Research on Reclamation and Implementation effect of abandoned cave dwelling in Loess area of Northwest China—Taking Xifeng District of Gansu Province for Example

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Key word: Loess area of Northwest China, Abandoned cave dwelling, Reclamation Technology, Implementation effect, Xifeng District

SUMMARY

The cave has been the main form of people living in the Loess Plateau. Gansu longdong regions and north area of Shaanxi is the most typical. With the continuous development of social economy, the disadvantages of cave dwelling appeared progressively, such as poor daylighting, poor ventilation, wet easy to mold. Now In addition to a very small number of residential, tourism landscape, the most has been abandoned. XiFeng district is a typical geological landforms on the loess plateau, in which the caves are widely distributed. At the same time, land use in Xifeng area is facing the problem of less per capita arable land area, and the construction land is not saved. How scientific and rational reclamation to distribute the abandoned cave become the way to solve Xifeng district land conflicts, complement of cultivated land resources, conservation and intensive land use is one of the important ways.

Taking Xifeng district of Gansu province as a study area, on the basis of analyzing present situation and types of the abandoned cave dwelling, this paper emphatically research the reclamation method for different types of cave, and evaluate the impact of reclamation after implementation from ecological, economic, social and other aspects of the landscape impact etc., in order to provide the scientific basis for reasonable reclamation and promotion of experience in local abandoned cave dwelling.

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1.Introduction

At ancient time, from the beginning of the living style "the cave dwelling in wild place", the cave has been the main form of Loess Plateau where people live on. As early as the Song Dynasty, the notes of "Western Expedition on Road"， documented by Zheng Gangzhong， has recorded several large cave areas on the northern of Shaanxi, eastern of Gansu, central of Shanxi, and western of Henan.Chinese cave has evolved from the troglodytism to the simple of the loess cave, cold kiln, and eventually into a highly traditional culture of "cave residents". In the social context of "farming civilization", the dwelling houses called "original ecological architecture", which has original green building thoughts, and is the most highly featuring of the local culture construction, the "root" of regional architectural culture, the origin of the Chinese "living culture".
The current studies on the loess plateau of northwest cave are mostly concentrated in construction science that is either from the stability of cave construction and geotechnical soil or from the exploration the ecological and energy-saving ideas of cave dwelling; there are still some focused on the perspective of the cave from history and culture. However, it is relatively less for the cave in regarded to land use research.
Land reclamation refers to the land that is used for production and construction activities, or damaged by natural disasters taking the improvement measure to make it achieving the available activities. For example, during the process of construction, due to the digging, collapse, and other causes, the damage land is taken remediation measures to back it to the available state. The existing major studies are focused on land reclamation in mining areas, or researching for other types of land reclamation, but the study for the North Village land reclamation has been found little, and the one of cave reclamation in the loess plateau for the northwest zone is far less. Shengpeng JING(2015) and other young researchers take the zones in Xifeng City of Gansu Province as the study. Based on the investigation for cliff cave, alley cave and pit cave, they combined the indices and law and feasible methods to evaluate suitability, in accordance with the potential level to analyze the reclamation potential of the study area’s abandoned cave. By the suitability evaluation of FAO,

Yongzhong FENG(2012) and other researchers elected the 8 effective indicators including thickness of soil, soil texture, soil salinity, soil pollution, pH value of soil organic matter, soilslope and surface stability for evaluation of land reclamation appropriately on the abandoned cave dwelling on Loess plateau. Guomin XIAN(2014) and other researchers have taken comparative study on the soil physical and chemical properties before and after land reclamation between cliff cave and alley cave on Xifeng area.
This article attempts to sort out the past study as basis, takesXifeng district of Gansu as an example, selects different typical types of plots from abandoned caves as the research area, determines the classification of reclamation technology, and makes the evaluation on ecological effect, economic effects, social effects and landscape effects after the reclamation make the evaluation, with a view to the reclamation on Loess Plateau area abandoned cave, and resolve conflicts of construction land supply, promoting intensive land use to provide a reference.

