Evaluation of Arable Land Reserve Resources and Analysis of Restrictive Factors: A Case Study of Hangjin Banner in Inner Mongolia

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Abstract Taking land available for cultivation and mining land available for reclamation in Hangjin Banner of Inner Mongolia Autonomous Region, using land use database of 2012 as evaluation base, it made evaluation of arability of 677 021.40 hm^2 reserve land resources by the restrictive factor evaluation method. Besides, it analyzed main restrictive factors of arable land reserve resources in Hangjin Banner. Results indicate that the total area arable land reserve resources is 52 200.02 hm^2, accounting for 7.71% of total area evaluated. Irrigation condition and soil thickness are major factors restricting development of arable land reserve resources in the study area. It is expected to provide reference for development of arable land reserve resources and land consolidation project in Hangjin Banner.

Key words Arable land reserve resources, Evaluation, Hangjin Banner

The arable land reserve resource is essential foundation for implementing land consolidation and also important guarantee for realizing balance between land requisition and compensation. The units occupying the cultivated land should be responsible for reclaiming the same amount of land in the same quality as that occupied according to the principle of "reclaiming the same amount of land used". Supplementing the same amount and quality cultivated land and developing arable land reserve resources become important source of cultivated land. This is of great significance for studying China's ecological construction, cultivated land protection, and Large Scale Western Development strategy[1]. Due to limitations of water and soil conditions, there is no much arable land in Hangjin Banner. Apart from ecological and environmental factors, it is required to take account of cost and economic benefits. Therefore, evaluating arable land reserve resources and analyzing factors limiting the development will be of great significance for ensuring social and economic development and protecting ecological environment.

1 Overview of the study area

Hangjin Banner (106°55′16″ - 109°16′08″ E, 39°22′22″ - 40°52′47″ N) is situated in northwest of Erdos City of Inner Mongolia. It crosses Erdos Plateau and Hetao Plain. The Yellow River flows across the whole banner from west to east about 242 km. Kubuqi Desert runs across the banner from east to west and divides the banner into southern area outside the ridge and northern area along the river. The southern area outside the ridge is mainly grassland and natural forest protection area and is important grassland ecological animal husbandry base; the northern area along the river is Yellow River alluvial plain, has abundant water source, fertile soil, so is a high efficient agriculture and animal husbandry base. Under the jurisdiction of Hangjin Banner, there are 5 towns and one sumu, 76 Gacha villages in total. The banner government handles official business in Xini Town, where there are Inner Mongolians, Han people, Hui people, Koreans, and Tibetans. In 2012, total population of Hangjin Banner was 142279, the total number of rural households was 23848, and total rural population was 69312, accounting for 48.7% of total population of the whole banner. The survey object of arable land reserve resources is land available for cultivation and mining land available for reclamation in Hangjin Banner in 2012. The land available for cultivation refers to unused land to be cultivated, including other grassland (043), inland mud flat (116), saline and alkaline land (124), marshland (125), and sand land (126) in the land survey database. The mining land available for reclamation refers to waste mining, quarrying and sand mining, and salt pan and brick and tile kiln land, as well as tailing stacking place, namely, the mining land (204) in the land survey database[2]. The total area of survey object is 67 7021.40 hm^2, including 89 982.78 hm^2 other grassland, 38 531.84 hm^2 inland mud flat, 829.84 hm^2 saline and alkaline land, 468.53 hm^2 marshland, 542 666.65 hm^2 sand land, and 4 541.76 hm^2 industrial and mining land.

2 Evaluation of arability of cultivated land reserve resources

2.1 Evaluation method The cultivated land reserve resources

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in Hangjin Banner were surveyed using the current land use database as evaluation base, with reference to Technical Regulations about Survey and Evaluation of National Cultivated Land Reserve Resources, using restrictive factor evaluation method. Using agricultural census, soil census, land consolidation plan, ecological protection zone, and ecological land conceding, on the basis of supplement of field survey, we selected 11 indicators to evaluate arability of cultivated land reserve resources in Hangjin Banner. As long as one indicator is not consistent, it will be deemed as not arable.

