Village planning based on GIS land suitability -- A case study of Longfenggou Village in Hebei Province

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Abstract. At present, science and technology have entered an accelerated development stage, which also provides new ideas for village planning. The rational use of land is the key task of village planning, and how to realize intensive use of land is an urgent problem to be solved. In this paper, Longfenggou Village in Hebei Province is taken as an example. With the technical support of ArcGIS software, the construction land of Longfenggou Village is selected as the evaluation subject, and the elevation, slope and slope are selected as the main evaluation factors, and the weight of the evaluation factor is determined by using AHP.

Key words: Town planning; village and town construction; GIS; Evaluation factor; Hierarchical analysis.

1. Introduction
At present, with the continuous development of science, technology and economy, social activities and construction work have steadily entered an accelerated stage, and today's new rural construction and planning have also entered a new stage of accelerated development. From 1985-1986, the central government's 'Five No.1 Documents', 2004-2009 focused on 'agriculture, rural areas and farmers', and 2018-2019 issued a rural revitalization strategy. Various policies have been fully implemented, such as rural construction throughout the country.

2. Chapter 1 Necessity of Land Suitability Evaluation in Village Planning
Village planning is an activity in which local governments, villagers and planners participate together. This is also the space where the government leads the implementation of public policy. This village is the target of planning, and its scale is very small. From the point of view of administrative organization, it is the smallest organizational unit. From the point of view of scale and land use, it can be said that the village is the smallest unit where human beings live. From the government's expectation, it is easier for such a small organization to verify its effectiveness, determine whether planning and implementation are separated, and find the crux. However, even if the village scale is small, its planning content needs to be comprehensive, involving social relations, industrial economy, natural ecology, policies and regulations, local culture and many other aspects. Under the guidance of village planning,

The construction of new countryside in China is not only conducive to improving the villagers' production and living conditions, but also to increasing farmers' income and promote the progress of
ideological and cultural level. At present, China's village planning has steadily entered an accelerated development stage. How to coordinate sustainable development and make the most rational use of construction land has become the main task at present. The intensive use of land is the premise of planning and construction. Therefore, from the overall urban planning to the village planning, the application of land suitability will become an indispensable part of the current village planning.

3. Concept introduction and operation steps

3.1. Land suitability evaluation
Land suitability assessment mainly refers to the process of matching land characteristics or land quality with the physiological and ecological requirements of crops or land use patterns. A simple understanding is to measure the suitability of a certain land use by comprehensively analyzing and evaluating the geographical, geological, humanistic, hydrological and biological characteristics of the land, and based on quantitative results.

Land use planning was first applied to the planning and construction of New York, USA, and then was widely used to assist the preparatory work of various construction activities. At present, land suitability evaluation has been widely recognized and applied in agriculture, industry and other fields.

Nowadays, with the rapid development of computer technology, geographic information system, remote sensing, global positioning system and other technologies have been greatly improved. Geographic Information System (GIS) is an important part of the three technologies, and its powerful analysis algorithm provides a powerful driving force for statistical analysis and geospatial analysis, and also provides strong technical support for land suitability evaluation. Therefore, it has gradually become the main method of village planning. Compared with the traditional land use suitability analysis method, GIS technology can accurately obtain the ground geographic information data, and present the analysis results in the form of images, which can be more intuitive and accurate, and thus provide a more scientific and reasonable planning scheme.

3.2. Village planning process under land suitability analysis
The purpose of village planning is to realize the sound development of the village and improve the living environment in rural areas. The main purpose of land suitability evaluation for village planning is to coordinate the land use and layout of various functional types in rural areas, and provide clear ideas for rural demolition, construction and planning layout. In order to meet the requirements of intensive land use at the present stage, the requirements for the simultaneous development of the two tasks are becoming more and more universal.

The general process of village planning based on land suitability assessment mainly includes:
1. Selection of evaluation objects.
   Combined with the construction objectives to be achieved in a certain period of time and other relevant policies, the land types to be assessed are determined.
2. Data collection and arrangement.
   After defining the land use types to be evaluated, it is necessary to collect evidence and data from various parties according to the characteristics of this type of land, so as to guide the determination of evaluation factors in suitability evaluation accurately and effectively.
3. Selection of evaluation factors.
   Through the analysis of the data collected in the early stage and on-the-spot investigation, the evaluation factors are widely determined, focusing on the factors that have great influence on the evaluation objects. Then, combining the opinions and suggestions of experts from all sides, the evaluation factors are finally selected and determined.
4. Quantifying the evaluation factors.
   This process mainly quantifies and scores the evaluation factors with the help of experts' opinions or under the discussion of many people, sums up the quantification of evaluation factors, and divide them into several gradients (generally divided into three categories: suitable, basically suitable and unsuitable,
with corresponding scores of 3, 2 and 1, and the value are positively correlated according to the suitability of the evaluation factor.

5. Reclassification of evaluation factors.
This stage is mainly applied to the re-classification function under the data analysis module in ARCGIS software, and realizes the digital visualization of the gradient state of each evaluation factor.

