Farmland scale develop benefit evaluation in ecologically vulnerable areas-taking Songyuan land consolidation project as example

Ying Nie[1], Ke Li[2], Yun Xia Wang[3*]

[1]*School of Economics and Management, Jilin Agricultural University, 2888 XinCheng Street, 130118 Changchun, China;*

[2]*School of international economics and trade, Jilin University of Finance and Economics, 3699 JingYue Street, 130117 Changchun, China*

[3]*School of Economics and Management, Inner Mongolia Agricultural University, 306 ZhaoWuDa Street, 010019 Hohhot,*

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Abstract

It is the most important issue in smoothly carrying out of agricultural land development project that the ecologically vulnerable areas can withstand the environmental impact brought by large-scale development or not . By using the Songyuan City, Jilin Province which is an agricultural land consolidation project area as a typical study area, using analytic hierarchy process to build a hierarchy and index system of agricultural land development and consolidation benefit evaluation, using the multi-level fuzzy comprehensive evaluation model to calculate the overall efficiency of agricultural land consolidation, it is concluded that the agricultural land development and consolidation in the ecologically vulnerable area can get good benefits, but needs to pay attention to the environment maintenance. Therefore, the benefit evaluation index setting should also highlight the ecological benefits and it needs to protect arable land, increase arable land vegetation, and the land use structure optimization. It is the first time to set an index system for an agricultural land development and consolidation project in western Jilin, and to discuss the feasibility of the benefit evaluation by using the multi-level comprehensive fuzzy evaluation model on the ecologically vulnerable area of agricultural land consolidation project, then in the expect of giving references to the land consolidation work in similar area and the relevant theoretical studies.

Keywords: ecologically vulnerable areas; agricultural development; reserved resources; fuzzy comprehensive evaluation; west Jilin

1 Introduction

Due to limitations in the use of ecologically vulnerable areas, there are generally a large number of agricultural reserved land resources. To develop and consolidate the unused agricultural land resources at proper time will have a positive and important impact on increasing the growth of grain and coordinating the conflicts between the human beings and the lands. It is a relatively big project to consolidate the ecologically vulnerable agricultural reserved land resources which are concentrated. The implementing of the large-scale projects will enable the development and utilization of land resources in the scale and intensity, land cover and ecological environment will also undergo tremendous changes, which will bring long-term and latent characteristics in affecting the development and consolidation of agricultural land [1]. With the trend of promoting sustainable development, it becomes a rule that reducing the combined effects of human activities on the environment and the society and setting goals that the development and consolidation of agricultural land which should ensure sustainable land use and should ensure the biodiversity and ecological balance. Therefore, the establishment of a scientific and rational agricultural land consolidation benefit evaluation index system along with the methods for the land consolidation projects and to handle the relationship between land development and coordination with the ecology have become the prior problems when carrying out land consolidation in ecologically vulnerable area.

In West Jilin, it is not only rich in reserved land resources, but also the typical ecologically vulnerable areas, which is known as "800 kilometers in the dry sea” [2]. Barren harsh nature and the vulnerability of the ecological environment limit the development and improvement of farmers` living standards in agricultural production in West Jilin. In 2007 Jilin Province activated the major projects to implement the western land development and consolidation, which relying on several major water conservancy projects including Daan Irrigation area, Hada Mountain Hydro, and leading Nen river into White river, respectively conducting construction in three main areas of Daan, Matsubara, Zhenlai, and with the aims to increase grain growth,

*Corresponding author’s E-mail: 1254626519@qq.com

ecological protection, and the development and construction of grain reserved areas.

Basing on the existed evaluation theories and methods, and by using the major land consolidation projects of Songyuan which is in the western region of Jilin as the study area, by building the index system of economic, social, and ecological benefits, by using multi-level fuzzy comprehensive evaluation model to evaluate the land consolidation, it is expected to provide scientific reference to the land consolidation project in vulnerable area.

