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Ecological Environment Evaluation of Yibin City Based on Remote Sensing Ecological Index

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Abstract

The ecological environment is the material basis on which people live. Monitoring the process of urbanization is very necessary for the ecological environment. Using remote sensing technology to objectively, timely and accurately monitor environmental changes has become a current research hotspot. According selects 2013 to 2017 Yibin Basin landsat 8 satellite remote sensing images to extract four evaluation indicators of greenness, humidity, heat, and dryness, and calculates the Yibin city Basin Ecological Index (RSEI) by principal component analysis. The results of the study found that: 1) The ecological index in 2013 to 2017 were 0.757 and 0.762, respectively, and the overall ecological situation showed a slight improvement trend; 2) The area with better ecological grade accounted for 14.13%, and the area with worse ecological grade only accounted for 5.23%, of which the areas with degraded ecological levels are mainly concentrated in Lingang District, Nanxi District, and Jiang'an County; 3) Research shows that the dryness index has the greatest impact on the environment, and the humidity index has the least impact on the environment. In summary, the overall ecological environment quality of the study area has improved, indicating that the area has strengthened environmental protection in the continuous social and economic construction, whichas gradually improved the ecological conditions of the Yibin city Basin.

Keywords

Remote sensing image, RSEI, Yibin, Landsat 8.

1. Introduction

Therefore, monitoring the state of the ecological environment in the region is of great significance to the development of human society. It is helpful to help decision-makers improve the development direction in time, so as to propose a win-win situation for the common development of the environment and economy, and truly realize a sustainable future. Located in the upper reaches of the city, The rapid, effective and accurate monitoring and management of the ecological environment in this region is of vital importance to the ecological civilization construction and ecological protection of the entire city basin.

This paper selects the Yibin city Basin landsat 8 satellite remote sensing images in 2013 and 2017, uses the RSEI index model to extract four evaluation indicators of greenness, humidity, heat, and dryness, and calculates the Yibin city Basin Ecological Index through principal component analysis. Provide data support for regional ecological environment monitoring and evaluation.

2. Materials and methods

2.1 Study area

The whole area of Yibin spans between 103°36′-105°20′ east longitude and 27°50′-29°16′north latitude. Its terrain is high in the southwest and low in the northeast. The terrain is dominated by

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middle-low mountains and hills, with alternating ridges and valleys. The terrain is complicated. The middle and low mountains in the city account for 46.6%, hills account for 45.3%, and flat dams account for 8.1% [1]. Due to its special geographical location, Yibin has become the intersection of the north-south trunk line and the east-west axis of the city in the national "five vertical and seven horizontal" transportation plan. It is the junction of Sichuan, Yunnan and Guizhou and the Liupanshui area of Panxi into and out of the city Golden Waterway, and the Chengyu Economic Zone connects to the south. The Guikun Economic Zone is an important gateway to Southeast Asia. It is one of the six important pivotal ports on the city planned by the state and a supporting city for the rolling development of hydropower on the Jinsha River.

2.2 Remote sensing image and processing

This paper uses the ENVI 5.1 remote sensing data processing platform, with the Yibin city basin as the main research area. The image data comes from the United States Geological Survey (USGS), and the second phase of the landsat 8 OLI remote sensing satellite of 2013-05 and 2017-05 is selected. Image (see Figure 1, 2). Image cloud cover is small and data accuracy is high. The selected remote sensing images have short time intervals, so the growth conditions of the vegetation are roughly the same, which ensures that the experimental results are comparable. This paper preprocesses remote sensing data such as water mask, radiation correction, atmospheric correction, and histogram registration.

