Diagnosis of Land Use Potential Conflict Based on DSE Model

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Abstract. Diagnosis of potential land use spatial conflicts plays an important role in land use spatial planning and regional spatial control. Taking Daye city as an example, a DSE diagnostic model is established from the three-dimensional perspectives of land adaptability, socio-economic driving force and ecosystem service value. Social-economic driving force is characterized by per capita net income of farmers, population density and night light data. Ecosystem service value is modified by illumination and soil erosion. The results show that the areas of extreme conflict, high conflict and moderate conflict in Daye are 28.43 km², 137.12 km² and 595.32 km², respectively, accounting for 1.82%, 8.75% and 38.01% of the total area; the areas of extreme conflict are mainly distributed around the main urban area of Daye, while the areas of high conflict are widely distributed around the main urban area and town centers. The results accord with the actual situation of Daye.

Introduction

Land use conflict refers to the contradiction between different land users in the use of land resources, land assets or land space[1]. Land use conflict is caused by the competition of scarce land resources[2], which is affected by the limited and multi-functional land resources. With the continuous development of industrialization and urbanization, land resources are becoming more and more intense, and land use conflicts are becoming more and more intense[3], which hinders the sustainable development of land use and harms the social, economic and ecological environment[4].

In view of land use conflict, some researchers have made useful explorations on conflict types[5], conflict causes[6], conflict evolution process and characteristics[7], conflict intensity assessment[8], and conflict mitigation mechanism[9]. In recent years, the spatial location identification of land use conflicts has become a research hotspot. W. Chen[10] diagnosed the conflict between cultivated land and construction land from the perspective of suitability; N. Ran[11] also considered the goal of “ecology-production-economy” comprehensively from the perspective of suitability, and discriminated the conflict mode of land use combination; Q. Li[12] considered the driving forces on the basis of suitability. The improved LUCIS conflict identification model was used to analyze the potential conflicts among construction, agriculture and ecological land use in desert areas. These studies are of great practical significance in diagnosing land use spatial conflicts and promoting the rational allocation of land resources.

This paper analyses the spatial conflict of land use from three levels: Drive, Suitability and Ecological Value, establishes a DSE discriminant model which can provide reference for the diagnosis and regional spatial control of potential spatial conflict of land use in Daye City.

Data Sources

Land use status map comes from Daye Land and Resources Bureau; soil map comes from soil and Fertilizer Station of Hubei Agriculture Department; digital elevation model (DEM) comes from geospatial data cloud of Chinese Academy of Sciences with spatial resolution of 30 m; DMSP_OLS night light data comes from NGDC website of National Oceanic and Atmospheric Administration of the United States.
Research Methods

Multi-objective Suitability Evaluation System

In the process of industrialization and urbanization of Daye City, the encroachment of a large number of agricultural land and the blind expansion of construction land are the main manifestations of land use spatial conflicts.

Following the principles of scientific, dominance, stability and availability, five factors are selected as evaluation indexes for agricultural use such as soil thickness, soil texture, soil acidity and alkalinity, slope and water resources guarantee degree. And four factors are selected as evaluation indexes for construction use such as central town influence degree, road accessibility degree, slope degree and geological hazard influence degree. The index weight is determined by AHP.

| Purpose                      | Evaluation Factor | Weight | Factor Value | Function Score | Factor Value | Function score |
|------------------------------|-------------------|--------|--------------|----------------|--------------|----------------|
| Agriculture                  | Soil thickness    | 0.22   | >=40         | 100            | 25-40        | 80             |
|                              |                   |        | 15-25        | 60             | <15          | 20             |
|                              | Soil texture      | 0.26   | Medium loam  | 100            | Light loam   | 80             |
|                              |                   |        | Sandy soil and heavy soil | 60 | Clay and sandy soil | 30 |
|                              | Soil acidity and alkalinity | 0.12 | 6.5-7.5 | 100 | 5.5-6.5, 7.5-8.0 | 80 |
|                              |                   |        | 4.5-5.5, 8.0-8.5 | 50 | >8.5, <4.5 | 30 |
|                              | Slope             | 0.15   | <=6          | 100            | 6-15         | 80             |
|                              |                   |        | 15-25        | 50             | >25          | 1 votes veto   |
| Water Resources              |                   | 0.25   |              |                |              |                |
| Construction                 | Influences of Central Cities | 0.32 | Determine by the method described herein |
|                              | Road accessibility| 0.25   | Determine by the method described herein |
|                              | Slope             | 0.12   | <=6          | 100            | 6-15         | 90             |
|                              |                   |        | 15-25        | 70             | >25          | 40             |
|                              | Geological hazard impact | 0.31 | Determine by the method described herein |

(1) Central Town Influences: The impacts of central cities are divided into two categories: urban impacts and township impacts, which represent the impacts of the main urban area of Daye and the town where the local government is located. The formula is as follows:

\[
E_j = 100 \times \frac{e_j}{e_{j_{-max}}} \quad (1)
\]

\[
e_j = \sum_{i=1}^{m} e_{ij} \quad (2)
\]

\[
e_{ij} = f_i \left(1 - \frac{d}{D}\right) \quad (3)
\]

In the formula: \(E_j\) is the central town influence score of evaluation unit j, with a score range of (0,100); \(e_j\) is the cumulative effect score of evaluation unit J affected by all central towns; \(e_{j_{-max}}\) is the maximum cumulative effect score of all evaluation units affected by central towns; \(e_{ij}\) is the role score of evaluation unit j affected by central town i; D is the actual distance from evaluation unit to town center i; D is the service radius of the town center i.

