Land Cover Change in Xiong' an New Area and Ecological Response Prediction for Its New Area Planning: Postprint

Authors: Xu Hanqiu, Shi Tingting, Wang Meiya, Lin Zhongli

Date: 2017-10-30T00:00:00+00:00

Abstract

Xiong' an New Area is a newly established national-level new area. How to adhere to ecological priority and green development in its construction is an issue that must be considered in the upcoming planning of the new area. Green ecological planning cannot be separated from a clear understanding of the ecological baseline of the planning area, nor from accurate prediction of the planning outcomes. Therefore, based on Landsat images from 2004 and 2015, using remote sensing inversion technology and the RSEI remote sensing ecological index, we assessed changes in the three major cover types—surface impervious surface, vegetation, and water body—in the area over the past 11 years, and predicted the ecological effects of new area construction and its impact on the thermal environment. The results show that although the areas of surface impervious surface, vegetation, and water body in Xiong' an New Area have experienced mutual increases and decreases over the past 11 years, the magnitude of change was less than 5% for all types. The overall development intensity was low, the baseline ecological quality was relatively good, and it remained stable with a slight upward trend. Quantitative analysis shows that among the three major surface cover types in the area, impervious surface has the greatest impact on regional ecology and land surface temperature. According to predictions based on the obtained relationship model, the population planning and land area scheme of the new area will affect regional ecological quality and the thermal environment. If we predict based on a scenario where newly added impervious surface area accounts for 25% of the new area's total area, it will cause ecological quality to decline by 10% and land surface temperature to increase by 1.1°C; however, if the proportion of impervious surface is controlled at 20%, the new area' s ecological quality will instead increase by 3.6% and land surface temperature will decrease by 0.3°C.

Full Text

Preamble

ACTA ECOLOGICA SINICA
ChinaXiv Partner Journal
Vol. 37, No. 19, Oct. 2017
DOI: 10.5846/stxb201705210941

Land Cover Changes in the Xiong' an New Area and a Prediction of Ecological Response to Forthcoming Regional Planning

XU Hanqiu[1,2,3,*], SHI Tingting[1,3], WANG Meiya[1,3], LIN Zhongli[1]
[1]College of Environment and Resources, Fuzhou University
[2]Key Laboratory of Spatial Data Mining & Information Sharing, Ministry of Education
[3]Institute of Remote Sensing Information Engineering, Fuzhou University, Fuzhou 350116, China

*Corresponding author. E-mail: hxu@fzu.edu.cn

Abstract

The Xiong' an New Area is a recently established state-level new area in Baoding, Hebei Province, China. Green construction and development are critical priorities for planners in the forthcoming construction of the new area. Green ecological planning cannot be implemented without a clear understanding of an area' s ecological status and an accurate prediction of how that status will respond to upcoming regional planning. Therefore, using Landsat images from 2004 and 2015, feature inversion and extraction techniques, and the remote sensing-based ecological index (RSEI), this study investigated changes in three main land cover types (impervious surface, vegetation, and water) in the Xiong' an New Area over the last 11 years from 2004 to 2015 and predicted the ecological and thermal effects responding to the upcoming regional construction.

The results show that the areas of impervious surface, vegetation, and water covers have changed over the 11-year study period, but the change intensity was less than 5%. In addition, the ecological status was stable during the study period as the RSEI increased only slightly from 0.629 in 2004 to 0.639 in 2015. Therefore, the overall development intensity was relatively low, and the area' s current ecological quality is good. Quantitative analysis indicates that the area of impervious surface has the strongest influence on both ecological quality and land surface temperature among the three main land cover types of the area. The area' s ecological responses to upcoming regional planning were predicted using regression relationship models of RSEI and land surface temperature with the three main land cover types. The prediction, based on the known goal of population and area development, revealed that the increase of population to

2.5 million with a 25% impervious surface cover in the new area would have noteworthy effects on regional ecological conditions, potentially decreasing the area' s RSEI by 10% and increasing land surface temperature by 1.1°C. Alternatively, if the proportion of impervious surface could be controlled within 20%, the area' s RSEI would increase by 3.6%, and land surface temperature would decrease by 0.3°C.

