

Cultivated Land Quality Assessment and Obstacle Factors Diagnosis in Changtu County, Northeast China

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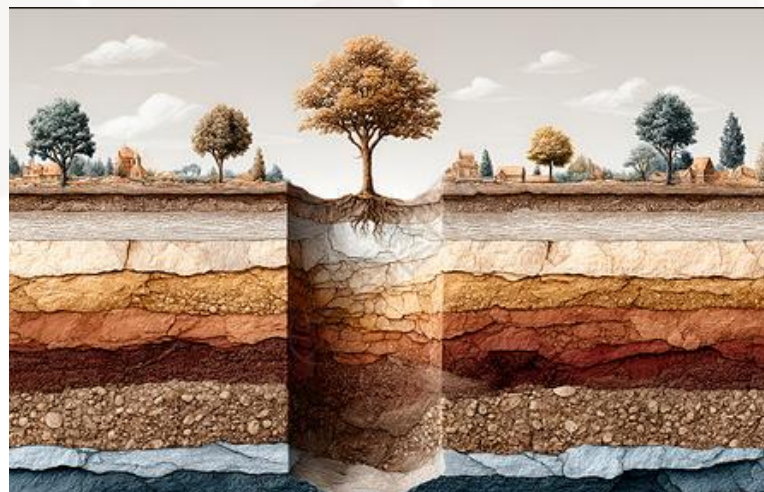
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1.

Background & Significance

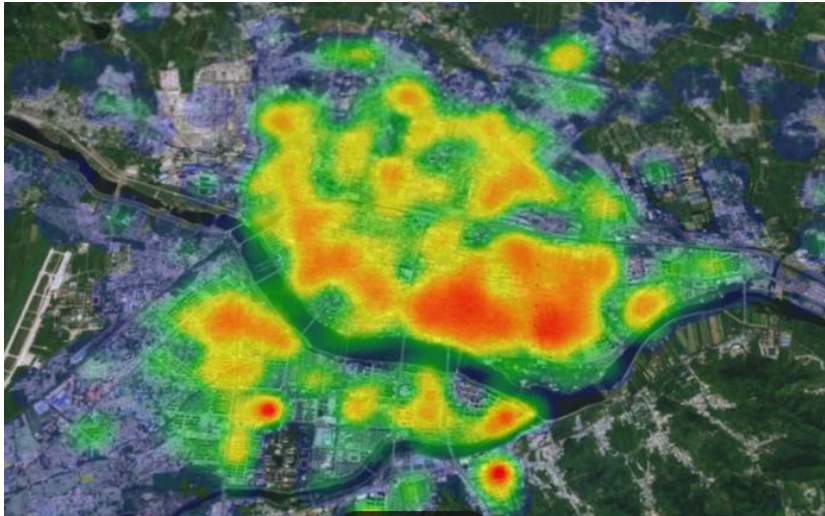
- Cultivated land quality → global food security
- Urbanization & intensive farming → land degradation
- Changtu County: major grain base (2.2 Mt annual yield)
- Need precise evaluation + obstacle diagnosis



2.

