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Dynamic changes and sensitivity of water Area of Huixiankarst wetland

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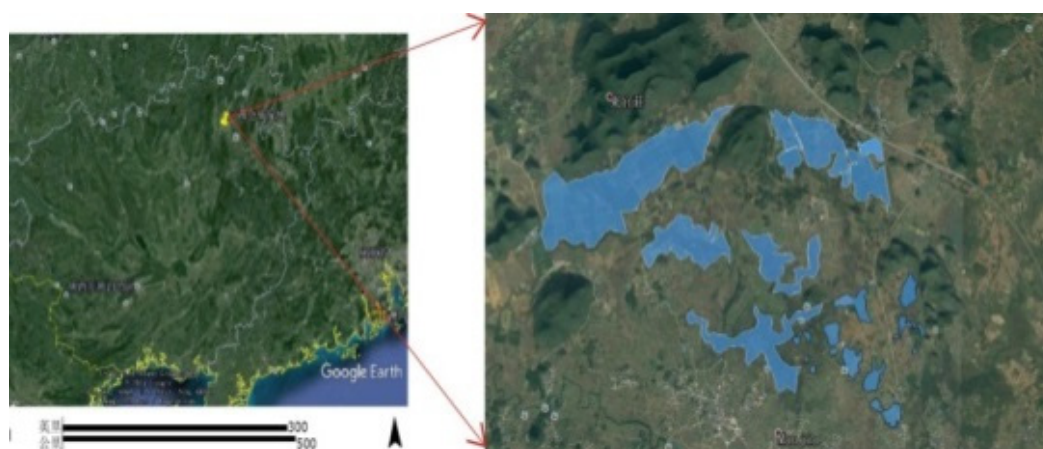
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Abstract. Affected by human activities and natural factors, the area of the Huixian karst wetland has been shrinking in recent years. As the main data source, Landsat5 TM remote sensing image was used to analyze the trend of wetland landforms and its driving factors. The changes of various types and the sensitivity of water influencing factors of Huixian wetland in the past 30 years were analyzed by visual interpretation, supervised classification and geographic information system. The analysis results show that the water area of the wetland has decreased significantly in the past 30 years, and the reduction is 4.52 km². The fish pond area appears an increasing trend, and the increase is 2.81 km². The increase of farmland and vegetation is 1.66 km² and 0.33 km² respectively. The increase of fish ponds is much smaller than the reduction of water bodies. Water bodies have been developed into farmland or vegetation land. The main driving factor of land type change is human activity, and natural driving is secondary. Sensitivity analysis shows that water for agriculture and fish ponds is the most important factor contributing to the shrinkage of natural water bodies in Huixian wetland.

1. Introduction

Wetland is one of the most important living environment for human beings and one of the richest biodiversity ecosystems in nature [1]. It not only has the functions of regulating climate, purifying water quality, and maintaining ecological diversity [2,3], but also has scientific research and education, tourism and other social functions [4]. Guilin Huixian Wetland is the largest natural karst wetland in China known in low and medium altitude karst areas in China [5]. It is located in the watershed of Lijiang River and Liujiang River Basin, the first tributary of the Pearl River system. It is the collective name of all wetlands in the Yanshan District of Guilin City, Huixian Town of Lingui District and Sitang Township [6]. Huixian Wetland is about 30 km away from the urban area of Guilin, with coordinates between 110° 8'53" ~ 110° 16'00" E, and 25° 5'25" ~ 25° 9'16" N (Figure 1). The core area of the wetland includes 18 administrative villages, including Huang Chatang, Dou Men, and FengJia. The total area of the study area is 40.94 km². The wetland is located in the transition area between Guilin Fengcong depression and Fenglin Plain, which is known as the "classical model of karst in the world". Its geological and geomorphological types are typical. The region has a subtropical monsoon humid climate with four distinct seasons and abundant rainfall. The average annual rainfall is 1902.6 mm and the average temperature is 18.99 °C. The rainfall is mainly concentrated in April to September.