2 The overview of study area

2.1 THE NATURAL CONDITIONS

The Songyuan project area is located in the west plains of Jilin Province, the north of the Nen River, Taoer River and Songhua River, to the south of Songliao watershed plateau, through which Huolin River and second Songhua River. The total area is of 203489.25 hm2 and in the district there are 14 townships, 123 administrative villages and three state-owned farms, with a total population of 10.31 million. The project areas involve three chip areas which are QianGuo, Yuzi and Housi. The main vegetation types in the project area belong to arid and semi- humid meadow steppe. The landform types are the accumulation erosion terrain and accumulation terrain, the terrain erosion mainly deposits in the south of the study area, with the causes of the high plateau morphology of gravel; the causes of accumulation terrain morphology are lake alluvial plains and valleys alluvial plain; the alluvial plains are divided into four units: Microwave -like hillock and sand-covered hillock wavy, slightly inclined plains, lakes depressions form. The climatic conditions in the project area are affected by the atmospheric circulation, with dry and windy spring, summer, warm and rainy autumn with cool temperature, and the long, cold winter, the water and heat conditions can meet the needs of growth and development of one-year-ripe crops.

2.2 THE SOCIO-ECONOMIC CONDITIONS

Songyuan City which belonging to ecotone, is a traditional agricultural economic zone with serious salinization and desertification. There are 87887.87 hm2 existing farmland in project area, accounting for 38% of the total area of the project, in which arable paddy are 41400.98 hm2, accounting for 47.1 % of arable land, field are 46407.13 hm2, accounting for 52 % of arable land. Dry land is mainly to grow corn, which accounting for 70% of total area with a single agricultural planting structure, farmers mainly engage in dry farming agriculture. Affected by drought and other natural disasters, the yield is low and unstable, the average annual harvest are of 5-7 tones/hm2, in the drought years it was only 3-4 t/hm2.Coupled with ecological degradation, environmental degradation, disasters, declining productivity, and significant ecological vulnerability result in the masses poverty and economic backwardness of the area.

2.3 CONSTRUCTION CONTENT

The total area of Songyuan project are 230677.54 hm2, the construction scale is 185362.24 hm2, the high-standard farmland to build are 166580.27 hm2, which including paddy field area of 98610.28 hm2, new farmland of 78692.4 hm2, new paddy of 57209.3 hm2, and new arable land will be 50.03% .

The project includes ponds backfill and severe saline with new soil mixed with sand are of 4,035,000 m3, the ridge construction are of 21,453,500 m3, tilling the land are of 78,700m3, to build branch canals of 511,500m, to construct bucket-type canal are of 1,525,000m, the construction of agricultural drainage are of 7,828,000m. The construction of the main road is of 372100m, the construction of sub- field channel is of 1,538,000m, and the construction road for production are up to 9,024,000m, shelterbelt planting seedlings are 12,845,000plants.

3 Comprehensive befit evaluation of the project area

3.1 METHODS SELECTED

At present, there are still no standardized methods for land development and evaluation of project benefits; the method includes the application of AHP, comparative analysis, gray correlation method, fuzzy, neural network analysis. This paper uses multi-level fuzzy comprehensive analysis method to evaluate the overall efficiency of major projects based on the actual situation in the project area and primarily on the basis of AHP research. With the optimal combination of the two methods, it is able to handle a comprehensive benefit evaluation of land consolidation complexity, and to achieve the desired results.

3.2 BUILD EVALUATION SYSTEM

Since the study area is typical of ecologically vulnerable areas, setting evaluation system should take full account of economic and social benefits and the development of infrastructure that projects can bring, and mainly focus on eco-efficiency indicators for system settings, social and economic development from the project area and from the features of the environment, from the overall efficiency of economic, social and ecological benefits, as well as on the basis of these four areas of agricultural land in the project area; we try to establish effective evaluation system of development and consolidation projects. According to the field survey and natural, economic conditions of the project area, considering the indicators of scientific and data availability, we will subdivide the three categories of benefit evaluation index into the following 13 indicators [2]. Based on actual survey data in the project area and the actual results of rice planted plots in Songyuan project area, by asking experienced farmers and visiting to relevant administrative departments of agriculture, studying land, water and other major projects, considering the plan of the project area, we obtain present Status indicators index value as shown in the following tables. (See Table 1)

