# Research in Crop Land Suitability Analysis Based on GIS

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**Abstract:** This paper based on GIS land suitable assessment principle and method, use supermap to analysis suitability of crop land of liao city. The suitability of comprehensive analysis was conducted in Study area for three crops .First, choosing representative and having the same impact the suitability of natural factors and social economic factors of the three kinds of crops; Then, interpolation and empowerment of overlap and analysis in supermap, and the appropriate level of land were classified according to land on crops. Thus can adjust measures to local conditions to crops layout and farming system reform and adjustment, the biggest production potential play land. Experimental results show that in the complex crop suitability assessment process, GIS is an effective, possiblel means.

**Keywords:** crop land; Suitable assessment; The geographic information system

## 1. Introduction

The land suitable assessment is to evaluate the suitability for a certain purpose land suitable degree of process. Through the comprehensive analysis of natural factors and the social economic factors which have influence on the land, divide the land into some level according to the suitability under the specified way, in order to show that the appropriateness of appropriate degree for a variety of use .At present, the wide application of GIS in land suitable assessment, make land suitable assessment more flexible, science. A single use land suitable assessment has been much attention, but evaluation basically all around economic crop, lack major crops on land suitability analysis research[1~3].

Liao city located in the western of shandong province, north latitude 35 ° 47 '-37 °, 03 ° east longitude'115°16′-116°30′, the total area is 8590 square kilometers ,the city is in the Yellow River alluvial plain, flat and tilt from southwest to northeast, average rail slope is about 1/7500, altitude is 27.5 -49.0 meters， belong to temperate and monsoonal climate area, has the remarkable season change and monsoon climate characteristics, belong to semi-arid continental climate. Large land degrees is for 62.8 -64.8, dry degree is in 1.7 -1.9. Overall, agricultural climate resource is more abundant and suitable for growing DuoZhong crops. The climate resources is also rich and from the Yellow River water for irrigation, the climate for DuoZhong crops has better adaptability, therefore, the planting industry has a long history, become the main crops north China cotton, wheat, corn on the region[2~5]. Due to the different influence on the land in liaocity of each factor differences,

And with the quickening of the process of urbanization, unreasonable planting and reclamation, so as to make the land resources will not be used reasonably, efficiently. This paper discuss how to apply GIS t0 crop land the suitability analysis in liaocity.

## 2. research methods

The research area (HuangFanOu)of this paper is located in north China plain, the main crops are wheat, corn and cotton. The region in the terrain, sunshine and rainfall, some natural factors change caused by small scale, the requirements of the conditions of land crop of great similarity, that is, in this regions have three crops in the suitability of basic level is consistent. Based on this law, this paper this can be three crops suitability degree analysis. First, choose is representative of the three kinds of crops, to have the same impact the suitability of natural factors and social economic factors; Then, in supermap interpolation, and empowerment of overlap and analysis, and according to land on crops, the appropriate level of land were classified. Thus can adjust measures to reform and adjustment for local conditions to crops layout and farming system, play the biggest production potential of land and create conditions for the rational utilization of land include making land planning.

## 3. evaluation factors selected

Land suitability level of each assessment unit is a comprehensive effect of Comprehensive role, reasonable choice of evaluation factors is the premise to ensure the suitability of the land quality, therefore, in selecting a factor should be followed in several principles

Leading-the main factor restricting the use of land.

Difference-choosing the factors which have obvious difference and can appear near the value in the study area.

Independence-each factors can't appear causality.

The possibility-factors must have the corresponding information.

According to the above principles, this paper selects 5 major factor as a land of liao city suitable assessment factors, namely: soil types (the class), soil texture, buried deep underground water level, soil fertility and soil pollution, among them soil fertility was expressed through the organic matter, total nitrogen, alkali solution nitrogen, rapidly-available phosphorus and potassium, soil pollution was expressed through the cadmium, mercury, lead, arsenic, chromium and copper six kinds of heavy metal. Through these five factors, we will get soil type distribution, soil texture map, buried deep underground water level distribution, soil fertility distribution, soil pollution distribution, then, this five distribution empowerment overlap add to get comprehensive evaluation distribution , and then get comprehensive evaluation distribution based on the land suitability of crops degree.

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# 4 The experiment

## 4.1 data preparation

1、 First, find a paper map, the map evenly distributed sampling points, then conduct field sampling according to the sample point distribution and the needed factor data.