(a)Huixian Wetland

(b)Core position

Fig.1 Geographical location map of Huixian karst wetland

For a long time, human economic activities have endowed rich cultural connotations to wetlands. At the same time, extensive reclamation has also caused serious damage to karst wetland ecosystems. The karst wetland ecosystem is highly sensitive to human interference [7], and the impact of human activities and climatic factors often causes major changes in the pattern of wetlands, which in turn leads to shrinking wetland areas. Since China's accession to the Wetland Convention in 1992, wetland research and protection have gradually received the attention of governments and scientific researchers [8,9]. Aiming at Huixian Wetland, Cai Desuo et al. [10] used high-precision multi-temporal and multi-platform series remote sensing digital image data and inverse sequence remote sensing inversion analysis method to carry out quantitative research and qualitative analysis of the evolution history and degradation cause of karst wetland in the past 40 years. Analysis; Cheng Yaping [11] comprehensively evaluated the surface water and groundwater in Huixian Wetland to obtain the overall degradation characteristics of the wetland; Cui Baoshan et al [12] established a wetland ecosystem health evaluation index system. In terms of the sensitivity of influencing factors, Liu Di [1] evaluated the ecological status of the Ordos inland plateau wetland using a fuzzy analytic hierarchy model; Gao Guiqin et al. [13] evaluated the Dongping Lake wetland in Shandong based on the APH method and constructed the wetland ecosystem health evaluation index system; Cao Zhipeng et al. [14] used the analytic hierarchy process to determine the evaluation index and the weight of each index, and then evaluated the degradation degree.

At present, some researches have been conducted on the changes of Huixian wetland ecosystem, but relatively few studies have been conducted on the dynamic changes of wetland types and quantitative analysis of driving factors. Based on the supervised classification method and 3S technology, this paper uses 7 remote sensing data of Landsat5 TM as the data source to carry out research on the changes of various categories and their driving factors. At the same time, it analyzes the main driving factors of the area degradation of karst wetlands in Huixian by means of analytic hierarchy process, in order to provide a positive reference for the environmental protection and reasonable development and utilization of Huixian Wetland.

2. Data source and image interpretation

2.1 Data source and processing

Remote sensing has the characteristics of large-area simultaneous observation, timeliness, comprehensiveness and comparability of data, and economy. It has become an indispensable research method in the fields of resource survey, environmental monitoring, regional analysis, and global

change [16]. According to the climatic characteristics of the Huixian karst wetland area, December 6, 1987, October 16, 1992, March 1, 1996, November 26, 2001, December 26, 2006, and November 13, 2011 were selected. TM5 image and OLI image on November 11, 2016 were used as data sources. The 7-phase images are all in dry season, with good imaging quality, less cloud cover, clear images, and spatial resolution of 30 m.

During remote sensing imaging, due to the influence of various factors, there are certain geometric distortions, atmospheric errors, and radiation distortions in remote sensing images. In order to reduce these distortions and distortions, pre-processing is necessary to eliminate the remote sensing images. Landsat5 TM and Landsat8 OLI data were pre-processed in ENVI by radiation calibration and atmospheric correction, and then supervised classification and human-computer interaction interpretation methods were used to obtain the preliminary results of area data of various categories in various periods. Interpret the logo in detail, verify the preliminary interpretation results of each period, re-interpret, analyze, judge, modify, supplement and arrange the results in the wetland resource information in different periods, and finally use ArcGis software spatial analysis technology to obtain changes in various categories. In-depth analysis of the drivers of change. The pre-processing process is shown in Figure 2:

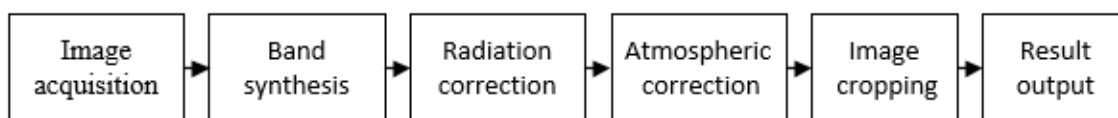
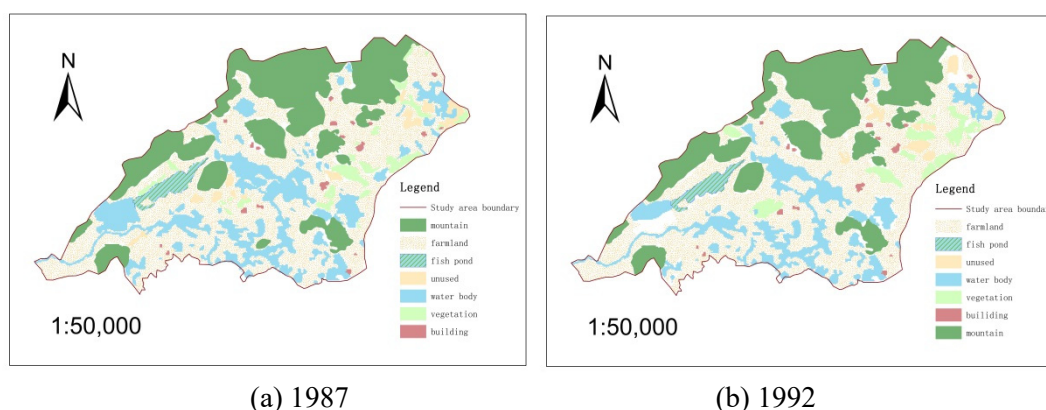


Fig.2 Pretreatment flow chart

2.2 Interpretation of Huixian Wetland Remote sensing image

On-site survey combined with ENVI software, adopted supervised classification and Support vectot machine (SVM) classifier classification, and used post-processing methods to interpret 7 periods of remote sensing image data to accurately extract information from various places and form 7 periods Extraction map of remote sensing information of Xian wetland. It can be seen from the classification map of the remote sensing images in the 7th period that the land types have changed greatly in the past 30 years (Figure 3).