(2) Road accessibility: Road accessibility reflects the degree of transportation convenience of the evaluation unit and it’s a characterization index of the location conditions. The calculation method...
of road accessibility is similar to the influence degree of central cities. The radius of road service is determined by $D = \frac{S}{2L}$. $S$ is the road service area and $L$ is the total length of road. The functions of roads can be divided into three types: national road, County road, and Township Road. According to the width and speed of various roads, the functions of roads can be divided into 100, 58, and 27 respectively. The linear attenuation mode is adopted for the functional sub-attenuation.

(3) Geological hazard impact degree: There are 115 geological hazard sites in Daye City, including collapse, landslide, collapse, debris flow, and unstable slope. Their distribution is mainly affected by stratum lithology, topography, and human engineering activities. Because of the variety of geological hazards and the complexity of their causes, considering that the existing geological hazards have been basically harnessed and monitored, this paper simplifies the impact of geological hazards on land use, and assigns 30, 50, and 80 points for [0,0.3], (0.3,0.5], (0.5,1] intervals (km) respectively, and 100 points for those over 1 km.

(4) Water Resources Guarantee Degree: Taking rivers, lakes, and reservoirs with stable water sources as buffer zones and assigning points, the total score of the evaluation unit was normalized and assigned according to the highest 100 points. Among them, rivers and lakes are allocated 100, 80, and 50 points per unit km, respectively, and those over 3 km are allocated 0 points.

The formula for calculating the comprehensive score of the evaluation unit is as follows:

$$F = \sum_{i=1}^{n} e_i \times \omega_i$$

In the formula: $F$ is the comprehensive score of the evaluation unit; $n$ is the number of evaluation factors; $e_i$ is the function score of factor $i$; $\omega_i$ is the weight of factor $i$.

**Drive Force**

Land resource suitability and limited supply are the root causes of conflict, and population and economic growth are the main driving forces of conflict[13]. In this paper, the net income per capita of farmers, night light data, and population density are selected to represent the driving forces of population and economic growth. The former two can better characterize the level of urbanization and economic situation[14], which is a good reflection of regional industrialization and urbanization; population density reflects the pressure of population demand.

The night light data assignment is determined by $E_j = 100 \times \left( \frac{OLS_j}{OLS_{j-max}} \right)$. In the formula, $OLS_j$ is the night light data value of the evaluation unit $j$, and $OLS_{(j-max)}$ is the maximum value of the night light data of the area. Population density is obtained by kernel density interpolation (POI) of interest points, so that population density can be implemented into each evaluation unit. The formula is as follows:

$$POI = \sum_{i=1}^{n} \frac{1}{D^2} \times \frac{X - C_i}{D} \times K$$

In the formula: $POI$ is the core density value of the evaluation unit; $i$ is the point of interest; $K$ is the spatial weight function of the point of interest; $(X - C_i)$ is the distance from the evaluation unit $X$ to $i$; $D$ is the service radius of interest points.

**Table 2. Driving force indicators.**

| Index                           | Weight | Classification | Function score |
|---------------------------------|--------|----------------|----------------|
| Per capita net income of farmers| 0.26   | <=3600         | 50             |
|                                 |        | 3600-4000      | 60             |
|                                 |        | 4000-5000      | 80             |
|                                 |        | >5000          | 100            |
| Night light data                | 0.53   | After normalization, the maximum score is 100. |
| Population density              | 0.21   | Using nuclear density interpolation |

**Value of Ecosystem Services**

Most of the estimation of ecosystem service value refers to Costanza's method. G. D. Xie revised Costanza's benchmark unit price of ecosystem service according to China's national conditions, and
put forward the equivalent scale of service value per unit area of terrestrial ecosystem in China. Based on the value table of ecosystem services per unit area in the middle reaches of the Yangtze River obtained by S. H. Yang[15], this paper divides ecosystem services into material product functions, ecological security maintenance functions and recreational and cultural functions. For cropland, woodland, grassland and other ecosystems dominated by plant photosynthesis, light conditions largely determine the potential of their material product functions, while soil erosion can reflect the size of ecological security maintenance functions. Therefore, illumination correction factor and erosion correction factor are introduced to modify the material product function and ecological security maintenance function of cultivated land, woodland and grassland respectively. The formulas are as follows:

$$ESV = ESV_{mp} \times \varphi_1 + ESV_{es} \times \varphi_2 + ESV_{al}$$  \hfill (6)

In the formula: $ESV_{mp}$, $ESV_{es}$ and $ESV_{al}$ respectively represent the material product function, ecological security maintenance function and recreational cultural function. $\varphi_1$, $\varphi_2$ represent the light correction factor and the land erosion correction factor.