2.2 Determination of evaluation indicators The evaluation indicators involve ecological environment, site condition, climatic condition, and location. Specifically, there are 11 evaluation indicators: ecological condition, annual accumulated temperature, annual precipitation and irrigation condition, soil pollution situation, drainage condition, soil thickness and parent materials, slope, salinization, soil texture, soil pH value, and farming convenience, as listed in Table 1[3].

Table 1 Evaluation indicators for arability of cultivated land reserve resources in Hangjin Banner

No.	Evaluation indicators	Evaluation results
1	Ecological condition	In the ecological protection zone or development may lead to land degradation or give rise to geological disaster
2	10 ℃ annual accumulated temperature	< 1 800 ℃
3	Annual precipitation and natural precipitation	≤350 mm and no irrigation condition, failure to satisfy growth requirement of crops
4	Soil pollution situation	Soil is polluted
5	Drainage condition	No drainage condition
6	Soil thickness and parent materials	< 60 cm
7	Slope	land available for cultivation ≥15° and land available for reclamation ≥6°
8	Salinization	Serious or above
9	Soil texture	Gravelly soil or more rough soil or rock outcrop higher than 2%
10	Soil pH value	pH≥9.5
11	Farming convenience	Difficult for farming

2.3 Evaluation results

2.3.1 Types and area of cultivated land reserve resources in Hangjin Banner. Through evaluation of 11 evaluation indictors restricting development of cultivated land reserve resources in Hangjin Banner, we reached that the total area of cultivated land reserve resources in Hangjin Banner is 52200.02 hm^2, accounting for 7.71% of the study area, and the area of non-arable land reserve resources is 624 821.37 hm^2, accounting for 92.29% of the study area.

In the cultivated land reserve resources, all are land available for cultivation with an area of 15 334.95 hm^2; the area of land available for reclamation is 0 hm^2. This includes 14669.90 hm^2 inland mud flat, 24.17 hm^2 other grassland, 36538.35 hm^2 sand land, 499.07 hm^2 saline and alkaline land, and 468.53 hm^2 marshland.

From Table 2, it can be seen that there is little land available for cultivation, only accounting for 7.71% of the study area, and the cultivated land reserve resources are mainly sand land and inland mud flat. In Hangjin Banner, there are two parcels of waste mining land, but they can not be reclaimed.

Table 2 Evaluation results of cultivated land reserve resources in Hangjin Banner

Types	Cultivated land reserve resources		Non-cultivated land reserve resources	
	Area//hm^2	Percentage to the study area	Area//hm^2	Percentage to the study area
Land for mining	0.00	0.00	4541.76	0.67
Inland mud flat	14669.90	2.17	23861.94	3.52
Other grassland	24.17	0.00	89958.61	13.29
Sand land	36538.35	5.40	506128.30	74.76
Saline and alkaline land	499.07	0.07	330.77	0.05
Marshland	468.53	0.07	0.00	0.00
Total	52200.02	7.71	624821.37	92.29

2.3.2 Spatial distribution of cultivated land reserve resources in Hangjin Banner. From Table 3, we can know that all towns have distribution of cultivated land reserve resources in Hangjin Banner, mainly Dugui Tala Town and Yihe Wusu sumu, respectively 20715.00 hm^2 and 21104.38 hm^2, accounting for 39.68% and 40.43% separately. The cultivated land reserve resources of Hangjin Banner are mainly distributed in three areas: in the east, they are mainly distributed in Chagabulage Gacha, Baiyinbulage Gacha, and Erge Danwan Village of Dugui Tala Town; in central area, they are mainly distributed in Bayinwusu Gacha, Bayinwenduer Gacha, Bayin Gacha, Xiniqirige Gacha of Yihe Wusu sumu; in the west, they are mainly distributed in Huhemudu Town, Balahai Village, Dataozi Village, Donghongliu Village, and Xinjian Village of Balagong Town.

