

Evaluation of the comprehensive potential for land reclamation in Huadian City

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Abstract. In order to understand the potential for land reclamation in Huadian City, this research constructs an evaluation model for land reclamation potential based on the double restraints of ecological security and social economy to measure comprehensive potential for land reclamation that conforms to the level of regional development and ecologic protection objective. The research shows: (1) Under constraint conditions, the potential for land reclamation in the towns of Huadian City has been reduced in different degrees, with the change of potential in urban areas being much smaller than in rural area. Under the restraint of ecological protection, Jiapigou Town, Erdaodianzi Town, Hongshilazi Town and Changshan Town suffer the high restraint. In terms of restraint of social economy, Huashulinzi Town is subject to the high constraint. (2) During the 13th Five-Year Plan Period, through arable land reclamation, Huadian City will have 4,121.47 more hectares of arable land and save 2,410.82 hectares of construction land. The findings provide an approach to land reclamation potential evaluation and form a basis for the compiling of the plan for land reclamation during the 13th Five-Year Plan Period.

1. Introduction

As a basic task of land reclamation planning, potential evaluation is the basis of project site selection of land reclamation and scheduling, and constitutes the key technology to land reclamation planning [1]. In the context of regional overall development, land reclamation is more than reclamation of agricultural land, but the overall management of field, water, road, forest, and village [2]. In addition, ecological development requires that land reclamation should not only increase the amount of arable land and land capability, improve the function of the ecological environment, but also ensure urban and rural development as a whole and regional coordinated development [3]. The purpose of land reclamation potential evaluation is to identify the amount of the potential, level status, and the spatial distribution, so as to provide the basis for the scientific compiling of land renovation plan.

Currently, the addable effective cultivated land area after reclamations is used to represent the land reclamation potential. Zhang Z F *et al* [4, 5] explored the connotation and evaluation methods at home and abroad with regard to cultivated land reclamation potential and village residential land readjustment potential. Guo H Q *et al* [6] applied the multi-factor evaluation methods for cultivated land reclamation potential to a land reclamation project of Yanqing County. Yang W *et al* [7] used



GIS in their study of evaluation of the agricultural land reclamation potential in the Changshou District of Chongqing City. Wu L L *et al* [8] conducted a land reclamation potential evaluation (LRP) based on landscape principle. In short, GIS and other technologies are widely used in LRP evaluation, with the focus shifting from quantity potential to quality potential. Discussions on multi-factor comprehensive evaluation methods have begun, but most of the discussions are limited to cultivated land consolidation and rural residential land consolidation, among other individual potential evaluation, with a perfect LRP evaluation system yet to be established. LRP evaluation is the prerequisite for the scientific land reclamation planning and the study of LRP in the context of ecological safety and social economy development will help gain a deeper insight into the current development trend.

Huadian is a city with complex terrain, abounding in mountains and hills while lacking flat grounds. With the implementation of the national reforestation policy, and the increasing demand for construction land, the contradiction between the land supply and demand in the city is intensifying. It is therefore to perform land reclamation and tap into the land potential. In this study, the LRP of four types of land is explored, and a land reclamation potential evaluation model based on the double restraints of ecological safety and social economy is built to measure the overall LRP in Huadian City, to provide approach to the evaluation of LRP, and to provide reference for the land reclamation planning during the 13th Five-Year Period for the city.

2. Methodology

LRP refers to the potential under the context of certain natural conditions, regional social economic development level and ecological risk degrees, which requires modification of the traditional multi-factor evaluation model based on the restraint conditions.

$$F_i = \sum_{j=1}^n A_{ij} \times W_j \quad (1)$$

$$F_i = \frac{\sum_{j=1}^n A_{ij} \times W_j(A, T)}{T + 1} \quad (2)$$

$$T = \alpha T_e + \beta T_s (\alpha + \beta = 1) \quad (3)$$

$$T_e = \sum_i^m W_E \times E_i \quad (4)$$

$$T_s = \sum_i^l W_s \times S_i \quad (5)$$

In the formula: F_i is the value of LRP of the i^{th} evaluation unit; A_{ij} is the standardized value of the j^{th} evaluation index of the i^{th} evaluation unit; W_j is the weight of the j^{th} evaluation index; $W_j(A, T)$ means the effect weight on evaluation target of index j under constraint condition (T); T stands for constraint condition; T_e is the restrain index of ecological safety; T_s is the restrain index of social economy; α and β represent the effects of regional ecological safety and social economy on land reclamation respectively; E_i and S_i represent the constraint index factors of ecological safety and social economy; W_E and W_s stand for the index weight of the effects on ecological safety and social economy. In this study, $\alpha = \beta = 0.5$. Based on the effects of index on LRP, leading indicators, positive constraint index and negative constraint index are defined. To offset the effect of measurement on data, extremum standardization is adopted for standardized processing of data, in addition to analytic hierarchy process for identifying the index weight. Drawing on the existing research results, a LRP evaluation index system based on ecological and social and economic constraints (see table 1).

Table 1. LRP evaluation index system and weight based on ecological and social and economic constraints.