2.Study area and data sources

2.1Regional overviewof study area

Study area is located inXifeng District, Gansu Province. Xifeng is in the middle east of Qingyang City, Gansu Province, located in the Dongzhiyuan hinterland.The geologic structure is as the platformunit of North China, located in the the east wing of Erdos syncline, situated at Guanshan - Erdos station area on east of Liupan Mountain fold belt. On the geological structure, it belongs to construct of the new Chinese system of inland basin sedimentary belt. The geomorphological features of the Loess Plateau in Xifeng aregully region, the sloping terrain is from northeast to southwest, the elevation is 1421 meters. Terrain is like Fan-shaped, the long from north to south is about 47.7 kilometers, the width from east to west is 34.8 kilometers. The land is flat and fertile. In 2013, the total land area is 99,901.82 hectares, including the agricultural land area of 62918.61 hectares (accounting for 62.98% of the total land area), construction land area of 14998.81 hectares (accounting for 15.01% of the total land area), and other land of 21984.40 hectares (accounting for 22.01% of the total land area).The rural residential land of 11823.15 hectares is accounting for 78.83% of the construction total land area. Xifeng cave area accounts for 47.09% of the region's rural residential land area, and most of them have been abandoned that have great potential of reclamation. At the same time, the land use in Xifeng faces with the few of average per person cultivated area, andgreat wasteful of construction land question: average per person cultivated area is 0.09 hectares, which is lower than the nation average per person 0.1 hectares level, is world average level 1/3; per capita area of cultivated farmland on countryside is 413.95 square meters, which is far more than the per capita land 150 square meters of the national standard.

2.2 Overview of study area

The Study area involves in different types of abandoned cave, located in Luohang Village, Xialiu Village and Ranli Village. There are 483.26 hectares of study area, 3490 population, and per capita arable land area is 0.09 hectares, Rural residential area per capita is 380 square meters.

2.3Data Sources

In this article, the remote sensing phantom data originates in 2009, 2012 and 2014, the vector data originates the second national land investigation change database in 2010 and in 2013, other data are mainlyfrom county level and the township level statistical data in Xifeng, and as well as inspects the investigation and study data on the spot.

3.Reclamation Technology of Abandoned Cave

3.1Types of cave

The cave in Loess Plateau can be divided into three categories: one is the cliff cave, which usually located at the edge of the plateau of loess slope and soil areas, and on both sides of ravines; secondly, alley cave, which is built with brick and adobe to form cave structures, then covered with soil, also known as soil or earth-sheltered cave; the last one is pit-caves. Some scholars call the third cave "sunken cave dwelling" or "pit houses", where is located in the underground. The main yard of the third one is formed by main caves and courtyards, and distribute scattered, -a pit yard in the middle of ground, shaped like quadrangle dwellings.

3.2 Reclamation Technology of Abandoned Cave

This paper contains three caves. Reclamation of abandoned cave will be according to the different types of caves, selecting different reclamation techniques.

3.2.1 Reclamation Technology of Cliff Cave

Cliff Cave distributed in study area A, which area is 245.62 hectares, involving 1750 farmers. This type of cave is built on hillside, and using "dig in half, fill in half" reclamation technologywith emphasis on reasonably determine the height and back terraces width based on the upper plateau surface and the bottom surface elevation cave, which was sort of ladder-type, complete the

appropriate the ridge, the production of road and ditch head protection to prevent soil erosion, improve water storage capacity plots, for farmers to cultivate.

3.2.2 Reclamation Technology of Alley Cave

Alley-style cave is located in study area B, and its area is 174.34 hectares, involving 1310 farmers.The type of alley caves are usually closed one by one. In the process of reclamation, the technology should combined with different topography, and original terrain, according to local conditions to design different elevation plots. When the cave demolished,the workersused bulldozers to pile up the organic slice from thefront and back of old house, old walls, then used bulldozers, loaders removal project in the old house, after removal of combined land leveling utilization. The corresponding production and field protection forest roadsin order to prevent the water loss and soil erosion, improve the field water storage capacity, facilitate farming.

