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Extraction of vegetation fraction information from CBERS images based on VBSI vegetation index in Kaixian county

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Abstract: Based on the mixed pixel model, the vegetation fraction of Kaixian county, China, was extracted with three free CBERS images. VBSI vegetation index suitable for CBERS images constructed with FCD (forest canopy density) model principle was put forward by ITTO (International Tropical Timber Organization) was used, considering the underestimation of vegetation fraction using NDVI in low mountain-hill region influenced by soils and shadows. And vegetation fraction was divided into five categories from low to high in order to study the special variation of vegetation cover. The results show that the vegetation cover of the region is overall good, with an average of 50%. The area of vegetation fraction below 30% accounts for 11.7% of the entire studied area, mainly concentrates in central eastern Kaixian county, where is the major development zone of cities and towns; that between 30% and 60% accounts for 62%; and that higher than 60% accounts for 26%, and mostly locates in northern middle-mountain area.
Key words: VBSI vegetation index; mixed pixel model; FCD model; CBERS

1 Introduction

Vegetation fraction (the ratio of vegetation projective area to unit area) is a very important parameter to describe ecosystem [1−3]. The methods of vegetation fraction estimating from remote sensing data can be split into two main sorts, empiric model and vegetation index transform plan [1]. The latter estimates the vegetation fraction through building the transformational relation between vegetation fraction and vegetation index. It is usually applied in practice because of not depending on the measured data of vegetation fraction [2].

At present, the NDVI is widely used for calculating vegetation fraction, and mixed pixel model considering underlying surface conditions is also often used [3−5]. However, vegetation fraction calculated with NDVI would be cut down especially in low mountain-hill region, influenced by mountain shadows and soils [6−10]. NDVI values at different resolutions may not be comparable. The nonlinearity of NDVI over partially vegetated surfaces becomes prominent with darker soil backgrounds and with presence of shadow [4].

In consideration of the geomorphological characteristics of Kaixian county, China, and the fact that common vegetation index is disturbed by mountain shadows, soil backgrounds, rocks and buildings, VBSI vegetation index suitable for CBERS data based on FCD (forest canopy density) model principle is constructed to replace NDVI in this work.

A linear mixed pixel model, based on the assumption that vegetation is dense where it exists, was also used when calculating vegetation fraction with VBSI vegetation fraction.

2 Overview of research area and data resource

2.1 Overview of research area

Kaixian county, China, is located in the northeastern Chongqing city (E107°55′48″−108°54′, N 30°49′30″−31°41′30″), on the tributary backwater of Xiaojiang river of the Yangtze river, Three Gorges reservoir. It lies at the foot of Daba mountain and in the north of parallel valley region of the eastern Sichuan Basin, covering a total area of 3 960 km^2, with altitude ranging from 134 m to

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262 m. The main topography type is mountain and hills, and there is a little valley and plain. The area ratio of mountain, hill and plain is 6:3:1. The mountains with low and middle altitude appear to be long strip in shape, and the low mountains appear broad. Hill and valley are usually wide.

Annual average temperature is 18.5−10.8 °C, which differs from altitude. The annual precipitation is 1200 mm. The character of the weather is long rainy season, many rainy days and abundant precipitation. The original vegetation type is subtropical evergreen large leaves forest. Plain and surrounding areas were mostly cultivated by human activities for a long history. Landscape in low altitude area is the mixture of cultivated land and human planting forest.

Kaixian county is rich in natural resources. It has been proved that there are 24 kinds of minerals, in which 14 kinds have been exploited. It is one of China's major coal-producing counties, the coal reserve is 1.2×10^{8} t. The natural gas reserve is about 3×10^{12} m^3 in theory. There are gypsum, lead, zinc, copper and other minerals. The exploitation of minerals had caused extensive damage to vegetation in mountain areas. Estimation of vegetation fraction is very important for ecological construction of these mine areas.

2.2 Data resource

Three images were taken by CBERS−2 (China-Brazil earth resources satellite) CCD camera in 2007, obtained from China Centre for Resources Satellite Data and Application for free. Radiometric correction and geometric correction were done. The map projection is UTM, the spherical coordinate is WGS_84, the spatial resolution at sub-satellite point is 19.5 m.

