

An Evaluation of Water Ecological Advancement in Hilly Areas at the Village Scale: A Case Study of Qingyuan Village in Yucheng District, China

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Abstract – This paper explores the current situation of rural water ecological advancement in hilly areas in western Sichuan Basin as well as its evaluation method, according to principles of the scientific method. 23 specific indices like maintenance degree of ecological water requirement and others are selected from the following 4 aspects: i) water ecological system, ii) water supply system, iii) water management system, and iv) water cultural system, to establish an evaluation index system of water ecological advancement in rural communities in hilly areas at the village scale. Analytic Hierarchy Process (AHP) is adopted to calculate the weight of each index and evaluate the level of water ecological advancement in Qingyuan Village of Yuchen District, China. The results show that the score of water ecological advancement in this village is 53 points, which is rated as “Medium”. Its main driving factors are: i) comprehensive utilization of manure in livestock's breeding industry, ii) satisfaction degree of ecological water requirement, iii) water environment protection, iii) flood control and flood drainage water supply project compliance rate, iv) operational degree of engineering facilities, and so on. The conclusion of the study will provide a scientific basis for the construction of water ecological advancement in Qingyuan Village. It will also show that the construction of rural water ecological advancement in hilly areas with abundant water resources cannot be ignored.

Keywords -- *Water ecology; Evaluation; Hilly areas; Qingyuan Village; AHP*

I. INTRODUCTION

Research on water ecological civilization in China is in the preliminary stage [1-3], correlative study is rather less and not perfect in its depth and completeness. Research hotspots mainly focus on the elaboration of concept and connotation of water ecological civilization construction [4-8], which are more in qualitative analysis while less in comprehensive and quantitative analysis. In the aspect of evaluation method, research on the index system of water ecological civilization is rather less and is mostly qualitative while less quantitative. Large-scale researches (nation, province) are relatively more [9-15], which take individual cities or provinces as objects; while researches on small-scale and village scale samples (under the Village) are relatively less.

Hilly areas in the western Sichuan Basin, located in moist areas of southern China, are rich in water resources with dense river networks. However, water resources problems like seasonal drought, engineering water shortage, pollution of water resources, rural drinking water difficulties happen occasionally. Therefore, water ecological civilization construction cannot be ignored.

According to principles like scientificity, quantifiability, 23 specific indexes are selected from the following 4 aspects such as water ecological system, water supply system, water management system and water cultural system to establish a set of evaluation index system standard of water ecological civilization in rural

communities in hilly areas based on village scale. Analytic Hierarchy Process is adopted to calculate the weight of each index, and empirical researches on the level of water ecological civilization in Qingyuan Village of Yuchen District in Ya'an are carried out. It not only enriches evaluation theory system of water ecological civilization, but also provides a scientific basis for the construction of water ecological and civilized villages in hilly areas as well as sustainable management of rural water resources.

2. II. MATERIALS AND METHODS

A. General Situation of Research Area

Qingyuan Village in Duiyan Town of Yuchen District in Ya'an is a typical rural community in western Sichuan province. It is located in the rural-urban fringe of Yuchen District, Ya'an, and is adjacent to Fenjiang River- a tributary of Qingyi River Basin. The geomorphic types in this village which is with altitudes of 580 to 1453 meters and distinctive features of hilly areas are mainly low mountains and hills. The soil type of this village is mainly purple soil with a small amount of yellow soil. Its land use types are mainly cultivated land, tea garden, orchard, woodland, etc [16]. The climate of this village belongs to subtropical monsoon climate, so dry and wet seasons in this village are clear. The average annual temperature is between 14.1 and 17.9 degrees centigrade and the average

annual rainfall is 1670mm, therefore, this village is full of humidity but lack of sunshine. This village has an area of 140 hectares, among which, fruit planting area is about 2 hectares and water area is about 22.34 hectares. There are 4 villager's groups, 440 households and a total number of 1600 people in this village, whose resident population are about 1600 people. The village is rich in water resources. There are 50 wells in this village and the part of Fenjiang River flowing through the village is about 2 kilometers long. Besides, centralized water supply facilities cover more than 80 households in the village and drainage canals is 1 kilometer long. In addition, two large pumps (800 kW) and several small pumps (60-200kw) provide powers for household water consumption. Its economic structure relies mainly on agriculture which is based on fruit planting (like peaches, grapes and pears). Per capita net income is about 12000 yuan and the gross output value of agriculture is about 19.2 million yuan. Temporarily there's no rural industry in this village. Fenjiang River Basin involves Yuchen District and its

villages and towns like Babu Village and Duiyan Town, which has a total population of almost 40 million people. Its planting industry and breeding industry are relatively developed (Fig.1). This village is a typical village in hilly areas in western Sichuan Basin, which is a strong representative for the study on the evaluation of water ecological civilization in hilly areas in western Sichuan Basin.

