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Study on Benefits Evaluation and Countermeasures of Land Consolidation in Ecologically Vulnerable Area: A Case Study from the Zhenlai Project Area, a Major Land Consolidation Project in West Jilin Province

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Abstract: In accordance with the changes of the economic, social and ecological benefits brought by rural land development and consolidation in ecologically vulnerable areas, this thesis associates with the major land development and consolidation projects in West Jilin Province with obvious ecological vulnerability, takes Zhenlai project area as the major research area, constructs the hierarchical structure and index system of the land development and consolidation benefits evaluation with Analytic Hierarchy Process, uses the Multi-level Fuzzy Comprehensive Evaluation model to calculate the comprehensive benefits of land consolidation and puts forward the countermeasures to a long-term efficiency improvement in land development and consolidation in the ecologically vulnerable areas considering the actual situation within the project area.

Key words: Ecologically vulnerable areas, land development and consolidation, analytic hierarchy process, fuzzy comprehensive evaluation, West Jilin province

INTRODUCTION

Due to the limitation of available conditions, there are usually plenty of untouched land resources in the ecologically vulnerable areas. Timely development of unused land resources will play a positive role in enlarging land, increasing grain and coordinating contradiction between population and land resources (Ying and Han, 2013). But the untouched land resources in the ecologically vulnerable areas are relatively concentrated and require a large-scale preparation works. The implementation of large-scale projects will promote the land resources development and utilization and bring tremendous changes in land cover and ecological environment. The effects of land development and consolidation are characterized by long term and latency. In the trend of promoting the sustainable development, it is mankind's common code to reduce the combined influences of human activities on the environment and society. The land development and consolidation should ensure the sustainable land use, the biological diversity and ecological balance as well. Therefore, it has become the primary problem of land consolidation in ecologically vulnerable areas to establish a scientific and reasonable land consolidation benefits evaluation index system and evaluation method, to carry on the scientific evaluation of land arrangement projects and to handle the relationship between land development and consolidation and ecology coordination.

The West Jilin Province, flat and rich in the untouched land resources, is most potential in the agriculture development within Jilin Province. Meanwhile it is a typical ecologically vulnerable area, known as the "hectares of droughts" (Nie and Wang, 2013). Droughts, with more evaporation than precipitation, increase the soil salt deposition on the surface of the earth and cause the soil desertification and salinization. Poor natural conditions and vulnerable ecological environment restrict the development of agricultural production and the improvement of farmers' living standards in the western region of Jilin Province. In 2007, land development and consolidation projects which aim to increase land and grains, protect the ecological environment and develop and construct grain reserve region, were launched in western region of Jilin Province, relying on several major water conservancy construction projects of Da' an irrigation districts, Hada Mountain hydro-junction and Nenjiang River-to-Baicheng water diversion, etc.

Based on the existing evaluation theory and methods, this thesis takes Zhenlai land consolidation project in West Jilin Province as its reach background, focuses on the economic, social and ecological benefits

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to build the index system, uses the Fuzzy Comprehensive Evaluation Mode to conduct comprehensive benefit evaluation of land consolidation and aims to provide a scientific reference for the land consolidation projects in the ecologically vulnerable areas.

GENERAL CONDITION OF THE STUDY AREA

Natural and environmental condition: Zhenlai project area is located in the east of Zhenlai County, southwest of Jilin province. It is divided into three areas: Hatuqi Area, Jianping Area and Heiyupao Area. Hatuqi Area is located at 45°58'40-46°14'28 N and 123°17'40-123°43'1 E. Jianping Area is located at 45°50'25-46°5'9 N and 122°53'38-123°16'45 E. Heiyupao Area is located at 45°45'18-45°57'24 N and 123°11'21-123°30'19 E. The project area, covering an area of 92794.64 hm^2, totally involves 8 towns and 33 administrative villages. This alluvial plain with flat terrain, as a west part Songnen Plain, is higher in northeast, lower in southwest, with an elevation of 137-140 m. the local microtopography here makes itself suitable for developing agriculture and animal husbandry.

Social and economic condition: As an agro economic zone, Zhenlai County is one of the state-level poverty counties. The main planting industry here is traditional dry farming. Corn, broomcorn and millet as its primary productions account for 85% of farming. The beneficial crops like rice and tobacco, etc. only account for around 15% of planting area. The unitary planting structure, ecological and environmental degradation, frequent disaster, declining productivity and obvious ecological vulnerability result in the mass poverty and economic backwardness in this area.

