Maturity Assessment for Typical Oasis in Middle Reaches of Heihe River Basin

Cuiwen TANG [1,a]*, Guocui QI[2,b], Ming GUO, [3,c], Guanglu HU [1,d] and Jie Fan [1,e]

[1]School of Environmental and Municipal Engineering, Lanzhou Jiaotong University, Lanzhou Gansu 730070, China

[2]School of Chemical and Biological Engineering, Hechi University, Hechi Guangxi, 5463000，China

[3]Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, Lanzhou Gansu 730000, China

[a]cuiwent73@mail.lzjtu.cn, [b]804710915@qq.com，[c] gming@lzb.ac.cn, [d]1072537121@qq.com, [e] 925989107@qq.com

Keywords: Degree of Developed Maturity of Oasis; Coefficient of Variation; Factor Analysis; Zhangye City

Abstract: Degree of developed maturity of an oasis (ODMD) is a quantization of the mature degree of oasis development. This paper proposes an assessment of the indicators system for ODMD from seven aspects using two methods, namely, coefficient of variation and factor analysis, to evaluate the three oases in Zhangye City, Ganzhou, Linze, and Gaotai, which lie in the middle reaches of Heihe River in northwest China. Results indicated that (1) Ganzhou had the highest value of maturity among the three oases based on the method of coefficient of variation. Gaotai had the lowest value of maturity. (2) Common factor one, which reflects mainly the level of social development, indicated significant differences among the three bases based on factor analysis. Ganzhou had the highest value (11.5097), whereas Gaotai (-10.6361) was nearly opposite that of Ganzhou and Linze had a value between the two oases. The values of common factor two reflects the levels of soil and water resources development and are shown as Linze > Ganzhou > Gaotai. (3) The result of the ODMD of the three oases was Ganzhou > Linze > Gaotai based on the comprehensive evaluation of the two methods mentioned above.

Induction

An oasis is a characteristic eco-geographical landscape in arid lands of the Earth and is also a major space for production and activity of people[1]. An oasis has all social, economic, and ecological elements of an arid area [2], highly heterogeneous and varied characteristics[3], and is sensitive to the environment [4-6]. An oasis is also the essence of natural conditions in an arid region [7-9], and its stability is directly related to human existence and economic development [10]. The evaluation of oasis stability has recently become a popular topic in arid zone research. Chinese scholars have achieved excellent results using advanced research methods for the quantitative analysis of oasis stability. Stability in sustainable development of an oasis in Hexi Corridor was studied by Su Peixi *et al* [11]. A model of evaluation on the Ejin natural oasis from the point of view of landscape health was completed by Caoyu *et al* [12]. A model evaluation on oasis, called the degree of developed maturity of oasis (ODMD), which is suited for an inland river basin, was proposed by Li Xiaoyu *et al.* [13] Li Xiaoyu defined ODMD as a composite indicator of soil and water resources development that carry the capacity and ecosystem performance of oasis. Moreover, ODMD indicates the process of oasification, which reflects the degree of conversion from natural to artificial oasis, or the degree of oasis construction. Li Xiaoyu produced a general evaluation of Chinese inland oases based on the concept of ODMD[13]. He Xinmei *et al.* compared the degrees of developed maturity of old and new oases in Sangonghe River Basin[14]. Zhangye Oasis is a typical arid area in the middle of the Heihe river valley, where oases have a wide geographic distribution. The scale of oases and the ecological and environmental problems

DOI: 10.25236/icssae.2019.061

encountered in the development of society and economy are both considered to be representative of issues in China's oases. The general evaluation of the stability of the oasis in the middle of the Heihe river valley is of important theoretical and directive significance to the sustainable management and building in China's oases. The present article cites the definition of ODMD based on preceding studies, puts forwards its assessment indicator system from seven aspects, and evaluates the ODMD of three typical oases (i.e., Ganzhou, Linze, and Gaotai) in Zhangye city, which is located in the middle reaches of Heihe River Basin. The evaluation used the coefficient of variation and factor analysis, which is based on the experts scoring method. Moreover, this article also compares quantitatively the ODMD of the three oases in space to provide decision basis for oasis builders and managers.

