

COMPARATIVE ANALYSIS OF SEVERAL TYPICAL APPROACHES OF DESERTIFICATION DYNAMIC MONITORING BASED ON TM DATE

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SS-7

KEY WORDS: Image processing; Detection; Space photogrammetry; Feature extraction; Environmental monitoring

ABSTRACT:

Land desertification is one of the most important problems about the issue of environment, social and economy in the world. Vegetation category and quantity is a significant criterion to measure the extent of land desertification, so desertification dynamic monitoring based on remote sensing depend on the distribution of vegetation. This paper take Huojitu mining area of the Erdos city, Inner Mongolia for example, extracting vegetation information by using methods of Normalized Difference Vegetation Index、scaled difference vegetation index and interpreting mixed pixels, based on three temporal Landsat remote sensing images. Meanwhile, relative analysis of these three methods has been made. The results showed that: Vegetation Indices behaved the best in the region of high coverage. However, Pixel Unmixing Models is better suitable for dynamic monitoring vegetation in low coverage area. The SDVI, which is a linear index, was found to be a more suitable approach for retrieval of vegetation fraction. Besides, this paper systematic analysis Time-space evolution tendency of desertification land in Western China, also puts forward some preventive and controlling measures against sandy desertification.

1. INTRODUCTION

Land desertification points mainly the geography phenomenon of the flowing and half fixed sand dune in arid and semi-arid region. Desertification usually occurs in the arid, semi-arid and parts of sub-humid district, under the condition of drought、windy and loose sand earth's surface, because the factors of over utilization by human on the land and others, the balance of frangible ecosystem was broken, turns the undeserting region into a deteriorate process, taking the sandstorm activity as the main marking.

Desertification is one of the most important environment's problem in the world now. Two thirds (more than one hundred) countries and regions in the world be endangered by the desertification, the number of population for more than 900 millions also be influenced. Particularly desertification is expanding for 50000-70000 kms every year; because of the desertification, lose amounts to 42 billion and 300 million annually. The United Nations environment Programme announces that if the trend going on, it will cause a global disaster soon. China is one of several countries that severely affected by land desertification. The desertification area reaches to 1 million and 610 thousands square kilometers, accounting to 16 percent of the national territory area, and still expanding by 2460 kms every year since 90's in 20 centuries. Because of the desertification, losing money reaching to 4 billion and 500 million dollars RMB annually directly, it is a disadvantage for national economy and society's development. So it is imperative to acquire high accuracy time-space variation of sandy desertification and provided a scientific basis for the decision makers timely.

The technical development in Remote Sense provide a ideal tool into obtaining the desertification information. The

satellite data have a lot of advantages, for example, the periodic overlay、large scope、cost lowly and so on. There are various methods for processing data and extracting change information in dynamic remote sensing monitoring on desertification development. Remote sensing thematic research on desertification has obtained rapid development in recent years, but the study of desertification information extraction from remote sensing data still in the exploring stage, basically according to the methods of vegetation information extraction. Vegetation category and quantity is a significant criterion to measure the extent of land desertification, so desertification dynamic monitoring based on remote sensing depend on the distribution of vegetation. This paper take Huojitu mining area of the Erdos city, Inner Mongolia for example, analysing the desertification in the last 20 years, extracting vegetation information by using Normalized Difference Vegetation Index (NDVI) method, scaled difference vegetation index (SDVI) method and interpreting mixed pixels method, based on three temporal Landsat remote sensing images. Meanwhile, relative analysis of these three methods has been made. Simultaneous, turn to analysis and estimate the trend of Huojitu mining area's desertification, then take forward preventing and curing measure.