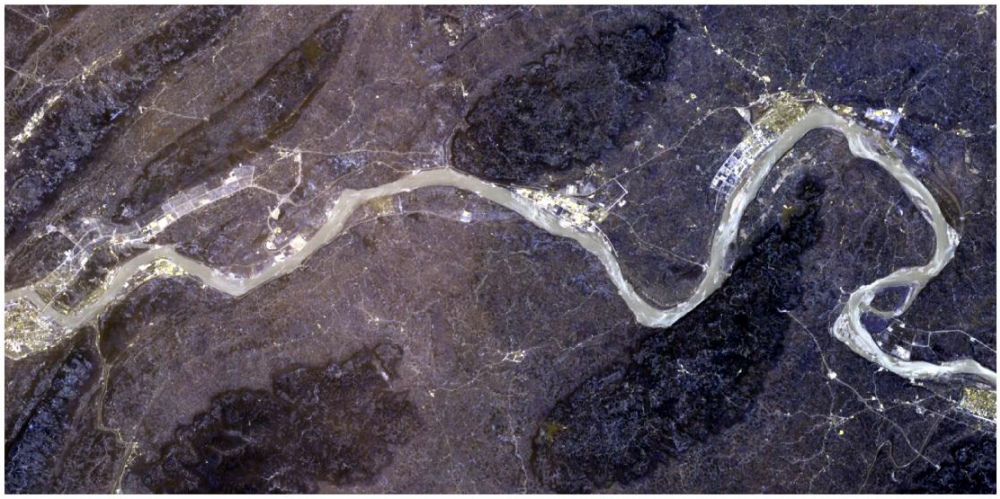

Fig 1. Remote sensing image of Yibin City in 2013

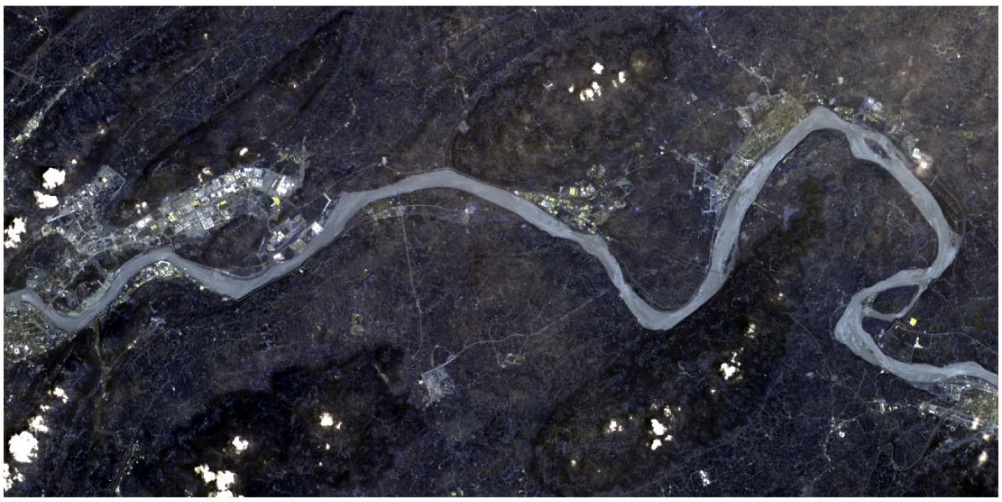

Fig 1. Remote sensing image of Yibin City in 2017

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3. Data Sources and Methods

3.1 Sources and preprocessing

(1) Greenness Index

Greenness index: The normalized vegetation index NDVI is usually used to represent the greenness index, which can show the abundance of plants, the distribution of vegetation, leaf coverage and the number of biological species[2],so NDVI is used to represent the greenness index.

$$NDVI = \frac{\rho_{NIR} - \rho_{\text{red}}}{\rho_{NIR} + \rho_{\text{red}}} \tag{1}$$

In the formula: NIR stands for near-infrared light band reflectivity, red stands for red light band reflectivity.

(2) Humidity index

Humidity index: The brightness, greenness, and humidity components obtained by remote sensing tasseled caps have been widely used in ecological environment monitoring[3]. The humidity component reflects the humidity of the water body, soil and vegetation, and the formula is[4]:

$$Wet = 0.1511\rho_{blue} + 0.1973\rho_{green} + 0.3283\rho_{red} + 0.3407\rho_{NIR} - 0.7117\rho_{SWIR1} - 0.4559\rho_{SWIR2} \tag{2}$$

In the formula: where blue, green, red, NIR, SWIR1, SWIR2 represent the reflectivity of blue, green, red, near-infrared, infrared band 1 and infrared band 2, respectively.

(3) Heat index

Heat index: With the deterioration of the environment, the problem of thermal environment is an urgent problem that people need to solve. The surface temperature, which characterizes the heat index, can be obtained by correcting the brightness temperature. Calculate by using the model of Landsat[5] user manual and the latest revised calibration parameters such as Chander[6]:

$$L_{10} = gain \times DN + bias \tag{3}$$

$$T = K_2 / \ln(k_1 / L_{10} + 1) \tag{4}$$

$$LST = T[1 + (\lambda T / \rho)\ln\varepsilon] \tag{5}$$

Where L10 represents the radiation value of the thermal infrared band of the OLI sensor at the sensor; DN is the gray value of the image; gain and bias are the gain and bias values of the thermal infrared band respectively, which can be queried from the header file of the remote sensing data; T is the temperature at the sensor; K_1 and K_2 are the calibration parameters, and the center wavelength of the 10 band is 11.48μm; and $1.438*10^{-2}$KM is the specific emissivity of the surface calculated using the NDVI threshold method.

