The research objects of human settlement suitability evaluation are mostly cities or villages, and towns are rarely used for analysis and evaluation. This paper takes Tianpeng town of Pengzhou city as the research area, divides the human settlement environment suitability evaluation factors into three-factor layers, 18 index layers, combined with relevant standards and literature data. Analytic hierarchy process (AHP) is used to obtain the weight of each factor, and uses ArcGIS to calculate with buffer analysis, overlay analysis and other spatial analysis methods, and the evaluation results of human settlement in the study area are obtained. The results showed that unsuitable and particularly unsuitable areas accounted for 25.13% are mainly distributed in the southeast and southwest, and more suitable areas accounted for 74.87% are mainly distributed in the middle and east.

1. Introduction
A livable town refers to a town with a beautiful environment, social security, civilization and progress, comfortable life, economic harmony, and a high reputation. This concept quickly becomes a new town development in the 21st century after it was put forward at the second UN Habitat Conference in 1996. The concept of “human settlement environment” in China was originated from the concept of “human settlement environment science” proposed by Wu Liangyong in 1993, this human settlement environment contains five subsystems, namely nature, human beings, housing, society and supporting system [1]. In 2018, Ma Ling and others used GIS technology and a comprehensive index method to analyze various human settlement environment-related data in Shanxi Province, and visually demonstrated the spatial pattern of the natural suitability of the human settlement environment in Shanxi. On this basis, they analyzed the characteristics of each district to draw relevant conclusions of suitability and restriction factors [2]. In 2018, Qing Feng and others used GIS and RS technology to build a set of human settlement evaluation system in Xindu District of Chengdu [3]. This paper analyzes the advantages and disadvantages of the existing urban human settlement environment suitability evaluation, combined with the existing characteristics of Tianpeng town of Pengzhou city, and proposes a set of urban human settlement environment based on the natural environment, social environment, and ecological environment of Tianpeng town of Pengzhou city. The suitability evaluation system divides the suitability of the human settlement environment in Tianpeng town of Pengzhou city into five
categories: the most suitable, suitable, relatively suitable, unsuitable, and particularly unsuitable areas [4].

2. Data sources and research methods

2.1. Data sources
The data used in this study include: remote sensing image data from Tianpeng town of Pengzhou city in 2019 from Google Earth, open source of Pengzhou normalized difference vegetation index (NDVI) image data from the Geospatial Data Cloud website, and Pengzhou Statistical Yearbook from the Pengzhou Municipal People’s Government Portal data. Due to different data sources, before performing spatial analysis, various types of data need to be converted and unified to the Xi’an 80 coordinate system. A small amount of data on gas stations, factories, etc. are obtained through field research.

2.2. Hierarchy Analysis
The analytic hierarchy process is to decompose the target element factor into the target layer, the criterion layer and the scheme layer. After the factors are determined, the weight of the factors is determined, which makes the whole method more scientific [5]. WHO divides evaluation indicators into safety, comfort, convenience, and health. With reference to such standards, this article starts from the three factors of health, comfort and convenience, and refines it into seven first-level evaluation indicators and eighteen second-level evaluation indicators to construct a human settlement environment suitability evaluation system in Tianpeng town. The evaluation content is shown in Table 1.

| Table 1. Livability Evaluation Index System. |
|---------------------------------------------|
| **Target layer (A)** | **Factor layer (B)** | **first-level index layer (C)** | **second-level index layer (D)** |
|---------------------------------------------|
| Suitability evaluation of human settlements in Tianpeng town of Pengzhou City | Comfort (B₂) | River waters (C₄) | Mall (D₁₄) |
| | Comfort (B₂) | Architectural style (C₅) | Commercial street (D₁₀) |
| | Convenience (B₃) | Convenience of life (C₆) | Cultural and education (D₁₂) |
| | Convenience (B₃) | Traffic convenience (C₇) | Medical facilities (D₁₃) |
| Health (B₁) | Chemical pollution (C₁) | Highway noise (D₁) |
| | Traffic noise (C₂) | Road noise (D₄) |
| | Greenbelt environment (C₃) | Railway noise (D₅) |
| | NDVI (D₆) | Parks and scenic spots (D₇) |
| | | Shanty town (D₁₀) |
| | | Government agency (D₁₆) |
| | | Bus Station (D₁₈) |