2. GENERAL SITUATION OF THE RESEARCH AREA

2.1 Background on research region

HuoJitu diggings lie inside the border of YikeshaoMeng Yijinhuoluo municipality of Mongolia. Traffic in diggings is convenient, with BaoShen railway across from the east WuLanmulun river to the north YiJinhuoluo AZhen along which covers a distance of 90 kilometers to DongSheng

city, 190 kilometers to BaoTou city, from the south Daliu tower along ShenMu and YuLin city with 172 kilometers, through ZhunGeer to HuHehaote city with 230 kilometers. The main was connected between railway special line and BaoShen railway road, and was jointed with HeiTan channel.

2.2 Analysis on desert forming

Desertification is the consequence of ruin the ecological system of sky, earth and life. The main reason of desertification is people's abused economic activities and suitable stratum condition. The former is the outside factor while the latter one is the inside factor. The wide existing sand origin is the material foundation of desertification; fitted climate is the catalyzed condition while people's unreasonable economic activities speed up the process of desertification.

Research region is the main body of north ShenMu mine area of ShenFu DongSheng, which has arrived a scale based on DaLiu Tower—SunJiaCha center facility. With further development of mine exploit and related industry, population in this area is swelling, adding the mine construction and facilities landing. Vegetation destroyed, water and land flows, water table descends. This scenario deteriorated eco-environment.

3. DATA PROCESSING

3.1 Technical route

The sandy desertification is land degeneration in real terms, which happens when the land ecosystem were interfered by external factors. Specifically speaking, it is macroscopically manifests as the vegetation and the soil's succession movement, microscopically manifests as the changes' in vegetation coverage or the soil material drain. And the vegetation coverage, which can be used as the indicators to assess the extent of land degradation and desertification, could be varied through the surface vegetation coverage. So, in Erdos, the relationship between sand-land vegetation coverage and desertification was close. And by those reliable information supplies by satellite, we could recognize the changing process, then establish vegetation index and vegetation coverage index correlation model.

Therefore this research's key point is to using the NDVI, SDVI and pixel unmixing way extracting vegetation information, and making the correlation analysis. Then on that foundation grasps the accurate data about the research area's desertification, studies on its evolution law, forecast the evolution trend of desertification, and provide the basis for desertification control. So the design route is as followed:

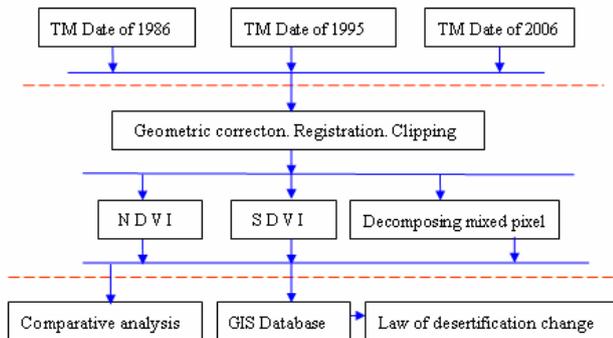


Figure 1 Technical route of the research

3.2 Vegetation Index

The vegetation information is reflected by optical spectrum feature of plant leafage and vegetation canopy and its difference and change. Vegetable information of different spectral channel, various vegetable element and certain characteristic state have some kinds of correlation. During research, vegetation index is adopted. Usually choice multispectral remote sensing image date to do analysis operation (such as the linear or nonlinear combination of add, subtract, multiplication and division), and then generate some designating significance values called vegetable index, which reflect the vegetation growth vigor and biomass. When vegetable index is calculated, visible light red band (0.6~0.7μm) and near-infrared waveband (0.7~1.1μm) are selected.