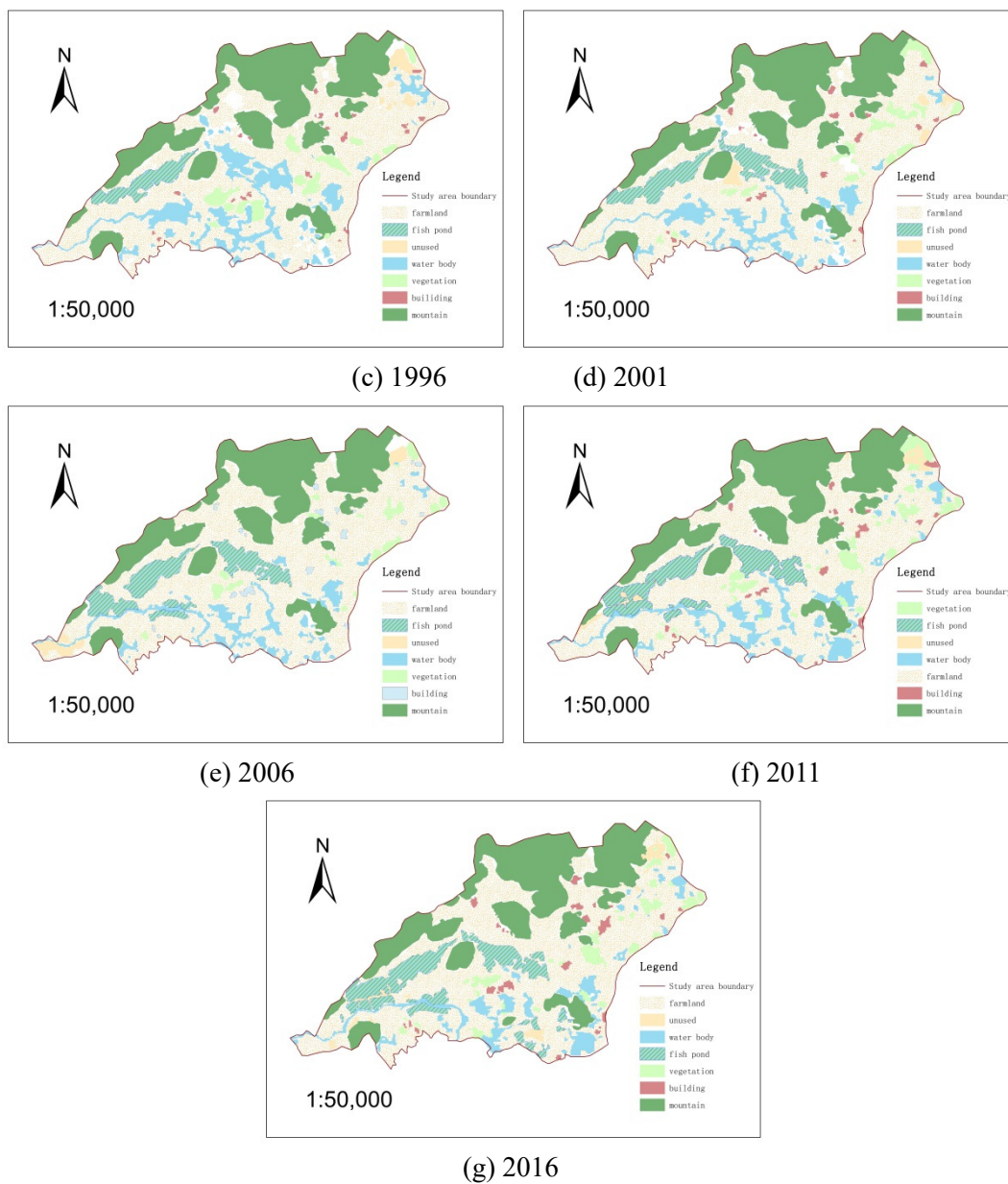


Fig.3 Remote sensing interpretation map of Huixian wetland from 1987 to 2016

3. Land category evolution and driving factors

3.1 Land type change

3.1.1 Land type change process

Huixian wetland includes 6 types of farmland, water bodies, fish ponds, vegetation, buildings and unused land. Figure 4 quantitatively analyzes the evolution of land types from the perspective of land area statistics.