(4) Dryness index

Dryness index: As more and more construction land replaces the original land surface, land desiccation will bring harm to the environment, and bare soil will also cause a certain amount of land desiccation, so the dryness index (NDBSI)[7] Integrated Building Index (IBI) and Soil Index (SI):

$$SI = \frac{\left(B_{SWIR1} + B_{\text{Red}} - B_{NIR} - B_{Blue}\right)}{\left(B_{SWIR1} + B_{\text{Red}} + B_{NIR} + B_{Blue}\right)} \tag{6}$$

$$IBI = \frac{\left[2 \times \frac{B_{SWIR1}}{B_{NIR} + B_{SWIR1}} - \left(\frac{B_{NIR}}{B_{NIR} + B_{\text{Red}}} + \frac{B_{\text{Green}}}{B_{\text{Green}} + B_{SWIR1}}\right)\right]}{\left[2 \times \frac{B_{SWIR1}}{B_{NIR} + B_{SWIR1}} + \frac{B_{NIR}}{B_{NIR} + B_{\text{Red}}} + \frac{B_{\text{Green}}}{B_{\text{Green}} + B_{SWIR1}}\right]} \tag{7}$$

Among:

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$$NDBSI = \frac{(SI + IBI)}{2} \tag{8}$$

3.2 Remote Sensing Ecological Index

Through the above steps, four ecological indicators, namely greenness; humidity; heat and dryness are obtained. Before the principal component analysis, because the dimensions of the four indicators are not uniform, if they are directly used in the calculation of PCA, it will inevitably cause an imbalance in weight. Therefore, these indicators need to be normalized first, and their value ranges are standardized to [0,1].

The principal component analysis method compresses the information of multiple variables into the first 1-2 principal components through the vertical transformation of the characteristic spectral space coordinate axis, and assigns their respective weights objectively and autonomously according to the contribution of the four indicators to the principal components. Avoid the deviation caused by artificially setting the weight or simply adding the indicators. The normalized formula of each indicator:

$$P_i = \left(M_i - M_{\min}\right) / \left(M_{\max} - M_{\min}\right) \tag{9}$$

In the formula, Pi represents the normalized results of the 4 indicators; Mi is the original value of the indicator in pixel i; Mmax is the maximum value of all pixels; Mmin is the minimum value of all pixels.

You can use 1 to subtract PC1 to get the initial RSEI value, that is, $RSEI_0$. In order to facilitate the comparative study of indicators, you can also normalize RSEI0 to get RSEI. The value range is between [0,1], and the closer to 1 means the better the ecological environment, the same goes for the opposite.

$$RSEI_0 = 1 - PC1 \tag{10}$$

$$RSEI = \left(RSEI_0 - RSEI_{0\_MIN}\right) / \left(RSEI_{0\_MAX} - RSEI_{0\_MIN}\right) \tag{11}$$

4. Results and analysis

4.1 Correlation analysis results of ecological environment indicators

Tab 1. Correlation statistics of various indicators and RSEI

Year	Indicator	NDVI	Wet	LST	NDBSI	RSEI
2013	NDVI	1	0.201	-0.398	-0.87	0.528
	Wet	0.201	1	-0.429	-0.603	0.612
	LST	-0.398	-0.429	1	0.484	-0.56
	NDBSI	-0.87	-0.603	0.484	1	-0.887
	mean*	0.49	0.411	0.437	0.652	0.747
2017	NDVI	1	0.187	-0.312	-0.866	0.603
	Wet	0.187	1	-0.455	-0.596	0.625
	LST	-0.312	-0.455	1	0.472	-0.541
	NDBSI	-0.866	-0.596	0.472	1	-0.796
	mean*	0.455	0.413	0.413	0.645	0.716
Mean of years	NDVI=0.473, Wet=0.412, LST=0.541, NDBSI=0.649, RSEI=0.732					

Table 1 is a statistical table of the correlation between the four indicators and the remote sensing ecological index RSEI, as well as the correlation coefficient between each indicator. From the table, it can be seen that among the individual indicators, the index with the highest correlation is the

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building bare soil indicator (NDBSI), the two-year average correlation coefficient reaches the maximum 0.649, the lowest average correlation is the humidity component (Wet), and the two-year average correlation coefficient reaches the minimum 0.412. The RSEI has an average correlation with these four indicators of 0.732, which is 12.79% higher than the building-bare soil component with the highest correlation of a single indicator, and 43.16% higher than the humidity component with the lowest correlation index. The correlation coefficient between the coefficient and each index is the highest, indicating that the remote sensing ecological index can integrate these four indexes well.