3.2.1 Normalized Difference Vegetation Index

Normalized Difference Vegetation Index (NDVI) is defined as a ratio from the difference and sum of near-infrared waveband (0.7-1.1μm) and visible light red band, as equation:

$$\text{NDVI} = (\text{NIR} - \text{R}) / (\text{NIR} + \text{R}) \quad \textcircled{1}$$

$$\text{S} = f \cdot \text{c} \cdot \text{Sveg} + (1 - f \cdot \text{c}) \cdot \text{Ssoil} \quad \textcircled{2}$$

From formulas ① and ②, it can deduce:

$$\text{NDVI} = f \cdot \text{c} \cdot \text{NDVIveg} + (1 - f \cdot \text{c}) \cdot \text{NDVIsoil} \quad \textcircled{3}$$

Namely, NDVI value of every image can be regard as NDVI weight average of region with vegetation cover and without vegetation cover. Among them, NDVI weight of region with vegetation is the degree of vegetation, and the NDVI weight of region without vegetation is 1-fc. In equation ③, where NDVIsoil is NDVI value of bare soil or region without vegetation, NDVIveg stands for pixel with vegetation cover completely.

From equation ③, we can get the computation formula of vegetation cover degree:

$$f \cdot \text{c} = (\text{NDVI} - \text{NDVIsoil}) / (\text{NDVIveg} - \text{NDVIsoil}) \quad \textcircled{4}$$

3.2.2 Scaled Difference Vegetation Index

Deferent vegetable index is defined as value difference of near-infrared waveband and visible light red band, as formula:

$$\text{DVI} = \text{DN}_{\text{NIR}} - \text{DN}_{\text{R}}$$

Where DN is count number of near-infrared waveband and red band. DN is sensitive to the change of soil background, which is advantaged to monitor the breakage of vegetable eco-environment.

$$N - R = N - R = f(N_v - R_v) + (1 - f)(N_s - R_s)$$

Hereby, it is called environment vegetable index.

$$f = \frac{N - R - (N_s - R_s)}{N_v - R_v - (N_s - R_s)}$$

First, the authors used minimum noise fraction rotation (MNF) to extract noise from data, MNF is a linear transform related to the main composition. Then, pixel purity index (PPI) can be employed to design and appointed the extreme pixel of the spectrum. Then 2-Dimensional Visualization can be used to estimation the number of spectral endmember and their pure features.

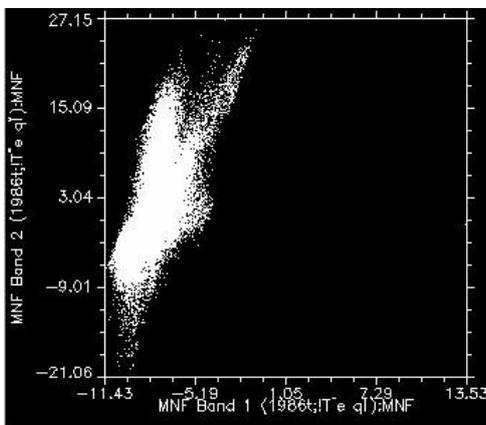


Figure 2 2-Dimensional Visualization of Band 1.2

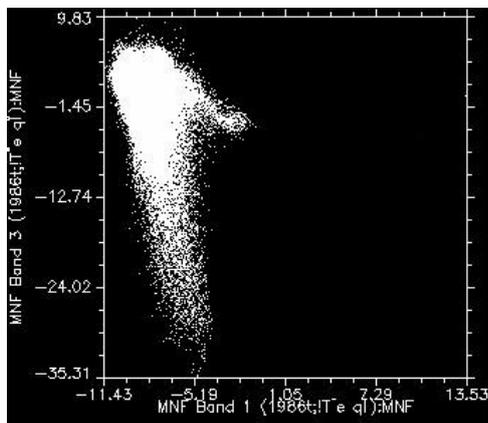


Figure 3 2-Dimensional Visualization of Band 1.3

Using coefficient f , we can get:

$$SDVI = \frac{DVI - DVI_s}{DVI_v - DVI_s}$$

3.3 Decomposing mixed pixel

The mixed pixel which signal is made up of multi-category, is an normal phenomenon. Contrary, which signal comes from only one surface feature is called pure pixel. There are two situations of mixed pixel: one is boundary pixel (Different surface features are adjacent in one pixel.), the other is subpixel (One pixel has more than two surface features.). Along with the improvement of space resolution, the number of mixed pixel is reduced. But no matter how much space resolution is, the phenomenon of mixed pixel is in existence (Fisher and Pat hirana 1990 ; Cloutis, 1996). In case of all of them are pure pixels, the conventional classification is that one pixel is one type. So when the image contains a lot of mixed pixels, the accuracy of classification will drop, especially quantity accuracy. To solve this problem, some scholars put forward a replacement classification method-mixed pixel decomposition. And experiments proved that this method can improve the accuracy of landcover classification (Quarmby, 1992). There are some factors, for example the space resolution of TM is low, it has the phenomenon such as same thing with different spectrum, and there are many mixed pixels in the boundary, which effect the accuracy. So the key technology is eliminate the phenomenon-same thing with different spectrum.

The solution of mixed pixel decomposition can be divided into two scenarios: modeling method (such as linear, probability, geometric-optics and stochastic geometric models) and classification method (such as fuzzy analysis model). In this paper, we adopted the latter one.

The principle of linear spectral mixture model is based on the hypothesis: spectrum of different land types which make up of mixed pixel is linear combination, namely, it is independence. The model is:

$$\rho(\lambda_i) = \sum_{j=1}^m F_j \rho_j(\lambda_i) + \varepsilon(\lambda_i)$$

Where $j=1,2,\dots,m$ stands for pixel component; $i=1,2,\dots,n$ stands for spectral channel; F_j is the area ratio of pixel component in pixel, which is parameter to be accessed; $\varepsilon(\lambda_i)$ is the errors of spectral channel.

We presume that in equation (1) endmember spectra of mixed pixel is integrity, so equation (1) is under the constrain:

$$\sum_{j=1}^m F_j = 1, F_j \geq 0$$

The normal solutions of model are: factor analysis method, least squares method without constrain and so on.

3.4 Result analysis

In this research, three temporal Landsat remote sensing images are used. With the ENVI remote sensing image processing software, it can be obtained that the images of NDVI, SDVI, LSMA of the research area. The same time sample regions are selected through visual interpretation of remote sensing image.

	Min	Max	Mean	Stdev
NDVI	-0.404255	0.685714	0.081289	0.09417
LSMA	0.000000	1.000000	0.17063	0.166981
SDVI	-0.399355	1.501943	0.115683	0.218259

Figure 4 Evaluation of different methods to derive vegetation fraction

Vegetation fraction interval(%)	NDVI	LSMA	SDVI
0-20	1.33	0.81	1.03
20-30	1.16	1.08	1.00
30-40	1.14	0.72	0.92
40-60	0.73	0.68	0.82
60-80	0.24	0.93	0.56
80-95	0.27	1.01	0.74
95-100	0.08	0.79	0.51

Figure 5 Vegetation index sensitivities as represented by the mean slopes of vegetation index-vegetation fraction curves

The results showed that: Vegetation Indices behaved the best in the region of high coverage. However, Pixel Unmixing Models is better suitable for dynamic monitoring vegetation in low coverage area. The nonlinearity of NDVI over partially vegetated surfaces becomes prominent with darker soil backgrounds and with presence of shadow. Thus, the NDVI may not be suitable to infer vegetation fraction because of its nonlinearity. The SDVI, which is a linear index, was found to be a more suitable approach for retrieval of vegetation fraction. Through the relative analysis of these three methods has been made, it can be found that vegetation coverage with the method of interpreting mixed pixels is more suitable to monitor dynamic change of desertification in the research area.

Desertification indicators system is the foundation of desert classification and evaluation and approval of desertification supervisor. It includes pattern of desertification, degree, dangerous degree, revolve effect etc, while the first two indicators are more important. A key matter is to confirm the basic standard of desert degeneration so as to evaluate a region's desertification degree. The definition of basic standard is what the eco-system can optimize under a certain climate condition, compared to the standard of desertification evaluation, desertification can be generally divided into four degrees: slight, middle, bad and extremely bad.