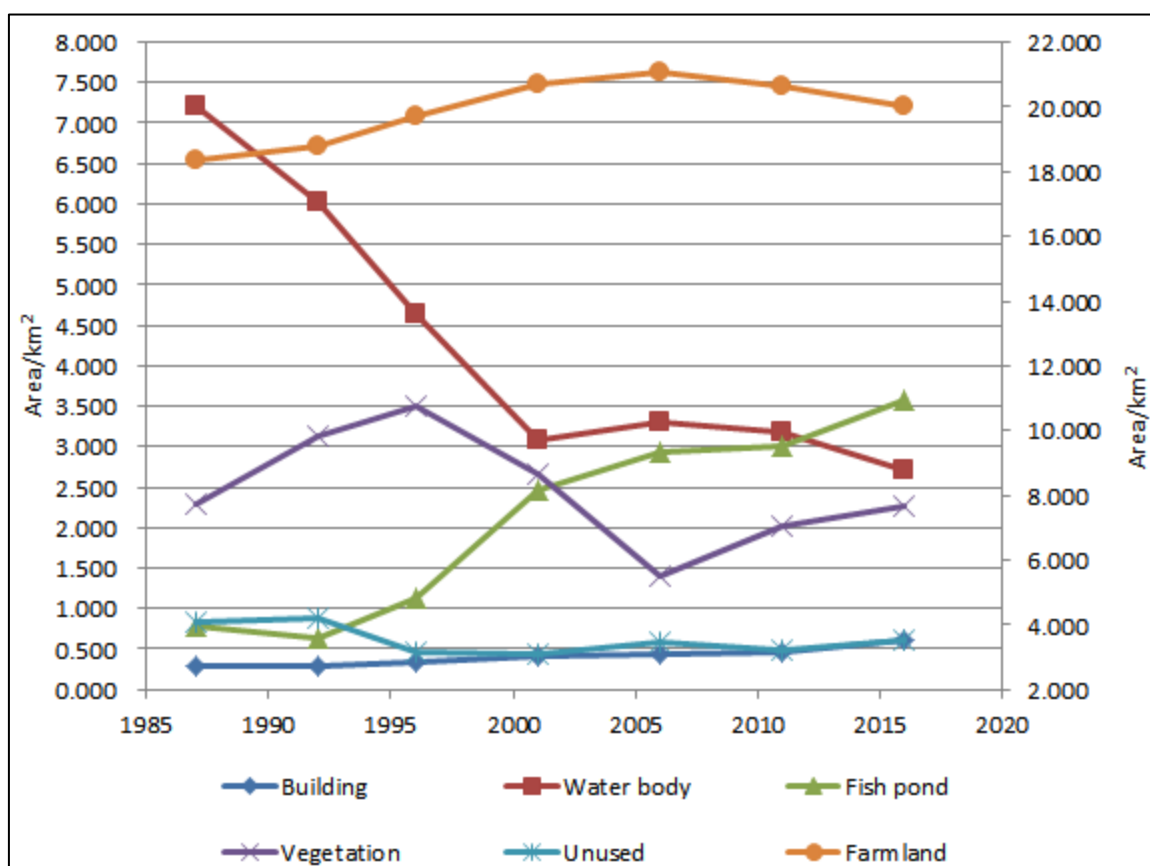


Fig.4 Area statistics of different land types

It can be seen from Figure 4 that during 1987-2016, the area of the water body showed a decreasing trend, with a total reduction of 4.52 km², of which the decline was sharp during 1987-2001, and fluctuations occurred during 2001-2016, which slowed down (research period) The comparison of initial and final water area is shown in Figure 5). The area of fish ponds is constantly expanding, with a cumulative increase of 2.81 km². The vegetation was well protected from 1987 to 1996, and the area increased year by year, reaching the largest in 1996, but the area of vegetation decreased sharply in the following 10 years, and only 1.39 km² remained in 2006, which has recovered in recent years. The overall farmland showed an increasing trend. The largest area of farmland in 2006 was 21.09 km². With the strengthening of the wetland management system, the disorderly development of wetlands has improved in the past 10 years, and the farmland area is relatively stable. The building area accounts for a small proportion of the total area, less than 1%, but it tends to increase as the population increases.

3.1.2 Land use dynamics analysis

Dynamic degree reflects the annual change rate of different land types, and represents the severity of land use type changes [15,16]. The dynamic calculation formula is:

$$K = \frac{U_b - U_a}{U_a} \times \frac{1}{T} \times 100\% \tag{1}$$

In equation (1), K is the dynamic degree of land use type change; T is the length of the study period; U_a and U_b study the area of a certain land type at the beginning and end respectively.

This paper uses statistic data from six periods from 1987 to 1992, 1992 to 1996, 1996 to 2001, 2001 to 2006, 2006 to 2011, and 2011 to 2016 to analyze the dynamic changes of land types. Table 1 shows.

Tab.1 Dynamic degree of land type change in wetland from 1987 to 2016(%)

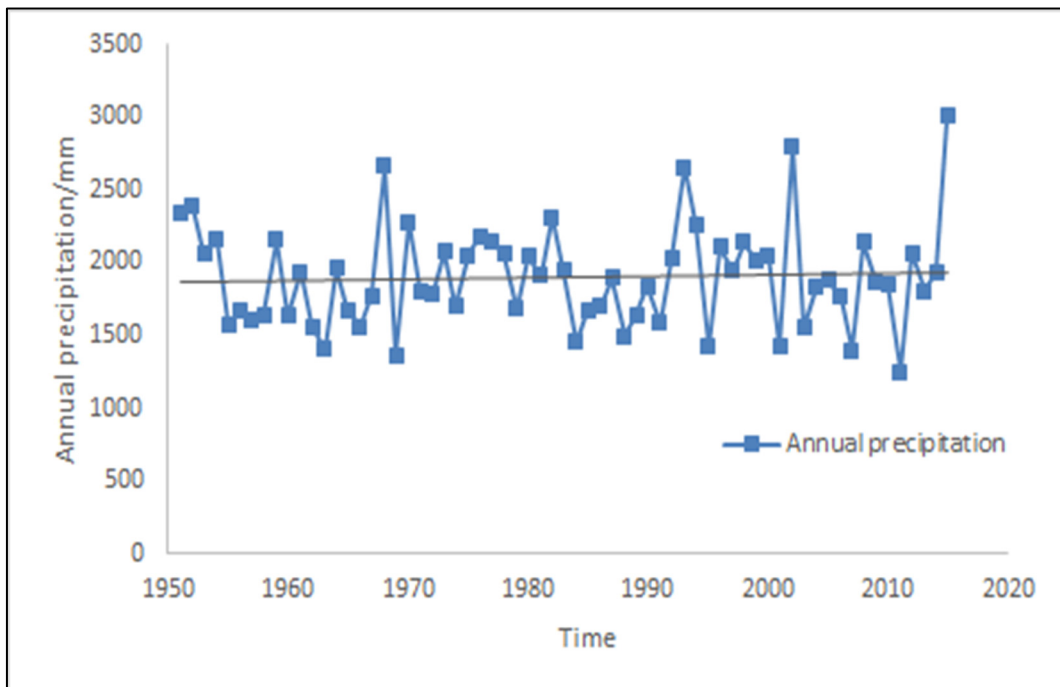
period	building	Water body	Fish pond	vegetation	Unused	farmland
1987-1992	0.00	-3.29	-3.43	7.17	0.96	0.50
1992-1996	5.56	-5.73	18.58	2.96	-11.59	1.17
1996-2001	3.38	-6.69	24.02	-4.68	-1.94	1.03
2001-2006	2.00	1.41	3.76	-9.57	7.81	0.38
2006-2011	1.01	-0.76	0.48	8.84	-3.67	-0.45
2011-2016	6.27	-3.04	3.86	2.43	4.94	-0.59