Primary index and weight	Secondary index and weights	Level 3 index and its weights	synthetic weight	orientation	
Natural potential/0.7	Farmland reclamation potential/0.462	newly-increased amount/0.166	farmland 0.116	leading	
		newly-increased coefficient/0.139	farmland 0.097	leading	
		Capacity increased/0.139	0.096	leading	
	Rural residential consolidation potential/0.220	Scale of rural residential consolidation/0.096	residential 0.068	leading	
		newly-increased coefficient/0.083	farmland 0.061	leading	
		Homestead idle rate/0.060	0.044	leading	
	land reclamation potential/0.124	wasteland scale/0.057	reclamation 0.030	leading	
		newly-increased coefficient/0.055	farmland 0.036	leading	
		Unused agricultural land development potential/0.194	Unused agricultural land scale/0.123	land 0.090	leading
	Ecological security constraint/0.15	Water ecological security/0.397	Coverage of water source/0.397	0.060	positive constraint
terrain slope/0.273			0.041	positive constraint	
Forest coverage/0.207			0.031	positive constraint	
Geological disaster risk/0.123		Geological disaster risk/0.123	0.018	positive constraint	
		Social development level/0.500	per-person cultivated area/0.236	land 0.035	positive constraint
			Road network density/0.134	0.020	negative constraint
Social economy constraint/0.15	Economic Feasibility/0.500	Population density / 0.071	0.012	negative constraint	
		Per Capita GDP/0.250	0.037	negative constraint	
		Rural per capita net income/0.169	0.027	negative constraint	
	grain yield per hectare/0.140	0.020	negative constraint		

- The evaluation index of natural potential consists of arable land reclamation potential, rural residential consolidation potential, mining wasteland reclamation potential and unused agricultural land development potential. (1) With the reduction of arable land, more importance is attached to the effect of land reclamation on the improvement of farmland quality, so the development potential for farmland quality should be included as a factor of natural potential. (2) Theoretical potential for rural residential consolidation is the difference between current rural residential area and that of the specified standard area, which can be

represented by the scale of rural residential consolidation. Rural residential area can be turned into arable land after consolidation so as to relieve the land use conflict, so the newly-increased farmland coefficient should be regarded as an important indicator of potential, with the practical potential being represented by the idle rate of homestead. (3) Mining wasteland reclamation is mainly decided by the reclamation scale of wastelands which are left over by history or anticipated, with its newly-increased farmland coefficient deciding the contribution of reclamation to increased arable land. (4) The scale of unused agricultural land directly decides its development potential, with its development level subject to the regional ecological security conditions and natural landscape, and the potential value can be reflected by the newly-increased farmland coefficient.

- Ecological safety constraint index consists of water ecological security, soil erosion and geological disaster risk. (1) The land reclamation project which is too close to the water source may affect the regional ecological balance. So, coverage of water source is used to reflect the ecological security constraint factor of land reclamation, that is, the proportion of the area of land under evaluation within 500m of water source to the total area of land under evaluation. (2) Soil erosion, as one of the mountain ecological risk types, has a direct effect on the sustainability of land reclamation. The terrain slope and vegetation coverage are the important indicators of soil and water loss risk. (3) It is relatively hard to carry out land reclamation in areas where there is bigger risk of geological disaster. In this study, the area affected by geological disaster is used to reflect the regional geological disaster risk.
- Social economy constraint index includes social development level and economic growth. (1) Per-person cultivated land area decides the needs for land reclamation, and the bigger the per-person area, the lower the needs. Also, towns with developed economy and convenient transportation tend to attract population and expand itself, which indirectly increase the needs for land reclamation. So, per-person cultivated land area, road network density and population density are used to reflect the social constraint on the LRP. (2) GDP per capital, rural per capital net income, and grain yield per hectare are used to reflect the economic constraint on LRP.

3. Findings and analysis

Table 2 shows that LRP varies significantly among the towns of Huadian City, so does the LRP without constrains. Ecological constraint index indicates that Jiapigou Town is subject to the highest constraints, which may be partly due to its abounding in mountains and mines. By contrast, urban areas are exposed to fewer constraints. The towns subject to relatively or absolutely high socio-economic constraints account for 62.5% of total towns of the city. Huashulinzi Town is subject to the most constraints, with others exposed to more constraints. Without constraints, the LRP varies greatly among towns, with that of urban areas lower than that of towns. Jiapigou Town, Hongshilazi Town, Hengdaoheizi Town and Gongji Town enjoy a higher potential. With constraints, the changes in the potential in urban areas are less than that in towns.

Table 3 shows that a new round of land reclamation can add 4,121.47 hectares of arable land, of which 2,593.5 hectares are turned from the rearrangement of farmland, accounting for 62.92% of the total area of arable land. Rural construction land, after consolidation, offered 350.18 hectares arable land, accounting for 16.15%; reserved land suitable for cultivation contributed 512.27 hectares, accounting for 12.43%. The distribution of newly-increased farmland shows that farmland rearrangement, land reclamation and reserved land resources suitable for cultivation have made little contribution to the total area of newly-increased farmland. Jiapigou Town, however, relied mainly on land reclamation, Erdaodianzi Town on reserved land suitable for cultivation, and other towns on the rearrangement of farmland in their newly increasing of arable land.