TABLE 1 the development and consolidation benefit evaluation index system of Agricultural land and index definitions and the status indicator value

Target layer A	Guidelineslayer B	Index layer C	Unit	Index definition	before consolidation	after consolidation
comprehensive benefit of land development and consolidation A	economic benefit B_1	Food production capacityC_1	Jin/per acre	aggregate food production of project area/the total cultivated land of project area	744	1075
		The net income of farmers per capita C_2	Yuan/per capita	Annual net income of farmers in the project area/the total population of project area	3188	7119
		Net income of arable landC_3	Yuan/per acre	Annual net income of farmers in the project area /arable land of project area	177.28	288.7
	social benefit B_2	arable land Per capita C_4	Acre/per capita	(Arable land of the project area/the total population of project area)×100%	10.5	20.02
		Land utilizationC_5	%	the used area of project area/project construction scale	48	99.3
		The density of the road networkC_6	Km/hm^2	The total length of roads in the project area / building scale	0.0015	0.0604
		Poverty alleviation resultsC_7	Dimensionless	Qualitative description	Qualitative description	Qualitative description
	ecological benefit B_3	Green vegetation coverageC_8	%	[(Forest and grassland area + Crop area)/ Total land area of the project area]×100%	16.06	80.1
		Biomass per unit areaC_9	t/hm^2	Biomass of project area/Total area of the project	12.2	23.58
		the proportion of ensured irrigated areaC_{10}	%	Arable land with irrigation facilities/the total cultivated area of project	47.1	97.78
		Wetlands effectC_{11}	Dimensionless	Qualitative description	Qualitative description	Qualitative description
		Ratio of saline area C_{12}	%	Saline area of project /total project area	18.6	0
		Organic matter contentC_{13}	%	(plant and animal residues and microbial decomposition of organic synthesis/Dry soil weight×100%	0.849	1.6

3.3 A COMPREHENSIVE INDEX WEIGHTS

Evaluation index weights are determined by using AHP, the specific steps are: according to the index system using the evaluation results of the experts questionnaire survey in various indicators, in accordance with the Saaty scale Table 1-9, we determine the relative importance of the various Evaluation index weights are determined by using AHP, the specific steps are: according to the index system using the evaluation results of the experts questionnaire survey in various indicators, in accordance with the Saaty scale Table 1-9, we determine the relative importance of the various indexes and establish pair wise comparison matrix; by using the plot method to work out the maximum characteristics of vector-valued, and use $CR = CI / RI$) in which is $CI = (\lambda_{\max} - n)/(n-1)$ as an indicator consistency test to determine the weight of each evaluation index. We establish pair wise comparison judgment matrix, and use the method to work out the maximum characteristics of vector-valued and then do the consistency tests to determine the weight of each evaluation index. According to the calculations in single-level weights of the B layer and C layer, we work out the index portfolio weights.

According to the mentioned method above, by using AHP, after participating in the evaluation indicators we will get the pair wise judgment matrix, and conduct a consistency checking, and the results of the judgment matrix and index weights are as follows:

TABLE 2 Comprehensive benefits judgment matrix and the level of single sort in Songyuan project area

A	B1	B2	B3	W
B1	1	6/5	1	0.35
B2	5/6	1	2/3	0.27
B3	1	3/2	1	0.38
$\lambda_{max} = 3.006$; $CI = 0.0028$; $RI = 0.58$; $CR = 0.0048 < 0.1$				

TABLE 3 Economic benefit judgment matrix and the level of single sort in Songyuan project area

B1	C1	C2	C3	W
C1	1	3/2	1/2	0.28
C2	2/3	1	1/2	0.22
C3	2	2	1	0.5
$\lambda_{max} = 3.018$; $RI = 0.58$; $CR = 0.158 < 0.1$				

TABLE 4 Social benefit judgment matrix and the level of single sort in Songyuan project area