4.2 Eco-environmental indicators statistics

Table 3 shows the statistical values of the 4 indicators in each year and the remote sensing ecological index RSEI. The statistical results show that during the period 2013-2017, the ecological index RSEI of the study area has been slowly improving. The ecological index has risen from 0.7515 to 0.7624, an overall increase of approximately 1.45%, the average value of humidity and surface temperature remained basically unchanged, and the average value of building-bare soil index and greenness increased, but the average increase of greenness was higher than that of building-bare soil index, indicating that the overall ecological environment was somewhat different Improvement, even if the urbanization of Yibin is developing rapidly, people strengthen the protection of the environment, so that the ecological environment and people's ecological living conditions are improved.

Tab 3. Statistics of four indicators and RSEI

Year	Item	NDVI	Wet	LST	NDBSI	RSEI
2013	Mean	0.708	0.918	0.386	0.223	0.752
	Std Dev	0.141	0.027	0.085	0.065	0.124
	PC1 Load	0.326	0.418	-0.542	-0.863	
2017	Mean	0.818	0.905	0.404	0.329	0.762
	Std Dev	0.145	0.028	0.073	0.062	0.128
	PC1 Load	0.339	0.512	-0.663	-0.728	

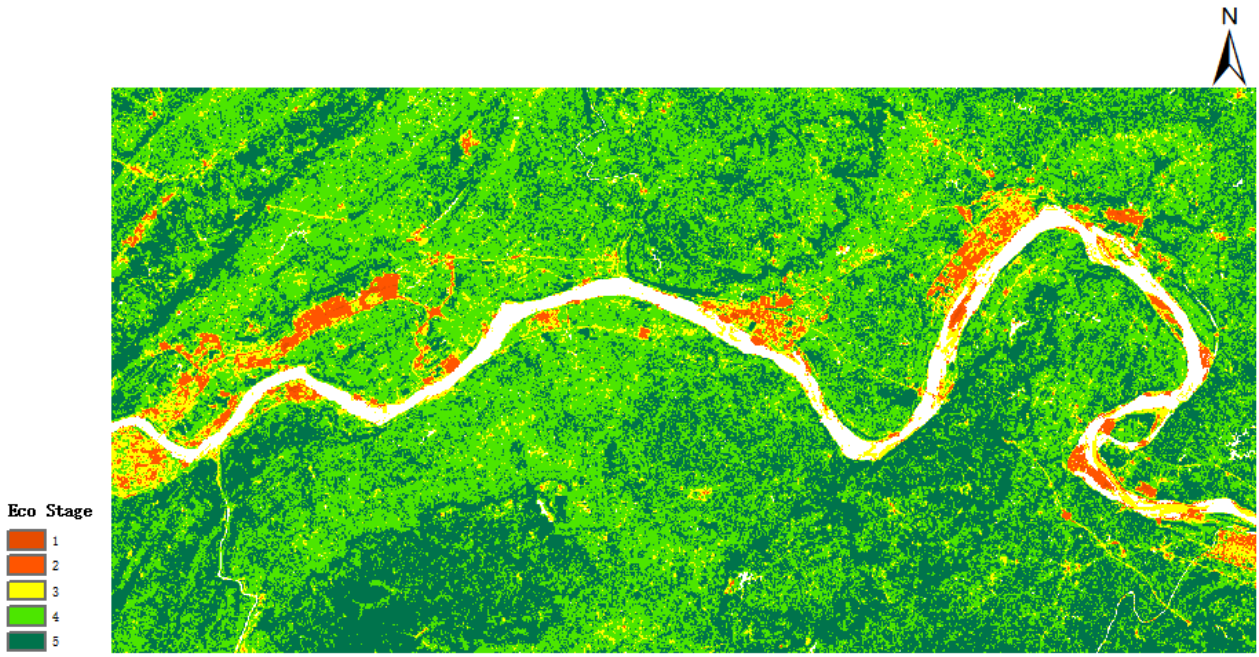

Fig 3. RSEI image in 2013

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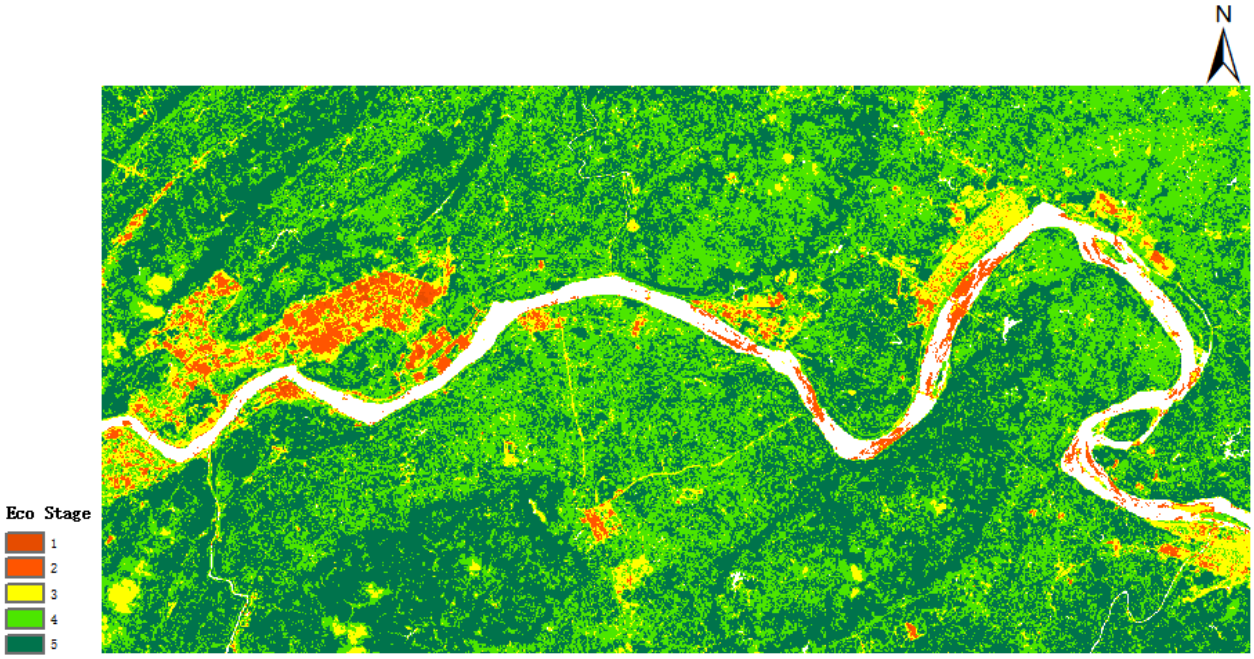

Fig 4. RSEI image in 2017

4.3 RSEI index change detection

The remote sensing ecological index in each year of the study area was classified area statistics (Table 4 below) and difference change detection (Table 5) in order to compare the area changes of environmental and ecological quality in different years.