Study Area

The Heihe River rises from section of Qilian Mountain in Qinghai Province and traverses Qinghai, Gansu, and Inner Mongolia. The Heihe River, which is the second largest inland river basin in China, basin is bounded by Yingluo and Zhengyi Gorges and is divided into three parts (i.e., the upper, middle, and lower reaches). The Zhangye Oasis, located in the middle reaches, is considered as one of the main bases of commercial grain and western vegetables shipped east. Moreover, the oasis is also one of the important factors in Gansu's economic development and has the highest utilization rate and amount of application of water resources of the whole river basin.

Zhangye Oasis is located in the middle of the Hexi Corridor and in the middle reaches of Heihe River Basin. Zhangye Oasis is also the name given to many distribution oases within Zhangye city. The total area of the city is 42,000 square kilometers. Zhangye City has jurisdiction over one district and five counties (i.e., Ganzhou District, Linze, Gaotai, Shandan, Minle County, and Yugur Autonomous County of Sunan). The city is located in a typical continental arid climate zone and has less annual rainfall, strong evaporation, and more wind and sand. The oasis is 1,453 square kilometers and accounts for 3.468% of the total land area. The vegetation coverage is 8.67%. Therefore, this place belongs to a typical ecological fragile zone. The total population of Zhangye City in 2014 is 1.2781 million. The population density is 28.22 persons per square kilometers. The agricultural population is 0.866 million, which accounts for 85.95% of the total oasis population. This place belongs to a typical agricultural oasis zone. The area has a high degree of land use. Agricultural cultivation has become increasingly intensive, and the oasis has a high degree of integrated maturity.

Data Resources and Calculation Methods

Data Resources and Calculation Methods of Indicators. An oasis is a complicated natural-social-economic index system. The assessment of its degreeof maturity embraces many features and conditions of the oasis. The assessment needs to evaluate synthetically from a multi-disciplinary angle. First, the degree of maturity is divided into five parts (i.e., water, soil, vegetation, social economy, and landscape structure) using the analysis method. Level, social economy, and spatial feature were used according to the reformation of the degree of maturity and further divided into seven standard layers (i.e., irrigation system, utilization level of water resources, plant and ecological construction, level of soil development, agricultural productivity, social and economic levels, and landscape pattern). Forty indicators were used to describe and measure oasis maturity.

Table 1 Indicators system of the degree of oasis maturity and their calculation methods

One class index	Two-level index	Unit	Computational method
A. Irrigation system	A1 Ratio of the scale of water storage project and water intake	%	Effective storage of irrigation reservoir/practical water intake
	A2 Trunk and branch canals density	%	Length of trunk and branch canals/oasis area
	A3 Water intake ratio of canal	%	net water consumption/rough water consumption
	A4 Rate of intactness of water works	%	Sum of all the rates of intactness of trunk and branch canals, trunk, and branch canals' building and electromechanical equipment, divided by three
	A5 Electric-mechanical wells density multiply by matching rate	hole /square kilometer	Product of the ratio of the total of mechanical wells/oasis farmland area multiplied by the ratio of the matching number of mechanical wells/the total of mechanical wells
	A6 Amount of capital investment of unit area	yuan / ha	Total amount of capital investment of irrigation/oasis area
B Utilization level of water resource	B1 Coefficient of utilization of canal series	%	Product of serious coefficient of utilization of trunk canal, branch canal, lateral canal, and farm canal
	B2 Coefficient of water resource	%	Actual oasis water intake/total amount of oasis water resource
	B3 Output value of one cubic meter water	yuan / cubic meter	Total value of farm output/total practical water intake
	B4 Crop irrigation quota	cubic meter/ha	Quota of crop irrigation in growth process in unit area
	B5 Ratio of ecological water consumption	%	Product when the forest and grass irrigation quota is multiplied by the sum of the forest, grass, and forest belt area/the oasis gross amount of water resources
	B6 Average amplitude of water table	M	D-value of the lowest water level and the highest water level in a year
	B7 Agricultural water/total of the industrial water and water for life	%	Water consumption of agriculture/ total of the water consumption of industry and life
C Plant and ecological construction	C1 Density of forest network	meter / ha	Length of forest belt/oasis area
	C2 Ratio of forest land	%	Area of forest land/oasis area
	C3 Ratio of grass land	%	Area of grass land/oasis area
	C4 Ratio of artificial vegetation	%	Sum of area of farm land, artificial forest, and artificial grass then divide by the oasis area
D Level of soil development	D1 Soil organic matter index	%	Sum of the products of all the percentages of oasis soil types by their soil organic matter content
	D2 Sum of ratio of anthropogenic-alluvial soil, irrigation silted soil, and vegetable garden soil	%	Sum of anthropogenic-alluvial soil, irrigation silted soil, and vegetable garden soil/oasis area
	D3 Sum of the ratio of saline soil, dry saline soil, Aeolian sandy soil, and adobe soil	%	Sum of the ratio of saline soil, dry saline soil, Aeolian sandy soil, and adobe soil/ oasis area
E Agricultural productivity	E1 Proportion of cultivated land	%	Area of cultivated land/the oasis area
	E2 Per unit yield	yuan/ha	crop yield per unit area
	E3 Area ratio of food supplies to cash crop and green stuff	%	Area of food supplies/sum area of cash crop and green stuff
	E4 Output value ratio of agriculture to the sum of forestry, animal husbandry, and fishery industry	%	Sown area of grain crops/sum area of cash crops and vegetables and fruits
	E5 Unit primary productivity	kg/ha	Ratio of farming to the sum of forestry, animal husbandry, and fishery industry
F Social and economic level	F1 Density of oasis population	person/ km2	Total person/oasis area
	F2 Ratio of city population	%	City population/oasis area
	F3 Output value ratio of primary industry to the sum of the second and tertiary industry	%	First industry output value/sum of the second and tertiary industry output value
	F4 Number of students in ten thousand people	Person/ ten thousand people	Number of students/10,000 people
	F5 Natural population growth rate	%	Birthrate takes away the mortality rate
	F6 Per capita GDP	yuan	Sum of GDP in oasis/Total oasis population
	F7 Farmer per capita net income		