B2	C4	C5	C6	C7	W
C4	1	1/4	1/3	1/2	0.093
C5	4	1	2	5	0.506
C6	3	1/2	1	2	0.263
C7	2	1/5	1/2	1	0.138
$\lambda_{max} = 4.072$; $CI = 0.024$; $CR = 0.027 < 0.1$					

TABLE 5 Effectiveness evaluation results score tables in Songyuan project area

B3	C8	C9	C10	C11	C12	C13	W
C8	1	1/2	1/4	1/3	1/3	1/3	0.057
C9	2	1	1/3	2	2	1/2	0.147
C10	4	3	1	3	3	2	0.343
C11	3	1/2	1/3	1	2	1/3	0.117
C12	3	1/2	1/3	1/2	1	1/3	0.093
C13	3	2	1/2	3	3	1	0.243
$\lambda_{max} = 6.225$; $RI = 1.24$; $CI = 0.045$; $CR = 0.036 < 0.1$							

TABLE 6 Land consolidation benefits evaluation index weight sorting table in Songyuan project area

Target layer A	Guidelines layer B	weight	Solution layer C	Relevant weight	Portfolio weight
Comprehensive benefit	Economic benefit B_1	0.35	Food production capacity C_1	0.28	**0.098**
			Annual net income of farmers per capita C_2	0.22	**0.077**
			The payback period C_3	0.50	**0.175**
			$\lambda_{max} = 3.018$; $CI = 0.00091$; $CR = 0.0158 < 0.1$		
	Social benefit B_2	0.27	Arable land per capita C_4	0.093	**0.025**
			Land utilization C_5	0.506	**0.136**
			The density of the road network C_6	0.263	**0.071**
			Poverty alleviation results C_7	0.138	**0.037**
			$\lambda_{max} = 4.072$; $CI = 0.024$; $CR = 0.027 < 0.1$		
	Ecological benefit B_3	0.38	Green vegetation coverage C_8	0.057	**0.022**
			Biomass per unit area C_9	0.147	**0.056**
			Rate of ensured farmland irrigation C_{10}	0.343	**0.122**
			Wetland ecological effects C_{11}	0.117	**0.044**
			Stalinization rate C_{12}	0.093	**0.035**
			Soil organic matter content C_{13}	0.243	**0.092**
$\lambda_{max} = 3.006$; $CI = 0.0028$; $CR = 0.0048 < 0.1$			$\lambda_{max} = 6.225$; $CI = 0.045$; $CR = 0.036 < 0.1$		

3.4 THE MULTI-LEVEL FUZZY COMPREHENSIVE EVALUATION OF AGRICULTURAL LAND CONSOLIDATION BENEFITS

3.4.1 Build evaluation model

After considering the circumstances and experts' advice, I build the multi-level fuzzy synthetic evaluation model to evaluate land consolidation benefit. That is, to combine fuzzy decision evaluation and analytic hierarchy process, which determine index weight, then hierarchically conduct fussy synthetic judgment, use fuzzy transformation theory and maximum membership principle, consider farmland consolidation efficiency-related factors and obtain comparatively objective results.

The basic model of fuzzy comprehensive evaluation is:

$$B = A \times R \tag{1}$$

B is evaluation result vector; A is evaluation index weight; R represents fuzzy relation matrix

A of the weight vector from the right front of each index, which is representation of the calculated index system weight. The principle of fuzzy relationship matrix R is obtained in this way:

Assuming the first evaluation factor U_i of i single factor evaluation, to get the equivalent of a fuzzy vector v_j,

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

r_{ij} is the u_i to i given comment v_j with respect to the evaluation factors of membership, and $0 \le r_{ij} \le 1$, if the elements of a comprehensive evaluation of the result is a line matrix, called the membership matrix R[4]:

$$R = \begin{bmatrix} R_1 \\ R_2 \\ \vdots \\ R_N \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & & \vdots \\ r_{N1} & r_{N2} & \cdots & r_{Nn} \end{bmatrix} \tag{3}$$