Construction content: The construction scale of the project area is 81010.48 hm^2 and of newly increased cultivated land 38252.49 hm^2 (47.22%). An area of 12685.76 hm^2 paddy field and 73410.49 hm^2 high standard farmland has been newly built in Hatuqi Area.

The construction content includes the area of 16,3300 m^3 of land leveling, swag backfilling and sanding 544500 m^3 of sever saline field, building 87, 7900 m^3 of balk of paddy field, plowing 38252.49 m^3 of newly increased farmland, constructing 325222 m of branch canal and 825895 m of lateral canal, building 63066.00 m of paths of main land, 1082793 m of paths of attaching land and 2559520 m of productive road and planting 4914304 saplings for windbreak.

COMPREHENSIVE BENEFITS EVALUATION ON THE PROJECT AREA

Methods: There are no unified and standardized methods in the benefits evaluation of land development and consolidation projects. The applied methods include analytic hierarchy process, comparative analysis, gray correlation method, fuzzy mathematics method and neural network analysis. In accordance with the actual situation of the project area and based on the study of the analytic hierarchy process, this thesis uses the multi-level comprehensive fuzzy analysis to evaluate the comprehensive benefits of major projects, expecting that the optimal combination of the two methods can deal with the complexity of benefits evaluation of land consolidation and achieve the desired results.

Construction of the evaluation index system: The construction of the evaluation index system of the land development and consolidation in the western region of Jilin Province takes the following four factors into consideration: namely the characteristics of economic and social development of this region and its environment condition, following the scientific, systematic and hierarchical, comparable and practical principle, considering the comprehensive benefits from the economic, social and ecological aspects. According to the investigation and the natural and economic conditions of this region, the three categories of the comprehensive benefits are subdivided into 13 indicators (Table 1).

According to the data from the investigation of the project area, consulting the experienced farmers, visiting agriculture, land, water and other related management departments, examining the factual planting results of Da'an project area rice experimental field and of Hatuqi eco-agriculture demonstration area in Zhenlai Project area and taking the major projects into consideration, the index value table of the current situation before and after land consolidation of the project area is made (Table 2).

Determination of the evaluation index weight: The determination of the evaluation index weight employs Analytic Hierarchy Process (AHP). The concrete steps are as follows: according to the evaluation results of the indexes in index system conducted by the questionnaire survey for relevant experts and the relative importance between every index determined by the scales of Saaty scale table 1-9, paired comparison matrixes are built. sum and integral method is adopted to calculate the maximum feature vector of matrix.

Table 1: Benefits evaluation index system and its definition of land development and consolidation in Zhenlai project area

Target layer A	Criterialayer B	Index layer C	Unit	Definition of indicators
Comprehensive benefits from Land development and consolidation A	Economic benefits B_1	Food production capacity C_1	Jin/mu	The total grain outputoftheproject area/ The total arable land area oftheproject area
		Farmers' per capita net income C_2	Yuan/person	Farmer's annual net income inthe project area/total population of project area
		Arable landnet income C_3	Yuan/mu	Farmer's annual net income inthe project area/Arable land area oftheproject area
	Social benefits B_2	Per capita arable landarea C_4	Mu/person	(Arable land area oftheproject area/total population of project area)×100%
		Land utilization rate C_5	%	Used land ofthe projectarea/The scale of construction
		Road network density C_6	km/hm^2	The total lengthofthepathofthe project area/ The scale of construction
		Poverty alleviation effect C_7	None	Qualitative description
	Ecological benefits B_3	Green vegetation coverage C_8	%	[(Forest and grassland area+Crop area)/the total land area of the project area]×100%
		Unit area biomassC_9	t/hm^2	Vegetationbiomassin project area/the total area of project area
		Guarantee the irrigated area ratio C_{10}	%	The area of arable land irrigation facilities/arable land area oftheproject area
		Wetlands effect C_{11}	None	Qualitative description
		Saline land arearatio C_{12}	%	Saline land/the total area of project area
		Organic matter content C_{13}	%	(Animalandplantdebris andmicroorganisms and their organic matter/the weight of dry soil)×100%

Table 2: Index value table of the current situation before and after the consolidation of the project area