Table 3 shows that Huadian City can save 2,410.82 hectares of construction land, with 387.12 hectares coming from the rearrangement of rural construction land, accounting for 16.06%, and 2,023.70 hectares from the rearrangement of industrial and mining land for construction purpose,

making up 83.94%. The scale of rearranged land for rural construction differs greatly from that for industrial and mining construction in the towns. The land rearranged for rural construction is mainly located in Yongji Sub-District, Jiapigou Town, Hongshilazi Town and Gongji Town, occupying 59.65% of the total rearranged land; the land rearranged for industrial and mining construction is mainly located in Yongji Sub-District, Jiapigou Town, Hongshilazi Town and Huajiao Town, accounting for 76.30% of the total rearranged land.

Table 2. Results of land potential evaluation in Huadian.

Township name	Ecological constraint index		Socioeconomic constraint index		Unrestricted potential value		Potential value under constraints	
	sort	Constraint level	sort	Constraint level	sort	Constraint level	sort	Constraint level
Minghua	14	Low	16	Low	13	Low	15	Low
Yongji	12	Low	11	General	12	General	12	General
Shengli	13	Low	12	General	16	Low	16	Low
Xinhua	15	Low	13	General	15	Low	14	Low
Qixin	16	Low	14	General	14	Low	13	Low
Jiapigou town	1	High	9	Higher	3	High	3	General
Erdaodianzi	3	High	8	Higher	5	General	10	General
Hongshilazi	2	High	15	General	1	High	2	General
Badaohezi	6	Higher	10	Higher	9	General	9	General
Changshan	4	High	4	Higher	11	General	11	General
Huajiao	11	General	7	Higher	7	General	6	General
Hengdaohezi	8	Higher	3	Higher	4	High	4	General
Jinsha town	10	General	2	Higher	10	General	8	General
Huashulinzi	9	Higher	1	High	6	General	5	General
Gongji town	7	Higher	6	Higher	2	High	1	General
Sumigou	5	Higher	5	Higher	8	General	7	General

Table 3. Supplementary cultivated land potential form land consolidation and intensive construction land saving potential in Hudian City.

Township name	Supplementary cultivated land potential /hectare					Intensive construction land saving potential/hectare		
	Agricultural land consolidation	Rural construction land consolidation	Land reclamation	Reserve land resources development	Total	Rural construction land consolidation	Urban and rural construction land consolidation	Total
Minghua	0.57	0	0.63	0.00	1.2	1.29	86.08	87.37
Yongji	29.54	40.86	12.44	34.68	117.52	45.41	270.18	315.59
Shengli	0	0	0.00	0.00	0	0	31.8	31.8
Xinhua	0.04	0	0.00	0.00	0.04	0	0	0
Qixin	0.2	0	0.00	0.00	0.2	0	0	0
Jiapigou	98.45	47.67	342.02	87.65	575.79	51.81	568.1	619.91
Erdaodianzi	62.41	11.30	23.60	173.18	270.49	11.77	80.3	92.07
Hongshilazi	456.23	52.04	67.09	53.24	628.6	56.57	488.84	545.41

Badaohezi	218.14	12.00	52.74	12.28	295.16	12.76	181.78	194.54
Changshan	101.31	15.17	23.65	41.75	181.88	16.49	58.18	74.67
Huajiao	260.88	19.76	75.44	22.12	378.2	21.71	216.91	238.62
Hengdaoh ezi	267.86	3.30	6.29	27.62	305.07	3.67	0	3.67
Jinsha town	245.87	5.96	16.35	21.59	289.77	6.69	8.12	14.81
Huashulin zi	164	50.76	9.12	14.01	237.89	54	4.97	58.97
Gongji town	521.18	66.33	21.49	11.60	620.6	77.14	10.42	87.56
Sumigou	166.82	25.03	14.66	12.54	219.05	27.81	18	45.81
Total	2593.5	350.18	665.52	512.27	4121.4	387.12	2023.7	2410.8
					7			2

4. Discussion and conclusion

Land reclamation is a necessary step towards the increase of utilization rate of arable land. In this study, the dual constraints of social economy and ecological security are introduced for a quantitative evaluation of the overall LRP in Huadian under the constraints of ecological security and social economy, based on an analytic hierarchy process and evaluation model with constraints. Jiapigou Town, Erdaodianzi Town, Hongshilazi Town, and Changshan Town are exposed to the high constraints of ecological security. Huashulinzi Town is subject to the high constraints of social economy. The findings show that social economy and ecological security have an important effect on LRP, the advanced the economy and the safer the ecological environment, the higher the potential, and vice versa. During the 13th Five-Year Plan Period, land reclamation can bring about newly-increased farmland of 4,121.47 hectares, and save construction land of 2,410.82 hectares. At last, the model under constraints, though reflecting to some extent the LRP in areas in question and fitting the local conditions, calls for further research to see whether it can apply to other areas. In addition, the evaluation indexes of the model of constraints established in this study are limited in number and need to be further improved.

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