Research Objectives

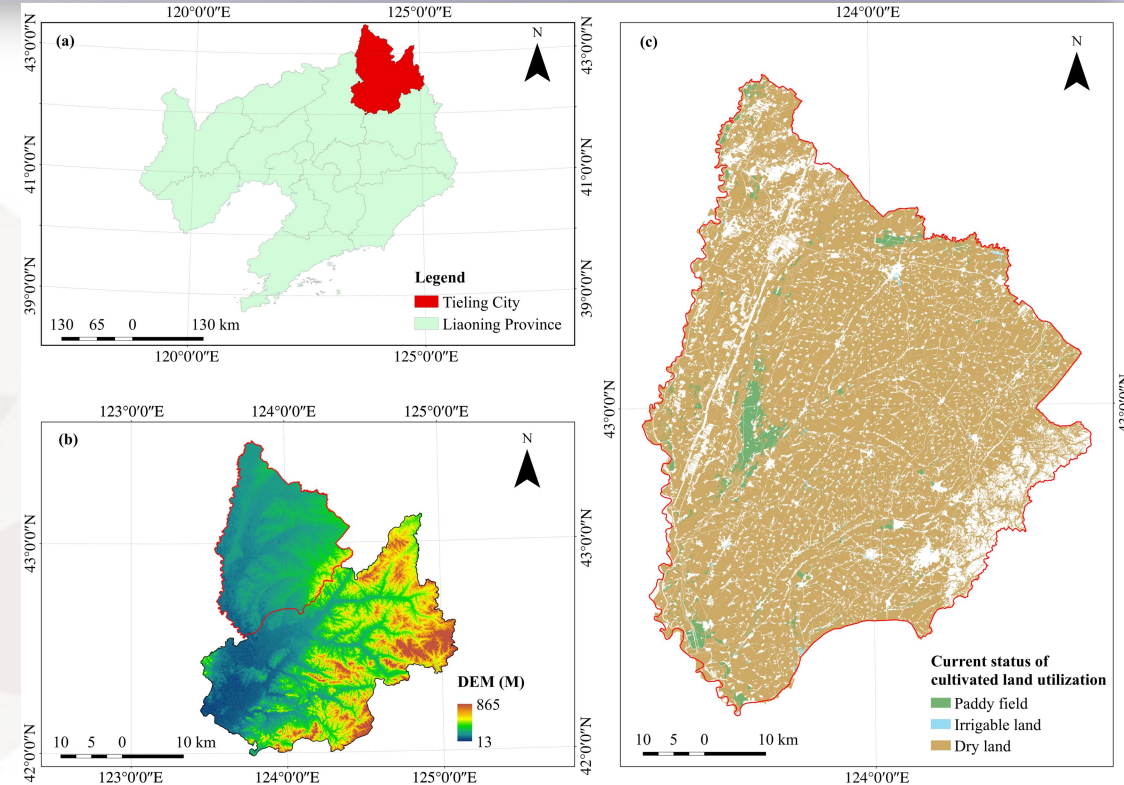
- Build an MDS evaluation system
- Analyze spatial distribution of land quality
- Identify and quantify primary obstacle factors



3.

Study Area

- Location: Northern Liaoning Province
- Area: ~3,408 km² cultivated land
- Climate: continental monsoon, 12°C, 655 mm
- Topography: plains, west to east
- Main crops: maize, peanut



4. Methodology

- 120 points, 7 soil indicators
- MDS: PCA + Norm value
- Quality index: Integrated Fertility Index (IFI)
- Obstacle diagnosis: Obstacle Degree Model
- Spatial analysis: Ordinary Kriging (Gaussian)



Obstacle Degree Model

$$M_i = \frac{\sum_{i=1}^n B_i V_i}{n V_i} \times 100\%$$

$$B_i = 1 - A_i$$

(3)

where A_i is the membership degree of the i indicator, $B_i = 1 - A_i$ represents the gap between the indicator and the ideal state, V_i is the weight of the i th indicator, M_i is the obstacle degree of the i indicator, and n is the number of sample points. The obstacle degree was classified into six grades based on the equidistance method, namely, severe obstacle degree (> 40%), high obstacle degree (30%–40%), intense obstacle degree (20%–30%), moderate obstacle degree (10%–20%), mild obstacle degree (0%–10%), and non-apparent obstacle degree (0).

$$N_{ik} = \sqrt{\sum_{j=1}^k (u_{ik}^2 e_k)} \quad (1)$$

where N_{ik} is the norm value of the i indicator in the first k PCs with eigenvalue ≥ 1 , u_{ik} is the loading of the i indicator in the k PC, e_k is the eigenvalue of the k PC.

5.