Index	Before	After
Grain production capacity (jin/mu)	869	1116
Per capita net income (yuan/person)	2188	5194
The arable landnet income (yuan/mu)	68.21	212.68
Per capita arable land area (mu/person)	8.8	18.39
Land utilizationrate (%)	44.4	90.62
The densityofthe road network (km hm^{-2})	0.0048	0.0505
Poverty alleviation effect	Qualitative description	Qualitative description
Green vegetationcoverage (%)	46.53	86.36
Unit area biomass (t hm^{-2})	15.71	23.02
Guaranteed rate offarmlandirrigation (%)	Qualitative description	Qualitative description
Wetlands effect	4.5	17.2
Saline land arearatio (%)	2.1	0
Organic matter content (%)	0.5	1.32

Table 3: Land consolidation benefits evaluation index weight table in Zhenlai Project area

Target layer A	Criterion layer B	Weight	Scheme layer C	Relative weight	Combination weight
Comprehensive benefits	Economic benefits B1	0.525	Grain production capacity C_1	0.430	0.226
			Farmers' per capita annual net income C_2	0.300	0.157
			Payback period C_3	0.270	0.142
	Social benefits B2	0.334	Per capita arable land area C_4	0.086	0.028
			Land utilization C_5	0.201	0.067
			The density of the road network C_6	0.254	0.085
			Poverty alleviation effect C_7	0.460	0.154
	Ecological benefits B3	0.141	Green vegetation cover C_8	0.297	0.041
			Biomass per unit area C_9	0.089	0.012
			Guaranteed rate of farmland irrigation C_{10}	0.238	0.033
			Ecological benefits of wetlands C_{11}	0.087	0.012
			Salinization ratio C_{12}	0.227	0.032
			Soil organic matter content C_{13}	0.062	0.008

CR = CI/RI CI = $(\lambda_{max}$-n)$(\lambda_{max}$-n)/(n-1) is used as a index to test the consistency and determine the weight of every evaluation index. Based on the sheer level weight of B layer and C layer after the calculation, we get the combination weight of the indexes.

THE MULTI-LEVEL COMPREHENSIVE FUZZY BENEFITS EVALUATION OF LAND CONSOLIDATION

Establishment of the evaluation model: Considering the actual condition of the project area and experts' advice, a

multi-level comprehensive fuzzy evaluation model is established to evaluate the benefits of land consolidation in the project area. That is to combine analytic hierarchy process and fuzzy decision-making evaluation method (Yue, 2009), use the analytic hierarchy process to determine weights of indicators and then use the fuzzy decision-making evaluation method to evaluate hierarchically. By using fuzzy transform principle and the principle of maximum membership degree and considering the factors associated with land consolidation benefits, more objective evaluation results are obtained.

Basic model of fuzzy comprehensive evaluation is as follows:

$$B = A \times R$$

B = Vector of evaluation result
A = Weight of evaluation index
R = Fuzzy relation matrix

A is the weight vector of index.

R suppose the evaluation factor is U_i, carry out the single-factor evaluation and obtain a fuzzy vector. v_j the r_{ij} is fuzzy membership of the evaluation factor i to index remark U_i and v_j. Enlarge the evaluation factors to (Jia, 2007), we can get a n×n membership matrix (Qi *et al*., 2011):

$$0 \le r_{ij} \le 1$$

$$R = \begin{bmatrix} R_1 \\ R_2 \\ \vdots \\ R_N \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & & \vdots \\ r_{N1} & r_{N2} & \cdots & r_{Nn} \end{bmatrix}$$

Standard mathematical model of Fuzzy Comprehensive Evaluation is:

$$R_i = [r_{i1}, r_{i2}, \ldots, r_{in}] \ (i = 1, 2, \ldots, N)$$

$$B = A \times R = [a_1, \ a_2, \ \cdots \ a_N] \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & & \vdots \\ r_{N1} & r_{N2} & \cdots & r_{Nn} \end{bmatrix} = [b_1, \ b_2, \ \cdots, \ b_N]$$

Calculation of membership and the evaluation model: The membership is determined by the combination of expert scoring and fuzzy statistical method. According to the results of each index after quantitative calculation and qualitative analysis, experts judge the condition of all indicators in the project area before and after consolidation of the project area. According to the evaluation results, the analysis and calculation of the fuzzy statistics are conducted (Jia, 2007). Then the membership of all indicators can be obtained and fuzzy evaluation matrix is established (Table 4).

