Analysis on Ecological Suitability of Land Use Planning in Industrial Park

Shao Jun¹, *, Yao Jiali¹, Luo Xue¹

¹School of Urban Construction, Wuhan University of Science and Technology, Wuhan, China

¹8041542@qq.com

Abstract. In the process of planning and construction of industrial park, it is necessary to analyze the suitability of construction land, and use it as a basis to guide and demonstrate the rationality of planning spatial layout and land use, so as to provide scientific basis for planning decision-making. In this paper, the ecological suitability of land use planning in Tongshan County Economic Development Zone Master Plan is taken as the research object, the planning land use types are combed, the ecological sensitive factors are screened by the method of benefit analysis, the evaluation index system and method system are constructed, the ecological adaptability of industrial park land use is evaluated scientifically, the ecological adaptability of regional land use is determined, the construction land is reasonably planned and the planning is improved.

1. Introduction

In the period of rapid urbanization, urban industrial land has expanded rapidly and land resources are becoming more and more tense. In the planning of industrial park expansion, it is necessary to evaluate and analyze the possible impact of land use planning on the ecological environment, and on the basis of which land development and use should be carried out.

Ecological suitability analysis is from the ecological point of view, according to the ecological requirements of industrial park construction, to analyze whether the supply of land quality (including the interaction of natural factors and social factors) can meet the needs of development. At the same time, fully considering the possible environmental problems involved in the planning decision of the industrial park, by analyzing the adaptability of all kinds of land use and natural, social and environmental characteristics of the industrial park, demonstrating the rationality of the planning spatial layout and land use, preventing the possible adverse environmental impact after the implementation of the planning, and providing a scientific basis for the planning decision.

Taking General Plan of Economic Development Zone of Tongshan County (2019-2030) as an example, this evaluation establishes an index system to analyze the ecological suitability of land use planning.

2. Planning land use types

According to General Plan of Economic Development Zone of Tongshan County (2019-2030), the land type is mainly industrial land, residential land, public management and public service facilities land, commercial service facilities land and road traffic facilities, green space and wide-field land and so on. The planning land is shown in Figure 1 and Table 1.
Figure 1. Land use plan.

Table 1. List of planned land use.

| Codes | Land Classification                  | Land area (ha) | Percentage (%) |
|-------|--------------------------------------|----------------|----------------|
| R     | Residential                           | 163.29         | 17.71          |
| A     | Administration and public services    | 67.46          | 7.32           |
| B     | Commercial and business facilities    | 34.15          | 3.70           |
| M     | Industrial                            | 504.27         | 54.68          |
| W     | Logistics and warehouse               | 9.79           | 1.06           |
| S     | Road, street and transportation       | 66.61          | 7.22           |
| U     | Municipal utilities                   | 18.75          | 2.03           |
| G     | Green space and square                | 57.85          | 6.27           |
|       | Urban Development Land                | 922.17         | 100            |

3. Construction of evaluation index system

According to the analysis of the planned land use types of Tongshan County Economic Development Zone, a group of factors which have the greatest influence on the determined land use objectives are selected as the evaluation indexes. In this evaluation, according to the layout of the overall planning, industrial land and residential land planning are selected for ecological suitability analysis. First of all, the single index classification evaluation is carried out, on the basis of which the comprehensive evaluation of two kinds of land use patterns is carried out.

In the Technical Guide for Regional Environmental impact Assessment of Industrial Park (HJ/T131-2003), it is pointed out that the three-level index system is adopted in the assessment of
ecological suitability in the environmental impact assessment of industrial park planning. Through the analysis of the environmental characteristics of Tongshan County Economic Development Zone, according to the nature and function of the planned area, the ecological factors are screened by the method of benefit analysis. The evaluation index system of land use ecological suitability is shown in Table 2.