MDS Selection & Validation

- MDS: cultivated layer thickness, SOM, pH, BD, texture
- 29% variable reduction (7→5)
- IFI-MDS vs IFI-TDS: $R^2=0.52$, significant correlation

TABLE 1 | Scoring functions and parameters.

Indicators	Function	Parameter				Function type
		a_i	c_i	u_{i1}	u_{i2}	
Effective soil thickness (cm)	$0, (u_i \leq u_{i2})$	0	100	0	100	Type S
Cultivated layer thickness (cm)	$1/[1+a_i(u_i-c_i)^2], (u_{i2} < u_i < c_i)$	0	30	0	30	Type S
SOM (g/kg)	$1, (c_i \leq u_i)$	0	60	0	60	Type S
pH	$0, (u_i > u_{i2} \text{ or } u_i < u_{i1})$	0.2	6.8	0.2	13.3	Type parabola
BD (g/cm ³)	$1/[1+a_i(u_i-c_i)^2], (u_{i1} < u_i < u_{i2})$ $1, (c_i = u_i)$	8.7	1.2	0.2	2.3	Type parabola

Note: (1) SOM = soil organic matter; BD = bulk density. (2) y_i is the degree of membership of the i evaluation indicator, u_i is the measured value of the sample, c_i is the standard indicator, a_i is the coefficient, and u_{i1} and u_{i2} are the upper and lower limit values of the index, respectively.

TABLE 5 | Pearson correlation of soil indicators.

	Cultivated layer thickness	SOM	BD	pH	Effective soil thickness	Cultivated layer texture	Texture configuration
Cultivated layer thickness	1	0.035	-0.113**	0.194**	-0.069*	0.168**	0.018
SOM	0.035	1	0.174**	0.03	0.095**	0.049	0.143**
BD	-0.113**	0.174**	1	-0.280**	0.122**	0.01	0.034
pH	0.194**	0.03	-0.280**	1	-0.488**	-0.313**	-0.257**
Effective soil thickness	-0.069*	0.095**	0.122**	-0.488**	1	0.522**	0.322**
Cultivated layer texture	0.168**	0.049	0.01	-0.313**	0.522**	1	0.534**
Texture configuration	0.018	0.143**	0.034	-0.257**	0.322**	0.534**	1

* $p < 0.05$.
** $p < 0.01$.

6.

Spatial Distribution of Quality

- “High center, low east-west”
- Grade III dominates (40.4%)
- Grade I & II: 24.4%, central plains
- Grade IV & V: 35.2%, western sandy areas

TABLE 6 | Area and percentage of cultivated land with quality grades.

Grade	Cultivated land area (km ²)	Percentage (%)
Grade I	137.1	4.1
Grade II	687.9	20.3
Grade III	1370.6	40.4
Grade IV	840.3	24.8
Grade V	352.5	10.4
Total	3388.4	100

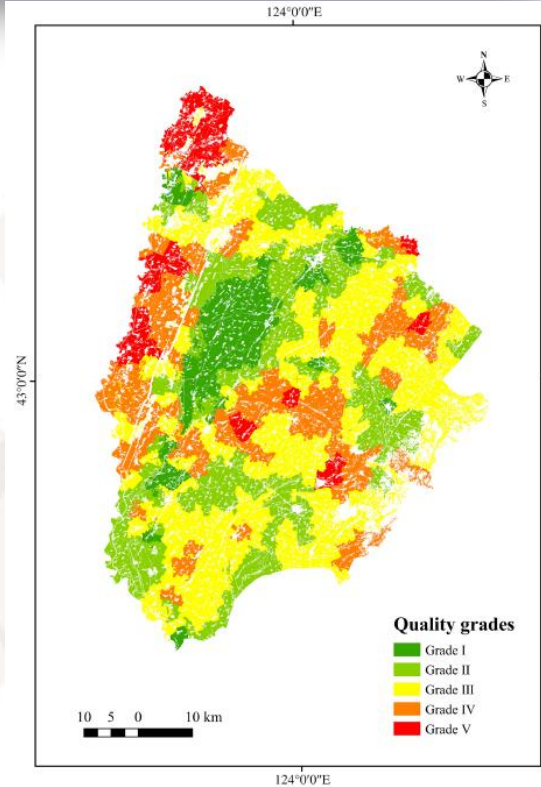


TABLE 2 | Classification of evaluation criteria.