6. Determination of the weight of evaluation factor.
That is to say, the mutual importance of each evaluation factor is determined by AHP, Delphi method, linear regression method and fuzzy comprehensive evaluation method.

7. Discuss and determine the overall village planning scheme.
Through the results of the previous several links, determining the suitability of various types of evaluation factors superimposed results, scientific guidance of village planning land layout, combined with the planning conditions and principles, the formation of the final program.

3.3. Principles and types of land suitability evaluation factor selection in village planning
As an important part of land adaptability assessment, the selection process of assessment factors should follow the basic principles of pertinence, measurability and stability. In the process of selection, priority should be given to the evaluation factors that have a significant impact on the evaluation objects.

The selected evaluation factors mainly include two types: socio-economic and policy factors, and natural factors. The socio-economic factors mainly include national or local policies, local culture and other factors. The natural factors mainly include hydrology, topography and soil conditions, including slope, aspect, elevation, water and soil loss and river influence. These factors are related to each other, but they also interact with each other, which together determine the suitability and utilization of land. Based on the above principles and classification, in the general suitability evaluation, we often choose elevation, slope, aspect, hydrology and road conditions for comprehensive evaluation.

4. Chapter 3 Case Analysis — Taking Longfenggou Village in Hebei Province as an example

4.1. Present Situation Analysis of Longfenggou Village
Longfenggou Village is located in Kuancheng Manchu Autonomous Prefecture in Chengde City, Hebei Province. It is located in the Taihang Mountain. The terrain is complex, with an altitude of about 409 meters, belonging to the temperate climate, with little rainfall, large evaporation and sufficient sunshine time.

The main problems existing in Longfenggou Village are as follows: the villagers' own homestead is large, and the abandoned houses are unreasonable to occupy the construction land within the village, followed by various types of cultivated land. The construction land is scattered, and land use intensity is extremely low.

In this case, the elevation, slope and aspect of the existing site in Longfenggou Village will be taken as the evaluation factors of suitability evaluation, and the specific distribution of construction land in Longfenggou Village will be analyzed and determined, and the general scope of suitable and unsuitable construction areas will be obtained.

![Fig. 1 Analysis of case topography](image-url)
4.1.1. **Elevation analysis.** The existing digital elevation model of Longfenggou Village shows that the overall topography of Longfenggou Village is low in the middle and high in the east, south and north. The highest elevation is 581 m, and the lowest elevation is 409 m, with obvious changes in overall elevation.

4.1.2. **Slope analysis.** After using ArcGIS to analyze the site elevation information, the slope analysis of the site is obtained. The analysis shows that the maximum slope in the site is 57.01, and the whole topography of Longfenggou Village has changed greatly. It can be seen that the slope is more obvious when evaluating the land suitability of Longfenggou Village.

4.1.3. **Slope analysis.** The analysis results of slope direction in Longfenggou Village show that the slope direction of the site is mainly distributed between $-1^\circ$ and $356^\circ$. Generally speaking, there are eight types of slope direction. Here, we use the spatial analysis module of ARCGIS to reclassify it and divide it into five gradients. The slope direction which is the most suitable for construction activities and the slope which is the least suitable for construction correspond to the corresponding values. The results show that the slope distribution law of the site is poor, which will affect the land layout and crop planting in residential areas to some extent.

**Fig.2** Results of elevation analysis  
**Fig.3** Results of slope analysis  
**Fig.4** Results of aspect analysis

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4.2. **Working methods of land suitability evaluation in Longfenggou Village**

4.2.1. **Selection of evaluation objects.** Limited by technical and manpower problems, this case only refers to relevant literature and evaluates the suitability of construction land in Longfenggou Village in combination with the actual situation of Longfenggou Village.

4.2.2. **Selection of evaluation factors.** Based on the analysis of the natural factors in Longfenggou Village, due to the limitation of manpower, the evaluation factors determined by this suitability evaluation include elevation, slope and slope direction.
4.2.3. **Quantitative analysis of evaluation factors.** Each evaluation factor is divided into five grades (corresponding to 1, 2, 3, 4 and 5 respectively) according to the suitability and unsuitability degree. The process of dividing slope is mainly based on the re-classification function of ARCGIS software. According to relevant regulations, the gradient is divided into five gradients by natural breakpoint method. The analysis results are as follows.

1) Results of highly reclassified

With the change of altitude, the difficulty of land development and construction is changing, which is positively correlated on the whole. As far as the actual situation of Longfenggou Village is concerned, the lower the altitude, the easier it is to develop the construction land. According to the survey, the elevation distribution of Longfenggou Village is divided into five grades: 400m, 500m, 600m, 700m and above.

2) Results of slope reclassification

The slope factor mainly affects construction projects. Generally speaking, the relationship between the difficulty of the construction project and the slope is similar to the relationship between elevation. According to the relevant technical standards and the actual situation of Longfenggou Village, the natural breakpoint method is used to divide the construction project into five levels above 2°, 6°, 15°, 25° and 25°.