2、Through the scanner, scanning liao city land map and forming grid data, using this grid data as a screen for reproduction, working in a vectorial. After scanning ,the grid data was stored for JPG format. Then use PhotoShop to pretreatment grid data ,improve the contrast of raster images and other quality, in order to improve the quality and efficiency of the vector .

3、Map in digital and attribute editor in supermap, getting sample point distribution (figure 1).

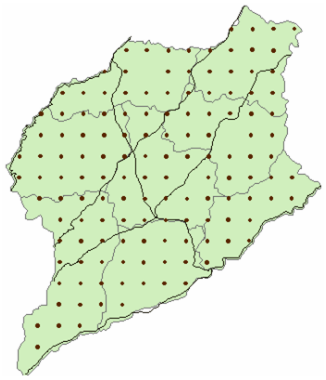

**Figure 1 sample point distribution**

## 4.2 suitability analysis process

1、soil type analysis

(1) First, score different soil types (table 1), then build " Soil types _v" column in the sample point data attributes list, the value is listed in table 1 for the "score". Set up the analysis environment.

**Table 1 soil type allocation**

| Soil types | score |
|---|---|
| Sand soil meadow | 1 |
| Meadows solonchak | 1 |

| | |
|---|---|
| Alluvial soil | 1 |
| solonchak | 1 |
| Chao soil salinization | 2 |
| Alkalize chao soil | 2 |
| Damp soil | 3 |
| Take off the tide soil | 3 |
| Chao soil | 4 |

(2) Choosing inverse distance square weights interpolation method to do interpolation analysis of soil types, making special charts to get soil type distribution (figure 2).

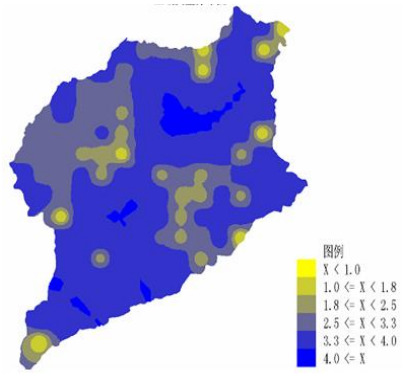


**Figure 2 soil type distribution**

2、the soil texture analysis

As for soil types analysis, first of all expert scoring (such as table 2), and then build " Soil types _v" column in the sample point data attributes list, the value is listed in table 2 for the "score". Finally interpolation soil texture map obtained (figure 3).

**Table 2 score soil texture**

| Soil texture | score |
|---|---|
| Soil mass sand | 1 |
| Clay soil mass | 1 |
| Stick loam accounting | 2 |
| Sandy loam stick | 2 |
| Sticky loam | 2 |
| Sandy loam | 3 |
| loam | 4 |

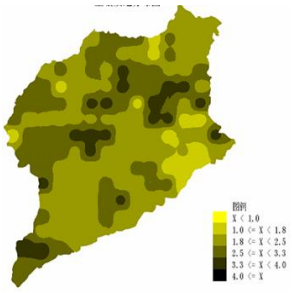

**Figure 3 soil texture map**

3、groundwater depth analysis

According to the underground water level in the region, score suitability of major crops (table 3), then interpolation analysis in the supermap and get in groundwater depth distribution, according to table 3 classify the buried depth of underground water level distribution, get buried depth underground water level classification figure (figure 4).

**Table 3 Groundwater depth allocation**

| Buried deep underground water level（m） | score |
|---|---|
| 2 – 10 | 4 |
| 10 – 30 | 3 |
| 30 – 50 | 2 |
| 50 – 60 | 1 |

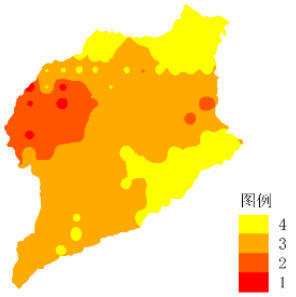


**Figure 4 buried deep underground water level classification figure**

4、 soil fertility analysis

(1) The soil fertility index system

Content of soil organic matter, the soil of nitrogen, phosphorus and potassium, etc fertility factor is the important influence factors of soil fertility and assessment of soil fertility changes, not limited to individual single fertility factors.

