RESEARCH AND APPLICATION OF REMOTE SENSING MONITORING METHOD FOR DESERTIFICATION LAND UNDER TIME AND SPACE CONSTRAINTS

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ABSTRACT:

Serious land desertification and sandified threaten the urban ecological security and the sustainable economic and social development. In recent years, a large number of mobile sand dunes in Horqin sandy land flow into the northwest of Liaoning Province under the monsoon, make local agriculture suffer serious harm. According to the characteristics of desertification land in northwestern Liaoning, based on the First National Geographical Survey data, the Second National Land Survey data and the 1984-2014 Landsat satellite long time sequence data and other multi-source data, we constructed a remote sensing monitoring index system of desertification land in Northwest Liaoning. Through the analysis of space-time-spectral characteristics of desertification land, a method for multi-spectral remote sensing image recognition of desertification land under time-space constraints is proposed. This method was used to identify and extract the distribution and classification of desertification land of Chaoyang City(a typical citie of desertification in northwestern Liaoning) in 2008 and 2014, and monitored the changes and transfers of desertification land from 2008 to 2014. Sandification information was added to the analysis of traditional landscape changes, improved the analysis model of desertification land landscape index, and the characteristics and laws of landscape dynamics and landscape pattern change of desertification land from 2008 to 2014 were analyzed and revealed.

1. INTRODUCTION

1.1 General Instructions

Land desertification is mainly characterized by wind erosion, sand burial and fixed sand dune activation， which is one of the most serious resource and ecological environmental problems in the world. China is a country that is seriously affected by desertification, the desert has a large area, a wide range of distribution, and a serious desertification hazard. Our government and various agencies of the entire society consume huge amounts of manpower, material resources and financial resources each year for desertification control and poverty alleviation. In the decision-making on desertification prevention and control, the strategic layout of national or regional prevention and control, the determination of the key areas and priorities of governance, all need to accurately grasp the overall situation, characteristics and changes in desertification land. Monitoring desertification land carries this important mission, it is an important foundation and prerequisite for the prevention of desertification. Through the regular monitoring of desertification land, we can understand and master the area, distribution and change of desertification land in a timely manner, study and analyze the causes of changes in desertification land, provide prevention and control countermeasures, evaluate the effectiveness of local prevention and control, formulate and timely adjust prevention and control measures. We will give early warning to some lands with desertification trends and provide prevention and control plans for major wind and sand hazards. The Horqin Sandy Land, which is one of the four major sand areas in China, poses a great ecological threat to the urban agglomerations in central Liaoning. The northwestern region of Liaoning is located on the southern edge of the Horqin Sandy Land. The border with the Horqin Sandy Land is 1044 km long. The province’s desertification land and land with obvious desertification tend to be concentrated in this area. It is a key area for preventing desertification in Liaoning Province. In recent years, a large number of mobile sand dunes in the Horqin Sandy Land have flowed into northwestern Liaoning under the action of monsoons, resulting in the loss of nutrients in large areas of farmland and the reduction in crop yields. According to the requirements of the First National Geographical Survey and the urgent needs of the relevant departments in northwestern Liaoning for desertification data. The related research on remote sensing monitoring of desertification land in northwestern Liaoning has been carried out.

With the large number of researches on land desertification information extraction and dynamic change monitoring, the method of extracting desertification information using remote sensing information has also made great progress. (Niu Baoru, 2005) based on analysis of status quo of desertification information extraction from remote sensing information, the method of vegetation cover segmentation and the method of the tasseled cap transformation are presented for desertification information extraction according to desert grade integrated sign of the remote sensing. The methods are also compared with traditional supervisory classification methods. It is concluded that vegetation cover segmentation and tasseled cap transformation are more suitable for dynamic monitoring of ecological environment. (Zeng Yongnian et al., 2005) discussed the relationship between desertification and NDVI and LST and proposed a desertification remote sensing monitoring difference index (DDI). (Zeng Yongnian et al., 2006) proposed a desertification remote sensing monitoring model based on the feature space of Albedo-NDVI. Desertification monitoring is a