3.2.3 Reclamation Technology of Underground Cave

Underground cave is located in study area C, and its area is63.3 hectares, involving 430 farmers. Underground cave isrelatively independent. The reclamation for such cave has two methods, one is to remain, which is used for greenhouses or breeding base, the other is to be filled it as a vegetable greenhouses or breeding base; one is to be filled with soil making the cave form with Mesa pattern.The technology for second one is including earthwork excavation, earthwork backfilling, drainage works and so on. First, the excavation pit Academy of Engineering before construction, must do a detailed investigation of the distribution of each pit hospital, hospital number and the number of pit cave. Earth backfill stage, the pit dug collapsed homes fill in real time, in the middle may not appear funnel-shaped, the hospital in the original rainwater harvesting pits must be tamped. Digging collapsed infill process, the need to consider the impact side pressure. After land leveling, drainage problems requiring further consideration, it should be drained and village drainage field combine to form a complete drainage system.

4. Reclamation of Abandoned Cave Effect Evaluation

The reclamation in project area of abandoned cave has been supported by the Ministry of Land as nonprofit industry research and special projects (No. 201111015), and completed in December on 2014.The paper made the evaluation on the effects of the implementation of the project area, making objective judgment for ecological, economic, social and other aspects of the landscape impact.

4.1Evaluation Index System

Land reclamation effect evaluation is a systematic, comprehensive, highly technical work. The reclamation for abandoned caves is relating to various aspects of the local ecological, economic, social and landscape, and every aspects influence and constraint each other, so the indicators that can infect evaluation involves many aspects after reclamation. The paper divided the implementation effect of reclamation into four effects: the ecological, the economic, the social and the landscape effects. The ecological effect refers to the abandoned cave after reclamation of the impact of changes in the ecological conditions. The economic effects after reclamation are due to a change in the cultivated land on income and the impact of the production scale. The social effects are the result of the life of the peasants' satisfaction, infrastructure to change on the inhabitants. The landscape effects arethe changes of a land-use view type, and the number in the structure of the rural landscape impact. In the principle of scientific, comprehensive and maneuverability, based on the reference of existing research, the paper builta implementation effect of reclamation of abandoned cave, as shown in the Table 1.

Table1 Index system of effect evaluation of reclamation of abandoned cave

Target layer	Criterion layer	Element layer
Reclamation of Abandoned Cave Effect Evaluation (*A*)	Ecological effect (B_1)	Improve degree of soil and water loss(C_{11})
		Change of soil bulk density(C_{12})
		change of protection forestdensity(C_{13})
	Economic effect (B_2)	the newly-increased cultivated land rate(C_{21})
		Change of Farmers' Income(C_{22})
		Change of the food yield output on unit area(C_{23})
		Change of production scale(C_{24})
	Social effect (B_3)	Change of public support(C_{31})
		Change ofdensity of road network(C_{32})
		Increase support population(C_{33})
	Landscape effect (B_4)	Decrease rate of landscape fragmentation(C_{41})
		Decrease rate of patch shape index(C_{42})

4.2Re-determination for The Right of The Evaluation Index

This article uses the analytic hierarchy process (the AHP law) to determine the right of the evaluation index. Taking the implementation effect of reclamation of abandoned cave dwelling as the target, by the four effects,the concrete appraisal factorsare selected for the target. In this paper, using 1 ~ 9 scale to measure the relative importance between the two factors, the author invited experts on the related factors between the relative importance of scale values are given, finally get the experts to scale value of geometric mean to form judgment matrix of each criterion layer. Calculate the weight vector and consistency check. By the calculation, at all levels between *CR* were less than 0.10, satisfies the requirement of consistency check. Finally through the hierarchy total sorts, get *A* - *C*, the weight of B_i - *C*, see table 2.