Table 2. Evaluation index system of ecological suitability of land use.

| Primary Index | Secondary Index                  | Thirdly Index                                      | Order of Evaluation                                      | II level Basic suitability | III level Inadequacy |
|---------------|----------------------------------|---------------------------------------------------|----------------------------------------------------------|---------------------------|----------------------|
|               | Evaluation of Ecological Suitability of Residential Land | Environment quality | Atmospheric environmental sensitivity | The direction of the upper and lower winds is farmland and residential areas. | The upper direction is type I industrial zone or type II industrial zone. | The upper direction is type II industrial zone. |
|               |                                   | Noise disturbance degree (dB (A)) | <55 | 55–60 | >60 |
|               |                                   | Traffic (m) | <500 | 500–1500 | >1500 |
|               |                                   | Cultural and educational medical (m) | <1000 | 1000–2000 | >2000 |
|               |                                   | Greening and landscape | Forest coverage rate | >30% | 15%~30% | <15% |
|               |                                   |                                  | Landscape | Good | General | Poor |
|               | Evaluation of Ecological Suitability of Industrial Land | Environmental coordination | Atmospheric environmental impact degree | The evaluation plot is type I industry, the downwind direction is industry or agriculture; the evaluation plot is a type II industry, and the downwind direction is industrial land. | The evaluation land is type I industry, the downwind direction is residential, the commercial land is commercial land; the evaluation land is type II industry, and the downwind direction is agricultural land. | The evaluation site is type II industry, the downwind is residential, and the commercial land is commercial. |
|               |                                   | Artificial and natural characteristics | Light and heavy pollution of industrial land and nearby wasteland, open space | Commercial district, non-polluting industrial zone | Residential land, cultural relics protected areas, schools, hospitals |
|               | Infrastructure                    | Distance from power facilities (m) | <500 | 500–1000 | >1000 |
|               |                                   | Distance from sewage network to (m) | <500 | 500–1000 | >1000 |
|               | Land use entropy S                 | Ratio of land condition (L) to population density (U) | >1.5 | 0.68~1.5 | <0.68 |

4. Index quantification and weighting

The contribution of each evaluation factor is different, so it has different weights in the evaluation. "arranged into comparison method" is used to determine the factor weight.

First of all, the importance of the latter factor to the previous factor is determined, expressed by multiple, and the importance of the first factor \( r_1 \) is determined to be 1. After the value of \( r_1 \) being determined, the weight of each evaluation factor is calculated according to the following formula:

\[
W_i = \frac{U_i}{\sum_{i=1}^{n} U_i}
\]

(1)

In the formula: \( W_i \) represents the weight of each evaluation factor. \( U_i = 1.0, U_2 = r_1 \times r_2, \ldots, U_i = r_1 \times r_2 \times r_3 \times \ldots \times r_i \)

According to the above formula, the weight of each evaluation factor is calculated, as shown in Table 3.

Table 3. Land use status classification.

| Number | Evaluation of Land Types | Division and Weight of Evaluation Factors |
|--------|--------------------------|------------------------------------------|
| 1      | Residential land         | The sensitivity of atmospheric environment is 0.25, the noise disturbance is 0.125, the traffic is 0.125, the cultural and educational medical treatment is 0.125, the green space coverage is 0.125, and the |
2 Type I industrial land

The influence degree of atmospheric environment is 0.2; the artificial and natural characteristics are 0.2; the entropy of land use is 0.2; the distance from the power network is 0.2; and the distance from the main pipe of sewage discharge is 0.2.

3 Type II industrial land

The influence degree of atmospheric environment is 0.2; the artificial and natural characteristics are 0.2; the entropy of land use is 0.2; the distance from the power network is 0.2; and the distance from the main pipe of sewage discharge is 0.2.

5. Ecological suitability evaluation

5.1. Unsuitable critical conditions

In the evaluation, a certain evaluation factor is considered to be an inappropriate region of land use, regardless of the appropriate degree of the remaining evaluation factors, once the appropriate critical condition is reached. In that case of historical sites, schools, government and other regions, no matter what other conditions are, it is not suitable for use as industrial land, but other evaluation indicators, such as good infrastructure, large land use degree, are suitable or basically suitable, in order to prevent the above situation from occurring in the evaluation process. It is suggested that the critical condition is not suitable. See Table 4 for the non-appropriate critical value of partial evaluation index.