Indicators	Criteria for the classification of indicators											
	Grade 1		Grade 2		Grade 3		Grade 4		Grade 5		Grade 6	
	Indicator value	Score	Indicator value	Score	Indicator value	Score	Indicator value	Score	Indicator value	Score	Indicator value	Score
Cultivated layer texture	Medium loam	100	Light loam	80	—	—	Sandy loam	60	Clay	40	—	—
Texture configuration	Upper loose and lower tight	100	—	—	Compact type	60	—	—	Thin type	50	Loose type	40

7.

Soil Properties by Quality Category

- SOM decreases with grade: 18.8→14.6 g/kg
- pH lowest in medium category (5.6)
- Cultivated layer thickness and BD vary little

TABLE 7 | Mean soil attributes value in cultivated land quality categories.

	Cultivated land quality categories		
	High	Medium	Low
Cultivated layer thickness (cm)	17.6	17.8	16.8
SOM (g/kg)	18.8	17.7	14.6
BD (g/cm ³)	1.21	1.22	1.25
pH	6.5	5.6	6.8

Note: The high category included Grade I and Grade II, the medium category included Grade III and Grade IV, and the low category included Grade V.

8.

Obstacle Factor Diagnosis

- SOM: obstacle degree 43.5% — Severe
- pH: 29.3% — Intense
- Texture: 7.3%, Thickness: 6.5%,
- BD: 2.4% — Mild

TABLE 9 | Obstacle degree of evaluation indicators.

Indicators	Obstacle degree (%)	Obstacle type	Grades
SOM	43.5	Severe degree	1
pH	29.3	Intense degree	2
Cultivated layer texture	7.3	Mild degree	3
Cultivated layer thickness	6.5	Mild degree	4
BD	2.4	Mild degree	5

9.

Spatial Patterns of Obstacles

- SOM obstacle severe in west (sandy soils)
- pH obstacle intense in east (acidification)
- BD mostly non-apparent

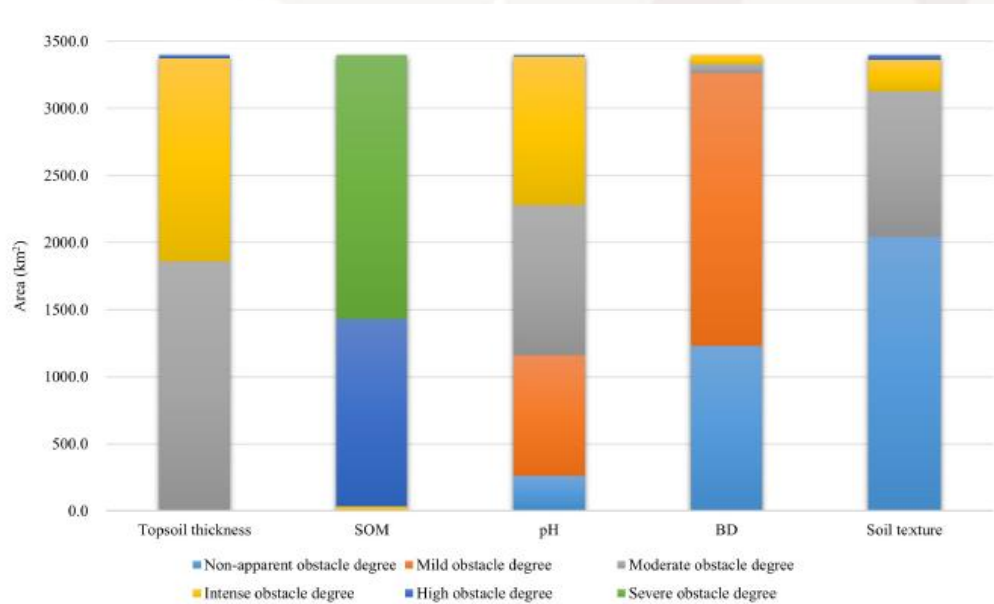


FIGURE 3 | Obstacle types distribution.