3 Analysis on restrictive factors of cultivated land reserve resources in Hangjin Banner

In the 11 evaluation indicators, there are 7 restrictive factors,

namely, ecological condition, precipitation and irrigation condition, soil thickness, slope, salinization, soil texture, and soil pH value. The irrigation condition and soil thickness are major factors restricting development of cultivated land reserve resources in Hangjin Banner, respectively accounting for 90.24% and 15.11% of the total non-cultivated land reserve resources, further proving the fact that there is no agriculture if no irrigation condition.

Table 3 Distribution of cultivated land reserve resources in Hangjin Banner (Unit: hm^2)

Line label	Non-cultivated land reserve resources	Reserve resources	Total
Balagong Town	55583.80	2510.71	58094.52
Huhemudu Town	64728.45	3220.86	67949.31
Duguitala Town	189626.08	20715.00	210341.08
Jirigalangtu Town	227336.35	1318.49	228 654.84
Xini Town	25784.11	3330.58	29114.69
Yihe Wusu sumu	61762.57	21104.38	82 866.95
Total	624821.37	52200.02	677021.40

Table 4 Restrictive factors of cultivated land reserve resources in Hangjin Banner

Restrictive factors	Restrictive area//hm^2	Percentage to non-arable land
Ecological condition	21 449.78	3.43
Precipitation and irrigation condition	563 857.45	90.24
Soil thickness	94 379.42	15.11
Slope	3 589.13	0.57
Salinization	24 817.92	3.97
Soil texture	29 078.58	4.65
Soil pH value	374.32	0.06

3.1 Restriction of ecological conditions The restriction of ecological condition is mainly due to the natural protection zone. There are three nature reserves in Hangjin Banner: Zhuoer Nature Reserve, Baiyin Engel Desert Endangered Plant Nature Reserve, and Kubuqi Desert Caragana korshinskii Kom. Nature Reserve. Zhuoer Nature Reserve is a comprehensive natural protection zone mainly protecting mud flat and wetland ecosystem along the Yellow River and grassland ecosystem in north of Kubuqi Desert in middle and upper reaches of the Yellow River and rare birds and various living things[4]; this zone is one of the areas with rich ecosystem types. Due to special natural environment, Zhuoer Nature Reserve can adjust semiarid ecological environment of surrounding areas through high evaporation capacity of mud flats and rivers, and form special ecological barrier, apart from common ecological function of wetland ecosystem[5]. At present, the water volume of Yellow River gradually declines. Desertification and discharge of pollutants in surrounding areas exert adverse influence on this area and seriously threaten habitat, breeding and migration of wild animals. Excessive grazing of surrounding grassland leads to accelerated desertification and also threatens wild plants and animals. Based on important functions of ecological protection zone, all evaluation objects in the ecological protection zone were included into the non-cultivated land reserve resources. Through evaluation, we obtained that the area of unused land not available for development due to ecological condition is 21449.78 hm^2.

3.2 Annual precipitation and irrigation condition The annual precipitation is relatively low in Hangjin Banner, and the regional distribution is not even and the interannual change is great. Its annual precipitation is 140 – 340 mm. Balagong Town has the lowest precipitation (only 142 mm); Xini Town has the annual precipitation of 286.4 mm, while the southeastern Xini Town has annual precipitation above 300 mm. All areas of Hangjin Banner have annual precipitation lower than 350 mm, so it is impossible to satisfy basic water demands for agriculture.

Besides, groundwater resources of Hangjin Banner are not evenly distributed. There are 25 large and small rivers flowing across Hangjin Banner, including the Yellow River flowing across Hangjin Banner about 220 km. Thus, the area along the Yellow River has better irrigation condition. Other rivers such as Molin River, Maobulakongdui River, and Taolai River have lower and lower water volume. Along both sides of Molin River in Yihewusu sumu, Alashan in Haoraochaidamu and Yanhaizi in Bayinwusu have plentiful groundwater, the water yield of single well is higher than 500 tons. However, the water volume of Maobulakongtui in Bayinbulage fluctuates greatly, the water yield of single well is only 0.5 – 100 tons. The water volume is the lowest in Kubuqi Desert and Maowusu Desert. Therefore, except areas along Molin River and surrounding areas of Maobulakongdui, few areas can satisfy water demands for farming through exploiting groundwater. In addition, there is no much land available for cultivation. Irrigation condition becomes the major restrictive factor for development of cultivated land reserve resources in Hangjin Banner. This indicator accounts for more than 90% in area of non-cultivated land reserve resources.