In this research land is taken as an foundation under natural stable ecology for confirming three classified system in HuoJitu region desertification patterns. The first degree is pattern of making use of land, the second degree is pattern of desertification, and the third is pattern of desertification degree.

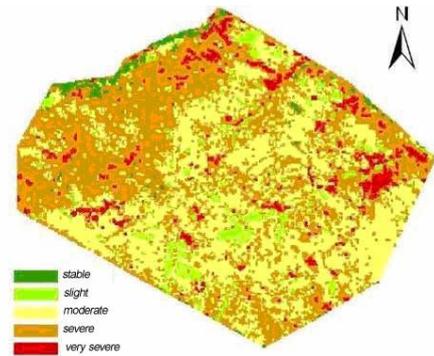


Figure 6 Desertification grade graph of HuoJitu 2006a

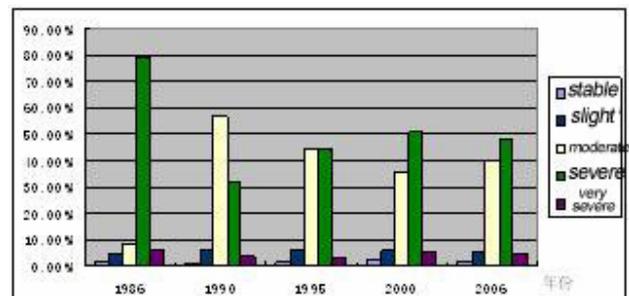


Figure 7 Desertification grade table of HuoJitu

grade		slight	moderate	severe	Very severe
1986	area	11066740	11653680	8069320	9957460
	percent	27.16	28.59	19.80	24.43
1995	area	14004000	10826500	8174900	11678600
	percent	31.34	24.23	18.29	26.13
2006	area	13105800	12525700	8378500	7276250
	percent	31.74	30.33	20.29	17.62

Figure 8 Results of dynamic change of desertification

It can be concluded through the result of the dynamic variation that:

(1) From 1986 to 2006, the acreage of sandy degradation in HuoJitu increases from 40.74 km² in 1986 to 41.29 km² in 1995, which manifested the tendency of increase. However, the acreage of it decreased to 41.29 km² in 2006, which manifested the opposite tendency. Totally, the acreage of desertification is increasing from 1986 to 2006. The change of weather and the anthropic activities links with the result directly.

(2) Desertification evolution law varies according to different types, which can be proved by the fact that the acreage of serious desertification land firstly soared and sharply decreased below the level in twenty years ago. That is because people emphasized on desertification more and more. Due to relative governing measures in the desertification areas Proper measures have been taken mainly on the regions with the most serious desertification, reversing it to the medium or less serious level which underwent expansion as the result of the strategy to deal with the desertification.

4. CONCLUSION

It is a valid method to monitor and evaluate dynamic change of land desertification through interpretation of multi-band remotely sensed materials, through this research, it can be concluded that vegetation coverage can be used as a reference standard to evaluate the extent of land degradation and desertification, in Huojitu mining area of the Erdos city, namely, it can be used to measure off the degree of land degradation. According to different authors, desertification in the study area caused by many factors, including the geologic structure, climate change and rodent damages. Human activities are also an important cause of land desertification in this region.

Therefore, to prevent the ever-increasing land desertification, it is important to improve the management and techniques of protection.

(1) Solve the problem of desertification in the source, it is imperative that we set up an authoritative land management organization, definite the use rights of land, design and implement a unified plan for rotational grazing, limit cultivation in the fragile eco-environment in order to avoid overuse of natural resources.

(2) Exploring new ways of the use of micro-biological crust spores plant to combat desertification.

(3) Modern agriculture replaces resources agriculture.

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