B. Construction of Index System

Based on the clarification of connotation of water ecological civilization, according to principles like scientificity, independence, systematic, quantifiability, overall and regional balance as well as combination with existing working foundation, 23 indexes are selected to establish a set of evaluation index system from the following 4 aspects such as water ecological system, water supply system, water management system and water cultural system.

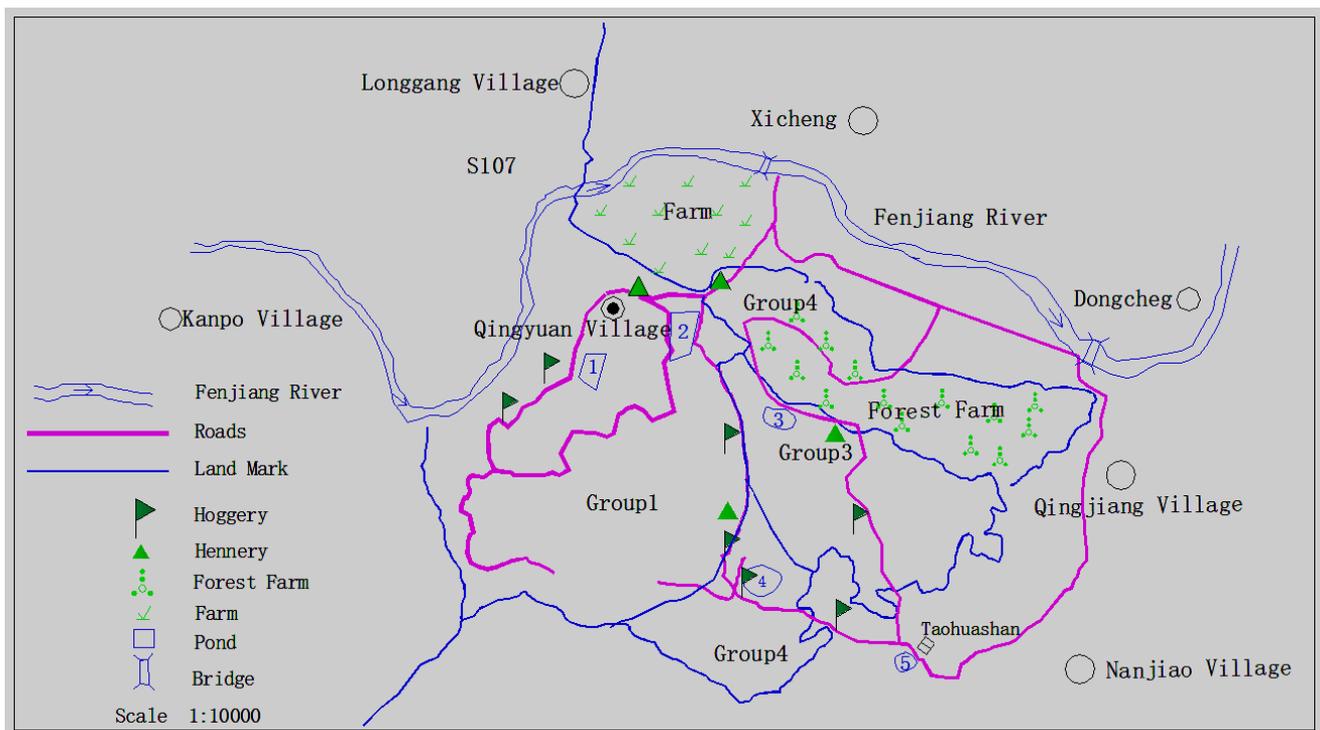


Fig.(1). Basic Situation of Qingyuan Village

C. Determination of Index Weight

By looking up relevant statistical yearbooks and combing with field survey, authors of this paper calculate the weight of each index through theoretical analysis, expert consultation, public participation and AHP, thus determining the scoring rules and methods of evaluation indexes of water ecological and civilized villages in hilly areas.

D. Classification of the Degree of Water Ecological Civilization

According to the commonly used five-category classification, the degree of rural water ecological civilization in hilly areas can be divided into five categories, which are Excellent (above 80 points), Good (60 points to 80 points), Medium (40 points to 60 points),

Poor (20 points to 40 points) and Inferior (below 20 points).