2.2.1. Determine the weight of the evaluation factor. The establishment of the index weight is obtained through the analytic hierarchy process. The matrix is judged by comparing each factor, and the weight of each index is finally obtained. As shown in Table 2, the evaluation model of the human settlement environment suitability of Tianpeng town is established.

| Table 2. Weight table of evaluation index system. |
|---------------------------------------------|
| **Target layer (A)** | **Factor layer (B)** | **first-level index layer (C)** | **second-level index layer (D)** |
|---------------------------------------------|
| | | | |
| | | | |
| | | | |
2.2.2. Rating factor classification. The buffer distances and scores of each factor are obtained based on various human settlement environment documents and standards, and the actual impact range of some factors is investigated and analyzed on the spot to ensure their rationality. The details are shown in Table 3.

Table 3. Buffer distance and evaluation table.

| Impact Factor                      | Classification                                      | Level |
|------------------------------------|----------------------------------------------------|-------|
| Industrial influence               | Over 1000 m, 200~1000 m, 100~200 m, 0~100 m        | 4,3,2,1|
| Gas station                        | 0~1000 m, 1000~2000 m, Over 2000 m                 | 4,2,1 |
| Highway noise                      | Over 500 m, 200~500 m, 0~200 m                     | 4,3,1 |
| Road noise                         | Over 50 m, 30~50 m, 0~30 m                         | 4,2,1 |
| Railway noise                      | Over 1000 m, 50~1000 m, 0~50 m                     | 4,3,1 |
| Vegetation coverage                | Over 0.3, 0.1~0.3, Below 0.1                       | 4,3,2 |
| Parks and scenic spots             | 0~300 m, 300~1000 m, 1000~2000 m, Over 2000 m      | 4,3,2 |
| River                              | 0~250 m, 250~500 m, Over 500 m                     | 5,4,3 |
| Irrigation canal                   | 0~100 m, 100~200 m, Over 200 m                     | 5,4,3 |
| Shanty town                        | Over 200 m, 200~2000 m, 0~20 m                     | 4,2,1 |
| Commercial Streets                 | 0~300 m, 300~500 m, 500~1000 m, Over 1000 m        | 5,4,3,1|
| Convenience of cultural facilities | 0~500 m, 500~1000 m, Over 2000 m                   | 5,4,3,2|
| Convenience of medical facilities  | 0~1000 m, 1000~1500 m, 1500~3000 m, Over 3000 m    | 5,4,3,2|
| Convenience of malls               | 0~500 m, 500~1000 m, 1000~2000 m, Over 2000 m      | 4,3,2,1|
| The convenience of banks           | 0~500 m, 500~1000 m, Over 1000 m                   | 4,2,1 |
| Convenience of government agencies | 0~500 m, 500~1000 m, Over 1000 m                   | 4,2,1 |
| Road                               | 0~500 m, 500~1000 m, 1000~1500 m, 1500~3000 m, Over | 5,4,3,2,1|
|                                    | 3000 m                                             |       |
| Bus station                        | 0~500 m, 500~1000 m, 1000~2000 m, Over 2000 m      | 4,3,2,1|

2.3. **ENVI extract NDVI**

Using ENVI software to extract NDVI can more intuitively analysis the vegetation coverage in the area, and facilitate the analysis of greening factors. The principle of this method is mainly to calculate by the sum of the near-infrared and visible light bands and the difference [6].

2.4. **Overlay analysis**

Overlay analysis is one of the most commonly used and very important analysis methods in GIS spatial analysis. Overlay analysis can effectively integrate a variety of geographic factors and extract implicit spatial information from them. The so-called overlay analysis is to superimpose multiple data layers
containing the spatial feature objects of interest to generate a new feature layer. This new layer integrates the attribution characteristics of the original multi-layer entity features.