	F8 Number of medical orderly in ten thousand people	person / ten thousand people	Number of medical orderly/10,000 people
G Landscape pattern	G1 Oasis concentration		Characterization by the nearest neighbor distance
	G2 Road density	m/km2	road length/oasis area
	G3 Adjacency ratio of farmland and sand	%	Percentage of the adjacent length of the farmland and sand
	G4 Average patch area of farmland		Total area of oasis farmland/ total number of farmland patch
	G5 Shape index		Average perimeter of farmland patch/ average area of farmland patch
	G6 Average nearest distance between settlement	km	Average nearest distance between patches of settlement place

The study uses the homologous data calculated simultaneously to assess the degree of oasis maturity accurately. Data were obtained from the annual report of farmland irrigation, statistical yearbook, and compilation of irrigation data of Zhangye City in 2014.

The calculation methods for the other indicators are shown in Table 2, except for oasis concentration, which was borrowed from the index of the nearest neighbor distance in settlement geography. The calculation formula is $R = D_a \times 2\sqrt{N/A}$, where D_a represents the average distance between one patch and its nearest patch, N represents the total number of patch in landscape, A represents the area of landscape. The small value of R corresponds to a highly concentrated distribution degree of oasis.

Treatment of the index value

The study discussed the indicators of oasis maturity from various aspects (i.e., importance, corresponds, modified importance, and completeness) as assessed by experts to ensure that the degree of oasis maturity is more scientific and comprehensive. The study then conducted a statistical analysis and screened out unsuitable indicators. The overall analysis shows that the whole index system is relatively complete.

Positive, negative, and moderate indicators were found in the process of calculation. The analysis required the transformation of negative and moderate indicators into positive indicators and then disposed them through a dimensionless form using standardized method. Among the negative indicators of B4, B7, D3, E3, F3, F5, G1, and G5, the multiplicative inverse of the values of B7, D3, E3, F5, and G1 are multiplied by 100. The multiplicative inverse of the value of B4 and G5 were multiplied by 1000 to transform them into evaluative index, the value of which is more than 1. The study applied the formula $x'_i = \frac{1}{1+|-x_i|}$ for the moderate indicator B6; hence, the value is transformed into a positive indicator. The standardized calculation formula of positive indicators is $y = \frac{x_i - \bar{x}}{s}$, where $\bar{x}$ represents the average value, and s and represents the standard deviation. The evaluative value is positive if the actual values are larger than the average and not negative.

