Suitability Evaluation of County Construction Land under the Constraint of the Key of Ecosystem Services

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Abstract. As the early stage of land planning and resource management, the evaluation of land use suitability provides a scientific basis for rational and effective use of limited land resources. This paper takes Chang’an District of Xi’an City, Shaanxi Province as an example, and the key of ecosystem services was taking as an important factor for developing the evaluation system of the suitability of construction land. The results show that the area of the highly suitable construction land in Chang’an District is 766.03 km², accounting for 48.18% of the total study area. The forbidden construction area is 585.00 km², accounting for 36.79%. Moderately suitable and low suitable construction regions account for 15.03%. The suitable construction regions are concentrated in the northern part of Chang’an District, which is suitable for large-scale development of cities and towns. The moderately and low suitable regions are mainly distributed along the northern foot of the Qinling Mountains. The Qinling Mountains have importance level of ecosystem services, which mostly are forbidden construction regions. The research results will provide a scientific reference for regional construction and development.

1. Introduction

In the 1960s, McHarg proposed a land suitability evaluation method, aiming at emphasizing the rational use of land. As a preliminary work of urban planning, the evaluation of land use suitability can avoid unplanned use of land and meet the harmonious and sustainable development of the city. Domestic scholars have made a lot of research on the evaluation of the suitability of construction land, and proposed a variety of methods and rich indicator systems. From the research scale, the suitability evaluation is mostly based on large region such as river basins and cities [1-3]. From the selection of evaluation factors, most of the factors selected in previous studies are natural factors and socio-economic factors, but insufficient consideration of ecosystem services[4-6]. According to the major function regionalization of Shaanxi Province, the northern foot of the Qinling Mountains has an important water source conservation function. As an important water source in Xi’an, it maintains the sustainable development of social economy. Based on the actual situation of the study region, under the constraints of key of ecosystem services[7], the evaluation of the suitability of construction land in Chang’an District, Xi’an City, Shaanxi Province, provides a scientific basis for the rational use of existing land resources.
2. Study area
Chang’an District is located at 108°38′-109°14′E and 33°47′-34°18′N. It is located in the Guanzhong Plain and the north of the Qinling Mountains. Chang’an District is under the jurisdiction of Xi’an City and contains 24 townships with a total area of 1590 km² (Fig. 1). It belongs to warm temperate semi-humid continental monsoon climate. Average annual precipitation is about 600mm, and the precipitation concentrates in July, August and September. The main rivers are the Fenghe River and the Chanhe River, all of which belong to the Weihe River system. The terrain in the region is low in the northwest and high in the southeast. It has excellent location and convenient transportation.

3. Research method and data sources

3.1. Research method
This paper constructed the corresponding evaluation index system and assigned values to each evaluating factor, in which indicators in the same level were compared to each other by using the analytic hierarchy process (AHP) for getting the objective weights. Then, the value and weight of each indicator was overlapped based on the spatial analysis in GIS. Finally, we divided the appropriate grades which was taken as the suitability evaluation on construction land according to the requirements for suitability assessment of construction land in urban planning combined with the revelent literatures.

3.1.1 Construction of evaluation index system
Under the constraint of the key of ecosystem services, this paper refers to relevant research content [8], citing urban planning and related regulations and standards, accounting the current status and functional positioning of natural conditions in Chang’an District, according to needs (evaluation work needs) and possibilities (indicators Data availability), 8 evaluation factors were selected, namely (1) slope; (2) nature reserve; (3) water source protection region; (4) geological disaster susceptibility; (5) water conservation (6) biodiversity conservation; (7) land use status; (8) traffic accessibility. The evaluation index system is divided into four levels, namely, forbidden construction land, low suitable construction land, moderately suitable construction land and highly suitable construction land [9-10], and the corresponding quantitative scores respectively are 1 point, 4 points, 7 points, and 10 points (Table 1).

3.1.2 Obtain weight by AHP method
In this paper, the AHP method is used to determine the index weights by inviting experts to subjectively score the selected evaluation factors, summarizing the results and obtaining the weight score according to the mathematical model (Table 2). The greater the weight is,
the greater the influence on the suitability of urban development and construction is. The smaller the weight is, the less influence the suitability on the suitability evaluation is [11].

3.1.3 Evaluation model and evaluation level

In this paper, the calculation model for the suitability evaluation of construction land is:

\[ S = \sum_{i=1}^{m} w_i \cdot x_i \]  

(1)

Within: \( S \) is the comprehensive score of the suitability evaluation of construction land
\( m \) is the number of evaluation factors
\( w_i \) is the i-th factor weight
\( x_i \) is the score assigned to the i-th factor

The spatial superposition analysis technique is used in ArcGIS to perform weighted operations, and the natural breakpoint method is used to classify the comprehensive results of construction land suitability.