3) Results of slope reclassification

The quality of life of villagers is closely related to the crop yield and appearance, which has a great influence on the village. Therefore, with the north direction of 0° and clockwise rotation calculation, the aspect is divided into five categories: 150° – 210°, 120° – 150°,

![Image](image.png)

**Fig.5** Results of slope reclassification

4.2.4. **Determination of weights.** In this case, the analytic hierarchy process (AHP) proposed by American operators is mainly used to determine the weight. The method is mainly simulated by yaahp.

1) Establish the hierarchy of analysis
Fig. 6 Establish the hierarchy of analysis

The ranking weight of elements to decision objectives in the first middle layer

| Middle layer elements |  
|-----------------------|
| Elevation             | 0.6738 |
| Aspect                | 0.2255 |
| Slope                 | 0.1007 |

1. Consistency ratio of suitability analysis: 0.0825; Weight of "suitability analysis": 1.0000; \( \lambda \max: 3.0858 \)

| suitability analysis | Slope | Aspect | Elevation | \( W_i \) |
|----------------------|-------|--------|-----------|----------|
| Elevation            | 1.0000| 0.3333 | 0.2000    | 0.1007   |
| Aspect               | 3.0000| 1.0000 | 0.2500    | 0.2255   |
| Slope                | 5.0000| 4.0000 | 1.0000    | 0.6738   |

2. Slope consistency ratio: 0.0000; Weight of suitability analysis: 0.1007; \( \lambda \max: 2.0000 \)

| Scheme 1 | Scheme 2 | \( W_i \) |
|----------|----------|------------|
| 1.0000   | 2.0000   | 0.6667     |
| 0.5000   | 1.0000   | 0.3333     |

3. Consistency ratio of slope direction: 0.0000; Weight of suitability analysis: 0.2255; \( \lambda \max: 2.0000 \)

| Scheme 1 | Scheme 2 | \( W_i \) |
|----------|----------|------------|
| 1.0000   | 0.5000   | 0.3333     |
| 2.0000   | 1.0000   | 0.6667     |

4. Elevation consistency ratio: 0.0000; Weight of suitability analysis: 0.6738; \( \lambda \max: 2.0000 \)

| Scheme 1 | Scheme 2 | \( W_i \) |
|----------|----------|------------|
| 1.0000   | 2.0000   | 0.6667     |
| 0.5000   | 1.0000   | 0.3333     |

Fig. 7 Establish a decision matrix
4.2.5. *Multi-factors superposition analysis of construction land*. On the basis of comparing the basic data of Longfenggou Village, the results of slope, aspect and elevation analysis are weighted and superimposed by using the grid calculator tool under the geographic algebra module of ARCGIS software, and finally the distribution of suitable buildings in Longfenggou Village is determined. The analysis results are as follows.

After repeated calculations, five critical values of each appropriate level are preliminarily determined, and the results corresponding to the five critical values are reclassified again. Finally, the village is divided into three types of construction areas: suitable construction area, general suitable construction area, and unsuitable construction area (corresponding to the numerical interval 1 – 2, 2 – 3, 3 – 5, respectively), so as to put forward more targeted suggestions for the implementation of village planning.
5. Summary and Improvement of Land Suitability Evaluation in Village Planning

5.1. Technological overview

Doing a good job of land suitability evaluation in village planning can not only protect and utilize resources, but also realize the rational use of land in the near and long term. According to the analysis results, we can put forward some references for the preliminary work of village planning in Longfenggou Village.

1. The distribution of construction land is relatively scattered. In the process of village planning, the problem of intensive land use should be focused on combining with the evaluation results.
2. The results of land suitability evaluation are in good agreement with the current situation, and most of the existing buildings are located in highly and moderately suitable areas.
3. Due to the influence of topographic factors within the project, the land suitable for construction is generally distributed in the flat terrain in the middle of the village, and it is not suitable for construction in the northern, southern and eastern mountainous areas.

5.2. Perfecting and improving

With the help of computer-aided analysis, unnecessary mistakes in the manual operation are avoided to the maximum extent, but there are still several aspects.

1. The selection of land suitability evaluation index needs to be perfected. The evaluation factors selected in the land suitability evaluation of Longfenggou Village are mainly natural factors which are convenient for collection and analysis, and the lack of consideration of social and economic factors will lead to the relative lack of objectivity of this study. If human interference is taken as one of the factors, the evaluation model will be relatively complete.
2. Weight Determination and Index Assignment Subjective Analytic Hierarchy Process (AHP) is used to determine the weight of evaluation factors, and the matrix judgment of AHP will lead to deviation of results due to subjective factors. In addition, there is subjectivity in the process of assigning evaluation factor, which affects the accuracy of evaluation results.
3. Deep applied research on evaluation results is not deep enough. This case studies the suitability of construction land in Longfenggou Village. The purpose of the research is clear and the thinking is clear, but there are still immature operation links, and it is necessary to explore more mature evaluation steps and methods in practice.

Through the collection of existing data, combined with objective analysis and judgment, the method of land suitability evaluation is combined with the work of village planning at this stage. The analysis results will serve as the basis for village planning and land development. It can not only solve and coordinate the layout of land planning reasonably, but also have certain guiding significance for village planning in the region.

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