Therefore, we combined with the local cropping system and the requirements of the fertility of the soil, the choose organic matter, total nitrogen, alkali solution nitrogen, phosphorus and phosphorus rapidly-available potassium as soil fertility evaluation index, and obtains the single soil fertility index level (table 4).

**Table 4 soil fertility index level**

| Organic matter （g/kg） | Total nitrogen （g/kg） | Alkali solution nitrogen （ppm） | Rapidly-available phosphorus （ppm） | Rapidly-available potassium （ppm） | level |
|---|---|---|---|---|---|
| 0.329 – 0.6 | 0.018 – 0.05 | 20.65 – 30 | Null | 6.45 – 30 | 6 |
| 0.6 – 1 | 0.05 – 0.075 | 30 – 60 | 3.8 – 5 | 30 – 50 | 5 |
| 1 – 2 | 0.075 – 0.1 | 60 – 90 | 5 – 10 | 50 – 100 | 4 |
| 2 – 2.1072 | 0.1 – 0.1372 | 90 – 120 | 10 – 20 | 100 – 150 | 3 |
| Null | Null | 120 – 123 | 20 – 40 | 150 – 200 | 2 |
| Null | Null | Null | 40 – 79 | 200 – 331 | 1 |

(2) the index weight determination

The index weights mean every soil fertility factor refer to comprehensive fertility soil of contribution. It is the key issue of comprehensive evaluation of fertility how to determine the weight of single fertility index. This paper represents the weight of each index by the analysis of correlation coefficient between each index. Calculation method is: first it calculates the correlation coefficient of single fertility index with SPSS software (table 5), and then it calculates average value （$\bar{r}$） of the correlation coefficients of a fertility index and other fertility index. And it uses the average of all fertility index correlation coefficient average absolute value and the sum total （$\sum \bar{r}$） ratio （$\bar{r}/\sum \bar{r}$） as the single fertility index in soil fertility of the comprehensive contribution value or weight (table 6)

**Table 5 correlation coefficient**

| | Organic matter | Total nitrogen | Alkali solution nitrogen | Rapidly-available phosphorus | Rapidly-available potassium |
|---|---|---|---|---|---|
| Organic matter | 1 | | | | |
| Total nitrogen | 0.959 | 1 | | | |
| Alkali solution nitrogen | 0.035 | 0.076 | 1 | | |
| Rapidly-available phosphorus | -0.0 | -0.38 | 0.563 | 1 | |
| Rapidly-available potassium | 0.036 | 0.92 | 0.222 | 0.137 | 1 |

**Table 6 each fertility index correlation coefficient and weight**

| Fertility index system | Correlationcoefficient average | Weight coefficient |
|---|---|---|
| Organic matter | 0.238 | 0.192 |
| Total nitrogen | 0.394 | 0.316 |
| Alkali solution nitrogen | 0.224 | 0.180 |
| Rapidly-available phosphorus | 0.06 | 0.048 |
| Rapidly-available potassium | 0.329 | 0.264 |

(3) Soil fertility changes evaluation

According to the results of the above and the application of the soil quality index and method, it quantitative reveals different areas of comprehensive fertility changes computation formula is:

$$IFI = \sum(W_i \times I_i)$$

Among them, for soil fertility index IFI comprehensive, Wi said each single evaluation indexes weights, Ii for each single evaluation index level, so, the size of the values IFI said the comprehensive soil fertility levels. And according to the change of the value range, IFI will soil fertility is divided into four levels (table 7), and then based on the above analysis and calculation get soil fertility grading figure (figure 5)

**table 7 soil fertility level**

| IFI | ≥5 | 4 – 5 | 3 – 4 | ≤3 |
|---|---|---|---|---|
| The soil fertility level range | 1 | 2 | 3 | 4 |