Table 4. Some evaluation indicators are not suitable for industrial/residential land threshold.

| Evaluating Indicator | Artificial and Natural Characteristics | Noise Disturbance Degree dB (A) | Atmospheric Sensitivity | Atmospheric Environmental Impact Degree |
|----------------------|----------------------------------------|---------------------------------|------------------------|-----------------------------------------|
| Unsuitable critical value of type II industrial land | Residential land, cultural relics reserves, schools, hospitals, parks | -- | -- | The upper and lower wind directions are residential areas. |
| Inappropriate critical value of residential land | The downwind direction of heavily polluted industrial land is within 500 meters. | >65 | The upper and lower wind directions are all type II industrial zones. | -- |

5.2. Overall merit

The comprehensive evaluation index of ecological suitability of industrial and residential land is calculated by the following formula:

\[ R_s = \sum_{i=1}^{N} W_i \cdot P_i \]  

(2)

In the formula: \( S \) represents the grid plot number; \( R_s \) represents the comprehensive ecological suitability value of Plot \( S \); \( W_i \) represents the weight corresponding to each evaluation factor; \( P_i \) represents the contribution value of each influencing factor, whose value can be determined according to the level of influence factor. The most suitable index value of each factor is the contribution value 18, and the least suitable value of each factor is set to 0. When the influence factor is divided into three levels, the \( P \) value of each factor is \( P_1, i=18; P_2, i=9; P_3, i=0; \) \( N \) represents the evaluation factor.

Firstly, the factors of investigation and statistics are graded in each plot, and then the individual evaluation value of each factor is calculated according to the weight of each index. Finally, the comprehensive evaluation value of each grid block is obtained by adding the individual evaluation value of each grid block, and the unsuitable critical conditions should be considered in the evaluation process. The evaluation statistics of land use ecological suitability of each plot are shown in Table 5.
Table 5. Statistical table for evaluation of ecological suitability of land use in each plot.

| Type of Land Use | Evaluation factor                        | Grid Plot $W \times P$ |
|------------------|------------------------------------------|------------------------|
|                  |                                          | Residential Area | Industrial Area | Administration and Public Services | Logistics and Warehouse |
| Residential      | Atmospheric environmental sensitivity     | 0.2               | 0.45            | 0.2                             | 0.3                     |
|                  | Noise disturbance degree                  | 0.2               | 0.45            | 0.2                             | 0.4                     |
|                  | Traffic                                   | 0.3               | 0.55            | 0.35                            | 0.2                     |
|                  | Cultural and educational medical treatment| 0.3               | 0.3             | 0.3                             | 0.4                     |
|                  | Forest coverage rate                      | 0.1               | 0.4             | 0.2                             | 0.15                    |
|                  | Landscape                                 | 0.2               | 0.1             | 0.2                             | 0.25                    |
| Rs               |                                          | 1.3               | 2.25            | 1.45                            | 1.7                     |
| Type I           | Atmospheric environmental sensitivity     | 0.6               | 0.15            | 0.7                             | 0.3                     |
| Industrial land  | Artificial and natural characteristics    | 0.25              | 0.25            | 0.25                            | 0.3                     |
|                  | Distance from power facilities            | 0.2               | 0.25            | 0.2                             | 0.2                     |
|                  | Distance from sewage pipe network         | 0.2               | 0.2             | 0.2                             | 0.2                     |
|                  | Land use entropy                          | 0.7               | 0.7             | 0.7                             | 0.7                     |
| Rs               |                                          | 1.95              | 1.55            | 2.05                            | 1.7                     |
| Type II          | Atmospheric environmental sensitivity     | 0.8               | 0.2             | 0.9                             | 0.5                     |
| Industrial Land  | Artificial and natural characteristics    | 0.9               | 0.2             | 0.9                             | 0.7                     |
|                  | Distance from power facilities            | 0.2               | 0.2             | 0.2                             | 0.2                     |
|                  | Distance from sewage pipe network         | 0.2               | 0.2             | 0.2                             | 0.2                     |
|                  | Land use entropy                          | 0.7               | 0.7             | 0.7                             | 0.7                     |
| Rs               |                                          | 2.8               | 1.5             | 2.9                             | 2.3                     |

5.3. Result

According to the assignment condition, the calculated results are about 1.0, 2.0 and 3.0, respectively. The smaller the calculated ecological suitability is, the more suitable it is.