It is found in Table 5 that the largest area with the same ecological environment quality is 849.03 km2, accounting for 80.64%, the area where the ecological environment level has increased is 148.77 km2, accounting for 14.13%, and the area where the ecological environment level has decreased is only It is 55.06km2, accounting for 5.23%. In general, the area with poor ecological grade is smaller than the area with better ecological grade.

From the time comparison, it can be analyzed from Table 4 that the range of better ecological level (0.6-0.8) rose from 39.73% to 47.47%, an increase of 19.48%, and the range of worse ecological level (0-0.4) Increased from 2.74% to 2.9%, and the area with worse grades increased by 5.84%.

Tab 4. The area change of each RSEI level from 2013 to 2017

	2011		2017	
RSEI Level	Area(km2)	%	Area(km2)	%
Poor (0-0.2)	0.63	0.06	0.95	0.09
Inferior (0.2-0.4)	28.22	2.68	29.59	2.81
Medium (0.4-0.6)	74.44	7.07	79.39	7.54
Good (0.6-0.8)	531.27	50.46	443.04	42.08
Excellent (0.8-1)	418.3	39.73	499.79	47.47
Total	1052.86	100	1052.86	100

From a geographical and spatial comparison, the red area with poor ecological environment in Figure 5 gradually spreads with the expansion of urban construction land. The areas with deteriorating ecological conditions are distributed in Lingang District, Nanxi District, and Jiang'an County near the city. Among them, the area with the most degraded ecological status is Lingang District. This is

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due to the requirements of the "Plan" issued by the provincial government in recent years. With the advantage of the city Golden Waterway, we will accelerate the construction of expressways, cross-river passages and collection and transportation systems along the city, and use the central urban areas of Yibin, Pingshan County, Jiang'an County and Nanxi District along the city, Minjiang River and Tuojiang River as nodes to scientifically advance the development of coastlines and Port construction, speed up the development of export-oriented economy. Promote the integration of urban resources along the river.