Table2 The Weight of The Evaluation Index of reclamation of abandoned cave

Target layer	Criterion layer	Element layer	Weight（*A*-*C*）	Weight（B_i-*C*）
Reclamation of Abandoned Cave Effect Evaluation (*A*)	Ecological effect(B_1)	Improve degree of soil and water loss(C_{11})	0.1878	0.6327
		Change of soil bulk density(C_{12})	0.0519	0.1749
		change of protection forestdensity(C_{13})	0.0571	0.1924
	Economic effect(B_2)	the newly-increased cultivated land rate(C_{21})	0.0847	0.2247
		Change of Farmers' Income(C_{22})	0.1747	0.4636
		Change of the food yield output on unit area(C_{23})	0.0914	0.2424
		Change of production scale(C_{24})	0.0261	0.0693
	Social effect (B_3)	Change of public support(C_{31})	0.0312	0.1359
		Change of density of road network(C_{32})	0.041	0.1790
		Increase support population (C_{33})	0.1569	0.6851
	Landscape effect(B_4)	Decrease rate of Landscape Fragmentation(C_{41})	0.0729	0.7500
		Decrease rate of patch Shape Index(C_{42})	0.0243	0.2500

Note：*A*-*B*，λ_{max}=4.1706，*C.I.*=0.0568，*R.I.*=0.8900，*C.R.*=0.0639；B_1—*C*，λ_{max}=3.0092，*C.I.*=0.0046，*R.I.*=0.5200，*C.R.*=0.0089；B_2—*C*，λ_{max}=4.2250，*C.I.*=0.0750，*R.I.*=0.8900，*C.R.*=0.0843；B_3—*C*，λ_{max}=3.0816，*C.I.*=0.0408，*R.I.*=0.5200，*C.R.*=0.0784；B_4—*C*，λ_{max}=2.0000，*C.I.*=0.0000，*R.I.*=0.0000，*C.R.*=0.0000

4.3 Determination of Index Membership

This article divided the evaluation indicators into five grades: A, B+, B, B－, C etc. to judge the results of reclamation.At the beginning, we invite 7 experts making judge for the situation on the reclamation before and after. Then, according totheir comments, the fuzzy statistical analysis will be analyzed to extablish a fuzzy evaluation matrix through the calculated index membership.

Table3 The membershipof the evaluation index of reclamation of abandoned cave

Element layer	Before reclamation					After reclamation				
	A	B+	B	B—	C	A	B+	B	B—	C
Improve degree of soil and water loss(C_{11})	0	0	0.29	0.29	0.43	0.43	0.57	0	0	0
Change of soil bulk density(C_{12})	0	0	0.14	0.43	0.43	0	0.86	0.14	0	0
change of protection forestdensity(C_{13})	0	0	0	0.43	0.57	0.57	0.29	0.14	0	0
the newly-increased cultivated land rate(C_{21})	0	0	0	0.57	0.43	0.57	0.29	0.14	0	0
Change of Farmers' Income(C_{22})	0	0	0.29	0.57	0.14	0	0.57	0.43	0	0
Change of the food yield output on unit area(C_{23})	0	0	0.29	0.43	0.29	0	0.43	0.57	0	0
Change of production scale(C_{24})	0	0	0.29	0.43	0.29	0	0.29	0.71	0	0
Change of public support(C_{31})	0	0	0.43	0.43	0.14	0.29	0.57	0.14	0	0
Change of density of road network(C_{32})	0	0	0.29	0.71	0	0.14	0.71	0.14	0	0
Increase support population (C_{33})	0	0	0.29	0.57	0.14	0	0.71	0.29	0	0
Decrease rate of Landscape Fragmentation(C_{41})	0	0	0.57	0	0.43	0	0.57	0.43	0	0
Decrease rate of patch Shape Index(C_{42})	0	0	0.29	0.43	0.29	0.14	0.43	0.43	0	0

According to Table 3, we can build the evaluation of the membership matrix of reclamation before and after.