It can be seen from Table 1 that during the 29 years from 1987 to 2016, the water area in the study area shrank severely, and the degree of dynamic reduction in the first 15 years was much greater than that in the last 14 years. Among them, the reduction rate from 1992 to 1996 was -5.73%. The reduction rate in 2001 was -6.69%, which means that the reduction of water area in the study area occurred mainly in these two stages. Vegetation dynamic degree was the largest at 7.17% from 1987 to 1992 and showed negative growth from 1996 to 2006. The dynamic degrees were -4.68% and -9.57%, respectively, and have gradually recovered in recent years. The area of fishponds showed an increasing trend. It increased at an average annual rate of 12.45% from 1987 to 2016. Dynamic analysis showed that the increase from 2006 to 2011 was relatively slow. Before 2000, the "surrounding the lake to make farmland" made some water bodies become farmland, and the maximum dynamic range of farmland area from 1992 to 1996 was 1.17%. With the continuous increase of the population, the building area in the wetland has increased year by year in the last 30 years, with a total increase rate of 116.5%, of which the most dynamic from 2011 to 2016 was 6.27%.

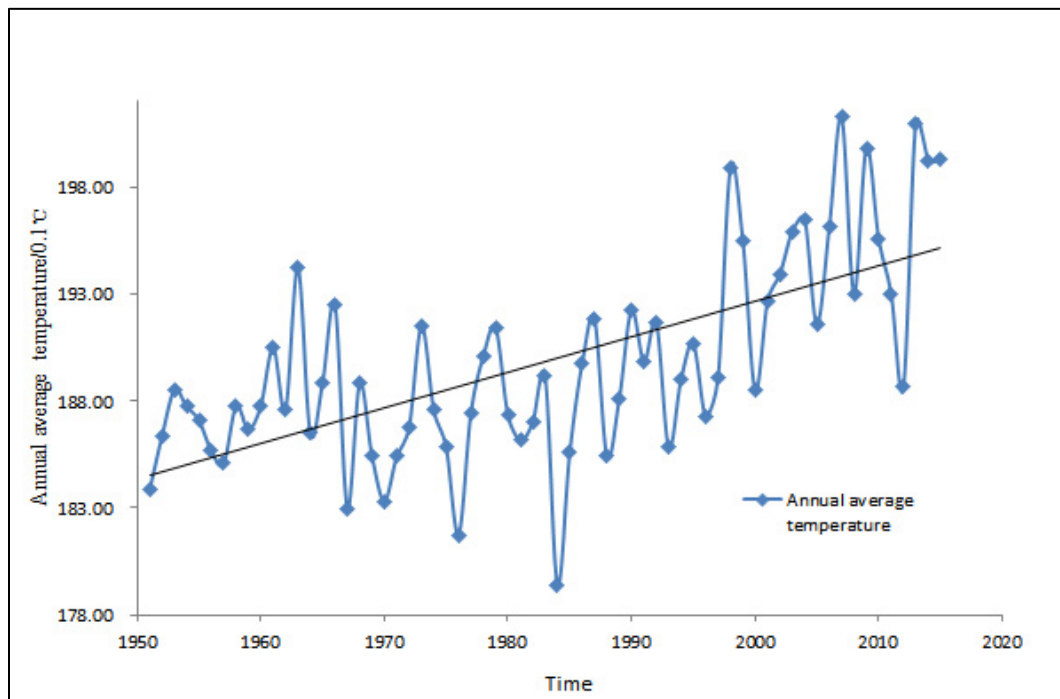
3.2 Analysis of driving factors of wetland change