3 Methods

3.1 Construction of VBSI vegetation index with FCD model

FCD model (forest canopy density model) principle put forward by ITTO (International Tropical Timber Organization), based on biophysical properties of forests, is mainly applied to Landsat-TM images (Fig.1). Four indexes were built: vegetation index, V_I; bare soil index, B_I; shadow index, S_I and thermal index, T_I (rarely used) [11−13].

AVI and NDVI can be used for vegetation index in the model. The formulas for calculation are as follows:

$$\mathrm{AVI}=\sqrt[3]{(B_4+1)(256-B_3)(B_4-B_3)} \quad (1)$$

$$\mathrm{NDVI}=(B_4-B_3)/(B_4+B_3) \quad (2)$$

$$B_I=(B_5+B_3-B_4-B_1)/(B_5+B_3+B_4+B_1) \quad (3)$$

$$S_I=\sqrt[3]{(256-B_1)(256-B_2)(256-B_3)} \quad (4)$$

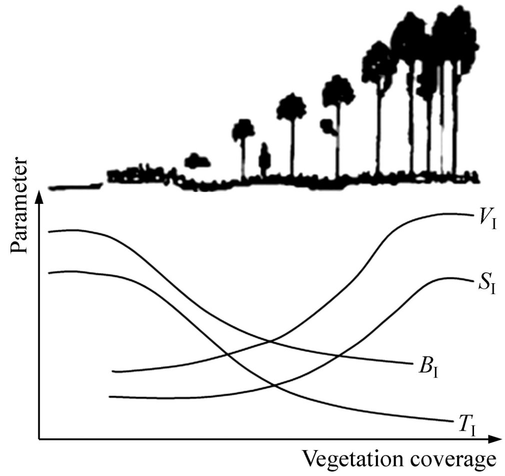

Fig. 1 Characteristics of FCD model

T_I is extracted from thermal infrared band.

CCD image data of CBERS has five bands, no short infrared wave band and thermal infrared band compared with TM data. Three indexes are modified on the basis of the characteristics of CBERS data (using NDVI for V_I):

$$V_I=\mathrm{NDVI}=(B_4-B_3)/(B_4+B_3) \quad (5)$$

$$B_I=(B_3+B_1-B_2)/(B_3+B_1+B_2) \quad (6)$$

$$S_I=\sqrt[3]{(256-B_1)(256-B_2)(256-B_3)} \quad (7)$$

Studies show that, S_I and V_I present a positive correlation. There is a negative correlation between B_I and V_I. On linear combination of V_I, S_I and B_I, the influences of shadows, soil backgrounds, rocks and buildings can be weakened to some extent. VBSI vegetation index is constructed on linear combination of V_I, S_I and B_I based on experiments, the basic formula is [13−14]:

$$\mathrm{VBSI}=f(V_I,B_I,S_I)=(V_I+nB_I)\times S_I \quad (8)$$

where VBSI is a combinational vegetation index; n is the correction coefficient determined by actual situations and experiments.

3.2 Vegetation fraction estimation with mixed pixel model

The mixed pixel model expresses relation of remote sensing information and vegetation fraction. S_{veg} and S_{non} denote respectively remote sensing information of pure pixels full of vegetation and no vegetation cover. It can reduce the influence of air and soil, etc, and keep information of vegetation cover nicely [15]. The formula is

$$f_c=(S-S_{non})/(S_{veg}-S_{non}) \quad (9)$$

where f_c is vegetation fraction; S is the VBSI value of pixels; S_{veg} is the mean value of pixels with full vegetation cover; and S_{non} is determined by sample values of pure bare soil pixels.

4 Results and analysis

4.1 Calculation of VBSI vegetation index

According to formulas (5)−(7), NDVI, B_I and S_I of the three images were calculated with calculation programs written by model maker tool in ERDAS. Then VBSI was calculated with formula (8), where n=−0.15 on the basis of relationship between NDVI and B_I in two-dimensional space. The calculation was also achieved by ERDAS program. After that, B_I, S_I, NDVI and VBSI maps of Kaixian county (Figs. 2−5) throw image cutting and splicing in ERDAS.

From Figs. 4−5, we can find that, the pixels in northern middle-mountain area are brighter in VBSI map compared with NDVI map. In other words, the value of VBSI is higher than that of NDVI of the same pixel. It proves that VBSI vegetation index can reduce the influences of shadows, soil backgrounds, rocks and so on obviously.