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process of obtaining and processing indicator data, the acquisition of indicator data can be obtained through remote sensing interpretation, expert surveys, actual measurement, statistics, and statistical data. The analysis of the relationship between vegetation and climate in the desertification region based on time series NDVI data is a hot topic in the research field of ecological environment at home and abroad. Internationally, researchers have used NDVI data series to obtain specific phenological parameters. For example, (Hanan et al., 1991) used NOAA-AVHRR data in the Sahel area to calculate grassland biomass based on the correlation between the cumulative NDVI value and biomass during the growing season. There are also some studies in China that show the NDVI time series can distinguish desert boundaries based on whether vegetation sprouts or not(Liu Aixia et al., 2004). This paper explores an indicator system for remote sensing monitoring of desertification land in northwestern Liaoning, and proposes a desertification land identification method based on multi-spectral remote sensing images under the constraint of time and space in the extraction process for desertification land, which effectively solve the problem of low precision of remote sensing automatic monitoring of desertification land and improve the efficiency of automatic monitoring.

2. MATERIALS

2.1 Study area

The northwestern of Liaoning lies between 39°59'-43°29' north latitude and 118°50'-125°06' east longitude. It covers 36 counties, 530 townships, total area of 68,600 square kilometers, accounting 47.03% of the area for Liaoning Province. The desertification land in Liaoning Province is mainly distributed in its northwestern part, where is the arid and semi-arid region bordering the southern end of the Horqin Sandy Land in Inner Mongolia. Its dry climate provides important environmental conditions for the formation of land desertification, the low surface vegetation coverage provides a source foundation for desertification, frequent high winds provide a dynamic condition for the formation of sandstorms and serious shortage of water resources reduces the desertification control. Through field investigations in northwestern Liaoning, the area is different from the large-area desertification area in northern China. The desertification land in this area is fragmented and the desertification land is mainly distributed in three types of land use: forestland, cultivated land and bare surface, which has typical regional characteristics. Chaoyang city is located in the western part of Liaoning Province, and is located in the southern edge of Horqin Sandy Land. It belongs to the northern temperate continental monsoon climate zone, it has a dry climate with less precipitation and is concentrated in June-August. It is one of the regions with severe desertification hazards in Liaoning Province. This study will use Chaoyang city as a research demonstration area in northwestern Liaoning to carry out desertification monitoring.

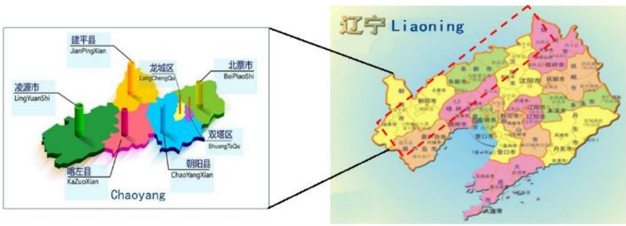

Figure 1. schematic diagram of study area

2.2 Data preparation

The collected image data and other auxiliary data are as follows:

2.2.1 The First National Geographical Survey results in 2014: These results are the land cover classification and geographic conditions factor vector data, which produced based on images better than 1 meter of spatial resolution, such as QUICKBIRD and WORLDVIEW2. The land cover classification data can distinguish different types of desertification land, and eliminate land use typeswhere desertification is impossible (e.g. residential areas, water bodies, etc.). In addition, the distribution of waters such as Daling River and Laoha River also helps to determine the correctness of the desertification land extraction. The integration of land use types related to desertification land monitoring in the national geographical survey results, and participate in the 2014 desertification land information extraction.

2.2.2 The Second National Land Survey results in 2008: The patches in the database record the use of each plot in terms of category, location, range, area, distribution, etc. Among them, sand and other land types can clearly indicate the location and scope of part of the desertification land in 2008.

2.2.3 Landsat TM image data: The 30 years Landsat TM images of the study area from 1984 to 2014 was downloaded from the NASA website, which with a spatial resolution of 30m and an image width of 185km, including red, green, blue, near-infrared, and thermal infrared. A multi images local adaptive regression analysis model is selected to process the strip of Landsat image acquired after 2008, to remove the rule strip information loss caused by the failure of airborne scanning line corrector (SLC). Then Landsat images of each scene are merged, clipped, and other pre-processing for the desertification land extraction.

