Analysis on Correlation between Land Use Change and Vegetation Index by TM image data

Hou Shiquan[1], Wang Zhiying[1], Liu Yun[1]*, Li Chunlei[2]*
1.The Beijing key laboratory of new technology in Agricultural application, Beijing University of Agriculture, Beijing 102206, China ; 2.Institute of forest ecology environment and protection, Chinese Academy of Forestry, 100091, China
* Corresponding author: Liu Yun, E-mail:housqly@126.com; Li Chunlei, E-mail: lclxj@sina.com

***Abstract*— This paper selected Changping District located in suburban area of Beijing as a case study, based on Land sat TM image data in 1998 and 2009 for extracting the information about vegetation index and land use. It analyzed the relationship between land use change and vegetation indexes for providing the basis and reference value to protect the future sustainable development of eco-environment. The results showed that it had developed a higher degree of land utilization in Changping district, regional land extension strength was significantly enhanced, the average of vegetation index had a strong decreased trend in the periods of 1998-2009: from 0.3918 to 0.1825 for the normalized difference vegetation index (NDVI), from 0.6779 to 0.5687 for the vegetation coverage (f), from 2.2819 to 1.3124 for the ratio vegetation index (RVI). Land use change in some degree was one of the main factors affecting the changes of different vegetation indexes. For example, the difference of decreased change rate for three vegetation index (NDVI, f and RVI) caused by arable land was particularly significant, respectively, 76.9%, 30.0%, 45.8%.**

Keywords- Vegetation index; Land use change; TM image data; Changping District

I. INTRODUCTION

In the past century, the global climate change caused by human activities had impact on a huge change of the global ecosystem, land use and vegetation cover, which has been paid more and more attention by people. Vegetation as a major component of the ecosystem is the basis of the existence of ecosystems, but also it links the soil, atmosphere and water for natural "tie" explaining its land surface energy exchange processes, biogeochemical cycle and the hydrological cycle plays, so it plays an important role in global change research by the method of biological indicator action[1]. The spatial and temporal changes of vegetation is the result of the interaction of natural and human activities, especially in today's increasingly severe impact of human activities on nature.

With the rapid socio-economic development in recent years, Changping District, by the impact of urbanization, had lead to dramatic land use changes: area of construction land had been increased year by year, however, arable land had significantly been reduced, so that the area of vegetation cover had the same decreasing trend. By identifying the relationship between changes of land use and vegetation index, it should more clearly explain the law about impact of human activity on the vegetation cover change, which would be helpful for the restoration of vegetation coveraget, also revealing the space variation of surface temperature and the ecological environment valuation in Changping District. It could provide a reference for the protection the ecological environment in Changping District.

II. BACKGROUND OF RESEARCH LOCATION

Changping district is (40°2′18″N ～ 40°23′13″N: 115°50′17″E～116°29′49″E) located in the northwest of Beijing center. Changping is characterized by warm temperate, semi-humid continental monsoon climate. The mean annual sunshine is 2684h. The mean annual temperature is 11.8, and means annual precipitation is 550.3 mm. Its total area is 1352 km^2. Changping is situated on the combined area of floodplain of Wenyu River and offshoot of Yanshan and Taihang mountains. Terrain is from high in northwest to low in southeast. Two third of total area is mountain or mid-mountain. The elevation of mountain area is from 800m to 1,000m, and plain area is from 30m to 100m. The types of land cover vegetation cover changes in elevation gradient.

III. DATA AND METHODOLOGIES

With the support of ArcGIS and ERDAS processing software, it selected TM image data in 1998 and 2009 for atmospheric correction, and then referenced the 1:50,000 topographic maps for geometric correction by selecting more than 30 control points to control error within 0.5 pixel, finally, it calculated three kinds of vegetation index

© 2013. The authors - Published by Atlantis Press

by using linear stretch with 2% for two bands of TM image data.