Assessment on Oasis Maturity Based on the Coefficient of Variation Method

Weight of Indicators in the Second Layer and the Assessment on Oasis Maturity. The present study calculated the weight of indicators using the coefficient of variation method; that is, each average value of standardized indicators was divided by its standard deviation to obtain the coefficient of variation, and the total coefficient of variation was then divided by each coefficient of variation to obtain the weight of indicators. The formula of weighted arithmetic mean is then used to obtain the second layer indicators and the totality of oasis maturity. The calculation formula is $y_i = \sum_{i=1}^{k} w_i x_i$, $w_i \geq 0$, $i = 1,2,...,k$, $\sum_{i=1}^{k} w_i = 1$.The results are shown in Table 2 and Chart 1.

Table 2 Assessing value of the first and second class indicators of oasis maturity

Second layer	Ganzhou	Linze	Gaotai	First layer	Ganzhou	Linze	Gaotai
A1	−0.0448	−0.002	0.0468	A	0.0414	−0.0841	0.0428
A2	0.0793	−0.0422	−0.0371				
A3	0.0011	0.0055	−0.0066				
A4	0.0031	−0.0039	0.0008				
A5	−0.0275	−0.0494	0.077				
A6	0.0302	0.0079	−0.0381				
B1	0.0085	−0.0017	−0.0068	B	0.0187	0.0163	−0.035
B2	0.0067	0.0041	−0.0108				
B3	0.002	−0.0117	0.0097				
B4	−0.0036	0.0117	−0.008				
B5	0.0002	0.0183	−0.0186				
B6	−0.0099	0.003	0.0069				
B7	0.0148	−0.0074	−0.0074				
C1	0.0098	−0.0078	−0.002	C	0.063	0.025	−0.088
C2	0.0102	−0.0006	−0.0096				
C3	−0.0017	0.026	−0.0243				
C4	0.0359	0.0049	−0.0408				
C5	0.0088	0.0025	−0.0113				
D1	0.057	−0.0174	−0.0397	D	0.1809	−0.1116	−0.0694
D2	0.0013	−0.0072	0.0059				
D3	0.1226	−0.087	−0.0356				
E1	0.0146	−0.0037	−0.0109	E	0.0272	0.0915	−0.1098
E2	−0.001	0.0017	0.0082				
E3	−0.0051	0.0574	−0.0523				
E4	0.0119	0.0213	−0.0331				
E5	0.0068	0.0148	−0.0217				
F1	0.0538	−0.0177	−0.036	F	0.1068	0.0483	−0.0584
F2	0.0427	−0.0224	−0.0203				
F3	−0.0223	−0.0044	0.0267				
F4	0.0286	−0.007	−0.0216				
F5	0.0012	−0.001	−0.0002				
F6	0.003	0.002	−0.005				
F7	0.0018	−0.0002	−0.0016				
F8	−0.002	0.0024	−0.0004				
G1	−0.0148	0.0016	0.0132	G	0.0159	−0.0317	0.0158
G2	0.0122	−0.0046	−0.0077				
G3	−0.0421	−0.0382	0.0803				
G4	0.0183	0.0151	−0.0334				
G5	0.0229	0.0038	−0.0266				
G6	0.0194	−0.0094	−0.01				
Totality	0.4539	−0.1429	−0.302	Totality	0.4539	−0.0463	−0.302

The value of the second layer indicators in Table 2 and the total value in Chart 1 show that only the value of oasis maturity in Ganzhou is positive. Ganzhou had the highest value of oasis maturity among three oasis at 0.4539. Among the second layer indicators in Ganzhou, the value of D3 is 0.1226, followed by A2, D1, and F1. The values are the highest in corresponding indicators among three oasis. Many indicators are above the average of the indicators of the three oases. Hence, Ganzhou had the highest oasis maturity among the three oases. Linze and Gaotai had negative values of oasis maturity. Linze oasis had the lowest value of indicators, with C3 and E4 being the highest. Linze oasis had a total value of oasis maturity of −0.1429, which is less than the average of the indicators of the three oases. Among the three oases, Linze had a development level in the middle state. The Gaotai oasis indicators of C3, A5, and A1 are the largest in corresponding indicators among the three oases. Given that many indicators are low, the total value of oasis maturity in Gaotai oasis is far from the average of indicators of the three oases. Hence, Gaotai had the lowest oasis maturity among three oases. The oasis structure and function of the Gaotai oasis is also the worst among the three.

