

The Environment Impact Assessment of Land Consolidation Based on the Theory of Ecosystem Service Value

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Abstract. A case study was made in Yuyang strict, in the city of Dangyang. The object of this paper is to analyze the environmental change resulting from land consolidation. The methods are based on Constanza's ESV computing formula and local ESV coefficients. The results indicated: (1) Its value before land consolidation is 3.311 million RMB. Its value after land consolidation is 3.554 million RMB. The increasing is 0.243 million RMB. (2) When the plan is put into effect, it's supposed to strengthen the protection of water area and forest. (3) Regional agricultural development should focus on adjusting the agricultural structure, it is necessary to increase input in the development of paddy fields. In the appropriate region, it should transform dry land into paddy fields.

1. Introduction

Since the promulgation and implementation of the *Land Administration Law* in 1998 in China, land consolidation has become one of the effective ways to promote the rational utilization of land resources and realize the dynamic balance of the total cultivated land. According to statistics, during the "12th Five-Year Plan", China has arranged a total of 533 million mu of agricultural land, built 403 million mu of high-standard farmland and added 27.67 million mu of cultivated land. The newly increased cultivated land area surpassed the cultivated land area occupied by construction or destroyed by natural disasters during the same period, ensuring the stable quantity of cultivated land with the quality improved noticeably. According to the "*National Land Renovation Plan (2016-2020)*" formulated and promulgated by the Ministry of Land and Resources, 20 million hm² of cultivated land will be replenished nationwide through land consolidation by 2020 [1].

Although tremendous achievements have been made in land consolidation, many problems have emerged in the current practice. The most prominent one is the ecological and environmental problems caused by the improper application of some technical measures. These problems have undermined the sustainability of land consolidation and become one of the main factors that restrict the development of land consolidation. Since the initial aim of land consolidation in China is to realize the dynamic balance of total cultivated land, the goal of land consolidation in most areas is to increase the area of cultivated land or other agricultural land. Even in the feasibility evaluation of land consolidation projects, more attention is paid to the evaluation of economic benefits, lacking the quantitative description of the assessment for the environmental impact.



In recent years, many scholars in China applied the theory of ecosystem service function value to the environment impact assessment of land consolidation [5-7]. From ecological point of view, land consolidation activities are man-made ecological succession processes. Biological and engineering measures have changed the types and spatial patterns of regional ecosystems, and the structure and function of ecosystems have changed accordingly. Therefore, it is necessary to introduce the value accounting of ecological service function in the environmental impact assessment after planning to provide a theoretical basis for the environmental feasibility of land consolidation.

Based on the theory of ecosystem service function value, this paper analyzes the environmental impact of land consolidation through a comprehensive and objective analysis using existing data of land consolidation results with an attempt to provide effective technical means for environmental management of land management.

2. Introduction of research area

The project is located within the territory of Yuyang Administrative Region, Dangyang, covering the villages of Yaowan and Aokou. The consolidation area totals 11,143.5184 hectares. The geographical coordinates are at the east longitude 111°47'04"-111°51'08", north latitude 30°43'13"- 30°46'15", which is the exactly the intersection of subtropical and northern subtropics, belonging to typical subtropical monsoon climate. The sunshine hours in the zone are 1550 hours (average over previous years), accounting for 41.8% of the annual illumination hours. The solar radiation is between 102 and 108 kcal/cm², and the accumulated temperature when the daily average temperature is greater than or equal to 10°C remains between 4900 to 5241°C. Frost-free period is generally about 270 days, with an average annual rainfall of 936~1000mm. Climatic conditions are suitable for a variety of crops. The project area is a typical hilly landform with a slope of 5° to 20°. The soil types in the area are complex and diversified, with abundant water resources. The main crops are rice, wheat and citrus.

3. Research methods

3.1. Data collection

The needed data were collected from the land use status map of the project area, the land use plan, the planning and design text, and the 2015 statistics.

3.2. Data processing

3.2.1. Land Use Changes. With reference to the general land classification system and the actual conditions in the project area, the land utility in the project area is divided into the following categories: cultivated land that includes paddy fields, irrigated land and dry land; orchards; woodlands, mainly open forest woods and immature woodland; traffic land, mainly rural roads; land for water conservancy facilities including pond water surface and farmland water use land; other land, mainly ridge; grassland covering mainly other types of grassland (Table 1). After the implementation of the land consolidation project, the area of cultivated land, especially the paddy fields in the project area increased significantly, and the area of grassland and other forest land decreased significantly.