Fig. 2 B_I map

Fig. 3 S_I map

Fig. 4 NDVI map

Fig. 5 VBSI map

4.2 Extraction of vegetation fraction

Based on the mixed pixel model principle, vegetation fraction was figured out with formula (9), where S_{veg} and S_{non} take 214 and 78 separately from the means of samples.

For clear identification of the vegetation coverage distributed pattern, pixels can be divided into several categories based on their attributes [16−19]. In this work, the vegetation fraction was divided into five levels: 0%−30%, 30%−45%, 45%−60%, 60%−75% and 75%−100%. Then a vegetation fraction classification map of Kaixian county with five classes was obtained (see Fig. 6).

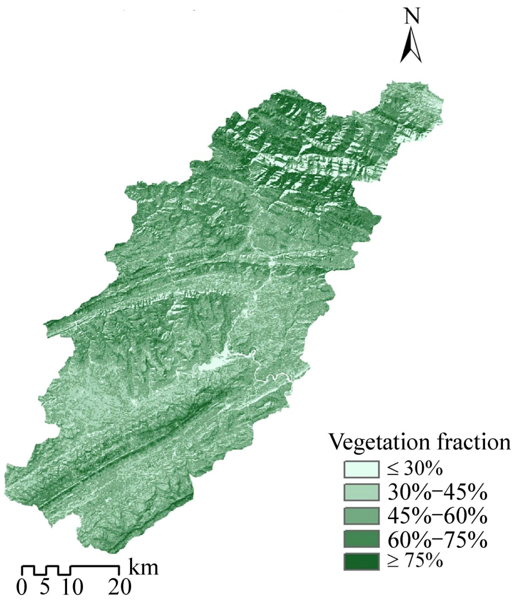

Fig. 6 Vegetation fraction classification map of Kaixian county

Statistical features of vegetation cover distribution can be obtained from the classification map (Table 1).

Table 1 Vegetation cover distribution of Kaixian county

Classes	Vegetation fraction/%	Area/km^2	Percentage/%
1	0−30	463.3	11.7
2	30−45	1005.8	25.4
3	45−60	1453.3	36.7
4	60−75	815.8	20.6
5	75−100	221.8	5.6

Table 1 shows that, the area of vegetation fraction less than 30% accounts for 11.7% of the entire study area, covers an area of 463.3 km^2 mainly in the plain of central eastern Kaixian county; this area is the major development zone of cities and towns; vegetation fraction is low there because of high-density human activities. Vegetation fraction between 30% and 45% covers an area of 1 005.8 km^2, accounts for 25.4%, and basically distributes in the southern parallel ridge-and-valley area and central eastern cities and towns development area; these areas are major agricultural regions of the county. Vegetation fraction between 45% and 60% covers an area of 1453.3 km^2, accounts for 36.7%, and mainly concentrates in west low mountain-hill area. The area of vegetation fraction higher than 60% accounts for 5.6%, and mainly distributes in northern middle-mountain area where is rarely disturbed by human activities and the vegetations bloom.

On the whole, vegetation cover of the study area is overall good, with an average of 50%. Vegetation cover of western mountain-hill area and northern middle-mountain area is significantly higher than southern parallel ridge-and-valley area and central eastern cities and towns development area. However, the area of vegetation fraction lower than 45% accounts for more than 37% of the entire area. These areas also concentrate most of the area's human activities of residence, economy and society, and degradations of vegetation cover occur constantly.

5 Conclusions

1) With three free CBERS images, VBSI vegetation index suitable for CBERS images is constructed with FCD model principle to reduce the influence of shadows and soil grounds. Vegetation fraction of Kaixian county is extracted by mixed pixel model and the result conforms to reality. This method is simple, feasible, and operable.

2) The classification map of vegetation fraction makes the vegetation coverage condition of Kaixian county clear, which lays the foundation for further study of eco-environment quality evaluation, environment development and protection. Certainly, analysis and study on remote sensing images series of several years, can realize vegetation fraction changes monitoring and development tendency predicting.