Standard form of fuzzy comprehensive evaluation mathematical model is

$$R_i = \lfloor r_{i1,} \quad r_{i2,} \quad \cdots \quad r_{1n} \rfloor (i = 1,2,\cdots N) \tag{4}$$

$$B = A \times R$$

$$= [a_{1,} \quad a_{2,} \quad ..., \quad a_N] \begin{bmatrix} r_{11} & r_{12} & ... & r_{1n} \\ r_{21} & r_{22} & ... & r_{2n} \\ \vdots & \vdots & ... & \vdots \\ r_{N1} & r_{N2} & ... & r_{Nn} \end{bmatrix} \tag{5}$$

$$= [b_{1,} \quad b_{2,} \quad ... \quad b_N]$$

3.4.2 Membership grade and evaluation model calculation

Membership grade and evaluation model calculation Membership grade is determined by combining fuzzy statistics and expert scoring. According to indexes, the experts qualitatively analyze or quantitatively calculating result, and evaluate the indexes before and after consolidation in project area. According to experts' judgment, I conduct an analysis and calculation of fussy statistics, obtain membership grade of indexes and build the fussy evaluation matrix.

(1) Economic Benefit Evaluation

1). A membership grade matrix before land consolidation project

$$R_1 = \begin{bmatrix} 0 & 0 & 0 & 0.58 & 0.42 & \\ 0 & 0 & 0.51 & 0.49 & 0 & 0 \\ 0 & 0.48 & 0.52 & 0 & 0 & \end{bmatrix}$$

2) A membership grade matrix after land consolidation project

$$R_1' = \begin{bmatrix} 0.38 & 0.63 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \end{bmatrix}$$

(2) social evaluation

1) A membership grade matrix before land consolidation project

$$R_2 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0.43 & 0.57 & 0 & 0 \end{bmatrix}$$

2) Amembership grade matrix after land consolidation project

$$R_2' = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0.86 & 0.14 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0.75 & 0.25 & 0 & 0 & 0 \end{bmatrix}$$

(3) Ecological Benefit Evaluation

1) A membership grade matrix before land consolidation project

$$R_3 = \begin{bmatrix} 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0.04 & 0.96 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0.2 & 0.8 & 0 \\ 0 & 0 & 0.7 & 0.3 & 0 \\ 0 & 0 & 0.51 & 0.49 & 0 \end{bmatrix}$$

2) A membership grade matrix after land consolidation project

$$R_3' = \begin{bmatrix} 0 & 0.8 & 0.2 & 0 & 0 \\ 0.32 & 0.68 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.8 & 0.2 & 0 \end{bmatrix}$$

3.4.3 Model calculation

index weight obtained by calculation above

$$A_1 = [C_1, \quad C_2, \quad C_3] = [0.28 \quad 00.22 \quad 0.50]$$

$$A_2 = [C_4, \; C_5, \; C_6, \; C_7] = [0.093 \quad 0.506 \quad 0.263 \quad 0.318]$$

$$A_3 = [C_8, \; C_9, \; C_{10}, \; C_{11}, \; C_{12}, \; C_{13}]$$

$$= [0.057 \quad 0.147 \quad 0.343 \quad 0.117 \quad 0.093 \quad 0.243]$$

Build economic, social and ecological benefit evaluation Scoring model $B = A \times R$ fuzzy to operation and get index evaluation vector after consolidation.

(1) Economic Benefit

1) Economic benefit evaluation model before consolidation.

$$B_1 = A_1 \times R_1 = [0.28 \quad 0.22 \quad 0.50] \times \begin{bmatrix} 0 & 0 & 0 & 0.58 & 0.42 \\ 0 & 0 & 0.51 & 0.49 & 0 \\ 0 & 0.48 & 0.52 & 0 & 0 \end{bmatrix} = [0 \quad 0.24 \quad 0.52 \quad 0 \quad 0]$$

2) Economic benefit evaluation model after consolidation

$$B_1' = A_1 \times R_1' = [0.28 \quad 0.22 \quad 0.50] \times \begin{bmatrix} 0.38 & 0.62 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \end{bmatrix} = [0.83 \quad 0.17 \quad 0 \quad 0 \quad 0]$$