III. RESULTS AND DISCUSSION

A. Evaluation Results

Evaluation results are shown in Table 1.

TABLE 1-Part-1. EVALUATION INDEXES, SCORING RULES, SCORE AND EVALUATION RESULTS OF WATER ECOLOGICAL CIVILIZATION IN QINGYUAN VILLAGE

Evaluation Item	Evaluation Index	Evaluation Content and Scoring Rules	Score	Evaluation Result
Water ecological system (B ₁) 55 points	Maintenance degree of ecological water requirement(X ₁) 7 points	Rivers and lakes in communities flows continuously and never dry up in a normal year (4 points). 3 points are assigned when main water systems are connected with each other or circulating; 4 points when both items are relatively good; otherwise, 0 point.	7	26
	Maintenance degree of water environment(X ₂) 5 points	2 points will be assigned if rivers and lakes are full of clear water and without debris and smell; 1 point if there are certain replenishment measures. 2 points are assigned when slopes mainly adopt ecological slope protection, otherwise, 0 point. 2 points will be deducted if debris piled up or littered in more than two places in slopes of rivers and lakes.	4	
	Water surface ratio(X ₃) 4 points	4 points will be assigned if water surface ratio is more than or equal to 10%. 1 point will be deducted for every reduction of 1%.	3	
	Standard-reaching rate of drinking water safety(X ₄) 4 points	4 points will be assigned if standard-reaching rate of drinking water safety is more than or equal to 95%. 1 point will be deducted for every reduction of 5%.	4	
	Centralized garbage disposal rate(X ₅) 2 points	2 points will be assigned if centralized garbage disposal rate is more than or equal to 90%, 1 point will be deducted for every reduction of 5%.	2	
	Richness of aquatic organisms(X ₆) 2 points	2 points are assigned when fish, shrimp and other animal species in the main rivers and lakes are rich, and its species number is greater than the average species number of this area; otherwise, 0 point.	0	
	Rationality of plant disposition (X ₇) 5 points	5 points (2.5 points each)will be assigned if the main rivers and lakes are allocated with various aquatic plants along the waterfront (tidal flat), or rivers and ponds are reasonably allocated with coastal plants. Otherwise, 0 point.	5	
	Forest and grass coverage rate(X ₈) 1 point	1 point will be assigned if forest and grass coverage rate is more than 30%; otherwise, 0 point.	1	
Water supply system (B ₂) 25 points	Comprehensive utilization of manure in livestock's scale breeding industry(X ₉) 25 points	25 points will be assigned if comprehensive utilization of manure in livestock's scale breeding industry is more than or equal to 80%, 3 points will be deducted for every reduction of 5%.	0	23
	Flood control and flood drainage water supply project compliance rate(X ₁₀) 12 points	12 points will be assigned if more than 95% flood control and flood drainage water supply projects reach the design standard, 4 points for each item. 1 point will be deducted for every reduction of 5%.	12	
	Intact degree of engineering facilities(X ₁₁) 8 points	8 points will be assigned if water conservancy engineering facilities like dikes are not damaged, or the intact rate is more than or equal to 85%. 1 point will be deducted for every reduction of 2%.	8	
	Covering rate of pipe network(X ₁₂) 2 points	2 points will be assigned if covering rate of pipe network is more than or equal to 90%. 1 point will be deducted for every reduction of 2%.	0	
Water management system (B ₃) 10 points	Leakage rate of water supply pipe network(X ₁₃) 3 points	3 points will be assigned if leakage rate of water supply pipe network is less than or equal to 18%. 0.5 point will be deducted for every increase of 2%.	3	1
	Standard-reaching rate of water sources protection(X ₁₄) 3 points	3 points will be assigned if standard-reaching rate of water sources protection is more than or equal to 90%. 1 point will be deducted for every reduction of 2%; otherwise, 0 point.	0	
	Rate of water project management in place(X ₁₅) 3 points	3 points are assigned when water projects are with sound institutions, complete system and adequate maintenance fund; 1 point when water projects are with sound institutions, basically complete system and funding sources. Otherwise, 0 point.	1	
	Water improvement rate(X ₁₆) 2 points	2 points will be assigned if water improvement rate is more than or equal to 90%; otherwise, 0 point.	0	
	Unified planning rate of water management (X ₁₇) 1 point	1 point will be assigned if water improvement rate is more than or equal to 90%; otherwise, 0 point.	0	
	Popularization of water saving society (X ₁₈) 1 point	1 point will be assigned if multiple forms of publicity and education are launched, the promotion of water-saving appliances is obvious, the construction of water-saving system is relatively perfect and water-saving society is construction is initially established. Otherwise, 0 point.	0	