Assessment on the First Layer Indicators of Oasis Maturity

Given that the second layer indicators differ among the three oases, the current study evaluated the weighed sum of the second indicators to determine the significance of the difference on the structure, function, and utilization level. The results are shown in Table 2 and Chart 2.

Each index of Ganzhou area is positive compared with the indices of the first layer in Figure 2. The index of the level of soil development, agricultural productivity, and plant and ecological construction are the highest among the indices of the three oases. Thus, the level of soil development, social and economic conditions, and plant and ecological construction are relatively improved. Therefore, Ganzhou has a high degree of development maturity. In the indices of the Gaotai oasis, only the irrigation system and landscape pattern were positive. The values of the indices are slightly different from the two indices of Ganzhou oasis. The negative value is higher than the positive value. Among the various indices, agricultural productivity, plant and ecological construction, and social and economic level were high. The irrigation system in Gaotai Oasis is well

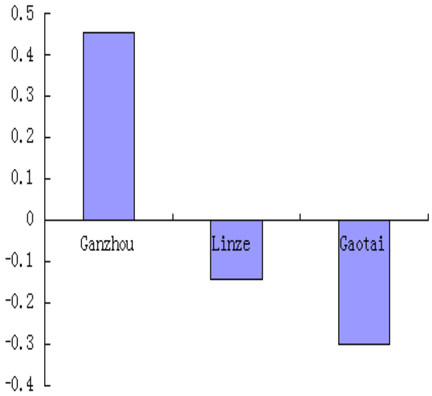

Figure 1 Assessment values of the second class oasis maturity based on coefficients of variation

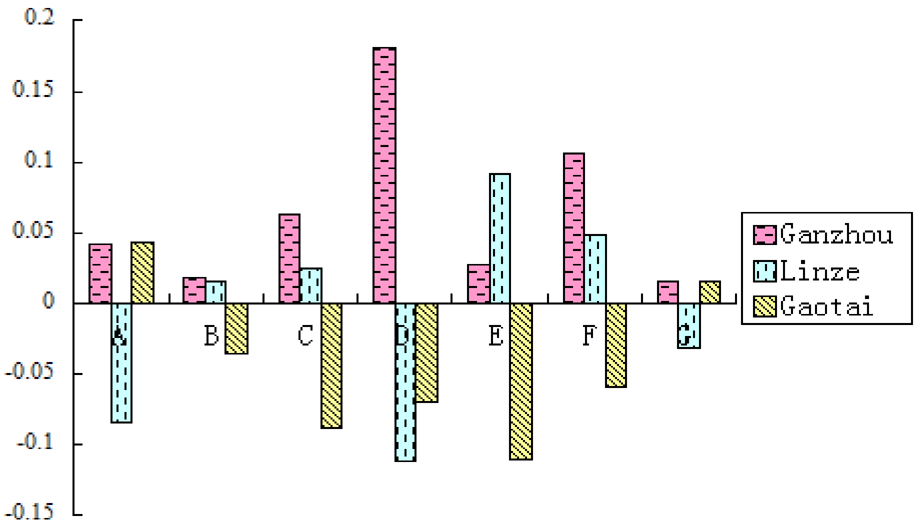

Figure 2 Assessment values of the first class oasis maturity based on coefficients of variation

constructed, and its landscape pattern is logical; however, water resource utilization level is not high, and plant and ecological construction is poor. The index value of Linze oasis is generally balanced. The highest positive appeared in the index of agricultural productivity, followed by the indices of plant and ecological construction and the utilization level of water resources. Other indices are negative. The level of soil development had the lowest negative index, which indicates that agricultural productivity and plant and ecological construction are high. Water resource utilization level is high, but the sandy area around the oasis is large and the level of soil development, irrigation system, social and economic level, and landscape pattern are poor.

Assessment of Oasis Maturity Based on Factor Analysis

Factor analysis is a method of pluralistic statistical analysis used for data simplification and dimensionality reduction. The concrete procedure involves dividing the variable quantities with intrinsic correlation into groups according to the size of the correlation. The correlation between variables within the same group is high, but the correlation of different groups is low. Hence, the variables in one group can represent a basic structure (i.e., factor) and reflect one aspect or dimension of the problem.