Before reclamation, the evaluation of the membership matrix:

$$R_1 = \begin{vmatrix} 0 & 0 & 0.29 & 0.29 & 0.42 \\ 0 & 0 & 0.14 & 0.43 & 0.43 \\ 0 & 0 & 0 & 0.43 & 0.57 \end{vmatrix} \quad R_2 = \begin{vmatrix} 0 & 0 & 0 & 0.57 & 0.43 \\ 0 & 0 & 0.29 & 0.57 & 0.14 \\ 0 & 0 & 0.29 & 0.42 & 0.29 \\ 0 & 0 & 0.29 & 0.42 & 0.29 \end{vmatrix}$$

$$R_3 = \begin{vmatrix} 0 & 0 & 0.430.43 & 0.14 \\ 0 & 0 & 0.290.71 & 0 \\ 0 & 0 & 0.290.57 & 0.14 \end{vmatrix} R_4 = \begin{vmatrix} 0 & 00.57 & 0 & 0.43 \\ 0 & 00.29 & 0.42 & 0.29 \end{vmatrix}$$

After reclamation, the evaluation of the membership matrix:

$$R'_1 = \begin{vmatrix} 0.43 & 0.57 & 0 & 0 & 0 \\ 0 & 0.86 & 0.140 & 0 \\ 0.57 & 0.29 & 0.140 & 0 \end{vmatrix} R'_2 = \begin{vmatrix} 0.57 & 0.29 & 0.140 & 0 \\ 0 & 0.57 & 0.430 & 0 \\ 0 & 0.43 & 0.570 & 0 \\ 0 & 0.29 & 0.710 & 0 \end{vmatrix}$$

$$R'_3 = \begin{vmatrix} 0.29 & 0.57 & 0.140 & 0 \\ 0.14 & 0.71 & 0.150 & 0 \\ 0 & 0.71 & 0.290 & 0 \end{vmatrix} R'_4 = \begin{vmatrix} 0 & 0.570.43 & 0 & 0 \\ 0.14 & 0.430.43 & 0 & 0 \end{vmatrix}$$

4.4 Multilevel Fuzzy Comprehensive Evaluation Model

By calculation, the index weight is known:
$A = (B_1, B_2, B_3, B_4) = [0.2968, 0.3769, 0.2291, 0.0972]$
$B_1 = (C_{11}, C_{12}, C_{13}) = [0.6327, 0.1749, 0.1924]$
$B_2 = (C_{21}, C_{22}, C_{23}, C_{24}) = [0.2247, 0.4636, 0.2424, 0.0693]$
$B_3 = (C_{31}, C_{32}, C_{33}) = [0.1359, 0.1790, 0.6851]$
$B_4 = (C_{41}, C_{42}) = [0.7500, 0.2500]$
According to the indexes membership matrix, we can create ecological effects, economic effects, social effects, landscape effects and overall efficiency of fuzzy comprehensive rating, and make fuzzy operation.
The ecological effects evaluation mood of reclamation before and after:
$B_1 = [0,0,0.2080,0.3414,0.4569]$
$B'_1 = [0.3817,0.5668,0.0514,0,0]$
The economic effects evaluation mood of reclamation before and after:
$B_2 = [0,0,0.2248,0.5264,0.2519]$
$B'_2 = [0.1281,0.4537,0.4128,0,0]$
The social effects evaluation mood of reclamation before and after:
$B_3 = [0,0,0.3090,0.5760,0.1149]$
$B'_3 = [0.0645,0.6910,0.2428,0,0]$
The landscape effects evaluation mood of reclamation before and after:
$B_4 = [0,0,0.5,0.1075,0.3950]$
$B'_4 = [0.0350,0.5350,0.4300,0,0]$