Normalized difference vegetation index（NDVI）is an effective indicator for monitoring regional or global vegetation and the best indication factor for identifying vegetation growth conditions and vegetation cover [3]. For the TM images, the NDVI could be calculated as following function[4]:

$$NDVI = (TM4-TM3) / (TM4+TM3)$$

Here, TM4 means the reflectance rate of the objects in the near-infrared bands; TM3 is the reflection rate of the objects in red band. The value range of NDVI is in (-1,1), when NDVI <0, it indicates ground cover with the cloud, sand, water, etc.; when NDVI=0, it indicates ground cover with rock or bare soil; when NDVI>0, it indicates ground cover with vegetation cover, and NDVI would increase with increasing coverage, in general, the range of NDVI value from 0 to 1 [5]. Based on calculating normalized difference vegetation index (NDVI) in 1998 and 2009 in Changping District, and according to the changes of NDVI value, it classified three levels for NDVI, namely, lower coverage (0 <NDVI ≤ 0.15), medium coverage (0.15 <NDVI≤0.3), higher coverage (NDVI> 0.3).

The vegetation coverage (f) could be defined as the area percentage of the vertical projection of vegetation within the unit area. It is an important indicator to measure the ecological and environmental conditions. Formula for calculating vegetation coverage is as follows[6]:

$$f=(NDVI-NDVImin)/(NDVImax-NDVImin)$$

Where, NDVI is the normalized difference vegetation index calculated; NDVImin and NDVImax respectively represent the minimum and maximum value of NDVI in the study area. Based on calculating the vegetation coverage (f) in 1998 and 2009 in Changping District, and according to the change range of f value, the value range of f could be divided into different levels. If f = 0, it could be defined as no vegetation cover; if 0 <f ≤ 0.25, it could be defined as lower vegetation coverage; if 0.25 <f ≤ 0.5, it could be defined as medium vegetation cover; if 0.5 <f≤0.95, it could be defined as higher vegetation coverage; if f> 0.95 , it could be defined as the full vegetation cover [7].

Ratio vegetation index (RVI) is the ratio of the two bands reflectivity. Because its structure is simple and it could be easily calculated, even it can effectively reduce noise from soil background and environment, it is widely used in the vegetation spectral analysis. The formula in the paper is as follows:

$$RVI= TM3/TM4$$

Where, TM4 represents the reflectance of the objects in the near-infrared band; TM3 indicates the reflectance of the objects in the near red band. For the area of green healthy vegetation cover, RVI is much larger than 1, without vegetation cover area such as bare soil, artificial construction, water bodies, withered or serious pest vegetation, the value of RVI is about1. In general, the value of RVI is greater than 2. Based on calculating the ratio vegetation index (RVI) in 1998 and 2009 in Changping District, and according to the changes of RVI value, it classified three levels for RVI, namely, lower coverage (0 <RVI ≤ 1), medium coverage (1 <RVI≤2), higher coverage (RVI>2).

Ⅳ RESULTS AND DISCUSSION

A. The trend of different vegetation indexes changes

According to above formulas for three vegetation indexes, it could calculate the normalized difference vegetation index (NDVI) of Changping District during the period of 1998-2009 (see Table 1 and Figure 1). It could be seen that average value of NDVI had the dramatic declined trend. There were obvious differences changes of NDVI among the different vegetation coverage levels, NDVI at the lever of lower and medium coverage had overall rising trend, however NDVI at the lever of higher had sharp decline trend.

Table 1 Normalized difference vegetation index (NDVI) change in 1998 and 2009 in Changping District

Vegetation coverage	1998	2009
Lower coverage（0<NDVI≤0.15）	1057	11145
Medium coverage（0.15<NDVI≤0.3）	3787	16662
Higher coverage （NDVI>0.3）	25156	2193
Average value of NDVI	0.3918	0.1825

It could calculate vegetation coverage (f) of Changping District during the period of 1998-2009 (see Table 2 and Figure 2). It could be seen that f value at the lever of full coverage and average value of f had the declined trend as the same the NDVI change trend. However, the value of f at the other three levers of coverage had the opposite trend.

Table 2 Changes of vegetation cover (f) in 1998 and 2009 in Changping District

Vegetation coverage	1998r	2009
Lower coverage（0<f≤0.25）	221	344
Medium coverage（0.25<f≤0.5）	3702	9029
Higher coverage（0.5<f≤0.95）	20627	26002
Full coverage (>0.95）	50	25
Average values of f	0. 6779	0. 5687

It could calculate the value of the ratio vegetation index (RVI) of Changping District during the period of 1998-2009 (see Table 3 and Figure 3). It could be seen that RVI value at the lever of medium coverage had the increasing trend, however, the RVI value at the other three lever of coverage have the decreasing trend..