Table 1. The factors grade dividing criterion of construction land suitable evaluation in Chang'an district

| Influencing factor | Evaluation factor | Forbidden construction land (1 point) | Low suitable construction land (4 points) | Moderately suitable Construction land (7 points) | Highly suitable Construction land (10 points) |
|--------------------|-------------------|-------------------------------------|------------------------------------------|-----------------------------------------------|--------------------------------------------|
| Natural factor     | slope             | ≥25°                                | 15°-25°                                  | 8°-15°                                       | ≤8°                                       |
| Water source protection region | Primary protection zone | Secondary protected region | Tertiary protection region | Other regions |
| Nature reserve | core region | Buffer region | Experimental region | Other regions |
| Geographical disaster susceptibility | High-prone region | Medium-prone region | Low prone region | None-prone region |
| Ecosystem services | Water conservation | Extremely important | important | Generally important | Generally important |
| Biodiversity conservation | Extremely important | important | Generally important | Generally important |
| Socioeconomic factor | Land use status | Wetlands(lakes, Reservoir/pit pond, river), woodland/Deciduous broad-leaved forest, Coniferous and broad-leaved mixed forest, Deciduous broad-leaved shrub forest | Woodland (evergreen coniferous forest, deciduous forest, other (bare rock)) | Woodland(deciduous coniferous forest, evergreen broad-leaved shrub forest, sparse forest), grassland (grass, sparse grassland), other (bare soil) | Cultivated land (paddy fields, dry land), artificial surface (construction land, traffic land), grassland/herbal grassland) forest land(arbor field, shrub green land) |
| Traffic accessibility | >2000m | 1200-2000m | 600-1200m | ≤600m |

Table 2. Weight of evaluation index

| Index | Weight | Primary indicators and weights | Secondary indicators | Secondary indicator weight |
|-------|--------|--------------------------------|----------------------|---------------------------|
| Natural factor (0.143) | | slope | 0.285 |
| | | Water source protection region | 0.167 |
| | | Nature reserve | 0.115 |
| | | Geological hazard susceptibility | 0.433 |
| Ecosystem services (0.577) | | Water conservation | 0.689 |
| | | Biodiversity conservation | 0.311 |
| Socioeconomic factor (0.280) | | Land use status | 0.367 |
| | | Traffic accessibility | 0.633 |
3.2 Data Sources
The basic evaluation data includes Chang'an District administrative division data, DEM data, and 2015 land use status data. The DEM data is derived from the geospatial data cloud website (http://www.gscloud.cn/). The classification of land use status is derived from the national ecological condition remote sensing survey and evaluation results [12], nature reserve, water source protection region and Geological disaster susceptibility is obtained through vectorized maps. The key of water and biodiversity conservation is based on the assessment method in the national guidelines of the ecological red lines[13]. The traffic accessibility factor is graded based on roads with accessibility, and buffers are generated using the buffer analysis tool in ArcToolbox.

4. Result analyses

4.1 Single factor evaluation result of construction land suitability
The slope factor is one of the important factors for the evaluation of the suitability of construction land. The space with a slope of 25° or more is mostly distributed in the Qinling Mountains, which has obvious restrictions on the choice of construction land. The slope less than or equal to 8° is laid out in the north of Chang'an District. The regions with a slope between 8° and 25° also have a certain degree of restriction on the choice of construction land, and need to be transformed into a construction land through certain engineering transformation(Fig.2-a).

Water is an important factor in maintaining ecosystem balance in urban construction. In accordance with the requirements of the Water Pollution Prevention and Control Act, the water source protection region in Chang'an District is the Shibianyu Reservoir, which is divided into the first-level protection region of the water region, the first-level protection region of the land region, and the second-level protection region of the land region (Fig.2-b). The low suitable construction area is 0.97km², and the forbidden construction is 0.47km². It is located in the first-level protection zone of the waters, and the region out of the scope of the water source protection zone is relatively more suitable.

As an important resource in a region, the nature reserve has a greater restriction on the suitability evaluation. According to the Regulations of the People’s Republic of China on Nature Reserves, the main nature reserve in Chang'an District is the Niubeiliang National Nature Reserve, which is mainly divided into core region, buffer area and experimental region. The suitability of these regions is enhanced (Fig.2-c). The moderately suitable construction area is 23.73km², the low suitable construction area is 27.23km², and the forbidden construction area is 13.69km². The rest are highly suitable construction regions.