(2) Social Benefit

1)A social benefit evaluation model before consolidation

$$B_2 = A_2 \times R_2 = [0.093 \quad 0.506 \quad 0.263 \quad 0.138] \times \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0.43 & 0.57 & 0 & 0 \end{bmatrix} = [0.093 \quad 0.059 \quad 0.079 \quad 0 \quad 0.769]$$

2) A social benefit evaluation model after consolidation

$$B_2' = A_2 \times R_2' = [0.093 \quad 0.506 \quad 0.263 \quad 0.318] \times \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0.86 & 0.14 & 0 & 0 & 0 \\ 0.02 & 0.98 & 0 & 0 & 0 \\ 0.75 & 0.25 & 0 & 0 & 0 \end{bmatrix} = [0.651 \quad 0.562 \quad 0 \quad 0 \quad 0]$$

(3) Ecological Benefit

1) An ecological benefit evaluation model before consolidation

$$B_3 = A_3 \times R_3$$

$$= \begin{bmatrix} 0.057 & 0.147 & 0.343 & 0.017 & 0.093 & 0.243 \end{bmatrix} \times \begin{bmatrix} 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0.04 & 0.96 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0.2 & 0.8 & 0 \\ 0 & 0.14 & 0.86 & 0 & 0 \\ 0 & 0 & 0.51 & 0.49 & 0 \end{bmatrix} = \begin{bmatrix} 0 & 0.013 & 0.233 & 0.354 & 0.4 \end{bmatrix}$$

2) An ecological benefit evaluation model after consolidation

$$B_3' = A_3 \times R_3'$$

$$= \begin{bmatrix} 0.057 & 0.147 & 0.343 & 0.117 & 0.093 & 0.243 \end{bmatrix} \times \begin{bmatrix} 0 & 0.517 & 0.483 & 0 & 0 \\ 0.32 & 0.68 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.6 & 0.4 & 0 \end{bmatrix} = \begin{bmatrix} 0.6 & 0.13 & 0.173 & 0.093 & 0 \end{bmatrix}$$

(4) Integrated Benefit

1) An integrated benefit evaluation model before Consolidation

$$B = A \times R$$

$$= \begin{bmatrix} 0.35 & 0.27 & 0.38 \end{bmatrix} \times \begin{bmatrix} 0 & 0.24 & 0.37 & 0.27 & 0.12 \\ 0.093 & 0.059 & 0.079 & 0 & 0.769 \\ 0 & 0.013 & 0.233 & 0.354 & 0.4 \end{bmatrix} = \begin{bmatrix} 0.025 & 0.105 & 0.240 & 0.230 & 0.400 \end{bmatrix}$$

2) An integrated benefit evaluation model after Consolidation

$$B' = A \times R'$$

$$= \begin{bmatrix} 0.35 & 0.27 & 0.38 \end{bmatrix} \times \begin{bmatrix} 0.83 & 0.17 & 0 & 0 & 0 \\ 0.631 & 0.362 & 0 & 0 & 0 \\ 0.6 & 0.13 & 0.173 & 0.093 & 0 \end{bmatrix} = \begin{bmatrix} 0.69 & 0.21 & 0.066 & 0.035 & 0 \end{bmatrix}$$

3.4.4 Land consolidation benefit evaluation scores counting

I adopt multi-level fussy synthetic evaluation to evaluate land consolidation benefit from low layer to high layer and obtain result from fuzzy operation on different layers. After that, I introduce arithmetic method to set up project evaluation grading standard and build the evaluation standard scoring matrix.

$$F = (f_1, \quad f_2, \quad f_3, \quad f_4, \quad f_5)^T \qquad (6)$$

$$= (100, \quad 80, \quad 60, \quad 40, \quad 20)^T$$

In this way, evaluation scores of economic, social and ecological benefit before and after consolidation in project area can be calculated.

$$Z_1 = B_1 \times F; \quad Z_2 = B_2 \times F; \quad Z_3 = B_3 \times F \qquad (7)$$

$$Z_1' = B_1' \times F; \quad Z_2' = B_2' \times F; \quad Z_3' = B_3' \times F \qquad (8)$$

For benefit evaluation scores in project area, see Table 7.