2.2.4 Digital Elevation Model: DEM data collected at a spatial resolution of 5m in this region for production in 2013 can be used to perform DEM and slope analysis. Based on this data, we can carry out DEM and slope analysis, and the area with higher elevation and higher slope can be obtained, which can improve the accuracy of desertification land monitoring.

3. DETERMINATION OF DESERTIFICATION LAND REMOTE SENSING MONITORING INDEX SYSTEM IN NORTHWESTERN LIAONING

“Technical code of practice on the sandified land monitoring” (Yang Weixi et al., 2009) expounds that desertification land refers to degraded lands with sand (gravel) matter as the main symbol due to various factors under various climatic conditions. Depending on the degree of vegetation coverage, the desertification land can be divided into four levels of mild, moderate, severe, and extremely severe. According to field surveys in the study area and references to relevant literature, it was determined that sandy soil distribution, vegetation coverage, land use types, and DEM/slope are used as desertification land remote sensing monitoring indicators in the study area.

3.1 Distribution of sandy soil

Through field survey and investigation of the study area, it is clear that the desertification land currently existing in northwestern Liaoning is a degraded land dominated by sand material on the surface, that is, sandy soil is a prerequisite for judging the desertification land. In study area, 46 soil samples

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were selected and sent to the Institute of Plant Nutrition and Resources, Beijing Academy of Agriculture and Forestry for sediment determination. Then, desertification land spatial distribution was determined based on the distribution of sandy soil.

3.2 Vegetation Coverage

Vegetation coverage is the basis for grading desertification land. According to the difference in vegetation coverage of desertification land (cultivated land is seedling deficiency rate), sandification degree can be determined.

3.3 Land Use Data

Land use data can be used to distinguish different types of desertification land, and help to eliminate some land types that cannot be desertified. In addition, dry riverbeds are also a source of land desertification. Therefore, the distribution of some water bodies in land use data can also indicate the location of desertification.

3.4 DEM and Slope

Using DEM/slope data can eliminate difficult sandy areas with high altitude and large slopes, eliminate the easily misclassified mining areas, and improve the accuracy of desertification land extraction.

4. DESERTIFICATION LAND IDENTIFICATION BASED ON MULTI-SPECTRAL REMOTE SENSING IMAGES UNDER SPATIO-TEMPORAL CONSTRAINTS

4.1 Preliminary Extraction of Desertification land Based on Multispectral Remote Sensing Images

First, try to use only the spectral information of the image, using different decision functions (minimum distance function, maximum likelihood function, parallel function, support vector machine function, etc.) for desertification land extraction. From the results of the extraction, there are some mistakes of classifications. The reason is mainly due to the fragmentation of its desertification land in northwestern Liaoning and the low spectral resolution of TM images, which makes the spectral details of desertified farmland and ordinary cultivated land not rich enough. Therefore, the difference in the spectral curves between the two is relatively low. At the same time, different contents of coarse sand and fine sand in sandy soil making different desertified soil samples spectrum also have subtle differences, which also causes interference. Through the analysis of the results extracted from various algorithms, combined with expert interpretation, the Mahalanobis distance is eventually selected as a preliminary extraction algorithm. Because it identified enough desertification land and the distribution results are in good agreement with the actual conditions. According to this method, preliminary extraction results of desertification land in 2008 and 2014 were obtained.

4.2 Time Shift Constraint Correction

Since the desertification land in the study area is mainly concentrated on the types of cultivated land and forest land, only select one phase image, especially during the vegetation growing season, then most of the land is covered by vegetation, and it is difficult to directly obtain the reflectivity information of desertification land（Ding Xiangyuan et al., 2017）. If non-growth seasons are selected, although the land reflectance information can be obtained directly, but the mild desertification lands and non-desertification lands are usually indistinguishable based on surface reflectance information only. Therefore, try to add vegetation phenology information, here means time series vegetation index information to extract desertification land. Since the average yield of cultivated land in the 1980s and the average density of forest can help to reflect soil fertility, the fertility of desertification land should be lower than that of non-desalinated land. By analyzing the growth of vegetation in the summer of 1984-2014, the cultivated land and forest grassland with less possibility of desertification were eliminated, and the results of extraction are corrected.
The specific methods as follows: First, construct the NDVI time series of Landsat images from 1984 to 2014, and perform SG filtering on the time series (window size is 7), so that each pixel has a smooth time series curve (Figure 2) .