Index weight is acquired from the calculation:

$$A = [B_1, B_2, B_3] = [0.525 \ \ 0.334 \ \ 0.141]$$

$$A_1 = [C_1, C_2, C_3] = [0.43 \ \ 0.3 \ \ 0.27]$$

$$A_2 = [C_4 \ C_5 \ C_6 \ C_7] = [0.356 \ \ 0.325 \ \ 0.194 \ \ 0.125]$$

$$A_3 = [C_8, C_9, C_{10}, C_{11}, C_{12}, C_{13}] = [0.297 \ \ 0.089 \ \ 0.238 \ \ 0.087 \ 0.227 \ \ 0.62]$$

Table 4: Evaluation index membership matrix table before and after the consolidation

	Before	After
Economic benefits	$R_1 = \begin{bmatrix} 0 & 0 & 0.69 & 0.31 & 0 \\ 0 & 0 & 0 & 0.34 & 0.66 \\ 0 & 0 & 0 & 0.16 & 0.84 \end{bmatrix}$	$R_1' = \begin{bmatrix} 0.58 & 0.42 & 0 & 0 & 0 \\ 0.45 & 0.54 & 0 & 0 & 0 \\ 0.05 & 0.95 & 0 & 0 & 0 \end{bmatrix}$
Social benefits	$R_2 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0.58 & 0.42 & 0 \end{bmatrix}$	$R_2' \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0.12 & 0.88 & 0 & 0 & 0 \\ 0.4 & 0.6 & 0 & 0 & 0 \\ 0 & 0.75 & 0.25 & 0 & 0 \end{bmatrix}$
Ecological benefits	$R_3 = \begin{bmatrix} 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0.7 & 0.3 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 \\ 0.79 & 0.21 & 0 & 0 & 0 \\ 0 & 0 & 0.32 & 0.68 & 0 \end{bmatrix}$	$R_3' = \begin{bmatrix} 0.13 & 0.87 & 0 & 0 & 0 \\ 0.2 & 0.8 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.44 & 0.56 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.45 & 0.55 & 0 \end{bmatrix}$
Comprehensive benefits	$R = \begin{bmatrix} 0 & 0 & 0.3 & 0.28 & 0.42 \\ 0.086 & 0 & .02668 & .0193 & 0.455 \\ 0.179 & 0.048 & 0.020 & 0.104 & 0.649 \end{bmatrix}$	$R' = \begin{bmatrix} 0.4 & 0.6 & 0 & 0 & 0 \\ 0.759 & 0.21 & 0.031 & 0 & 0 \\ 0.522 & 0.329 & 0.028 & 0.072 & 0.049 \end{bmatrix}$

A fuzzy comprehensive evaluation model of economic benefits, social benefits, ecological benefits and comprehensive benefits is established:

$$B_i = A_i \times R_i \quad B = A \times R$$

Then a fussy operation is conducted. After that, the evaluation results vector of each index before and after consolidation are obtained (Table 5).

Table 5 the evaluation results vector table of each index before and after consolidation of the Zhenlai Project area.

Score caculation of the benefits evaluation of land consolidation: We adopt Multi-level Fuzzy Comprehensive Evaluation Method to evaluate the benefits layer-by-layer from low to high and get fuzzy operation results at all levels. Then we introduce arithmetic method to set evaluation grading standards and establish a score function of evaluation:

$$F = (f_1, f_2, f_3, f_4, f_5)^T = (100, 80, 60, 40, 20)^T$$

Then we calculate evaluation scores of economic, social and ecological benefits before and after consolidation:

$$Z_1 = B_1 \times F \quad Z_2 = B_2 \times F \quad Z_3 = B_3 \times F$$

$$Z'_1 = B'_1 \times F \quad Z'_2 = B'_2 \times F \quad Z'_3 = B'_3 \times F$$

Comprehensive benefits evaluation scores:

$$Z = B \times F \quad Z' = B' \times F$$

The results of land consolidation benefits evaluation scores is shown in Table 6.

It can be seen from Table 6 that each benefit evaluation score of the project area before the consolidation is less than forty points on average. The social economic condition and ecological environment of project area are at the "poor" level, unfavorable to steady and continuous development of social economy and ecological environment in the project area. The implementation of the project has brought huge economic social and ecological benefits. After the land consolidation, the benefit evaluation score on average is 80 points or more, at the "great" level which indicates that the implementation of the project is successful in general and belongs to the master project.