TABLE 7 Benefit evaluation scores in Songyuan project

	Before consolidation	After consolidation
Economic benefit	54.6	96.6
Social benefit	34.14	92.06
Ecological benefit	37.18	84.5
Comprehensive benefit	42.5	91.16

Table 7 show that before consolidation, evaluation scores of social benefit and ecological benefit are both Below 40; evaluation scores of economic benefit are slightly above 50. This shows the social and economic conditions and ecological environment in project area is on the grade INFERIOR that greatly hampers the steady and sustainable development of social economy and ecology. This project brings about fantastic economic, social and ecological benefit. After consolidation, benefit evaluation scores are all above 80 and on the grade EXCELLENT. The project is excellent and successful on the whole.

3.5 ANALYSIS OF EVALUATION RESULT

3.5.1 Analysis of economic benefit

Located on a low alluvial plain, Songyuan project area is favorable for developing agriculture. Songyuan project area locates within the old Qianguo irrigation area, its excellent geographic condition is suitable for paddy field planting. Of the existing farmland, dry farmland has a larger proportion. Paddy field is distributed mainly over Qianguo area. Yuzi area and Housi area is based on dry farmland planting. Salinization area has a larger proportion in the project area. Besides 740,800mu of wasted grassland exist here. The unused land accounts for 55.5% of total area. The dry and wind-prone climate causes the low and unsteady output of dry land planting. In this area per mu yield for a good year is 518kg, but 150 kg for a dry year. Per mu yield for an average year is only 240 kg. Drought is the major factor which hampers agriculture here. After consolidation in this area, 42,800.09 hm^2 lands without irrigation is changed into high standard farmland without fear of drought and flood. In the meanwhile, with Hada Mountain hydro project, 49,386.5 hm^2 of wasted grassland and 43,043.65 hm^2 of Salinization land is changed into paddy field. The advantage of paddy field planting is fully taken in the old irrigation area. Yield of farmland and farmers' income will be increased soon. A calculation shows that after the consolidation, the average grain productivity will be increased from 358 kg to 537.5 kg, accounting a 50.1% increase. The gross productivity rises from 471,000,000 kg to 1,343,000,000kg, accounting a 184.8% increase. The per capita net income and farmland net income is improved by 128.3% and 414% respectively. Thus this project brings out huge economic benefit. A calculation shows that scores of economic benefit evaluation rise from 54.6 to 96.6 after consolidation which would play a major role in increasing farmers' production and income.

3.5.2 Analysis of social benefit

Per capita arable land in Songyuan project area occupies the first place among the three project area and reaches 10.5 mu per person, and it reaches 20.02 mu per person after consolidation. Per capita arable land index has little effect on social benefit evaluation in Songyuan project area where 103,165.87 hm2 of unused land exists. After consolidation, farmland rises from 87887.87 hm2 to 166580.27 hm2. The paddy field is increased from 41,400.98 hm2 to 98,610.28 hm2 after consolidation. Profits from paddy field planting make the per capita reach 7119yuan which occupies the first place among the three project area.

By calculation, social benefit evaluation scores are increased from 34.14 to 92.06 in project area. Social benefit mainly depends on improving land utilization rate, agricultural infrastructure, grain output and farmers' income. The calculation shows land utilization rate rises from 48% to 99.3% after consolidation. Road network density is increased from 0.0015 km⁄hm2 to 0.0015 km⁄hm2. It is a fourfold increase. Road network construction is the best part in the three project area.

The good original production condition and land consolidation will greatly improve land utilization rate, production facility and farmers' income after consolidation. At last, land consolidation will received positive social effect.