Table 3 Ratio vegetation index (RVI) change in 1998 and 2009 in Changping District

Vegetation coverage	1998	2009
Lower coverage（0<RVI≤1）	503	4242
Medium coverage（1<RVI≤2）	8585	25373
Higher coverage（RVI>2）	20912	385
Average value of RVI	2.2819	1.3124

B．Relationship between land use and different vegetation indexes

It respectively overlaid three vegetation indexes with the land use map in 1998 and 2009, so it could see the relationship between land use and NDVI (Table 4), f (Table 5) and RVI (table 6).

Table 4 Relationship between different land use and NDVI in 1998 and 2009 of Changping District

Land use types	1998	2009	Change rate (%)
Arable land	0.3418	0.0788	-76.9
Woodland	0.4114	0.1599	-61.1
Grass land	0.3907	0.1731	-55.7
unused land	0.4115	0.1152	-72.0

Table 5 Relationship between different land use and f in 1998 and 2009 of Changping District

Land use types	1998	2009	Change rate (%)
Arable	0.6610	0.4960	-30.0
Woodland	0.7335	0.6151	-16.1
Grass	0.7098	0.6344	-10.6
Unused land	0.7336	0.5494	-25.1

Table 6 Relationship between different land use and RVI in 1998 and 2009 of Changping District

Land use types	1998	2009	Change rate (%)
Arable	2.1729	1.1784	-45.8
Woodland	2.4585	1.4064	-42.8
Grass	2.3484	1.4238	-39.4
Unused land	2.4449	1.2264	-49.8

From the Table 4,5 and 6, it could see that the reason of declined trend of vegetation indexes came from decreased arable land and woodland, but increased constructed land. Compared with change trend of f and RVI, the NDVI changes had the most dramatic declined trend with arable land reduce, which could defer that more closer relationship between NDVI and land use than the f) and RVI.

With the rapid socio-economic development, there will be more impact of human activity for the land use changes on the vegetation index. Land use change is bound to affect vegetation coverage status, and no doubt affect the change of vegetation index. Therefore, if it does not pay more attention to the protection ecological environment in the region, it can predict what will happen in the future in Changping District. With continuously improving the degree of land use and the gradual expansion of the constructed land in some area, vegetation index changes in Changping district will appear continuous declined trend.

IV. ACKNOWLEDGMENT

Partial funding for this research was provided by National Natural Science Foundation of China (No. 40871232 & 40501029) and Beijing youth backbone teachers project" of Beijing higher education school education plan in 2011 (No. PHR201108286), and the creative group project from Prof. Zhao Jianzhuang. Otherwise, Liu Yun and Li Chunlei have the same contribution for the article, and they are the corresponding authors.

REFERENCES

[1]. Zhang Y X, Li X B, Chen Y H. Overview of field and multi-scale remote sensing measurement approaches to grassland vegetation coverage.Progress in Geography, 2003,18 (1):85-93.

[2]. Xin Z B, Xu J X, Zheng W. Impact of climate change and human activities on vegetation coverage change. Science in China: Series D, 2007, 37 (11) :1504-1514.

[3]. Zhang X X, GE Q S, Zhang J S. Impacts and lags of global warming on vegetation in Beijing for the last 50 years based on remotely sensed data and phonological

information. Chinese Journal of Ecology, 2005,24 (2) :123-130.

[4]. Qi J Y, Chehbouni A K. External factor consideration in vegetation index development .6th International Symposium on Physical Measurements and Signatures in Remote Seneing, 1994,17 (26) :723-730.

[5]. Zheng R B, Zhuang J S, Zhang J Q. The relationship Between NDVI change and land use in Guangzhou city. Remote Sensing for Land & Resources, 2008,76:102-108.

[6]. Zhao Y, et al. Principle and method of Remote sensing application analysis [M]. Beijing: Science Press,2003.374-393.

[7]. Chen YH, Li X B, Shi P J. Estimating vegetation coverage change using remote sensing data in Haidian District, Beijing. Acta Phytoccologica Sinica, 2005,25 (5) :588-593.