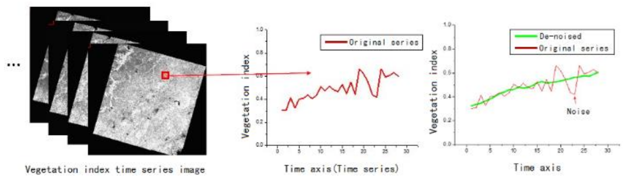

Figure 2. Time series analysis of vegetation index

Then, combined with time-series information and field samples information to do statistical analysis. The average value of NDVI from 1984 to 2014 was used to represent the vegetation growth in the study area. Regression analysis of average vegetation growth index and sediment content of soil samples collected in the field. The result is shown in Figure 3.

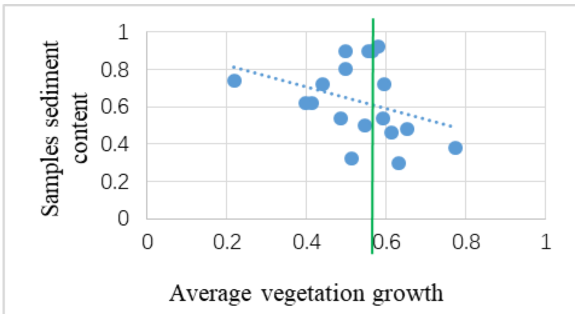

Figure 3. Regression analysis of sample sediment content and average vegetation growth

Figure 3 shows that the sediment concentration of the sample is negatively correlated with the growth status of the vegetation. That is, the better the vegetation growth, the lower the soil sediment content, on the contrary, the worse the vegetation growth, the higher the soil sediment content. From the regression analysis results that: when the average growth of vegetation> 0.6, the sample sediment concentration <50%. This feature was used to modify the preliminary extraction results. In order to ensure the accuracy of the correction, the average vegetation growth threshold was set to 0.6, 0.7 and 0.8 respectively, and the preliminary results were subjected to a local correction test. By selecting random samples and judging accuracy by visual interpretation, it is found that it is reasonable to set the threshold value to 0.7.

4.3 1.1 The spatial distribution constraint correction

Compared to soil, sand has a high fluidity, especially after being rain erosion, it is difficult to gather on a mountain with a high slope. According to the field investigation, the steeper mountains of the study area is difficult to remain desertification land. In addition, there are many exposed tailings in the northern part of the study area, the spectral characteristics of desertification land and tailings particles are less different. Therefore, in the preliminary extraction results, many wrongly extracted desertification lands are distributed on the mountain tops and slopes. We extracted slope information from DEM data, referencing the DEM, slope extraction results and field sampling results, the time series correction results were screened in the areas with elevations greater than 640m and slopes greater than 9.7. Such a practice excluding desertification at the areas, which with higher elevations and higher slopes, such as mountain tops and ridges, that are unlikely to be desertified. To a large extent, the misdivision of tailings and bare rock into desertification land has been greatly reduced, The extraction accuracy of desertification land is further improved. Figure 4 shows a small area showing the effects of time shift constraint and spatial distribution constraint corrections.

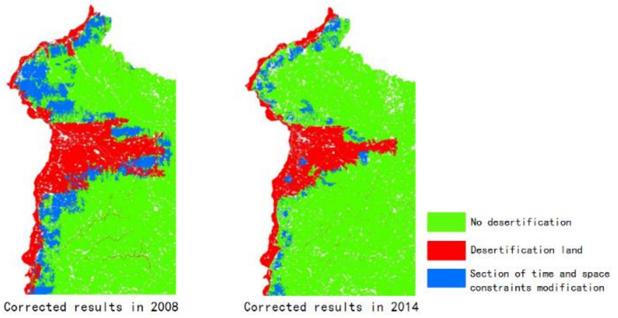

Figure 4. Desertification land extraction results by correction

4.4 Classification and Grading of Desertification Land

Based on the results of the national geographical survey data, the second national land survey data and local actual conditions, it was determined that the desertification land in the study area were divided into desertification cultivated land, fixed sandy land, and sandy land surface.