Table 1. The statistics of various types of land-use area in the project area

I-level land	II-level land	Before consolidation	After consolidation
Name	Sub-name	Area	Area
Cultivated land	Paddy field	232.475	292.229
	Irrigated land	30.105	12.166
	Dry land	131.63	102.111
	Sub-total	394.21	406.506
Orchard	Fruit orchard	92.718	441.57
	Another orchard	14.685	0
	Sub-total	107.403	441.57
Woods	Other woods	312.204	0
	Sub-total	312.204	0
Traffic facility land	Rural road	33.71	41.016
	Sub-total	33.71	41.016
Land for water conservancy facilities	Pond water surface	38.579	40.617
	Farmland water use land	3.528	8.683
	Sub-total	42.107	49.3
Other land	Ridge	16.163	7.046
	Sub-total	16.163	7.046
Grassland	Other grassland	39.642	0
	Subtotal	39.642	0

3.2.2. Determination of Ecological Service Value

3.2.3. *Equivalent Factor Scale of Ecosystem Services Value in the Project Area.* In this paper, we refer to the Table of Equivalence of Ecosystem Services in China developed by Xie Gaodi et al and revised the coefficients according to the specific conditions in the study area [3]. Among the many existing evaluation systems, both paddy field and dry land are considered as a kind of cultivated land for value evaluation. However, due to many differences in farming methods and crop types, their actual service functions are quite different [8]. Therefore, paddy field ecosystem services value per unit area is adjusted as follows: since paddy fields known as "constructed wetlands" as its moisture, soil and local microclimate are similar to wetlands, the unit value of paddy field's gas regulation, climate regulation, water conservation and soil formation and protection is the average value of the corresponding services in dryland and wetland. The paddy field is mostly located in the overland area of the dryland in the water area, which has the characteristics of three kinds of ecosystem of farmland, wetland and water body. Its biodiversity protection function is better than the average value of the dry farmland, wetland and water body. The value of paddy fields in food production, waste disposal, raw materials, entertainment and recreation is not so different from dry farmland, and the corresponding service value of dry farmland is temporarily replaced here [8]. From this, the ecological equivalent value factor scale of ecosystem services in the project area after correction is as follows:

Table 2. equivalent weight factor of economic value of ecosystem services per hectare in the project area

	Forest	Grassland	Dry land	Wetland	Water body	Unavailable land	Paddy field
Gas regulation	3.5	0.8	0.5	1.8	0	0	1.15
Climate regulation	2.7	0.9	0.89	17.1	0.46	0	8.995
Water conservation	3.2	0.8	0.6	15.5	20.38	0.03	8.05
Soil formation and protection	3.9	1.95	1.46	1.71	0.01	0.02	1.585
Waste disposal	1.31	1.31	1.64	18.18	18.18	0.01	1.64
Biodiversity conservation	3.26	1.09	0.71	2.5	2.49	0.34	1.9
Food production	0.1	0.3	1	0.3	0.1	0.01	1
Raw material	2.6	0.05	0.1	0.07	0.01	0	0.1
Entertainment and culture	1.28	0.04	0.01	5.55	4.34	0.01	0.01
Sub-total	21.85	7.24	6.91	62.71	45.97	0.42	24.43

3.2.4. Unit farmland ecosystem food production service function of economic value. Based on the specific conditions of the project area, the economic value of annual natural grain yield per unit area of farmland is adjusted as follows: The average yield of grain in the project area is 6077.5kg/hm². The main crops are wheat, citrus and rice. The grain unit price takes the national average price of main crops to be 2.25 yuan/kg. Considering the economic value provided by natural ecosystems with no manpower investment is 1/7 of the economic value of the food production services provided by the existing farmlands per unit area [4]. The economic value of the farmland ecosystem food production service function in the project area is 1953.48 yuan/ km².

