The Influence of Large-Scale Construction on Remote Sensing Ecological Index in Surrounding Areas

Ting Xu, Weiheng Qian, Huaidong Ma, Wenrui Yao
Liaoning Institute of Science and Technology, School of Resources and Civil Engineering, Benxi 117004, China.

Abstract: The construction of large-scale projects will have an impact on regional ecological quality, so it is of great significance for regional development to evaluate the ecological quality of large-scale projects and surrounding areas scientifically and accurately. In this paper, the outward extension of Beijing Daxing Airport is taken as the research area, with a total area of 165.439 square kilometers. Landsat-8 remote sensing images in 2013 (before the construction of the airport), 2017 (during the construction of the airport) and 2019 (after the construction of the airport) are selected. The support vector machine method was used to classify the land cover types in the study area, and the normalized vegetation index, surface temperature, humidity and dryness were extracted as ecological indexes to analyze the impact of large-scale projects on the surrounding areas before and after construction. The results showed that the overall remote sensing ecological index decreased from 2013 to 2019, vegetation decreased, impervious water surface and bare soil area increased, surface temperature increased, humidity and dryness increased.
Keywords: Beijing Daxing Airport; Landsat-8; Heat Island Effect; Remote Sensing Ecological Index

Introduction

Large-scale engineering construction will inevitably have an impact on regional ecological environment. Therefore, accurate and scientific assessment of the ecological quality of large-scale projects and surrounding areas is of vital significance for promoting regional economic development. Yang Huiting[1]accurately described the urban environment with four evaluation indexes, namely vegetation index, humidity component, surface temperature and building index, which were easy to obtain without manual intervention. Yang Dehu et al[2]. analyzed that due to the relatively small water area, it was difficult to identify water bodies with small patch area based on medium-resolution Landsat-8 remote sensing image data, so the land cover types in the study area were divided into vegetation, bare soil and impervious surface.

1. Study area and data source

The research area of this paper extends outward from Beijing Daxing District Airport, with a total area of 165.439 square kilometers. The image data in this paper is from the U.S. Geological Survey (USGS) (earthexplorer.usgs.gov), and the satellite imagery is Landsat-8. A total of three periods of remote sensing image data were obtained in 2013 (before the construction of the airport), 2017 (during the construction of the airport) and 2019 (after the construction of the airport), which can reflect the changes of the remote sensing ecological index of Beijing Daxing Airport before, during and after the construction.

Table 1 Image time and cloud cover

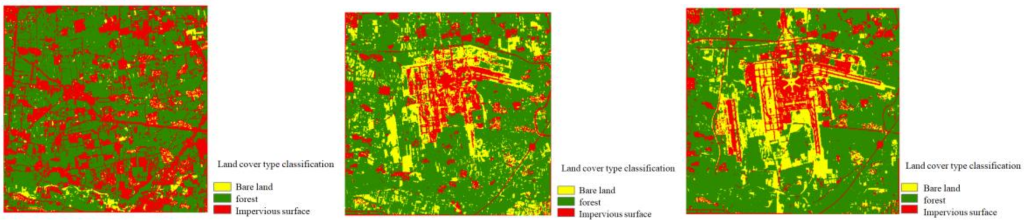
Year	Mouth	cloud cover
2013	9/1	0.80

2017	9/28	0.07
2019	9/2	0.03

2. Experimental results and analysis

2.1 Land cover type classification

In this paper, support vector machine (SVM) is used to classify and extract land cover types in the study area. Firstly, remote sensing images are preprocessed, including radiometric calibration, atmospheric correction, image clipping, etc. Subsequently, the land cover types of the study area mainly include vegetation, bare soil, impervious water surface and some water bodies, among which impervious water surface includes airport runways, roads, residential land and airport buildings.