The susceptibility to geological disasters is one of the main factors for the evaluation of the suitability of construction land. The geological disasters are mainly located in the Qinling mountainous region on the south side of Chang'an District. Therefore, the evaluation of the suitability of construction land on the south side of Chang’an District has certain restrictions, while the north side is mostly plain, and the probability of occurrence of geological disasters is small, so the suitability is relatively higher (Fig.2-d).
Ecosystem services are the basis for maintaining sustainable social and economic development, and have an important impact on the development of the region itself and the entire region. According to Fig.3-a and Fig.3-b, the most important regions of biodiversity and water conservation are mainly distributed in the Qinling region, while the general importance is distributed in the north of the Qinling Mountains, which leads to the low suitability for urban construction activities of the Qinling region.

The grading results of the suitability of land use status show that the south of Chang'an District has low suitability and the northern part have relatively high suitability except for some regions (Fig.3-c).

According to the data, the region of Chang'an District, land area 2,000 meters away from the traffic line is 398.68km², and the area within 600 meters of the traffic line is 690.46km². Highly suitable regions are mainly distributed in the plain region (Fig.3-d).

4.2 Spatial pattern of construction land suitability
From the results of the evaluation of the suitability of construction land (Fig.4), Chang'an District overall presents the characteristics that the south are not suitable but the north is. The north area of the Qinling Mountains is not suitable construction regions, which has a large slope and poor construction conditions. At the same time, there are nature reserve and water source protection region. Therefore, there are a few highly suitable construction regions.

The area highly suitable for construction is 766.03km², accounting for 48.18%. It has the largest proportion of the four grades and is mostly distributed in the northern plains. These regions are concentrated and connected. The agglomeration effect is obvious. The terrain is flat. It is close to the downtown. It has convenient traffic conditions, suitable slope, and will not be harmed by geological disasters. It is most suitable for large-scale development of cities and towns.
The area of moderately suitable construction and low suitable construction are 72.55 km² and 166.51 km², respectively accounting for 4.56% and 10.47%. Compared with highly suitable construction regions the two types of construction regions account for a relatively low proportion and mainly distribute along the northern foot of the Qinling Mountains. Affected by various restrictive factors such as mountains and rivers, the landforms are relatively complex with respect to plains. Due to the influence of topography and slope, large-scale urban construction cannot be formed, and it needs to be transformed after certain engineering.

The forbidden construction area is 585.00 km², accounting for 36.79%. This part of the region cannot be constructed due to some rigid factors, and it is easy to cause damage to nature and ecological environment. It has extremely important level of water and biodiversity conservation. The region has nature reserve and water source protection region. At the same time, the slopes are large, and most are forest land, and are also more susceptible to geological disasters. Traffic is not convenient enough, either. Therefore, construction in this region is prohibited, and the protection of ecological environment should be strengthened.

![Fig.4.Construction Land Suitability Evaluation Result Chart of Chang'an District](image)

5. Conclusion and discussion

5.1 Conclusion
The total area of the highly suitable construction in Chang'an District is 766.03 km², accounting for 48.18%. The highly suitable construction regions of Chang'an District are mainly distributed in the northern part of Chang'an District. These regions are relatively flat, with convenient traffic conditions, and good foundation, will not be affected by landslide, collapse and other geological disasters.

The total area of moderately suitable construction and low suitable construction is 239.06 km², respectively accounting for 15.03%. The moderately suitable construction and low suitable construction regions are mainly distributed along the Qinling Mountains. The moderately suitable regions scatter in the eastern Guanzhong Plain. The low suitable regions in the Qinling Mountains are mainly distributed along the river and along the highway.

The Qinling Mountains is mainly forbidden construction with an area of 585 km², accounting for 36.79%. This region is the main water source conservation region and biodiversity habitat in Chang'an District, which plays an irreplaceable role in maintaining regional socio-economic development water demand and ensuring ecological security.

5.2 Discussion
Due to the size of the city and the scarcity of mountains, rivers, lakes, etc., the illegal construction of mountain houses, farmhouses, etc. occurs and has caused great damage to the environment and irreparable damage to the ecosystem. Therefore, environmental protection has become the top task of the urban construction activities. As a national and regional ecological security barrier, Qinling has a
variety of ecological service functions and rich biodiversity resources. The supervision and control of the Qinling Mountains should be strengthened and the ecological protection red line should be delineated in order to protect the biodiversity and ecological environment of the Qinling Mountains. In the evaluation of the suitability of construction land, the region should be considered first, and the region should be kept away from the ecological protection region to avoid damages.

There are still some limitations in the evaluation results of this paper. The evaluation results of the suitability of construction land are not absolute. The degree of suitability depends on various factors such as capital status, technical conditions and land resources. Due to the lack of a unified evaluation grading standard, the selection and assignment of suitability evaluation factors are subjective [14], and the evaluation results are only suitable under certain conditions.

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