Factor extraction

The study applied factor analysis using the statistical analysis program SPSS 11.5 and extracted factors through principal component analysis. The study then rotated the factors using the maximum variance cross rotation method. A factor with an eigenvalue of more than 1 is considered a public factor (i.e., the main component). Thus, the eigenvalues and squared loadings of factors can be obtained in Table 3. The eigenvalue of two factors is more than 1, and the total variance of the sum is 100% for total variance. Hence, the two factors can summarize 100% of the information in the entire data set instead of using the 40 original variables to explain all the information.

Table 3 Eigenvalues and squared loadings of factors

Component	Eigenvalues	% of variance	Cumulative %
1	27.149	67.873	67.873
2	12.851	32.127	100

Analysis of the Component Matrix

Table 4 shows rotated components matrix of the extracted factors and indicates that the relative importance of each variable occupied in two factors can be obtained. Table 4 shows that for Factor 1, the load factor on the average distance to the nearest settlement, the ratio of channel utilization, and the sum of water consumption of industry and domestic is divided by agriculture, people density, the proportion of city population, and the natural population growth rate. The per capita net income for farmers and road density are both above 0.9. The load factor on the average distance to the nearest settlement is 1. Therefore, Factor one can be seen as the factor of the level of social and economic development. For factor two, the load factors on the proportion of forest, crop irrigation quota, ratio of ecological water consumption, unit primary productivity, and water intake ratio of canal are all above 0.7. The load factor on the proportion of forest is 1. Therefore, Factor two can be seen as the factor of water and land resources exploitation.

Table 4 Score and rotated component matrix of factors

Variables	Rotated component matrix		Component score coefficient matrix	
	Component one	Component two	Component one	Component two
A1	−8.863	−0.505	−0.031	−0.019
A2	0.998	−0.609	0.047	−0.029
A3	0.182	0.983	−0.009	0.024
A4	0.731	−0.682	0.046	−0.059
A5	−0.383	−0.924	−0.002	−0.058
A6	0.773	0.635	0.025	0.030
B1	0.953	0.302	0.039	0.004
B2	0.638	0.770	0.016	0.041
B3	0.130	−0.991	0.023	−0.070
B4	−0.272	0.962	−0.029	0.070
B5	0.044	0.999	−0.015	0.067
B6	−0.982	−0.187	−0.042	0.004

B7	0.999	−0.033	0.047	−0.020
C1	0.934	−0.356	0.050	0.041
C2	0.904	0.428	0.035	0.013
C3	−0.027	1.000	−0.019	0.069
C4	0.824	0.566	0.028	0.024
C5	0.763	0.646	0.024	0.031
D1	0.982	0.188	0.042	−0.004
D2	0.135	−0.991	0.024	−0.070
D3	0.964	−0.267	0.049	−0.035
E1	0.970	0.244	0.041	0.000
E2	−0.947	−0.322	−0.038	−0.005
E3	−0.047	0.999	−0.020	0.069
E4	0.384	0.924	0.002	0.056
E5	0.339	0.941	−0.001	0.058
F1	0.987	0.161	0.043	−0.006
F2	0.998	−0.062	0.048	−0.022
F3	−0.798	−0.602	−0.027	−0.027
F4	0.968	0.252	0.041	0.000
F5	0.926	−0.378	0.050	−0.042
F6	0.624	0.781	0.015	0.042
F7	0.934	0.357	0.037	0.008
F8	−0.757	0.654	−0.047	0.058
G1	−0.924	−0.383	−0.036	−0.010
G2	0.994	0.113	0.044	−0.010
G3	−0.552	−0.834	−0.011	−0.047
G4	0.575	0.818	0.013	0.046
G5	0.813	0.583	0.028	0.026
G6	1.000	−0.012	−0.047	−0.018

Analysis on the Component Score

The regression method in SPSS can obtain the score coefficient matrix of the two selected factors. The method can then obtain the score of the main factor according to the component score coefficient. The calculation formula is $F_{jk} = \sum W_{ik} X_{ik}$, where X_{ik} represents the standardized value of the variance i in factor k, and W_{ik} represents the score coefficient of the variance i in factor k. Hence, the component score of each oasis is obtained.

Assessment of Oasis Maturity

Factors 1 and 2 can represent most of the information on the evaluation index system of oasis maturity. Therefore, the value of assessment of the oasis maturity is obtained by calculating their weighed averages. The calculation formula is $F = a_1 z_1 + a_2 z_2$, where a_i represents the variance contribution rate of one factor, and z_i represents the one component score (i.e., above F). The result is shown in Table 5.