Keywords: Xiong' an New Area; Remote Sensing-based Ecological Index (RSEI); land cover; regional planning; model prediction

Foundation item: National Natural Science Foundation of China (41501469)
Received date: 2017-05-21; **Revised date:** 2017-07-17

1. Introduction

On April 1, 2017, Xiong County, Anxin County, and Rongcheng County in Baoding City, Hebei Province, along with some surrounding areas, were established as a national-level new area. Located in the hinterland of the Beijing-Tianjin-Baoding urban triangle, the Xiong' an New Area will make significant contributions to relieving Beijing of non-capital functions and optimizing the urban spatial layout and structure in the Beijing-Tianjin-Hebei region. Since early urban planning in China often lacked ecological and environmental considerations, decades of development have revealed the flaws in original planning approaches. Currently, Chinese cities commonly suffer from serious "urban diseases" such as urban heat island effects and air pollution. Therefore, adhering to ecological priority in the construction of Xiong' an New Area is the primary issue that must be considered in the upcoming new area planning.

Green ecological planning cannot be separated from a clear understanding of the ecological baseline of the planning area and an accurate prediction of planning results. Therefore, it is necessary to investigate the basic ecological conditions of Xiong' an New Area and predict the ecological effects of the forthcoming new area planning, which has important practical significance for ensuring the green ecological construction of Xiong' an New Area and important scientific significance for green planning of Chinese cities.

Spatial information technology represented by remote sensing earth observation technology has been widely applied in the ecological environment field. Whether internationally or domestically, remote sensing technology has been applied to ecological surveys and assessments at various scales. For example, the United States' ecological dynamic monitoring of national nature reserves, the "National Ecological Environment Ten-Year Change (2000-2010) Remote Sensing Survey and Assessment" carried out by the Ministry of Environmental Protection, and the currently ongoing national ecological protection red line demarcation work all use remote sensing as an important supporting technology. More and more remote sensing technologies are also being applied to ecological monitoring and assessment of regional and urban planning and construction, and the application of remote sensing ecological index to evaluate ecological effects is gradually increasing.

Since the quality of planning will directly affect the regional ecological environment, the ability to scientifically predict the ecological effects of planning becomes very important. However, current methods, whether traditional or remote sensing-based, lack the ability to predict the potential ecological impacts of planning, and no relevant research reports have been seen to date. Therefore, this paper will use remote sensing information technology to investigate the land cover types and ecological quality changes in Xiong' an New Area in recent years, and combine the planning and construction goals of the new area to predict its potential land cover changes and ecological responses.

---

2. Study Area

The Xiong' an New Area mainly includes Xiong County, Anxin County, and Rongcheng County in Baoding City, Hebei Province. The geographical location is 38°43 -39°10 N, 115°38 -116°20 E. The terrain within the area is basically flat. The area is only tens to more than one hundred kilometers away from Beijing, Tianjin, and Baoding, thus having obvious location advantages. The total area of the three counties is 1566 km^2, with a GDP of 1.88 million yuan. The land cover is mainly farmland, with cultivated land accounting for 69.20% of agricultural land. The area has a warm temperate continental monsoon climate, with an average annual temperature of 12.1°C and average annual rainfall of 560 mm. Baiyangdian Lake, the largest lake in the North China Plain, is distributed within the territory.

[FIGURE:1] Location map of Xiong' an New Area
[FIGURE:2] Landsat remote sensing images of the study area (RGB: bands 7,5,2)

---

3. Remote Sensing Data Sources and Preprocessing

To maintain data source consistency, Landsat series satellite remote sensing images were used. The 2004 image was Landsat 5 TM, and the 2015 image was Landsat 8 OLI/TIRS Level 1T. The images were downloaded from the United States Geological Survey (USGS). The product has already undergone geometric correction, so no geometric correction was needed. The main preprocessing steps were radiometric correction and atmospheric correction.