The evaluation results of land use ecological suitability of each plot in Tongshan County Economic Development Zone are statistically shown in Table 6.

According to the evaluation results of land ecological suitability of Tongshan County Economic Development Zone in Table 6, it can be seen that the overall planning of the development zone is generally consistent with the conclusion of the evaluation of ecological suitability, especially in the planning of one kind of industrial land and the second kind of industrial land, the conclusion of the overall planning of the development zone and the evaluation of ecological suitability is quite consistent, indicating that the overall planning of the development zone has been taken into account in the industrial layout. It is scientific to a certain extent.

Table 6. Statistical table of ecological suitability evaluation of land use in each plot of the park.

| Grid Block               | Evaluation Conclusion                                                                 |
|--------------------------|----------------------------------------------------------------------------------------|
| Residential Area         | Suitable for residential land; basically suitable for a class of industrial land, the impact of atmospheric environment will have a negative impact on the residential environment; there are sensitive points such as residential areas in the area, which exceeds the unsuitable critical value of residential land and is not suitable for type II industrial land. |
| Industrial Area          | Basically suitable for residential land; suitable for type I, type II industrial land. |
| Administration and Public Services | Suitable residential land is basically suitable for a class of industrial land, and the impact of atmospheric environment will have a negative impact on sensitive targets such as schools in public management and public service facilities. There are sensitive points such as residential areas in the area, which exceeds the unsuitable critical value of residential land and is not suitable for type II industrial land. |

5
Logistics and Warehouse Area

Basically suitable for residential land; basically suitable for type I and II industrial land.

References

[1] Zhao X, Shu F, Wang J. Ecological Suitability Evaluation and Land-Use Allocation for Industrial Manufacture in a Metallic Polluted Area[J]. Journal of Computational & Theoretical Nanoscience, 2015, 12(9):2791-2796.

[2] Salui C L, Hazra P B. Geospatial Analysis for Industrial Site Suitability Using AHP Modeling: A Case Study[M]. Environment and Earth Observation. 2017.

[3] Chen S. Measurement and Evaluation of Ecological Environment Suitability in Binzhou City[J]. Meteorological & Environmental Research, 2018, 9(2):34-37.

[4] Fan Y, Qi Q, Lin F. Network analysis of industrial metabolism in industrial park – A case study of Huai'an economic and technological development area[J]. Journal of Cleaner Production, 2017, 142:1552-1561.

[5] Lu Y, Chen B, Feng K, et al. Ecological network analysis for carbon metabolism of eco-industrial parks: a case study of a typical eco-industrial park in Beijing. [J]. Environmental Science & Technology, 2015, 49(12):7254-64.

[6] FERRETTI, Valentina, POMARICO, et al. Ecological land suitability analysis through spatial indicators: An application of the Analytic Network Process technique and Ordered Weighted Average approach[J]. Ecological Indicators, 2013, 34(11):507-519.

[7] Jie L, Jing Y, Wang Y, et al. Environmental Impact Assessment of Land Use Planning in Wuhan City Based on Ecological Suitability Analysis[J]. Procedia Environmental Sciences, 2010, 2(1):185-191.

[8] Malczewski J, Rinner C. Development of GIS-MCDA[M]. Multicriteria Decision Analysis in Geographic Information Science. 2015.

[9] Fan S, Liu Y, Zhang H, et al. Undertaking industrial land spatial suitability evaluation based on hierarchical fuzzy matter element model[J]. Transactions of the Chinese Society of Agricultural Engineering, 2015, 31(6):266-276.

[10] Mosadeghi R, Warnken J, Tomlinson R, et al. Comparison of Fuzzy-AHP and AHP in a spatial multi-criteria decision making model for urban land-use planning[J]. Computers Environment & Urban Systems, 2015, 49:54-65.