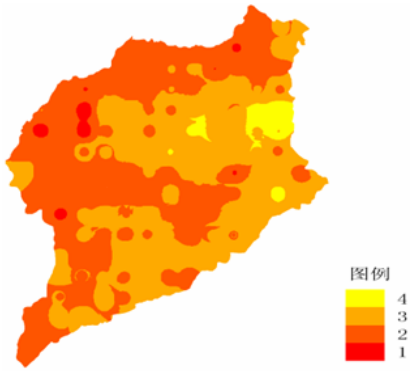


**Figure 5 soil fertility grading figure**

## 5、 soil pollution analysis

At present heavy metal pollution of the cultivated land area accounts for about 1/5 of the total area of arable land in China, every year because of pollution land it cuts food about 10 million Ton , and another 12 million Ton food pollutants exceed standard, both of them the direct economic loss are more than 20 billion RMB. The soil pollution are provided with latent, hysteresis, cumulative, not reversible and difficult management. through the analysis of the data acquisition, data and expert consultation, we think it's scientific and reasonable that the soil pollution as important factor. We use six heavy metals such as mercury, cadmium, lead, arsenic, chromium and copper to show pollution of soil condition in this analysis. According to each of the mean and the maximum metal content and the maximum value of elements, it calculates the heavy metal pollution index (nemero index), formula is:

$$P_g = \sqrt{\frac{(\frac{C_i}{L_i})^2_{最大} + (\frac{C_i}{L_i})^2_{平均}}{2}}$$

Ci is the measured elements of i; Li is the highest tolerances elements of i. (the secondary standard of GB 15618-1995); Ci /Li is elements pollution value of i; （Ci /Li ）最大 is the largest maximum of Ci/Li;（Ci /Li ）平均 is the sum of the average of Ci/Li . According to above analysis calculate comprehensive index, with comprehensive pollution index method pollution level division standard, it divides heavy metal composite pollution values of the division standard grades of the study area in the study area and the heavy metal pollution values (table 8). According to above analysis results, first it constructs " Pg " column in attributes list, second enters each Pg value, then interpolation analysis and heavy classification, last it gains the soil pollution grading graph (figure 6).

**table 8 the comprehensive pollution index of soil and classification**

| Comprehensive soil pollution index | Pollution degree | Pollution levels | Level (score) |
|---|---|---|---|
| 0.7 – 1.0 | warning limit | Is clean | 3 |
| 1.0 – 1.4 | Light pollution | Pollution than starting pollution value, the crop began to pollution | 1 |

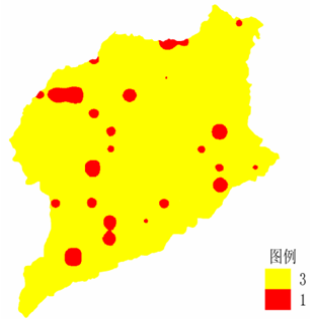


**Figure 6 soil pollution grading figure**

## 6、 land comprehensive evaluation analysis

Thought the above 5 results in this paper, the analytical process gives a certain weight stack according to the local conditions to grow crops on soil types factor, the soil texture factor, the underground water level buried depth factor, soil fertility factor and the soil pollution factor. In the paper it uses three scale two steps analytic hierarchy processes to identify weight

The basic principle: the first step is to compare between the two factors to a comparison matrix by three scale; The second step is to use comparison matrix and mathematical formula to obtain structure matrix; The third step is to use consistency check with the matrix, use the important factor of the maximum eigenvalue to represent the corresponding level. The specific procedure is as follows:

1、It compares between the two factors for quantitative with the next type, then composes comparative matrix by numerical value (table 9).

$$K_{ij}=\begin{cases}0(\text{i factor is less important than j factor})\\1(\text{i factor is as important as j factor})\\2(\text{i factor is more important than j factor})\end{cases}$$

Kij is the comparison quantitative value of factor “i“ and factor “j”, also it’s the relevant elements of the matrix. If i = j, K11 ， K22 ， ----， K66 ,it means the factor compare themselves. Diagonal of comparative matrix the number is 1.If the comparison matrix appear 0, 1, 2 in the triangle then other value is 2, 1 and 0 in the corresponding position under triangle in table 9

**table 9 comparative matrix**

| Each factor | K1 | K2 | K3 | K4 | K5 | $\sum_{i=1}^{5}$ Ki |
|---|---|---|---|---|---|---|
| Soil types K1 | 1 | 0 | 2 | 2 | 0 | 5 |
| Soil texture K2 | 2 | 1 | 2 | 2 | 0 | 7 |
| Buried deep underground water level K3 | 0 | 0 | 1 | 2 | 0 | 3 |
| Soil pollution K4 | 0 | 0 | 0 | 1 | 0 | 1 |
| soil fertility K5 | 2 | 2 | 2 | 2 | 1 | 9 |