3.5.3 Analysis of ecological benefit

After consolidation, the ecological efficiency scores do not reach 90 but increase largely. Before consolidation, waste grassland, saline and low-yield dry land caused by drought and extensive management take a larger part of Songyuan project area. Coverage rate of green vegetation is low. In addition, the diminishing swampland caused by successive drought weakens wetland effect. Drought is the major factor which hampers ecological environment improvement. The land consolidation and Hada Mountain hydro project turn 740,800mu of waste grassland and 645,000mu of saline into paddy field, and turn 642000mu of low yielding dry land into irrigated land. Coverage rate of green vegetation and irrigation rate of farmland will be increased largely. The enlarged paddy field and irrigated land make soil retain more water and fertilizer. Thus soil salination is relieved and farmland output is largely increased. After the consolidation, ecological benefit evaluation scores are increased from 37.8 to 84.5. The range of the increased reaches 123%. The ecological benefit evaluation scores are almost equal to other project area. The ecological benefit conducted by this project is clear enough.

3.5.4 Integrated benefit Analysis

Among the three project areas, Songyuan project area has the best producing condition and largest constructing area. After the consolidation, economic benefit scores and social benefit scores are both above 90. Ecological benefit scores reach 84.5. The project uses land leveling, road protection and irrigation & drainage etc. to eliminate drought and construct 964,200mu of high standard farmland free of drought and flood. Thus integrated benefit evaluation scores are increased from 42.5 to 91.16. The project is successful on the whole and has satisfactory results in the field of economy, society and ecology etc.

4 Conclusions

With the regard to land development and consolidation in ecologically vulnerable areas and the benefits, it is concluded as following:

First, the satisfactory results can be achieved from the land development and consolidation in ecologically vulnerable areas.

It is a perpetual conflict between ecology protection and economic development which is not irreconcilable. A proper land development, consolidation and land utilization will develop economy and protect environment simultaneously during resources development and utilization meanwhile effectively developing and utilizing land resources. The evaluation shows the project clearly brings about social, economic and ecological benefit, and it is successful on the whole. This shows that land consolidation in ecologically vulnerable areas can obtain good benefit.

Second, it should be given priority to synthetic benefit evaluation on land development and consolidation in ecologically vulnerable areas

At present, in China, organized and large-scale land development and consolidation in ecologically fragile zone is on the initial stage which does not target at improving ecological environment and land quality. People focus on quantity instead of quality and ecology. Therefore, land development and consolidation benefit evaluation in ecologically fragile zone should not only emphasize economic benefit evaluation. We should take integrated benefit improvement as the starting point, fully coordinate improvement of economic, social and ecological benefit.

Third, It should be given prominence to ecological benefit of land consolidation in ecologically vulnerable areas.

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Authors

Ying Nie, 1963.7, Longjing City, Jilin Province, P.R. China

Current position, grades: the Associate Professor of College of Economics and Management, Jilin Agricultural University, China.
University studies: received his bachelor degree of in Agricultural Economics Management from Jilin Agricultural University, China. He received his master degree of Agricultural Economics Management from Jilin Agricultural University. He received his doctor degree from Jilin Agricultural University
Scientific interest: Land Consolidation, Agricultural Resource & Environment Evaluation
Publications: more than 16 papers published in various journals.
Experience: teaching experience of 29 years, has completed 18 scientific research projects.

Ke Li, 1977.11, Jilin City, Jilin Province, P.R. China

Current position, grades: the lecturer of College of International Economics and Trade, Jilin University of Finance and Economics, China.
University studies: received his bachelor degree of Economics in International Taxation from Jilin University of Finance and Economics, China. He received his master degree of Public Administration from Jilin University of Finance and Economics.
Scientific interest: Agricultural Economy, International Business
Publications: more than 10 papers published in various journals.
Experience: teaching experience of 12 years and completed three scientific research projects.

Yunxia Wang, 1973.10, Hohhot city, Inner Mongolia Province, P.R. China
Current position, grades: the Associate Professor of College of Economics and Management, Inner Mongolia Agricultural University, China.
University studies: received her B.Sc. in Agricultural Economics Management from Inner Mongolia Agricultural University, China. She received her M.Sc. from Inner Mongolia Agricultural University. She received her D.Sc. from Inner Mongolia Agricultural University
Scientific interest: Ecological Economy, Resources Economy
Publications: more than 12 papers published in various journals.
Experience: teaching experience of 18 years, has completed four scientific research projects.