Sunshine hours play an important role in the quality of plants, and are the main indicators of total solar radiation. The model of illumination correction factor is established as follows:

$$\varphi_1 = \frac{DI_j}{DI_{mean}}$$  \hfill (7)

In the formula: $DI_j$ is the annual sunshine hours of the grid $j$; $DI_{mean}$ is the average annual sunshine hours of all the grids of the same kind. The formula for calculating annual sunshine hours is as follows:

$$DI = DI_S \times S = \frac{(\omega_2 - \omega_1) \times 180}{15\pi}$$  \hfill (8)

In the formula: $DI$ is annual sunshine hours; $DI_S$ is annual sunshine hours; $S$ is annual sunshine percentage, which is estimated by regression model of longitude, latitude and altitude obtained by W. H. Huang[16]; $\omega_2$ and $\omega_1$ are sunrise and sunset hours respectively, which are determined by the estimation method proposed by Sun Q. Han [17].

The model of soil erosion correction factor is as follows:

$$\varphi_2 = \frac{A_j}{A_{mean}}$$  \hfill (9)

In the formula: $A_j$ is the soil erosion amount of grid $j$; $A_{mean}$ is the average soil erosion amount of the same kind of land. The general soil erosion equation (RUSLE) was used to estimate the amount of soil erosion.

$$A = R \times K \times LS \times C \times P$$  \hfill (10)

In the formula: $A$ is the amount of soil loss; $R$ is the factor of rainfall erosivity; $K$ is the factor of soil erodibility; $LS$ is the topographic factor, in which $L$ is the length of slope, $S$ is the slope; $C$ is the cover factor; $P$ is a factor of soil and water conservation, where cultivated land, woodland and grassland are 0.25, 0.60 and 0.45, respectively.

**Results**

The results of adaptability evaluation were graded by natural breakpoint method, and the spatial distribution map of suitability was obtained (figure 1, figure 2).
Conflict identification matrix based on suitability was constructed (table 3), and the preliminary results of land use conflict discrimination in Daye City were obtained (figure 3).

Table 3. Conflict Preliminary Discrimination Matrix Based on Suitability.

| Suitability of construction | Suitability of cultivated land |
|---------------------------|-------------------------------|
| High(P3)                  | High(G3)                      |
| Moderate(P2)              | Moderate(G2)                  |
| Low(P1)                   | Low(G1)                       |
|                           | $S_3(G3P3)$                   |
|                           | $S_2(G2P3)$                   |
|                           | $S_1(G1P3)$                   |
|                           | $S_3(G3P2)$                   |
|                           | $S_2(G2P2)$                   |
|                           | $S_1(G1P2)$                   |
|                           | $S_3(G3P1)$                   |
|                           | $S_2(G2P1)$                   |
|                           | $S_1(G1P1)$                   |

According to the DSE (figure 4) analysis model, driving force and ecosystem service value are introduced to correct the preliminary discrimination results of conflict. S1, S2 and S3 represent the low, medium and high intensity of initial conflict, D1, D2 and D3 represent the small, medium and large driving force respectively, and E1, E2 and E3 represent the low, medium and high value of ecosystem service respectively. This paper divides it into five types: minimal conflict, Low degree, moderate, height, extremely high.

The data shows that extremely strong conflict zones is 28.43 km$^2$, accounting for 1.82% of the total area, moderate conflict zones is 137.12 km$^2$, accounting for 8.75%. The distribution of potential spatial conflicts is shown in Figure 5. The extremely strong conflict zone is around the main urban area of Daye, including the existing woodlands of Jin Shan, Luo Qiao and Dong Yue streets, as well as the woodlands of Chen Gui, Jin Niu, Liu Renba and other township governments; the highly conflict zone is widely distributed, and it is distributed around the main urban area and around the town center.

**Conclusions**

1. DSE model can synthetically discriminate potential spatial conflicts of land use from three-dimensional perspectives of land adaptability, socio-economic driving force and ecosystem service value, which can better reflect the causes and nature of conflicts.
(2) The multi-objective suitability evaluation system of Daye City was established, as well as characterizing socio-economic driving forces with per capita net income of farmers, population density and night light data. Based on the model and method of correcting ecosystem service value by illumination condition and soil erosion, the discriminant matrix of potential spatial conflict of land use based on DSE is formed. The results basically conforms to the actual situation of Daye.

(3) The causes of land use spatial conflicts are complex and have spatial heterogeneity and scale effect. It is necessary to strengthen the study of spatial heterogeneity and multi-scale (macro-meso-micro) coupling.

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