From 1987 to 2016, the number of people in the wetlands continued to increase. A large number of wetlands were reclaimed into fish ponds and farmland under the driving of profits. At the same time, pollution caused by pesticides, fertilizers and feeds accelerated the destruction of wetlands. The area of wetland reclamation and fish pond excavation related to human activities has gradually increased, resulting in a continuous decrease in wetland area. Human activities are the direct driving force of wetland destruction, and human factors are the main factors affecting wetland health.

Climate change has a significant impact on the material and energy cycle of wetlands. It is a major factor in determining evaporation and an important factor influencing changes in water area. It can be seen from Figure 6 that the period from 1982 to 1992 was the period of scarce rainfall and the period from 1993 to 2002 was the period of abundant rainfall, but the rainfall generally showed a downward trend; at the same time, the annual average temperature rose year by year. From the perspective of natural factors, combined with the aforementioned changes in water bodies, the changes in air temperature and rainfall during the study period are consistent with the trend of water area growth and decline. Natural factors are also unfavorable factors affecting the healthy development of wetlands.



(a) Annual precipitation



(b) Annual average temperature

Fig.5 Curves of mean temperature and amount of precipitation in the Study Area

4. Influencing factor sensitivity analysis

4.1 Analytical method

Analytic Hierarchy Process (APH) is a multi-objective, multi-decision analysis method that combines qualitative and quantitative analysis. It can compare different complex factors to calculate the

sensitivity of each influencing factor. This method has the advantages of systematicness, flexibility, easy operation, and simplicity [17,18]. The area change of the water body (Z) is the target layer to be solved, and agriculture (A1), population (A2) and climate (A3) are the plan layers at the time of decision-making. Agricultural water (B1), fish pond (B2), domestic water (B3), building area (B4), rainfall (B5), and evaporation (B6) as the criterion layer. The three-level structure model is shown in Figure 7.

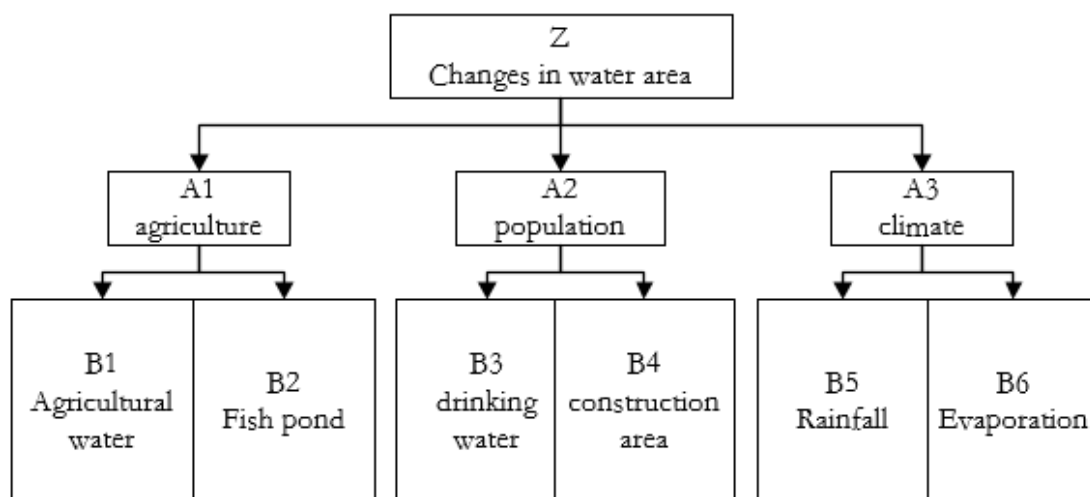


Fig.6 Three-level structure model

4.2 Sensitivity analysis

Construct a hierarchy of indicators, use expert knowledge and experience to compare pairs of indicators at the same layer, determine their relative importance, and construct a judgment matrix according to the specified scale values to determine the weight of each influencing factor [19]. The specific analysis steps are as follows:

(1) Determine the relative weight. The relative weights were determined using the 1-9 scale method proposed by T.L.Saaty et al. [20] (Table 2).