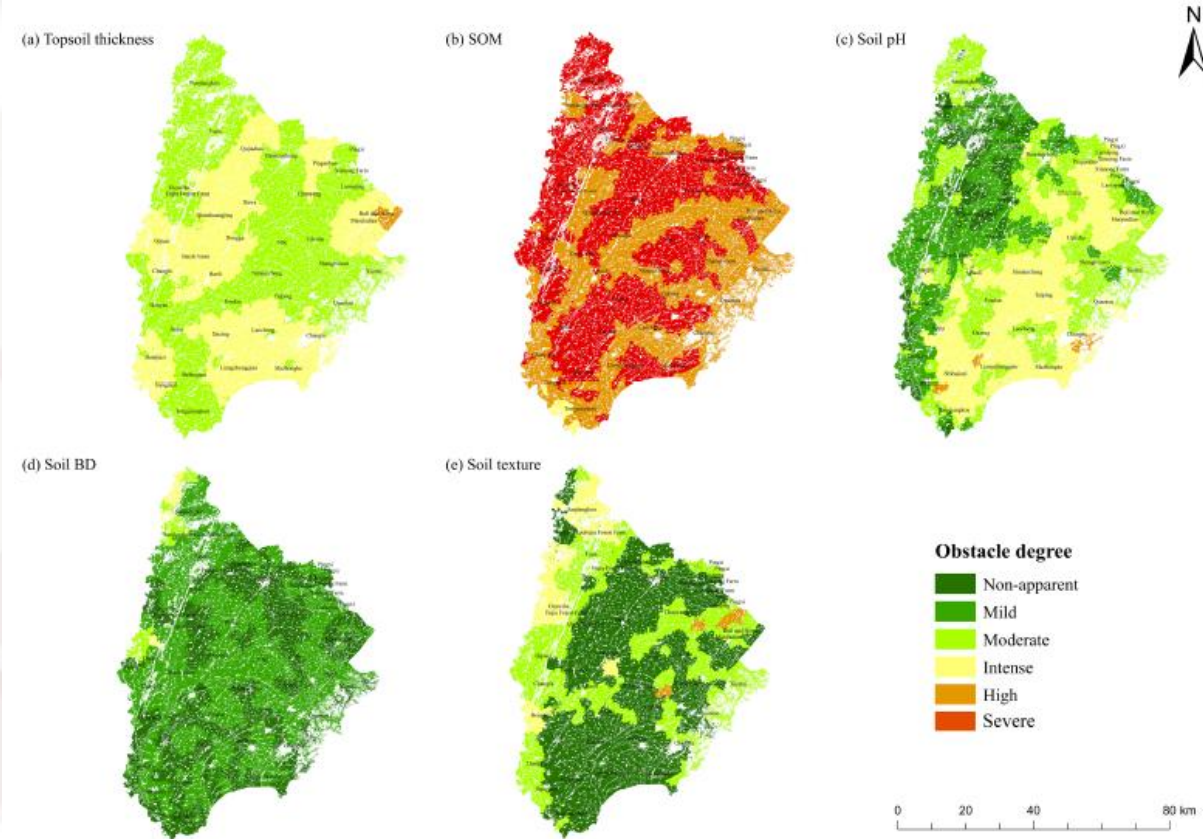


FIGURE 4 | This figure presents the spatial distribution characteristics of obstacle factors, including topsoil thickness (a), SOM content (b), soil pH levels (c), BD (d) and soil texture (e).