a.2013 b.2017 c.2019

Figure 1. Land cover type classification results

2.2 Remote sensing ecological index

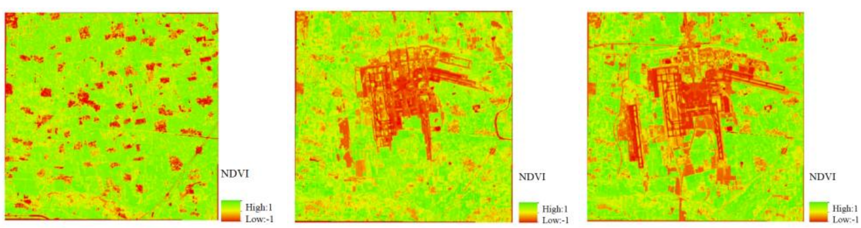
The remote sensing Ecological Index (RSEI) proposed by Xu Hanqiu [3] is a novel index that can achieve real-time and dynamic monitoring of ecological environment in recent years. In this paper, the remote sensing ecological index consists of four evaluation indexes, namely vegetation index, surface temperature, humidity component and building index, which represent the four ecological factors of greenness, heat, humidity and dryness respectively, and then the principal component analysis is carried out.

2.2.1 Normalized Differential Vegetation Index（NDVI）

Normalized Differential Vegetation Index（NDVI）is a remote sensing index used to assess the condition of land cover vegetation, defined as the sum of the difference between near-infrared channel reflectance and visible channel reflectance. The calculation formula is as follows

$$NDVI=(NIR-R)(NIR+R)\ / \qquad (1)$$

In the formula, NIR represents the reflection value of the near-infrared band, and R represents the reflection value of the red band. By calculating the normalized vegetation index, as shown in Figure 2. It can be seen that the normalized vegetation index in the study area was significantly reduced.



a.2013 b.2017 c.2019

Figure 2. NDVI

2.2.2 Land surface temperature retrieval

The single-window algorithm was first proposed by Qin Zhihao[4] to calculate the surface temperature by calculating NDVI, vegetation coverage and surface emissivity. According to the single-window algorithm, the inversion formula of the true surface temperature is as follows:

$$T_s = \{a_6(1-C_6-D_6)+[b_6(1-C_6-D_6)+C_6+D_6]T_6-D_6T_a\}/C_6 \quad (2)$$

$$C_6 = \tau_6\varepsilon_6 \quad (3)$$

$$D_6 = (1-\tau_6)[1+\tau_6(1-\tau_6)] \quad (4)$$

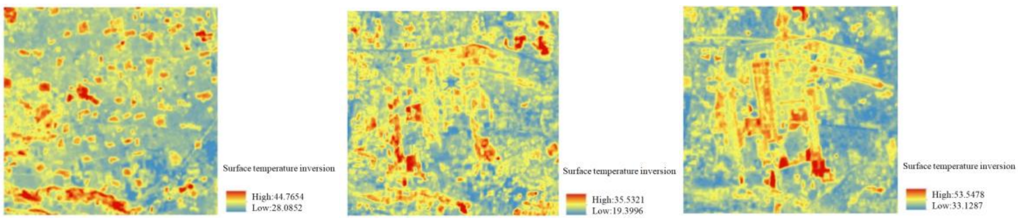
a_6=-60.3263 (5)

b_6=0.43436 (6)

T_S is the surface temperature (K), T_6 is the pixel brightness temperature (K) detected by the satellite altitude sensor, Ta is the average atmospheric action temperature, and τ_6 is the atmospheric transmittance, the surface specific emissivity, Ta's estimation, calculated according to the empirical formula of the tropical average atmosphere:

$$T_a=16.0110+0.9262T_0 \quad (7)$$

T_0 is the measured temperature data (K) of the weather station, and the surface specific emissivity τ is obtained by the threshold method of NDVI. As shown in Figure 3, The area where the airport is being built shows signs of a sudden rise in surface temperatures due to a large number of construction projects. After the construction of Daxing Airport, the high surface temperature area is concentrated in and around the airport, and the high temperature area roughly matches the outline of the airport, indicating that the heat island effect in this area is relatively significant.