The “Technical code of practice on the sandified land monitoring” defines desertification land grading standards, mild desertification: vegetation coverage> 40%, desertification land with little sand flow, or normal growth of crops, lack of seedlings (generally desertification of crops with seedling deficiency rate< 20%); moderate desertification: 25%<vegetation coverage ≤ 40%, sandy desertification with unobvious sand movement, or crop growth, lack of seedlings (generally 20% ≤ crops with seedling failure rate< 30%) and unevenly distributed desertified farmland; Severe desertification: 10% < vegetation coverage ≤ 25%, sandy desertification with obvious wind-sand flow activity or clear sand texture, or vegetation coverage ≥ 10% Wind erosion residual mounds, wind erosion and Gobi, or poor crop growth, crop failure rate of ≥ 30% of desertified farmland; extremely heavy desertification: desertification with vegetation coverage ≤ 10%.

According to the above technical regulations, vegetation coverage is the only criterion for judging desertification degree. Cui Yaoping（2011） suggested that vegetation coverage in arid desert areas can be obtained indirectly from vegetation components extracted from remote sensing images. In this study, we select two classical vegetation indices: NDVI and MSAVI, and then calculate the vegetation index separately. NDVI is sensitive to areas with low vegetation coverage. MSAVI can eliminate some soil background effects. The dichotomy method was used to calculate the vegetation coverage through the vegetation index. See equation (1).

$$f = (VI - VImin)/(VImax - VImin) \quad (1)$$

where VI: indicates NDVI or MSAVI index
VImax: maximum exponential value in NDVI or MSAVI
VI min: minimum exponential value in NDVI or MSAVI

Then, the vegetation coverage calculated by the two indices was compared and verified, and we choose the optimal index to extract the vegetation coverage. Because the Cultivation of maize is the main cultivated land in the study area, and the growth is better, so soil background has little influence on the vegetation coverage. In theory, NDVI can reflect the true vegetation coverage more correctly. In the course of the study, NDVI and MSAVI calculation results were used for vegetation coverage inversion separately, by using the layered site selection method, we select 30 verification points on the vegetation coverage were 0-20%, 20%-40%, 40%-60%, 60%-80%, 80%-100% five levels. Then perform visual interpretation on the 0.5m spatial resolution DOM where the verification point is located, and use the visual interpretation results as real vegetation coverage of verification points. By analyzing the consistency of the results of the two index calculations, it is concluded that: compared to MSAVI, the vegetation coverage of NDVI inversion is more consistent with the true vegetation coverage, as shown in figure 5. Therefore, the NDVI index is used in this paper to calculate the vegetation coverage, thus obtaining the desertification land Graded results in 2008 and 2014.

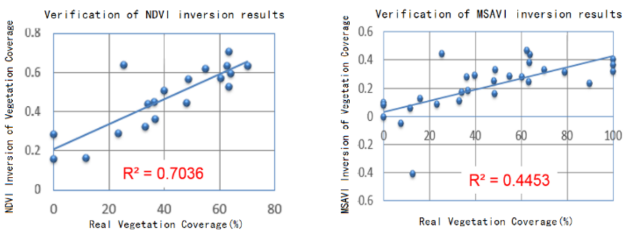

Figure 5. Comparison of vegetation coverage using NDVI and MSAVI inversion

5. ACCURACY ASSESSMENT

In the results of the desertification land extraction in the study area in 2014, several test samples were selected for different types of land desertification (severe sandstorm area, sand erosion zone, etc.). By collecting soil samples on the ground, taking photographs, recording specific names of townships and villages of each sample point, latitude and longitude, elevation, photo number, spectral number, land use type, vegetation type and other information to check the accuracy of desertification land extraction. Field survey sample points are distributed as Figure 6 shows.