10. Driving Mechanisms & Recommendations

- SOM: sandy texture, warm climate, insufficient inputs
- pH: urea overuse, crop cation uptake
- Strategies: organic amendments, soil testing, lime, zone-specific management

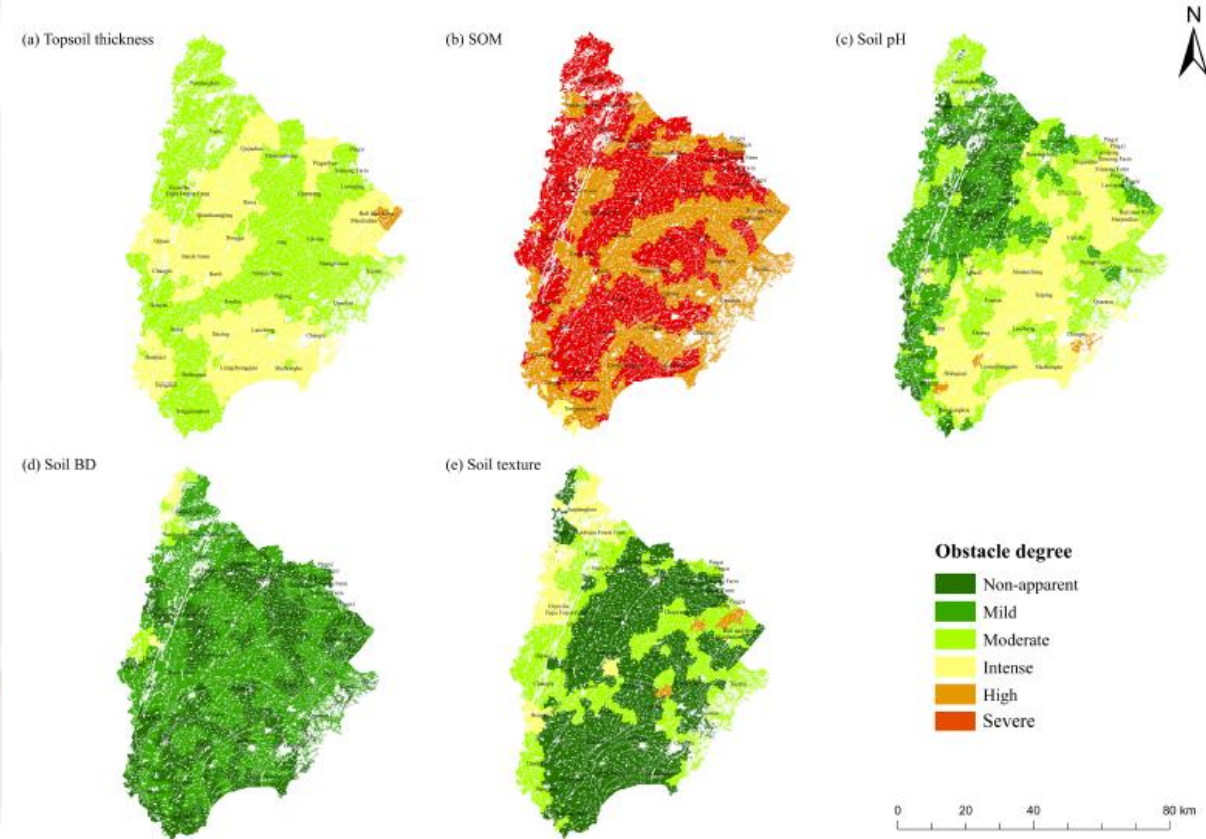


FIGURE 4 | This figure presents the spatial distribution characteristics of obstacle factors, including topsoil thickness (a), SOM content (b), soil pH levels (c), BD (d) and soil texture (e).

11.

Conclusions

- MDS efficient and reliable for county scale
- Quality pattern: center > east/west
- SOM and pH are core limiting factors
- Zone-targeted management crucial

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Thank you for your attention