a.2013 b.2017 c.2019

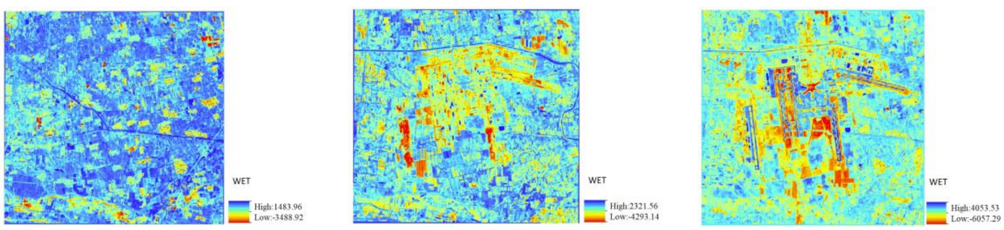
Figure 3. Surface temperature inversion

2.2.3 Humidity index（WET）

The soil moisture index is inverted by hat and hat transformation. The formula for calculating the humidity index is as follows:

Wet=0.2626 B2+0.2141 B3+0.0926b4+0.0656B5-0.7629B6-0.5388B7 (8)

In the formula, B2 represents the blue wave band, B3 represents the green band, B4 represents the red band, B5 represents the near infrared band, B6 represents the short wave infrared band, and B7 represents the short wave infrared band 2.



a.2013 b.2017 c.2019

Figure 4. WET

2.2.4 Dryness index（NDBSI）

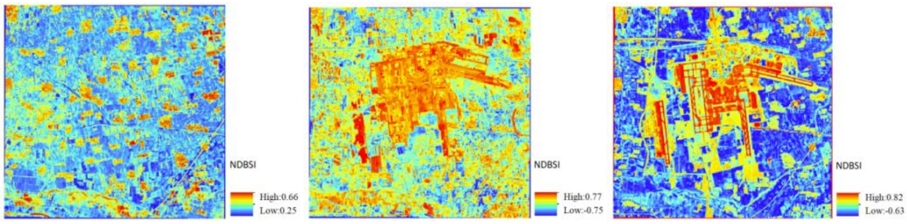
The construction index of the dryness index is selected IBI construction index, which was proposed by Xu Hanqiu in 2007, and the soil index SI is combined. The following is the formula for calculating dryness:

$$SI=B4+B6-B5+B2[B4+B6+B5+B2] \quad (9)$$

$$IBI=\{(2B6B6+B5-[B5B5+B4+B3B3+B6]\}\{(2B6B6+B5+[B5B5+B4+B3B3+B6]\} \quad (10)$$

$$NDBSI=(SI+IBI)/2 \quad (11)$$

As shown in Figure 5：



a.2013 b.2017 c.2019

Figure 5. NDBSI

4. Conclusion

Large-scale engineering construction will inevitably have an impact on regional ecological environment. In this paper, normalized vegetation index, surface temperature, humidity and dryness are used as ecological indexes to monitor the study area. By obtaining remote sensing images in 2013 (before the airport construction), 2017 (during the airport construction) and 2019 (after the airport construction), remote sensing ecological index was extracted. The experimental results showed that: The overall decrease of remote sensing ecological index from 2013 to 2019 was due to the decrease of vegetation, the increase of impervious water surface and bare soil area, the increase of surface temperature, humidity and dryness in the study area.

References

[1] Yang HT, Xu HQ. Vegetation cover change and ecological quality assessment of Wuyi Mountain National Nature Reserve based on remote sensing spatial information [J]. Applied Ecology. 2020(5):533-542.

[2] Yang DH, Meng D, Li YL, Song JY, Gu YC, Yin SZ, Liu W. Remote sensing assessment of ecological quality in surrounding areas before and after large-scale project construction: A case study of Beijing Daxing International Airport [J]. Journal of Earth Sciences and Environment, 2002,44(5):839-849.

[3] Xu HQ. Remote sensing evaluation index of regional ecological environment change. China Environmental Science,2013,33 (5) : 889-897.

[4] Qin ZH, Zhang MH, Arnon Karnieli, Pedro Berliner. A single-window algorithm for land surface temperature calculation using landsat TM6 data[J]. Acta Geographica Sinica, 2001(04): 456-466.

Fund Project: Basic Scientific Research Project (Youth Project) of the Department of Education of Liaoning Province, "Key Technology Research on the characteristics of Temporal and Spatial changes of Urban Heat Island Effect" (LJKQZ20222333).

About author: Xu Ting (1988 -), female, master, lecturer.