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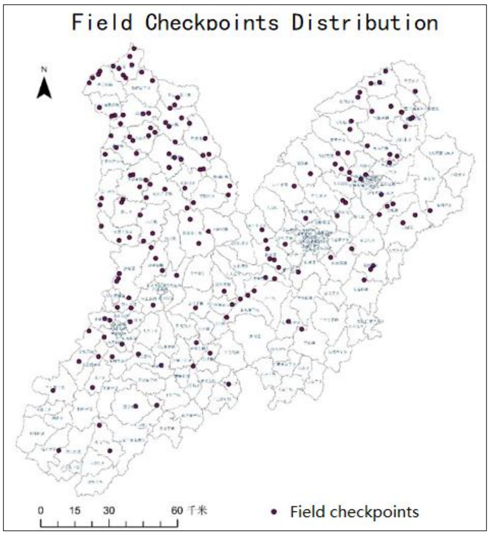

Figure 6. Distribution of field checkpoints

The field collected soil samples were sent to the Institute of Plant Nutrition and Resources, Beijing Academy of Agriculture and Forestry Sciences for soil particle size analysis, detecting different soil particle sizes in soil samples. According to the U.S. classification standard for soil texture, the particle size of each soil sample are as follows: 0.25mm-2.0mm (coarse sand), 0.05mm-0.25mm (fine sand), 0.02mm-0.05mm (coarse grain) 0.002-0.02mm (fine silt), <0.002mm (clay). Then determine the soil texture according to the percentage content of coarse sand and fine sand. A total of 177 field survey samples were selected for field verification, among them, 155 are correct and 22 are incorrect and the accuracy rate is 87.6%.

In 2015, the State Forestry Administration organized and developed the fifth desertification and desertification monitoring. Our monitoring results are consistent with each other, showing that the desertification area is decreasing, the desertification degree is decreasing, and the vegetation condition is improving. Chaoyang city assumed the task of constructing sandification harnessing project in northwestern Liaoning in 2011, according to the monitoring report issued by Liaoning Water and soil Conservation Institute to the project area, the soil erosion in the project area has changed from moderate erosion to mild erosion, this is highly consistent with the monitoring results in this paper. The monitoring results are verified, at the same time, the effectiveness of local land desertification control measures is also tested.

6. DESERTIFICATION LAND CHANGE MONITORING AND LANDSCAPE CHANGE ANALYSIS

6.1 Desertification change monitoring

According to the extraction results of desertification land in 2008 and 2014, the post-classification comparison method was used to monitor the change of land desertification during the six years. Change monitoring consists of two parts: space change and changes in nature. Space change monitoring is to calculate the difference of pixel by pixel between 2008 and 2014. At the same time, track and record the changes of each pixel from 2008 to 2014, then form a change monitoring matrix. According to the change monitoring matrix, the circulation of desertification land from 2008 to 2014 can be obtained.

Due to the special nature of local desertification land (crops and vegetation on desertification land remain dense), most of the desertification land, including all fixed sandy and desertified farmland belongs to mild desertification. Only the surface of the sandy surface has relatively low vegetation coverage, which belongs to moderate desertification. The change of desertification degree in study area is mainly include slight desertification-no desertification, no desertification-slight desertification, a small amount of moderate desertification-no desertification, no desertification-moderate desertification, and very little flow between moderate and mild desertification. The desertification degree change is consistent with the spatial distribution of desertification land.

In the study area, the desertification land type changed from desertification farmland to common cultivated land or other land types, and fixed sand to ordinary forest grassland or other land types. Which indicated that the local desertification land is being reduced in large areas, and the measures taken by the government to control desertification land have achieved remarkable results. However, there is still a small amount of conversion from ordinary land to desertification land, which is mainly distributed on the edge of the distribution profile of desertification land. This may be due to the erosion of the annual wind force. The edge of the desertification land will spread slightly outward, and the edge area will be easily eroded slightly desertification land. In addition, it also contains a very small amount of shift from fixed sandy land to desertification land, this may be due to artificial cultivation of forest land or grassland as cultivated land.

The specific process of desertification is abstract and complex, and it is very difficult to directly and quantitatively to analyze the evolution process of desertification. With the help of landscape pattern change research, it can be well reflected. At present, most researches are conducted on small and medium scales through experimental observations. Due to the complexity of ecological processes and the constraints of the nature of landscape indices, landscape indices are often difficult to objectively reflect landscape features and ecological significance, and are questioned by many scholars (Hu Weiwei et al., 2008).