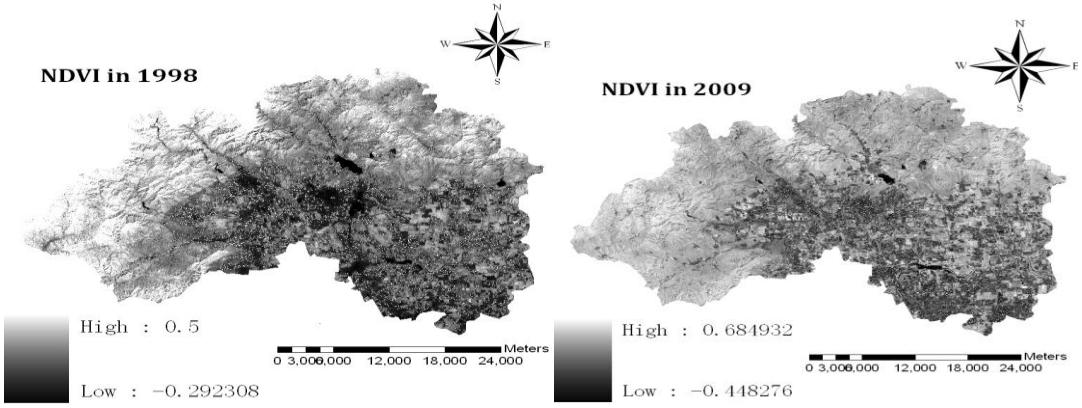

Figure 1 Normalized difference vegetation index (NDVI) distribution in 1998 and 2009 in Changping District

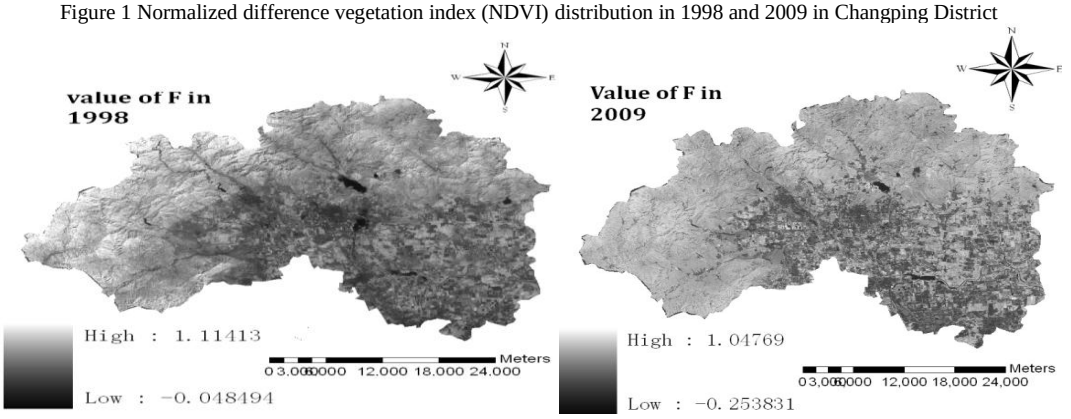

Figure 2 Vegetation cover (f) distribution in 1998 and 2009 in Changping District

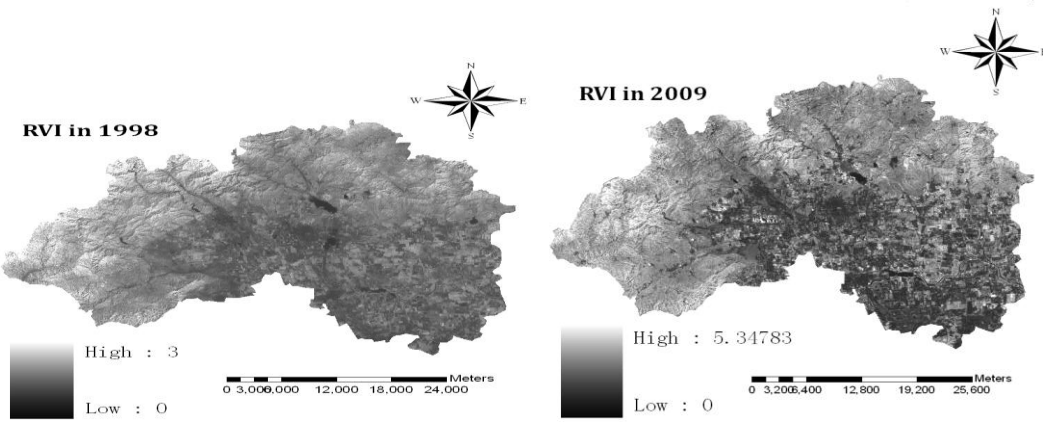

Figure 3 Ratio vegetation index (RVI) distribution in 1998 and 2009 in Changping District