Analysis of evaluation results

Analysis of economic benefit: The geomorphology of Zhenlai project area is alluvial plain which is appropriate for agricultural development. However, in this project area, the saline area is larger than nonsaline area. There is 644000 mu waste grassland and the unused land area occupies 55.5% of the whole project area. In the area of cultivated lands, dry farmland cultivation accounts for larger proportion. The dry crops, such as corn, sorghum and so on, occupy 85% of the plant industry. The sown area of the more profitable crops like rice, occupies only about 15%. What is worse, the catastrophe climate, such as droughts and floods, more windy days and so on, causes the backwardness of production and the poverty of the farmers in this project area. After the land consolidation, all the waste grasslands and saline lands will be changed into paddy fields and the area of the paddy fields will be raised from 127000-203000 mu after the consolidation. The original 515000 mu dry lands will be wholly changed into watering fields. The capability of the soil's production will be largely improved. Through calculating, the crops' production increases by 28.4%, the per capita annual net income 151.12% and the net income 211.8% compared with that before consolidation. Obviously, the implementation of the project brings a large economic benefit to this project area. Through calculating, the evaluation score of economic benefit in the project area is increased from 37.6-88 after the

Table 5: Before and after finishing efficiency index value evaluation results vector tables in Zhen'lai project area

Before	After	
Economic benefits	[0 0 0.30 0.28 0.42]	[0.60 0.40 0 0 0]
Social benefits	[0.086 0 0.2668.. 0.193 0.455]	[0.473 0.496 0.031 0 0]
Ecological benefits	[0.179..0.048..0.02 0.104 0.649]	[0.522..0.329..0.028..0.072 0.049]
Comprehensive benefits	[0.0539..0.0068..0.25..0.226 0.46]	[0.54..0.43 0.014 0.01 0.007]

Table 6: Benefits evaluation score in Zhenlai project area

	Before consolidation	After consolidation
Economic benefits	37.60	88.00
social benefits	32.42	88.84
Ecological benefits	40.08	84.06
Comprehensive benefits	39.17	87.26

consolidation. All these show that this project practically plays an important role in increasing the farmers' yield and revenue.

Analysis of social benefit: Before consolidation, the per capita cultivated land in Zhenlai project area is 8.8 mu is above the average with the Jilin Province. In these three project areas, it is just lower to Songyuan. However, in this project area, the infrastructure is poor, the water conservancy facilities are unrepaired for a long time, the density of the rural roads is low and the agricultural production cost is high. In addition, because of the larger rate of dry land cultivation and the frequent occurrence of droughts and floods, the productivity of the cultivated lands is not high. After the land consolidation, through the construction of land flattening project, farmland water conservancy facilities project, road engineering and farmland shelter project, the condition of agricultural production is improved with fields in square, roads in net, irrigation canals and ditches in freedom and infrastructures in assort. The farmlands reach the standard of irrigating in droughts, dewatering in flood and high and stable yield. the capability of resisting against the natural disaster is increased and the farmers' yield and living level are improved. Through consolidation, the newly added cultivated lands reach 38252.49 hm^2 and the rate of the newly adding cultivated lands is 47.22%. It obviously increases the area of effective cultivated lands and improves the ratio of farmlands utilization. Through calculating, the per capita cultivated land increases from 8.8-18.39 and the rate is increased to 108.9%. The ration of farmlands utilization is increased from 44.4-100% after consolidation. The road net density is increased from 0.0048-0.0505 km hm^{-2}. The evaluation score of social benefit in the project area is increased from 32.42-88.84. All these show that the implementation of the project has a good social effect.

Analysis of ecological benefit: During the past half century, the ecological environment of the project area is deteriorating. The good grassland is less than 760 hm^2, accounting for 0.82% of Zhenlai project area; inferior grassland occupies the vast majority, accounting for 45% of Zhenlai project area, among which the wild grassland and saline-alkali soil is about 40000 hm^2. Because of the large area of inferior grassland, the green vegetation coverage rate of the project area has been at a low level of 46.53%. The farmland water conservancy infrastructure of project area is weak and there are no irrigation facilities in the dry farmland, so the required irrigation can not guarantee. The project area is lack of public facilities and the village environment is poor. After the consolidation, combining diversion works, a large area of paddy fields is increased. Using engineering backwater can restore a large area of dry wetland and wetland effect is significantly increased. Through ditches governance and water conservancy facilities system, the no irrigation security fields are able to be irrigated. Farmland ecosystem will be greatly improved. Ecological benefit evaluation indexes are greatly improved. The evaluation score of ecological benefit is increased from 40.08-84.06 points, improving the ratio of 109.7%. Obviously, the ecological benefit brought by the project implementation is very significant.