3.3 Soil thickness and parent materials Parent materials are results of rock weathering and are material basis of soil formation[6]. In dry environment, physical weathering and mechanical weathering preponderate, and wind erosion and water erosion are accompanied with little chemical action. In this situation, soil in Hangjin Banner forms 4 different parent materials: alluvial, diluvian, residual, and aeolian parent materials. Alluvial parent materials were deposited by moving water bodies such as rivers and streams. The texture of the deposit depends on the energy of the water body. Fast-moving water deposits only coarse material such as rocks and gravel. If the water velocity decreases, finer particles (sand and silt) are deposited, while fine silt and clay particles are deposited by slow-moving water such as that found associated

with deltas. Alluvial type of parent material is associated with such landforms as old streambeds, flood plains, deltas, fans, and levees. In Hangjin Banner, alluvial parent materials are mainly distributed in the north area along rivers, have excellent water and rich nutrients, so they are fertile soil. Soil developed by alluvial parent materials includes irrigation-silted soil, bog soil and saline soil. Diluvian parent materials are mainly distributed in low-lying land between hills and terrace in river valleys. Such parent materials have excellent water and rich nutrients, and mainly develop fluvo-aquic soil, meadow chestnut soil, and meadow gray desert soil. Residual parent materials are mainly distributed in ridges of high plain and ridge top and slope of hilly areas, and they develop such types of soil as chestnut soil, brown calcic soil, gray desert soil, and skeletal soil. Aeolian parent materials are mainly distributed in Kubuqi Desert and Maowusu Desert and mainly develop sandy soil.