Tab 5. Change detection

Class	Level	Level area/km2	%
Degraded	-3 -2 -1	55.06	5.23
No change	0	849.03	80.64
Improved	1 2 3	148.77	14.13

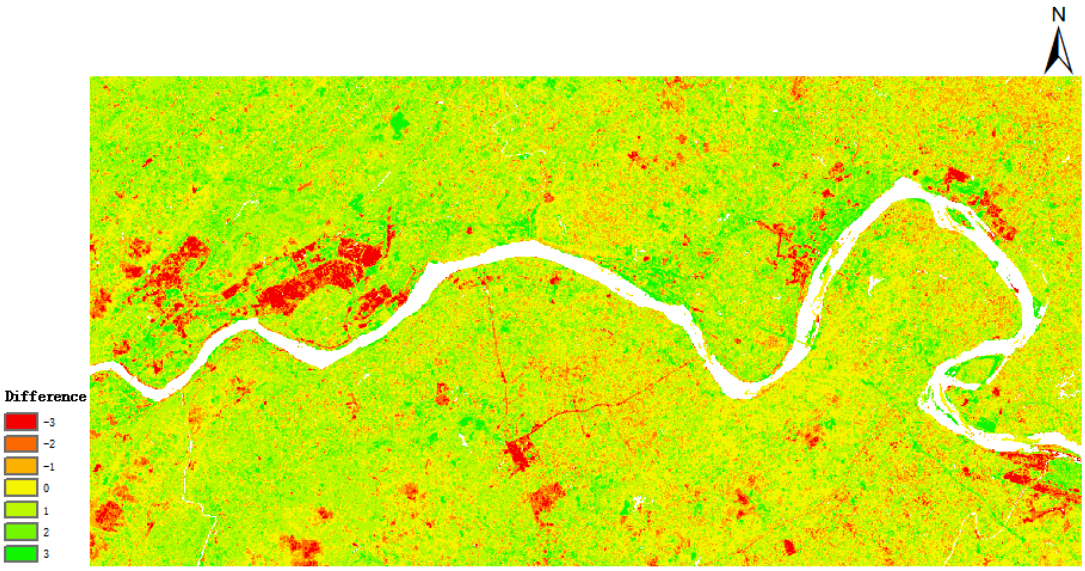

Fig 5. Chang map of Yibin's area between 2013 and 2017

5. Conclusion

It can be seen from the remote sensing ecological index that the suburban ecological index of Yibin rose slightly from 0.752 to 0.762 from 2013 to 2017. The area of land with better ecological conditions was 148.77 km2, while the area of land with worsened land only reached 55.06 km2. The urban planning and construction process of Yibin City is fast, but it has not caused a substantial decline in the overall ecological environment quality, which is due to the city's scientific planning and construction.

Among the four ecological indicators, NDBSI, which represents the bare-soil index for buildings, has the largest relationship with the RSEI ecological environment indicator, indicating that land use and urban architectural planning are closely related to the ecological environment. If more green plants and trees are added to the urban planning, To offset the damage caused by urban construction to the environment to a certain extent, people should enhance their environmental awareness, adapt measures to local conditions, and plan urban construction reasonably.

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In summary, this article is based on the Landsat 8 remote sensing satellite data to study the Yibin city Basin, and analyzes the four ecological indicators of greenness, humidity, heat, and dryness combined with the principal component analysis method. The established remote sensing ecological index can couple these four ecology The main information of the indicators allows people to understand the ecological environment of the study area more intuitively and concisely, and conduct real-time monitoring and evaluation of the ecological environment. However, there are still shortcomings in this article. For example, due to the cloudy and foggy environment in the southwest region, many remote sensing images are blocked by clouds, which increases the difficulty of image selection, and economic development, cultural and technological construction, and tourism planning can be added to future research The impact on the environment is included in the evaluation indicators, and the sustainable development of urban economy, social and cultural development and the environment is studied from many different perspectives.

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