Analysis of comprehensive benefit: Before consolidation, dry farmland cultivation accounts for a larger proportion in Zhenlai project area. The simple production structure and high cost results in the low profits of the farming. After consolidation, the project area change the main dry planting structure and increase a large area of paddy planting area that can obtain good paddy planting benefits. Meanwhile, the regional ecological environment will be also improved. Development contrast analysis shows that, after the project implementation, it will change the insufficient and unreasonable original land use situation. Through the land settling, building roads, protection, irrigation and drainage and a series of engineering construction, the appearance of villages will change radically. A good social effect is achieved. By calculation, the comprehensive benefits of project evaluation will scores from 39.17-87.26 points and the comprehensive benefit value is at a high level among three project areas. All these show that the implementation of the project is generally successful and can achieve satisfactory effect in the aspects of economy, society, ecology etc.

CONCLUSION AND COUNTERMEASURES

The space changing rate of the environmental factor in ecologically vulnerable area is big and it is very sensitive to the outside interference. The economic exploration affects the ecologically vulnerable environment seriously. Land development and consolation is a process to change actual land utilization phase. The process will destroy the initial phase of land resources in the area and will have direct or indirect, beneficial or harmful effects on the water resource, soil, plants, creatures and many other environmental factors and ecological process (Li, 2010). Therefore, the land development and consolidation in the ecologically vulnerable area should take the characteristics of the region ecological vulnerability into full consideration and

enhance the ecological adaptability of land exploration, plan farming, forestry and animal husbandry development policies as a whole, achieve mutual benefits of economic development and ecological protection. As for the land development and consolidation and the benefits evaluation in the ecologically vulnerable areas, we can safely draw the following conclusions:

Firstly, the land development and consolidation in the ecologically vulnerable areas can gain good benefits.

The ecological protection and economic development is a pair of paradox. The outstanding economic development results in the most seriously ecological destroy and the outstanding ecological protection causes the biggest economic loss (Xue and Bai, 2012). Generally, it is thought to be too difficult to accept or reject. In fact, the contradiction between land exploration use and ecological protection is not irreconcilable. As long as we control the degree of the land development and consolidation and attach great importance to the ecological environment protection, the economic development in ecologically vulnerable area can protect the environment during the resources exploration. We can explore and use the land resources effectively in the environmental protection and get a better benefit.

The guiding concept of "increase land and grain, protect the ecology" put forward by the major project of land development and consolidation in the western region of Jilin province adapts to the concept of modern land consolidation. The preceding evaluation results show that the implement of the project plays an important role in increasing effective land area, enlarging the land production capacity, improving the agricultural production condition and ecological environment and promoting economic development of the countryside. The implement of the project has created great economic benefit and obvious social benefit. The ecological benefit will also acquire good effect. Therefore, the implement of the project is successful on the whole, the land development and consolidation in the ecologically vulnerable areas can get good benefits. The unused land in this kind of area should choose the latter between abandoning and timely development.

Secondly, the land development and consolidation of ecologically vulnerable area should take the comprehensive benefits evaluation as priority.

For the ecological vulnerable area, the vulnerability of ecology is mainly due to, besides a few natural factors, the interference and damage of human. How to avoid the ecological negative effect is the premise and foundation of land development and consolidation in the ecologically vulnerable area with reserved resources to obtain long-term benefits.

At present, organized and large-scale land development and consolidation in the ecologically vulnerable area is still in the initial stage in our country. The main purpose is to expand the quantity of cultivated land to compensate for non-agricultural occupation of cultivated land without considering improving the quality of the environment and land. So the phenomenon of "quantity over quality, ecology overlooked" exists generally. Therefore, the land development and consolidation in the ecologically vulnerable areas should not be evaluated particularly by economic benefit. Instead the improvement of comprehensive benefits should be considered at the starting point. So the idea and scheme of land development and consolidation should make economic benefit, social benefit and ecological benefit coordinate well and improve at the same time.