References

[1] NIU Bao-ru, LIU Jun-rong, WANG Zheng-wei. Remote sensing information extraction based vegetation fraction in semiarid area [J]. Geo-information Science, 2005(1): 84−86. (in Chinese)

[2] YU Shao-wen, SUN Zi-yong, MA Rui. Using remote sense and GIS techniques to assess soil erosion in Sanggan river watershed [J]. Safety and Environmental Engineering, 2008, 15(2): 8−12. (in Chinese)

[3] DIAZ B M, BLACKBURN G A. Remote sensing of mangrove biophysical properties: From a laboratory simulation of the possible effects of background variation on spectral vegetation indices [J]. International Journal of Remote Sensing, 2003, 24: 53−73.

[4] JIANG Zhang-yan, HUETE A R, CHEN Jin, CHEN Yun-hao, LI Jing, YAN Guang-jian, ZHANG Xiao-yu. Analysis of NDVI and scaled difference vegetation index retrievals of vegetation fraction [J]. Remote Sensing of Environment, 2006, 101(3): 366−378.

[5] MONTANDON L M, SMALL E E. The impact of soil reflectance on the quantification of the green vegetation fraction from NDVI [J]. Remote Sensing of Environment, 2008, 112(4): 1835−1845.

[6] NIE Yong, FAN Jian-rong, YANG A-qiang. A study on auto-assessing soil erosion in Kaixian of Chongqing [J]. Soil and Water Conservation, 2007, 14(3): 109−111. (in Chinese)

[7] FITZGERALD G J, PINTER P J, HUNSAKER D J, CLARKE T R. Multiple shadow fractions in spectral mixture analysis of a cotton canopy [J]. Remote Sensing of Environment, 2005, 97: 526−539.

[8] GAN T Y, BURGES S J. Assessment of soil-based and calibrated parameters of the Sacramento model and parameter transferability [J]. Journal of Hydrology, 2006, 320: 117−131.

[9] GEBREMICHAEL M, BARROS A P. Evaluation of MODIS gross primary productivity (GPP) in tropical monsoon regions [J]. Remote Sensing of Environment, 2006, 100: 150−166.

[10] CHEN Yun-hao, SHI Pei-jun, LI Xiao-bing, CHEN Jin, LI Jing. A

combined approach for estimating vegetation cover in urban/suburban environments from remotely sensed data [J]. Computers & Geosciences, 2006, 32(9): 1299−1309.
[11] RIKIMARU A. LANDSAT TM data processing guide for forest canopy density mapping and monitoring model, ITTO workshop on utilization of remote sensing in site assessment and planning for rehabilitation of logged-over forest [R]. Bangkok, 1996: 1−8.
[12] JOFCA. Utilization of remote sensing in the assessment and planning for rehabilitation of logged-over forests [R]. Project report on PD32/93 Rev.2(F) Rehabilitation of logged-over forests in Asia/Pacific region, Sub-projectIII. Yokohama, 1997.
[13] LUO Zhi-jun, ZHAO Xiao-min, LIU Yao-lin. Dynamic monitoring of vegetation fraction based on remote sensing in Three Gorge area [J]. Transactions of the CSAE, 2008, 24(S1): 57−60. (in Chinese)
[14] JIANG Hong, WANG Xiao-qin, CHEN Xing. A method for abstraction of vegetation density from SPOT image [J]. Geo-information Science, 2005, 7(4): 113−116. (in Chinese)
[15] JIANG Hong, WANG Qin-min, WANG Xiao-qin. Remote sensing dynamic monitoring of vegetation coverage of Changting county, Fujian Province [J]. Natural Resources Journal, 2006, 21(1): 126−132. (in Chinese)
[16] YU Zheng-zheng, WU Guo-xi, LIU Liang-yun. Research on vegetation coverage evolution of Mentougou district by remote sensing [J]. Research of Soil and Water Conservation, 2011, 18(3): 32−35. (in Chinese)
[17] LIANG Bao-ping, LI Yi, LIU Qing-ye, LI Hui. Research on vegetation coverage and changes monitoring based on TM images in Guilin [J]. Environmental Monitoring in China, 2011, 27(4): 36−40. (in Chinese)
[18] WU Li-xin, MA Bao-dong, LIU Shan-jun. Analysis to vegetation coverage change in Shendong mining area with SPOT NDVI data [J]. Journal of China Coal Society, 2009, 34(9): 1217−1222. (in Chinese)
[19] ZHANG Xi-wang, LIU Jian-feng, ZHANG Bo. Spatial distribution analysis of vegetation fraction in Yiluo river basin [J]. Heilongjiang Agricultural Sciences, 2010(10): 105−108. (in Chinese)

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