6.2 Analysis of landscape change

In this paper, the landscape pattern index of the study area is analyzed using the Second National Land Survey data in 2008 and the First National Geographical Survey data in 2014, combined with the above desertification monitoring results. Due to the inconsistency of data classification hierarchy of Second National Land Survey data and the First National Geographical Survey data, we need to reclassify and reorganize these data, the main approach is to divide the land use types such as buildings, roadsand water into other categories, achieve the purpose of reducing the impact of different classification systems on the calculation of landscape indices. Then, the forest, farmland and grassland were divided into non-desertification forest, non-desertification farmland, non-desertification grasse and desertification forest, farmland and grasse. The landscape pattern index was calculated and analyzed for farmland, desertification farmland, forest, desertification forest, grassland, desertification grassland and sandy land surface, a total of 8 types of land use in the study area. On the basis of traditional landscape change analysis, adding the desertification information, analysis and reveals the characteristics and laws of dynamic landscape changes in desertification land during 2008-2014.

When the landscape pattern index is selected, the characteristics of the landscape pattern index, the characteristics of the underlying surface of the study area and the data source conditions are comprehensively considered, we analyze and evaluate some of the landscape level indices at the county scale (Zhang Xinyi et al., 2013). The selected seven kinds of landscape indices are: the number of plaques (NP), the average plaque area (MPS), the maximum patch index (LPI), area weighted average Shape index (AWMSI), area weighted average of fractal

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dimension (AWMPFD), Shannon diversity index (SHDI) and Shannon evenness index etc. Objective to analyze seven types of landscape metrics that identify potential interest from the law. By associating the spatial characteristics of the landscape with the time process, it is used to study the influence of the time change, succession and external disturbance on the landscape pattern. Therefore, it can reveal the influence of landscape pattern change caused by land use change on ecological environment.

Take a township with more serious desertification in the study area as an example, the statistical results of its landscape pattern index are shown in Table 1. As can be seen from the table, NP increased 51,205 patches in 6 years from 200are8 to 2014, indicating that with the development of economy, the increase of public infrastructure occupied places the landscape pattern to be more fragmented. The MPS decreased significantly, indicating that the landscape pattern was more fragmented, the number of plaques increased, which meets the increasing trend of NP. LPI has increased, indicating that the dominant types of patches in the landscape are becoming more and more obvious. The increase in AWMSI indicates that landscape shapes have become more complicated and irregular. AWMPFD did not change much, indicating that there was less interference from human activities in past 6 years. SHDI has decreased but not much. SHEI has increased, not much. Both the 2008 and 2014 SHEIs are close to 1, indicating that the landscape types are close to uniform distribution.

YEAR	NP	LPI	MPS	AWMSI	AWMPFD	SHDI	SHEI
2008	27080	6.4638	8.7287	14.0605	1.2737	1.5765	0.7581
2014	78285	7.5004	3.1667	16.1478	1.285	1.545	0.794

Table 1. Landscape pattern index calculated by adding desertification data in a Township

7. CONCLUSION

(1) In recent years, some scholars have used remote sensing technology to extract desertification land automatic or semi-automatic. However, looking at existing research results, most of them focus on areas with high levels of desertification, use single measurement or one time observation data. Most of the research contents belong to the macro level, especially for areas such as northwest Liaoning, the applicability is not strong. The technical method proposed in this study further promotes the effective application of long-term sequence multi-source remote sensing data and the progress of desertification land monitoring technology by remote sensing. It has achieved good economic benefits and its research results have further promoted the role of remote sensing in industrial applications.

(2) In view of the particularity of desertification land in northwest Liaoning, Based on the supervised classification results, the method of modifying the preliminary extraction results by using Landsat long time series data and DEM data as assistant is explored in this study, which effectively solves the problem of low precision of automatic monitoring of desertification land, improved automatic monitoring accuracy. However, this method is only universal in northwestern Liaoning and its similar areas, its application in other desertification areas needs further exploration.

(3) Traditional landscape analysis method is mainly based on the land use information. According to the landscape model, the significance of different landscape indices combined with the analysis of regional characteristics is obtained. In this study, based on the traditional land use classification, the influence of desertification information on each landscape index is studied. It can effectively improve the landscape analysis method in the desertification area. However, this study only made some preliminary attempts, there is also a need for more in-depth research in this area.

(4) Data of the First National Geographical Survey results, the Second National Land Survey results and the multi-source auxiliary data, such as DEM, were used in the extraction of desertification land. On the one hand, the method optimizes and effectively improves the extraction accuracy, on the other hand, it makes full use of the survey result. Which provide better service for industry and departmental requirements.

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