Tab.2 Scale value table

B_i index and B_j index ratio	Extremely important	Very important	important	Slightly important	equal	Slightly unimportant	unimportant	Very unimportant	Extremely unimportant
B_i index evaluation value	9	7	5	3	1	1/3	1/5	1/7	1/9

Note: Take 8, 6, 4, 2, 1/2, 1/4, 1/6, 1/8 as the intermediate value of the above evaluation values.

(2) Construct a judgment matrix. For different factors (represented by B_i and B_j respectively), a pairwise comparison method is used to obtain a judgment matrix for each indicator. The expert scoring method is used to determine the index weighting coefficients. When the consistency of the judgment matrix given by each expert is poor, the experts negotiate and judge its importance. After all the relative importance coefficients of B_i and B_j are given as required, the expert opinion is synthesized to form a judgment matrix of influence factors of Huixian wetland, as shown in Table 3:

Tab.3 $Z-B_i$ judgment matrix table of Huixian wetland

Z	B_1	B_2	B_3	B_4	B_5	B_6
B_1	1.00	1.83	3.40	4.11	3.16	3.13
B_2	0.55	1.00	5.00	7.67	4.73	3.44
B_3	0.29	0.20	1.00	4.33	1.10	0.23
B_4	0.24	0.13	0.23	1.00	0.17	0.16
B_5	0.32	0.21	0.91	5.87	1.00	2.05
B_6	0.32	0.29	4.44	6.18	0.49	1.00

(3) The calculation result is normalized by the standard average method to obtain the weight of the lower-level elements to the higher-level elements. The weight calculation results are shown in Table 4:

Tab.4 Weight data table of each factor of Huixian wetland

Z	B_1	B_2	B_3	B_4	B_5	B_6	W_A
B_1	0.37	0.50	0.23	0.14	0.30	0.31	0.30
B_2	0.20	0.27	0.33	0.26	0.44	0.34	0.30
B_3	0.11	0.05	0.07	0.15	0.10	0.02	0.09
B_4	0.09	0.04	0.02	0.03	0.02	0.02	0.03
B_5	0.12	0.06	0.06	0.20	0.09	0.20	0.13
B_6	0.12	0.08	0.30	0.21	0.05	0.10	0.15

(4) Check the consistency of the matrix. Generally speaking, as long as the constructed matrix has relative consistency, it can meet the needs. The smaller the relative consistency index CR, the better the consistency of the judgment matrix. After analysis and calculation, the relative consistency index CR of the wetland is $0.014 < 0.1$, that is, the judgment matrix has satisfactory consistency [21].

It can be concluded from Table 4 that agricultural water (0.30) and fish pond water (0.30) have a greater impact on changes in water area, rainfall (0.13), evaporation (0.15), domestic water (0.08), and building area (0.03).) Has the second smallest impact on water area. Among all the influencing factors, agriculture and population, namely human-driven factors including agricultural water, fish pond water, domestic water and building area, are the main factors, with a weight of 0.72; natural driving factors including rainfall and evaporation Is a secondary factor with a weight of 0.28.

5. Safeguard

(1) Attaching importance to theoretical research, strengthening the combination with investigation and evaluation, theoretical research provides ideological guarantee for scientific development, but investigation and evaluation is the basis of theoretical research.

(2) Coordinated economic, social and ecological development to promote sustainable and stable economic development

(3) Formulate laws and regulations to protect wetlands, strengthen management, and promote the rational use of land by human beings

6. In conclusion

(1) In the past 29 years, the area of fish ponds in Huixian karst wetland has increased the most dynamically, while the natural water bodies and vegetation areas of rivers and lakes have shrunk severely.

(2) Human activities and natural factors work together on the ecological environment of the wetland. The factors that affect the change of the wetland pattern are mainly human (agriculture + population) factors, supplemented by natural factors.

(3) The weights of agricultural, climatic and demographic factors are $B_1 = 0.60$, $B_2 = 0.28$, and $B_3 = 0.12$. To maintain a good and healthy environment in Huixian karst wetland, human activities in the wetland must be reasonably controlled.

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