TABLE 1-Part-2. EVALUATION INDEXES, SCORING RULES, SCORE AND EVALUATION RESULTS OF WATER ECOLOGICAL CIVILIZATION IN QINGYUAN VILLAGE

Water culture system (B ₄) 10 points	Villagers' cognitive degree of water ecological civilization (X ₁₉) 3 points	3 points are assigned when it is more than or equal to 90%; otherwise, 0 point.	0	3
	Popularity rate of water ecological civilization consciousness(X ₂₀) 1 points	1 point is assigned when it is more than or equal to 90%; otherwise, 0 point.	0	
	Cognitive degree of harmonious relationship between people and water(X ₂₁) 1 point	1 point is assigned when it is more than or equal to 90%; otherwise, 0 point.	1	
	Ornamental value of water area and the surrounding scenic spots(X ₂₂) 1 point	1 point will be assigned if water area and the surrounding natural environment is beautiful and the overall landscape effect is good; 0.5 point will be assigned if that is basically reached. Otherwise, 0 point.	1	
	Water cultural characteristics and publicity(X ₂₃) 4 point	4 points will be assigned if there are water cultural characteristics, propaganda signs (monuments) and pamphlet as well as education campaigns. If one item is missed, 1 point will be deducted.	1	
Total Score and Evaluation			53.0	Medium

It can be seen from table 1 that total score of Qingyuan Village is 53 points, its degree of water ecological civilization is rated as "Medium", which shows that water ecological civilization in Qingyuan Village is not optimistic.

B. Discussion

Qingyuan Village is located in the humid areas in hilly areas in Western Sichuan Basin and is rich in water resources with dense river networks. However, by taking systems like water ecology, water supply, water management and water culture into consideration, it can be found that the main driving factors in this village are as follows:

(1) Water ecological system is the primary driving factor in water ecological civilization in Qingyuan Village, which accounts for 55% of the total score, in which, comprehensive utilization of manure in livestock's scale breeding industry accounts for 25% of the total score, ranking first; maintenance degree of ecological water requirement and maintenance degree of water environment take up 7% and 5% of the total score respectively, ranking second and third. The main reason for poor water ecological system in Qingyuan Village is that comprehensive utilization of manure in livestock's scale breeding industry scores zero. It is investigated that there exist 7 hoggeries and 4 henneries in this village, and most breeders have not built biogas digesters, septic tanks, or the capacity is too small for breeders to clean. Pollution control measures such as separation of dry and wet, rainwater and sewage shunting are not taken by breeders, besides, they are not willing to shovel shit manually, so septic tanks overflow seriously. Sites of breeding farms are randomly chosen and most of them are close to functional water source areas, densely populated areas and environmental sensitive areas. Because of obvious

contradictions between people and land as well as few arable lands, feces and urine from livestock and poultry breeding can not be comprehensively utilized very well, they are directly discharged into the river basically without any treatment. Breeders who have built pollution control facilities focus on construction but ignore operation and maintenance, so some facilities are not running properly or in poor operating effect, and some even do not work. Especially the pollution of family breeding farms with almost 100 pigs on hand perennially is the most serious. Those farms mostly follow the trend of market, when the price goes up, breeders will increase the number of breeding by privately and arbitrarily building and expanding breeding houses which are basically without pollution control facilities. Besides, they directly discharge feces and sewage, which

causes environmental pollution and especially seriously pollutes ditches, streams and rivers, thus seriously affecting production and life of villagers as well as local ecological environment. A few years ago, a steady stream of visitors came to visit Taohuashan in this village every spring. However, in recent years, due to an increasing number of pig farms, pollution in Taohuashan has become very serious, and there has been almost no tourists. It has led to severely damaged tourism resources in Taohuashan. Therefore, it is the village's top priority to consume and utilize livestock and poultry manure through mulching, biogas, compost, substrate and other ways. In addition, it is also important to pay attention to water environment protection and restoration of water ecological environment.