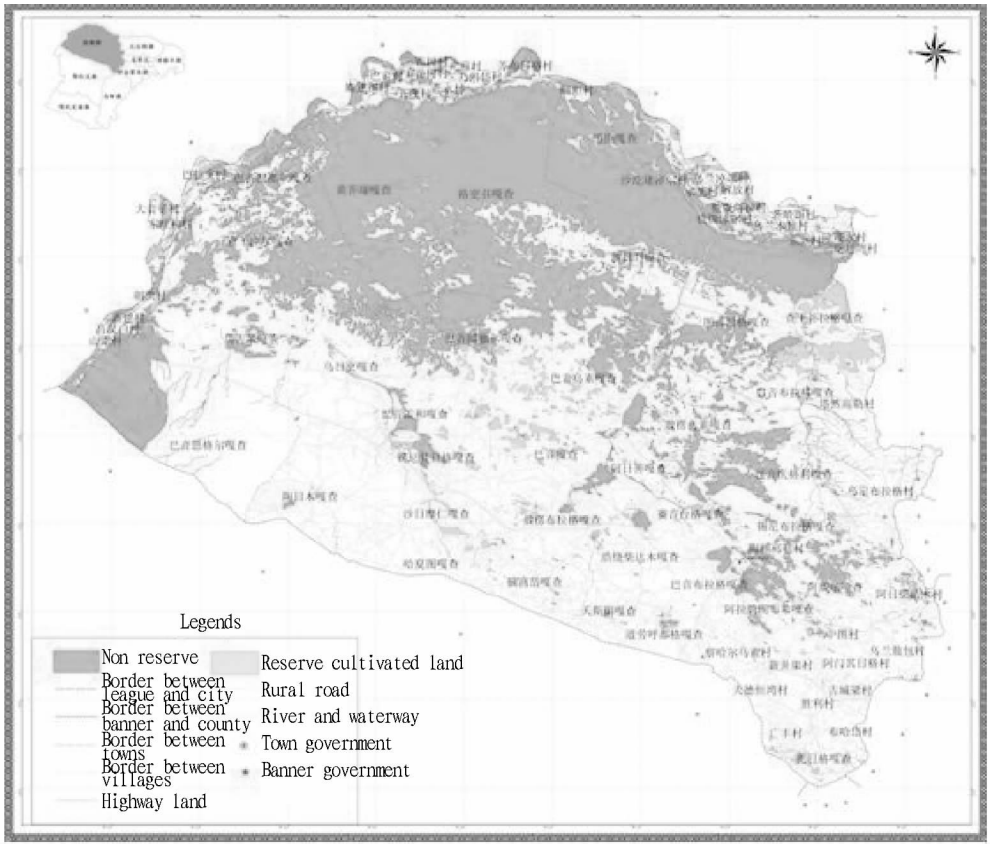

Fig. 1 Schematic map for distribution of cultivated land reserve resources and non-cultivated land reserve resources in Hangjin Banner

Classification of soil in Hangjin Banner adopts 4 levels[7]: soil group, subgroup, soil genus, and soil local type. In the whole Hangjin Banner, there are 8 soil groups, 18 subgroups, 43 soil genera, and 119 soil local types. According to soil classification type and area statistical table of Hangjin Banner, major soil types are chestnut soil (41.76%), fluvo-aquic soil (39.77%) and brown calcic soil (10.12%). Only 5 soil local types have topsoil thickness greater than 60 cm, while the rest 114 local types have topsoil thickness less than 60 cm (accounting for 95.21% of the total land area). Therefore, soil layer thickness becomes the second largest restrictive factor for development of cultivated land reserve resources in Hangjin Banner. This factor restricts about 94379.42 hm^2 unused land.

3.4 Salinization Salinization of soil in Hangjin Banner is mainly the result of natural factor and human factor. Salinized soil is mainly distributed in areas along rivers and mud flat. Firstly, dry climate promotes development of soil salinization[8]. According to meteorological data of Hangjin Banner, the annual average precipitation is 286.4 mm, the annual evaporation is 1128.3 mm, and the ratio of evaporation to precipitation is 5:1. In areas along rivers and mud flat, this ratio is up to 7:1 to 9:1. In addition, the rainfall is little in spring, while the evaporation is high. As a result, the vertical movement of groundwater is violent. This is favorable for rise of salt to earth surface, leading to salinization. Besides, the groundwater level is low and mineralization is high, promoting deterioration of soil salinization. Thirdly, the early stage drainage and irrigation system is not well established. Since the introduction of the Yellow River water, due to flood irrigation for a long time, it deteriorates salinization. Fourthly, extensive farming method, especially extensive field management, also leads to salinization[9]. This indicator restricts about 24 817.92 hm^2 unused land.

4 Conclusions

Firstly, through evaluation of 11 evaluation indictors restricting development of cultivated land reserve resources in Hangjin Banner, we reached that the total area of cultivated land reserve resources in Hangjin Banner is 52 200.02 hm^2, accounting for 7.71% of the study area, and the area of non-arable land reserve resources is 624 821.37 hm^2, accounting for 92.29% of the study area. The arable reserve resources are mainly distributed in areas along rivers and mud flat.

Secondly, in evaluation indicators of cultivated land reserve resources in Hangjin Banner, ecological condition, annual precipitation and irrigation condition, soil thickness and parent materials, and salinization are major factors restricting development of unused land. Therefore, to ensure grain security and to ensure that China's farmland at or above the red line of 120 million hectares, it is required to make effort in water and soil, to improve fertility of soil in Hangjin Banner.

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farmer cooperatives, the nonprofit rural organizations between government and the market, assume the functions of managing rural social and economic affairs. It is necessary to strengthen the professional skill training within cooperatives. The government should give special technical training funds and special subsidies for introduction and promotion of agricultural science and technology achievements; give subsidies and credit support for the production facility construction of cooperatives. It is also necessary to develop new rubber farmer cooperatives to enhance the ability to resist market risks; provide professional and technical training to constantly improve the quality of rubber farmers; conduct unified purchase of production materials to reduce farmers' production costs and perform unified marketing of products to reduce transaction costs; change the small-scale production into large-scale production through the new rubber farmer cooperatives to improve the operation and management level of rubber industry.

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