3. Results and analysis

3.1. Health analysis

The chemical pollution involved in this article mainly includes three indicators: industry, contaminated waters and gas stations. Figure 1 shows that the overall chemical pollution of the studied area is still concentrated in the area near Zhihe town on the south side, where factories and gas stations are located stations, which have a greater impact on the environment. This paper extracts two types of roads and railways within the town area as the sources of noise pollution. Figure 2 shows that traffic noise is mainly concentrated in the southeast part and the impact of the dense road network in the town. At the same time, the railway network in the southwest part also causes noise pollution nearby. Due to inconvenient traffic in the farmland area, the noise impact is relatively small.

![Figure 1. Chemical Pollution map.](image1)

![Figure 2. Noise pollution assessment map.](image2)

![Figure 3. Vegetation evaluation map.](image3)

![Figure 4. River evaluation map.](image4)

3.2. Comfort analysis

The green space system in this study considers two factors: one is vegetation coverage, and the other is parks and scenic spots. Due to the large number of buildings in the urban area, the vegetation coverage will be lower than that of the fields. Some areas have extremely low vegetation coverage. Parks and scenic spots are mainly located in the southeast. Figure 3 shows that the green space environment of the southeast of the studied area is divided with higher value. As shown in Figure 4, the distribution of river waters is relatively concentrated, and the central and northern parts have higher scores and are more comfortable. There are shanty towns in Tianpeng town, according to the survey, shanty towns are mainly distributed in the southwest of Longxing Temple. The comfort of the shanty towns and surrounding areas is poor. The scores of the rest are not changed because they are not affected by shanty towns. As shown in Figure 5.

![Figure 5. Shanty towns distribution.](image5)

3.3. Convenience analysis

Whether life is convenient or doesn’t affect the quality of life of the people living there. This article has identified five categories, including culture and entertainment, medical care, shopping malls, banks, and government agencies for a comprehensive analysis. To a certain extent, the convenience of transportation can promote the flow of population, travel frequency and economic development in the region, and there are two types of main roads and stations. As shown in Figure 6, the areas with high convenience scores in Tianpeng town are still concentrated on the south side, the old city and Peony New City, and the 10,000-person community on the north side also has better living convenience. As shown in Figure 7, the convenience of the area far from the town center is poor. The scores of the areas in the town and along the north side of Mudan Avenue are higher, and the scores of other areas are medium or low.

![Figure 6. Convenience analysis.](image6)

![Figure 7. Convenience distribution.](image7)
4. Conclusion

Most areas of Tianpeng town of Pengzhou city are suitable for living, as shown in Figure 8. Unsuitable and particularly unsuitable areas are accounted for about 25.13%, the most suitable areas and particularly suitable areas, and this area is accounted for nearly 74.87%. There are still a large number of buildings in unsuitable areas, accounting for about 45.61%. The living area in the most suitable area accounts for very small, less than 1.12%. A large number of buildings are located in more suitable areas, accounting for about 54.39%.

At present, some buildings in suitable areas and the overall style need to be rectified. The shanty towns near Longxing Temple are in suitable and more suitable areas. If they can be better repaired, the suitability will be improved to a certain extent. The overall development of Tianpeng town has gradually shifted from the center of the town to the seat of the government in the east, that is from the old town to the Peony New Town, and this part of the area is suitable for living.

References

[1] Liangyong W. (1996) Science of human settlements. Urban Studies, 1996(01):1-5.
[2] Ling M., Wangtian L., Chong Z. (2018) Suitability Evaluation of Human Settlements in Shaanxi Province. Henan Science., 36(04): 621-626.
[3] Feng Q., Kexue X., Zhaoyong Z. (2018) Evaluation on Human settlements suitability in the Xindu district of Chengdu city based RS and GIS. Journal of Qiqihar University(Natural Science Edition), 34(02):76-80.
[4] Yanjun D. (2018) Ecological Suitability Evaluation of Urban Construction Land Based on ANP-GIS Coupling Model-A Case Study of Changchun City. Jilin University, Changchun.
[5] Qixian C., Zheyu F., Chunyan Q. (2019) The urban livability research of Xinyang City based on analytic hierarchy process. Environment and Development., 31(01):5-7.
[6] Xiaohua W. (2014) Use ENVI extracting vegetation coverage. Environment and Development., 26(07):71-72.