Table 5 Assessment values of oasis maturity based on factor analysis

Component	Ganzhou	Linze	Gaotai
1	11.5097	−0.8736	−10.6361
2	−0.0187	0.3272	−0.3085
Totality	11.4910	−0.5464	−10.9446

The result of the assessment of oasis maturity in Table 5 shows that Factor one of the level of social and economic development has a significant difference among three oases. Ganzhou had the highest value of oasis maturity at 11.5097, with Linze oasis coming second. The numerical value of Gaotai oasis almost crossed that of the value of Ganzhou at −10.6361. Therefore, Gaotai had the worst social development. This finding is explained by the rapid development of population and economy in the recent years and the unreasonable exploitation and utilization of land resources. Many serious problems are found, including the loss of balance in the ecological system and the aggravated desertification that threatens sustained economic and social growth in an oasis. The value of the Factor 2 on water and land resources exploitation in Linze oasis is the highest at 0.3272, followed by Ganzhou oasis, which is the lowest at −0.3085. The difference of Factor 2 is less than Factor 1. The evaluation of the estimate in Ganzhou oasis is much higher than the other two oases. Ganzhou oasis had the best degree of maturity.

Integrated Assessment on Oasis Maturity

Based on expert scoring, the similarities and differences on the evaluation results of oasis maturity because of different perspectives were found using the coefficient of variation and factor analysis methods. The coefficient of variation reflects mainly the different degrees among index values. A greater difference and weight corresponds to a larger evaluation that effectively reflects the maturity difference among oases. However, the factor analysis emphasized the information contribution on indicators. The measured common factor had higher integration, which usually reflects the society, nature, and economy of oasis growth. The common factor can forecast future oasis development. However, the two methods have pros and cons. The study calculates the arithmetic average value of the evaluations of estimate using the two methods to assess oasis maturity objectively. The integrated evaluation values of the maturity of the three oases are obtained. The results are shown in the Table 6.

Table 6 Integrated values of oasis maturity

Methods	Ganzhou	Linze	Gaotai
Coefficient of variation	0.4539	−0.1429	−0.3020
Factor analysis	11.4910	−0.5464	−10.9446
Integrated assess	5.9680	−0.3445	−5.6239

Table 6 shows that the Ganzhou has the highest degree of oasis maturity, followed by Linze and Gaotai. The evaluation values of Linze and Gaotai are positive. The value of Linze is closer whereas the value of Gaotai is farther from the average. Hence, the maturity degree of Ganzhou oasis is the best, whereas the maturity degree of Gaotai is the worst.

Conclusions

Zhangye oasis is a typical oasis in the higher development level of agricultural oasis and has a long history of agricultural development in Hexi Corridor oasis. The extent of land utilization is higher, farming is intensive, water conservancy facilities are in good condition, and the level of urbanization is fast. The study selects three typical oases (i.e., Ganzhou, Linze, and Gaotai) as study objects based on the method of experts scoring. Coefficients of variation and factor analysis methods are used to assess and compare the maturity of the three oases. The conclusions are as follows.

(1) The Ganzhou area had the highest index value of maturity among three oasis based on coefficient of variation, whereas that of the Gaotai oasis is the lowest.

(2) Common Factor 1, which reflects mainly the level of social development, indicates the significant differences among the three bases based on factor analysis. Ganzhou area had the highest value (11.5097), whereas that of Gaotai (−10.6361) was nearly the opposite of the Ganzhou area. Linze oasis was between the two oases. Common Factor 2, which reflects the levels of soil and water resources development, shows that Linze had the highest value, with the Ganzhou area coming second, and Gaotai the last. However, this difference is not distinct from that in Common Factor 1.

(3) The results of the comprehensive evaluation of the ODMD of the three oases in are as follows: Ganzhou > Linze > Gaotai.

The main reasons for these results are listed as follows:

(1) The position of the oasis topographic feature and height of elevation are deciding factors for water and land resource conditions. Ganzhou oasis, which is located in the piedmont alluvial plain in a tributary of Heihe River, has abundant water resources and fertile soil. Ganzhou has a low

underground water level, and deep earth layer. The Linze and Gaotai oases are distributed around the old low-order oasis, which is located along the river in the alluvial plain of the tributary of Heihe River. Their geographical positions are not superior to the Ganzhou district; however, the local residents constantly construct, transform, and optimize the oasis structure and attempt to reduce the gap in this aspect. This phenomenon can reflect Factor 2 in the method of factor analysis.