3.2.5. Determination of ecological service value. Use the revised Ecosystem Value Table and apply the following Costanza ecosystem services value (Ecosystem Services Value, ESV) calculation formula to calculate [2]:

$$ESV = \sum A_k * VC_k \quad (1)$$

$$ESV_f = \sum (A_k * VC_{fk}) \quad (2)$$

In the equation, ESV is the ecosystem service value (yuan), A_k is the area (km²) of k land use types in the study area, VC_k is the ecological value coefficient (yuan/hm²·a), ESV_f is the ecosystem service value (yuan), and VC_{fk} is a single service function value coefficient. In order to facilitate the comparison, the ecological service value contribution coefficient (C_i) is introduced, which is, the ratio of the proportion of the total area of a certain type of landscape area to the ratio of the total value of ecosystem services in the landscape to the value of landscape ecological services. The larger C_i is, the greater the ecological value contribution of landscape i is.

In order to obtain the area of different ecosystems, the types of land use in the project area are matched to the types of ecosystems in Table 1. In calculating the value of ecological services, the equivalence factor of seven major types of land is operated according to the following principle: cultivated land is defined as the land for planting crops in the status quo classification of land use, while the cropland ecosystem is an ecosystem formed by energy and material exchange and its interaction between the biological community and ecological environment in the crop-centered farmland. Therefore, the arable land is matched with farmland ecosystems; the orchard is similar to

forest ecosystems in terms of food production and economic benefits, so the orchard corresponds to forest ecosystems; Other land is mainly ridge and temporarily classified as land for transportation. The traffic land has no need to evaluate the economic value of its ecosystem services according to the method of Costanza et al. (Table 3).

Table 3. The corresponding types of ecosystems and the ecological value per hectare

Land use type	Irrigated land Dry land	Orchard	Forest	Grassland	Traffic land	Land for water conservancy facilities	Other lands	Paddy field
Corresponding ecosystem	Dry land	Forest	Forest ecosystem	Grassland ecosystem	-	Water body ecosystem	-	Paddy field
P I Ecological value per unit area P i	1.35	4.27	4.27	1.41	0.00	8.98	0.00	7.96

4. Results and analysis

4.1. Changes in the Value of Ecosystem Services in the Project Area

The value of ecosystem services of different ecosystem types before and after the project area calculated according to (1) is shown in Table 4 and 5. The total ESV was 33,116,300 yuan before the consolidation and 35,549,400 yuan after the consolidation, increasing by 2,343,100 yuan. Before the consolidation, the main land types in the study area are arable land and forest land, accounting for 42% and 33% of the total area. Among the components of ecological service value, the top two are arable land and forest land with ESVs of 13.2777 million yuan and 13.326 million yuan, accounting for 41% and 40% of the total ESVs, followed by orchard, grassland and water conservancy facilities. However, the comparison between the ecological value proportion and the area ratio shows that the ecological value contribution rate of water conservancy facilities land is the largest, while the water conservancy facilities land occupies an area ratio of less than 2%, and the ecological service value accounts for about 4%. The contribution coefficient is 2. The contribution coefficients of paddy field, garden plot and woodland to the value of ecological service are all greater than 1, being 1.36, 1.27 and 1.21 respectively. Most of the forest land in the project area is low-efficiency forest. After transformation, it is used for planting citrus trees and developing scale-operated citrus trees into pieces. The ground types are also adjusted accordingly. Therefore, after the consolidation, the main land types in the study area are arable land and orchard, accounting for 43% and 37% of the total area respectively, with ecological values of 43% and 53% respectively. The largest contribution rate comes from the land for water conservancy facilities with the contribution coefficient of 2 and the contribution rates more than 1 are paddy fields, garden, with respectively 1.26 and 1.13. The contribution rate of dryland, irrigated land, and grassland are all less than 1. It can be inferred that the ecosystem service function of paddy field is better than the dry land. Although the above results are related to the value of ecosystem services, they do not affect the important role of natural landscape in maintaining the value of ecosystem services.