Comprehensive evaluation effect is based on the above four effects that constitute the judging matrix of evaluation of the effect of comprehensive, abandoned cave before and after the implementation of comprehensive benefit evaluation of land reclamation of judgment matrix is:

$$R = \begin{vmatrix} 0 & 0 & 0.20800.3414 & 0.4569 \\ 0 & 0 & 0.22480.5264 & 0.2519 \\ 0 & 0 & 0.30900.5760 & 0.1149 \\ 0 & 0 & 0.50000.1075 & 0.3950 \end{vmatrix}$$

$$R' = \begin{vmatrix} 0.3817 & 0.5668 & 0.05140 & 0 \\ 0.1281 & 0.4537 & 0.41820 & 0 \\ 0.0645 & 0.6910 & 0.24280 & 0 \\ 0.0350 & 0.5350 & 0.43000 & 0 \end{vmatrix}$$

Therefore, the comprehensive evaluation effect mood of reclamation before and after is:
$A = [0,0,0.2659,0.4421,0.2953]$
$A' = [0.1797,0.5496,0.2703,0,0]$

4.5 Evaluation Results

In order to compare the effect before and after the reclamation, the real objective reflects the comprehensive benefit of land consolidation, in the use of multi-level integrated assessment of fuzzy reclamation comprehensive efficiency from low to high-level evaluation layer note,we get fuzzy operation at all levels based on the results of arithmetic method reintroduction benefit evaluation and set standards, establish evaluation criteria scoring functions:

$$F = (f1, f2, f3, f4, f5)^T = (100,80,60,40,20)^T$$

The grades of four effects before and after reclamation can be calculated that is :$Z_i = B_i \times F$;
$Z'_i = B'_i \times F$
(1)The Ecological Effects
Before reclamation:$Z_1 = B_1 \times F = 35.27$
After reclamation:$Z'_1 = B'_1 \times F = 86.61$
(2)The Economic Effects,
Before reclamation$Z_2 = B_2 \times F = 39.58$:
After reclamation:$Z'_2 = B'_2 \times F = 74.20$
(3)The Social Effects
Before reclamation:$Z_3 = B_3 \times F = 43.88$
After reclamation:$Z'_3 = B'_3 \times F = 76.29$
(4)The Landscape Effects
Before reclamation:$Z_4 = B_4 \times F = 42.20$

After reclamation:$Z'_4 = B'_4 \times F = 72.10$
(5)The Comprehensive Effect
Before reclamation: $Z = B \times F = 39.54$
After reclamation:$Z' = B' \times F = 78.16$
By calculating results, before the reclamation, we can see that the ecological, economic, social, landscape and comprehensive effect were less than 60 points, all conditions are in C level. It is not conducive to the stable development of the project area ecological economic and social environment; the implementation of the project, the for the project area are of great ecological, economic, social, and landscape effect, after finishing, ecological effect in more than 85 points, achieved the level of B+, the remaining three and comprehensive effect between 70-80, achieved the level of B.

5. Conclusion

(1)By finishing the land development, the land effectively increases the area of arable land, improves agricultural production conditions, improves land utilization, thereby increasing labor productivity, incomes of farmers in terms of tangible foresting an important role in local economic development. In project area, the land reclamation rate and the capacity of farmland disaster-resistant have improved significantly which has played a significant role for improving the ecological environment in the project area.
(2)The ecological effects, economic effects, social effects and landscape effects have been good improvement by calculation, the scores respectively are from 35.27, 39.58, 43.88, 42.20 to 86.61, 74.20, 76.29, 72.10. The score of comprehensive effects is from 39.54 to 78.16. the scores's changing from collating before and after can be seen that the overall implementation of the project is success because the scores are all above 70, reaching the excellent level, and achieving satisfied results.
(3)In the first evaluation process,the methods of AHP and expert scoring are combination in index weight, followed by the use of multi-level fuzzy comprehensive evaluation of the benefits of consolidation around the project area that was evaluated, considering various factors affect the comprehensive effectiveness of the land development. The comprehensive evaluation of the plurality of experts' opinions, qualitative and quantitative analysis of organic combination of not starting, not only can fully reflect the ambiguity of the evaluation factors and evaluation process, and minimize the personal subjective evils, than the average rating scoring and other methods more in line with objective reality.

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BIOGRAPHICAL NOTES

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