(2) The Ganzhou oasis has a more intensive distribution of residents and is subject to more extensive human activity. The Gaotai oasis has a more concentrated agricultural land and population distribution, whereas Linze oasis has a more scattered population distribution, and partial agricultural land is scattered in the outer oasis area.

(3) Ganzhou district has a high urbanization level. The government maximizes the advantages and highlights the area's characteristics in its oasis development and management. Hence, the development of oasis construction is hastened. Linze and Gaotai oases developed slowly in terms of agricultural productivity and social and economic levels. The structure and function of the oases are far from perfect and can cause significant limitations and obstacles to economic development and sustainable utilization, which reflects on the Factor one in the factor analysis. Thus, the government should strengthen and improve on oasis management and construction.

Purposeful engagement in the protection, renovation, construction, and management of oases and development toward a harmonious direction may be achieved through scientific evaluation and objective measure.

Acknowledgement

Supported and funded by the Key r&d project of science and technology department of Gansu province (18YF1NA015)；the foundation ability enhancement project in young teachers of Guangxi universities in 2017(2017KY0578); the Natural science foundation of china (NSFC) project (40901095)；the national social science fund of China (NSSFC) project (09XSH014)；the natural science foundation of China (NSFC) project (41561102)

Reference

[1] Hu Ruji, Jiang Fen-qing, Wang Yajun. To have a Correct Understanding of Stability of Oasis in Arid Lands of China[J], Arid Zone Reserch,2010,27(3):319-323.

[2] Li Qisen, Zhao Wen-zhi, Ma Changchun. Theory and application of forage and livestock coupling for mountainous-desert country in the Heihe River basin of Linze demonstration area in the middle reaches of Heihe River basin for example.Acta Pratacul Turae Sinica,2004,13(4):13-20

[3] Jiao Yuanmei. Integrated assessment on the landscape pattern and maturity of manual oases in middle reaches of the Heihe River Basin[D]. Cold and arid regions environmental and engineering research institute, Chinese academy of science, may 2003

[4] Chen Huailu, Yao Zhixiang, SU Fang. With Urbanization in the West of China. Jouranal of Desert Research,2005,25(3):357-363

[5] Zhang Linyuan Wang Naiang . On the Oases Genesis Types and Evolution in Time and Space. Journal of Arid Land Resources and Environment, 1995,9(3):32-43

[6] Guo Jian, Xue Xian, Wang Tao, Sun Junxi, LI Xinquan. Journal of Desert Research, 2009,29(3):397-403

[7] Han Delin. The Progress of research on oasis in China[.Scientia Geographica Sinsca, 1999,19(4):313-319

[8] Wang Tao. Some Issues Oasification Study in China. Journal of Desert Research,2010,30(5): 995-998

[9] Zhang Yufang, Yang Degang, Zhang Xiaolei, Deng Hongtao. Research on Regional Struture and Fractal Characteristics of Urban Agglomerations at Northern Slope of Tianshan Mountain. Journal of Desert Research, 2008,34(9):1750-1760

[10] Wang Yaobin, Liu Guangxiu, Feng Qi, Si Jianhua, Chang Zongqiang, Xi Haiyang. Evaluation of Oasis Stability in Ejina Based on Rough Set and Grey Theory. Resources Science, 2012,34(9):1750-1760

[11] Su Peixi, Zhang Xiaojun, Liu Xinmin. Characteristics of the Oasis PRED System and Quantitative Study on Its Sustainable Development[. Scientia Geographica Sinsca,2001, 21 (6): 519- 523

[12] Cao Yu, Ouyang Hua, Xiao Duning, Chen Gao. Landscape change and its eco-environmental effects in Ejin natural oasis. Geographical Research, 2005,24 (1): 130-139

[13] Li Xiaoyu, Xiao Duning, He Xingyuan, Chen Wei. Integrated Assessment of Oases Maturity in Inland River Basins of China. Acta Geographica Sinca, 2006, 61(8) : 855-864 .

[14] He Ximei, Li Xiaoyu, Xiao Duning, Li Yan. Developed maturity degree of old and new Oasis in Sangonghe River Basin[J]. Arid Land Geography, 2006,30(3):343-347