Table 4. The land-use area and the value of ecological services before land consolidation

Land use type		Area before consolidation (hm ²)	Proportion	ESV before consolidation (10,000 yuan)	Proportion	Ci
Arable land	Irrigated land, dry land	161.735	17%	218.32	7%	0.41
	Paddy field	232.475	25%	1109.45	34%	1.36
Sub-total		394.21	42%	1327.77	41%	0.98
Orchard		107.403	11%	458.43	14%	1.27
Forest		312.204	33%	1332.6	40%	1.21
Grassland		33.71	4%	47.68	1%	0.25
Traffic land		42.107	4%	0	0%	0
Land for water conservancy facilities		16.163	2%	145.15	4%	2
Other land		39.642	4%	0	0%	0
Total		945.439		3311.63		

Table 5. The land-use area and the value of ecological services after land consolidation

Land use type		Area after consolidation (hm ²)	Proportion	ESV before consolidation (10,000 yuan)	Proportion	Ci
Arable land	Irrigated land, dry land	114.277	12%	154.26	4%	0.33
	Paddy field	292.229	31%	1394.62	39%	1.26
Sub-total		406.506	43%	1548.88	43%	1
Orchard		441.57	47%	1884.78	53%	1.13
Forest		0	0%	0	0%	-
Grassland		41.016	4%	58.01	2%	0.5
Traffic land		49.3	5%	0	0%	0
Land for water conservancy facilities		7.046	1%	63.27	2%	2
Other land		0	0%	0	0%	-
Total		945.438		3554.94		

4.2. Changes of Ecosystem Services Value Structure

Ecosystem service value structure refers to the ratio of ESV_f to total ecosystem services (total ESVs) of ecosystems. According to the plots of grassland ecosystems, Tilman et al. found that the functional diversity of ecosystems and their composition have more significant impacts on ecosystem processes than species diversity. Some ecosystem services provided by ecosystems do not stand alone but are closely linked to other services and functions. As people demand higher and higher quality of life, human needs for ecosystem services (such as food, clean water and fresh air) are on the increase, but humans are also undermining the capability of the ecosystems to provide certain services. The increase of the total value of ecosystem services does not mean that the value of individual service functions of ecosystems is also increasing. Therefore, the change of the total value structure of research ecosystem services is of great significance for measuring the regional ecological effects [9].

Table 6. The ecosystem services structure in the project area

	ESV _f before consolidation	ESV _f after consolidation	Δ ESV _f	Change rate	Trend
Gas regulation	3601842.6	3851308.9	249466.3	6.93%	↑
Climate regulation	6653110.2	7741065.53	1087955	16.35%	↑
Water conservation	7164546.4	7834330.6	669784.2	9.35%	↑
Soil formation and protection	4506623.5	4751263.26	244639.7	5.43%	↑
Waste disposal	2997018.6	2787528.73	-209490	-6.99%	↓
Biodiversity conservation	3909783	4176822.12	267039.1	6.83%	↑
Food production	874964.65	905775.754	30811.1	3.52%	↑
Raw material	2211823	2326311.75	114488.8	5.18%	↑
Entertainment and culture	1196575.9	1175009.62	-21566.3	-1.80%	↓
Sub-total	33116288	35549416	2433128	7.34%	-

According to (2), the value of ecosystem services of different ecosystem types before and after the project area consolidation is shown in Table 6. Ecosystem services function value, gas regulation, climate regulation, soil formation and protection, water conservation, biodiversity conservation, food production and raw materials are on the rise while only the waste treatment and entertainment and culture show a downward trend. Among them, climate regulation has increased by the most, up to 16.35%, mainly due to the increase of forest area with the highest coefficient in climate regulation. The greatest reduction in waste disposal capacity is achieved with a change rate of 6.99%, mainly due to a decrease in land use for water conservancy facilities with a high coefficient of ecosystem services value.

5. Conclusion

1) The total ESV was 33.116 million yuan before the consolidation and 35.554 million yuan after the consolidation, increasing by 2.4331 million yuan. The change rate is 7.34%. Although the ecological benefits of the project area have not been significantly improved, the implementation of land consolidation will obviously improve the ecological landscape of the project area. After the completion of the project, there will be a modernized woodland-scale agro-ecological park featuring "slope terraced, paddy field grid facilitated by irrigation and drainage as well as planting diversification".

2) Based on the analysis of the value changes of ecosystem services, it can be concluded that the Baotagang land consolidation planning reduces the waste disposal function in the planning area due to the decrease of the water area. Due to the increase in the forest area, the climate regulation function has been greatly increased. Therefore, during the implementation of the planning design project, the protection should be strengthened for the pond water surface and forest. Since paddy fields are similar to wetlands in terms of water, soil and microclimate, its ecosystem services are better than drylands. Therefore, regional agricultural development should pay attention to the internal adjustment of agricultural structure, increase investment in paddy field development and transform dry fields into paddy fields at proper areas.

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