(2) Water supply system is the second driving factor in water ecological civilization in Qingyuan Village, which accounts for 25% of the total score, in which, flood control and flood drainage water supply project compliance rate and intact degree of engineering facilities rank first and second separately, taking up 12% and 8% of

the total score respectively. Water resources in this village are abundant. There are 50 wells and 5 ponds in this village and the part of Fenjiang River flowing through the village is about 2 kilometers long. Besides, two large pumps (800 kW) and several small pumps (60-200kw) provide powers for household water-consumption. This village is located in the rural-urban fringe of Yuchen District, Ya'an. Several years ago, problems of centralized water supply in more than 80 households in the village were solved by urban pipe network extension, which only occupies 18% of the total number of households while the rest are served with decentralized water supply. Therefore, low covering rate of pipe network is the major issue in water supply system. Active measures should be taken to increase the funds of centralized water supply projects, and to effectively improve low covering rate of pipe network in this village.

(3) Water management system is the third driving factor in water ecological civilization in Qingyuan Village, which accounts for 10% of the total score, in which, standard-reaching rate of water sources protection, rate of water project management in place and water improvement rate rank first, second and third separately, taking up 3%, 3% and 2% of the total score respectively. Except for rate of water project management in place whose score is only 1 point, standard-reaching rate of water sources protection, water improvement rate, unified planning rate of water management, popularization of water saving society of this village score zero respectively. The main reason is that Wenchuan earthquake on May 12th in 2008 and Lushan earthquake on April 20th in 2013 have greatly damaged the geological environment of the upstream region of small watershed in the part of Fenjiang River flowing through the village, causing 22 geological disasters such as debris flow, landslide, collapse and unstable slope[20]. Comprehensive management of small watershed is implemented in Fenjiang River Basin, in which reconstruction projects include one center school, one health center, one comprehensive cultural station and one Shigang bridge in Babu Village, Sichuan and Yunnan trade logistics park, settlements in Luojiagou and Gulu New Area of Babu Village as well as integrated settlements in Canpocan Village and so on. Intensive human activities and the construction of Yakang highway aggravate water and soil erosion. The village is located along the river bank of Fenjiang River, abundant in precipitation and foreign water resources, however, seasonal water shortage and engineering water shortage also occur. Standard-reaching rate of water sources protection in the water quality of both Fenjiang River and decentralized water supply is significantly low under the influence of intensive human activities and earthquake. Therefore, water ecological civilization construction in Qingyuan Village should protect water sources, increase the intensity of centralized water supply, pay attention to

the top-level planning and design of water management and strengthen the popularization of water-saving society.

(4) Water culture system is the fourth driving factor in water ecological civilization in Qingyuan Village, which accounts for 10% of the total score, in

which, villagers' cognitive degree of water ecological civilization and popularity rate of water ecological civilization consciousness score zero respectively, while the score of water cultural characteristics and publicity is only 1 point. Villagers' cognitive degree of water ecological civilization, popularity of water ecological civilization consciousness and evacuation of water cultural characteristics and publicity all directly determine the level of difficulty in the village's water ecological civilization construction. Therefore, water ecological civilization construction in Qingyuan Village should promote water ecological civilization propaganda, awaken villagers' consciousness of water ecological civilization and fully evacuate water cultural characteristics like Ya yu (a special species of fish in Ya'an) and Ya yu(rain in Ya'an that is barely seen in other places).

IV. CONCLUSION AND SUGGESTIONS

(1)Water ecological civilization is a comprehensive social problem with so many influencing factors. Establishing a set of index system based on local conditions and applying Analytic Hierarchy Process to make an empirical analysis of qualitative and quantitative evaluation of water ecological civilization not only enriches theories and systems of water ecological civilization evaluation but also provides a scientific basis for water ecological civilization construction in hilly areas.

(2) The degree of water ecological civilization in Qingyuan Village is rated as "Medium", which shows that livestock and poultry breeding, low covering rate of pipe network, weak water sources protection, less attention to the top-level planning and design of water management, low cognitive degree of water ecological civilization and low popularity rate of water ecological civilization consciousness all have serious impacts on water ecological civilization construction in humid areas with superior natural water resources endowment in hilly areas in Western Sichuan Basin.

(3) Qingyuan Village should integrate the idea of water ecological civilization into exploitation, utilization and protection of water resources, small on-farm waterworks planning and design, small on-farm waterworks construction and management as well as other aspects, thus improving the level of water ecological civilization construction in general and motivating internal driving forces for the development of the village. Active measures should be taken to legally transfer land, adjust agricultural planting structure, prohibit large-scale livestock and poultry breeding, strengthen ecological

management and construction of rivers, focus on soil and water conservation and ecological revetment, further improve water conservancy investment and financing system and so on.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

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