Thirdly, regional characteristics and ecological benefit should be considered in the land development and consolidation in the ecologically vulnerable area.

Most reserved cultivable land resources in ecologically vulnerable area are mostly located in where water is relatively in shortage and have more limits for development (Qiao and Yan, 2008). Most unused land is the desolated beach, grassland and alkaline land, development will very probably destroy the ecological environment and negative environmental impact on environment background of the ecologically vulnerable area has expansion effect which may lead to the change of ecological system and reverse succession and there just will be a little chance of restoration to the original state. All of the factors determine the project of land development and consolidation in the ecologically vulnerable area several times more efforts to protect the ecological environment than other regions. The economic benefits of land development and consolidation individual or local but the environmental damage it makes is social and public. Therefore, for the development and consolidation of unused land in ecologically vulnerable area, the premise should be the improvement of the ecological environment and the design should be fully demonstrated the effects of project implementation process on the ecological environment especially negative effects. Otherwise, it will cause the problems of ecological environment, or even social and economic problems. So the effect of development and consolidation should put more emphasis on ecological benefit.

Based on the conclusion and evaluation results from the above, the following suggestions are proposed to promote the benefits of the project area:

- **Develop land in the light of water conditions and develop moderately:** We should abundantly take the

vulnerability of the project area into consideration, protect ecological environment, develop land in accordance with local water conditions and develop moderately. When programming land developing scales and schedule, we should consider the soil conditions and the conditions of water source protection, act according to local circumstances, step-by-step, tending towards advantages and avoiding disadvantages. According to the three keeping water control projects, agricultural irrigation water in irrigation areas should be fully used in project areas, without having effects on the distributions of the volumes of water and the water-used plan. We ensure project construction from the water-used perspective, avoiding competing for water with cities, wetland and prairie

- **Soil improvement:** Apart from the paddy filed, most of the lands are dry land and unused land, in which saline alkali land accounts for a big part. At the same time, saline alkali land belongs to the typical area of sodicity and salinization. We can effectively improve saline alkali soil sandy soil and other soil that is weak in ventilating, dewatering and water conservation by physical measures, such as land leveling, alien earth mixed with sand, irrigation cooperating with sewerage,rice cultivating, spreading more organic fertilizer,alien earth mixed with clay, deep plowing paddy field, irrigated harrowing etc. By these ways, we can improve soil physical change and soil fertility
- **Rationally arrange land use and optimize land use structure:** The new arable land in project area mainly derives from saline alkali land, unused land, in which swampland, barren earth, reed marshes are scattered. Some can be used as paddy fields while others can be used as irrigating land. Besides the scattering develop in planned paddy fields, we should keep unused land that has the character of wetland in reservation and forbid developing large-scale and center-scattered swampland, reed marshes and tideland etc. Garden plot, forest land, grassland and the surface of river should be reserved. At the same time, it will not be permitted to develop the unique numerous wetland which will be combined with agricultural land to form a rational land use arrangement and structure
- **Enlarge land cover**

  First, strengthen the farmland shelterbelt construction: Land development and construction at the same time should be synchronized construction with field, water, forest, road, unified planning. Plan farmland protection forest should adapt to suit local conditions in the light disaster pretention, long-term planning and reasonable allocation. Salt-tolerant tree should be planted in the main field and medium field on both sides. The building shelterbelts and forest in the channel sides and lake make farmland protection forest and existing protection forest organic union and form a complete protection forest system, played a sand-fixing, reduce disaster, protection of farmland. Through the construction of field irrigation system, road and land leveling and soil improvement project, a "square farmland, wired forest, connected road" ecological system will be built to improve the abilities of fighting natural calamities

Second, establish three-dimensional complex agricultural ecology system.

Unused land should be turned into irrigated paddy field under local conditions; keep the original garden, woodland, grassland, reed, swamp and Numa water in project area, form irrigated land, orchard, woodland, grassland, river and lake pond, reed marshes and other land. The project area of trees and shrubs, grassland, farmland and wetland formation structure is large and stable forest - grass - land and wetland ecological system is formed to change the current land salinization, desertification situation fragile, single ecological landscape and it plays an important role in improving total amount of high biological resources and keeping biodiversity conservation, etc.

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