2、The second step that by comparison matrix stack value ( $\sum_{i=1}^{5} Ki$ ), press type can obtain hierarchical analysis, calculation of judgments matrix structure (table 10).

$$R_{ij}=\begin{cases}(K_i-K_j)*(B_m-1)/(K_{max}-K_{min})+1(K_i>K_j)\\ 1/[(K_i-K_j)*(1-B_m)/(K_{max}-K_{min})+1](K_i<K_j)\end{cases}$$

Rij is the table structure in the judgment matrix element, Ki, Kj respectively represent each table corresponding factor accumulate value ( $\sum_{i=1}^{5} Ki$ ),Kmax 、Kmin are the maximum and the minimum of $\sum_{i=1}^{5} Ki$ ; Bm generally instead by Kmax 、Kmin, means the sum of the most important factor and the least important factor related coefficient, then in the paper Bm=9+1=10; So we can get tectonic judgment matrix (table 10). Then it uses matlab software to solve the maximum eigenvalue λmax =5.2855, and（5.2855-5）/（5-1）=0.071375<0.1, it can pass the consistency check, so the maximum eigenvalue vector matrix:W=[0.2034，0.4286，0.0961，0.04886，0.8737]

Then, it gets the weight value factor by unification (table 11).

**table 10 structure judgment matrix**

| factor | R1 | R2 | R3 | R4 | R5 |
|---|---|---|---|---|---|
| Soil types R1 | 1.0000 | 0.3077 | 3.2500 | 5.5000 | 0.1818 |
| Soil texture R2 | 3.2500 | 1.0000 | 5.5000 | 7.7500 | 0.3077 |
| Buried deep underground water level R3 | 0.3077 | 0.1818 | 1.0000 | 3.2500 | 0.1290 |
| Soil pollution R4 | 0.1818 | 0.1290 | 0.3077 | 1.0000 | 0.1000 |
| soil fertility R5 | 5.5000 | 3.2500 | 7.7500 | 10.0000 | 1.0000 |

**table 11 each factor weight**

| factor | K1 | K2 | K3 | K4 | K5 |
|---|---|---|---|---|---|
| weights | 0.1232 | 0.2597 | 0.0582 | 0.0296 | 0.5293 |

Through the above analysis, the soil type distribution, soil texture map, groundwater depth grading figure, soil pollution grading figure and soil fertility hierarchical graph empowerment overlap add (Table 11), we can get the land comprehensive evaluation distribution (FIG 7)

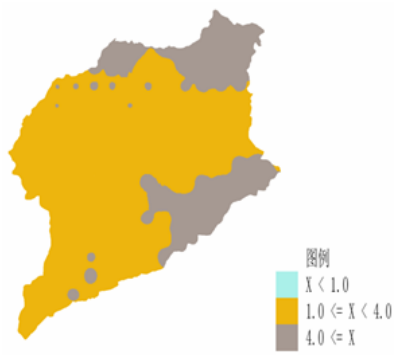


**Figure 7 land comprehensive evaluation distribution4 conclusion**

## 7、conclusion

Based on GIS land suitability assessment principle and method, it used supermap to analyzing suitably crops of Liao city land, than we get the following:

1、With united analyzing respectively of rivers and soil type distribution map, groundwater depth buried depth distribution, it can be found soil salinity is most serious, groundwater depth is the biggest in GuanXian. But five big rivers through Liao city are not through GuanXian (WeiHe and Maxia river are all in the edge) and some of the main canal perennial dry, therefore, in the region we should increase the water resources and avoid the soil salinity become heavier. Also we should adjust the agricultural structure and change the agricultural development model.

2、Liao city agricultural land quality gradually reduce from the east to the west, therefore, it should pay attention to adjusting agricultural layout. In the east we must give full play to the rich soil water resources and fertile soil advantages to improve crop quality and output. In the west land we can adjust measures to local conditions reform land conditions to develop forestry, orchards and other production.

3、The soil heavy metal pollution reach light pollution levels in some areas, the crops has caused the damage in a certain degree in the region. Therefore, some polluting factories should be banned that prevent soil pollution become worse.

It is concluded that the present situation and the existence problems in Liao city crop land suitability assessment process of agricultural land. It shows that GIS is an

effective and operational technology in complex evaluation process to the crops suitability.

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