The Chavez model was used for atmospheric correction to convert the Digital Number (DN) values of the 6 images to at-sensor reflectance. The following formula was used for radiometric correction:

$$\rho = gain \times [L_\lambda - L_h]/(ESUN \times cos\theta_Z \times \tau)$$

where gain is the gain value, L_λ is the spectral radiance value, L_h is the atmospheric correction value (obtainable through the darkest pixel method), ESUN is the average solar irradiance at the top of atmosphere, θ_Z is the solar zenith angle at the image center, and τ is the atmospheric transmittance estimated based on θ_Z. The above parameters can be obtained from the Landsat user manual or image header files. However, since this calculation often leads to overestimation of τ, especially in clear sky conditions, large solar zenith angles, or high northern latitudes, τ is often ignored in practical applications.

For Landsat 8, the following formula was used for radiometric correction:

$$\rho = M_\rho \times Q_{cal} + A_\rho$$

where M_ρ and A_ρ are the adjustment factor and adjustment parameter respectively, and Q_{cal} is the calibrated standard product pixel value (DN). These can be obtained from the image header file.

---

4. Land Surface Temperature Retrieval

The Landsat 5 TM sensor has one thermal infrared band (TM6), while the Landsat 8 TIRS sensor has two thermal infrared bands (TIRS 10, 11). However, due to unresolved calibration parameter errors for the TIRS 11 band, the official website recommends using only the TIRS 10 single band to retrieve land surface temperature. This method can achieve accuracy better than 1.3K when atmospheric water vapor content is less than 3 g/cm^2 and is therefore widely used.

The atmospheric water vapor content on the imaging dates was 1.32 g/cm^2 (2004) and 2.89 g/cm^2 (2015), so this algorithm can be used to retrieve land surface temperature. The Jiménez-Muñoz et al. single-channel algorithm was used to retrieve the land surface temperature of the TIRS 10 band:

$$LST = \gamma \times [(\psi_1 \times L_{sen} + \psi_2)/\varepsilon + \psi_3] + \delta$$

where LST is land surface temperature, L_{sen} is the spectral radiance value at the sensor for the TIRS 10 band, ε is land surface emissivity, and $\gamma, \delta, \psi_1, \psi_2, \psi_3$ are parameters. The emissivity ε was calculated using the algorithm based on vegetation coverage proposed by Sobrino et al. According to the research results of Sobrino et al. and Nichol, the emissivity values for forest land, cultivated land, buildings, and water bodies in the TIRS 10 band are 0.9722, 0.9212, 0.9908, and 0.9813, 0.9823, 0.9908 respectively.

5. Retrieval of Main Surface Parameters

The main surface covers in Xiong' an New Area are construction land represented by impervious surface, vegetation dominated by farmland, and water represented by Baiyangdian Lake. Therefore, this paper focuses on these three main surface cover types.

5.1 Impervious Surface Retrieval

Impervious surface refers to ground that prevents water infiltration, typically composed of roofs, paved roads, and parking lots. Large areas of impervious surface can induce a series of negative ecological effects, such as watershed water pollution, urban heat island effects, destruction of natural habitats, and blocking biological migration. Impervious surface has been used as an important indicator reflecting the ecological environment since the 1970s.

This study used the Normalized Difference Impervious Surface Index (NDISI) to retrieve impervious surface information:

$$NDISI = [TIR-(VIS1+NIR+MIR1)/3]/[TIR+(VIS1+NIR+MIR1)/3]$$

where TIR, VIS1, NIR, and MIR1 are the thermal infrared, one visible light, near-infrared, and mid-infrared bands of the image respectively. NDISI can better distinguish impervious surface from bare soil information without requiring pre-masking of water bodies, and can also quantify the proportion of impervious surface in pixels. It is therefore evaluated as an innovative and relatively simple and efficient technology.

5.2 Vegetation and Water Information Retrieval

The retrieval of vegetation and water information used the NDVI vegetation index and MNDWI water index:

$$NDVI = (NIR - Red)/(NIR + Red)$$
$$MNDWI = (Green - MIR1)/(Green + MIR1)$$

where Red and Green are the red and green bands of the image respectively.

6. Remote Sensing Ecological Index Retrieval

The Remote Sensing Ecological Index (RSEI) is a completely remote sensing information-based ecological index proposed in recent years. It couples four indicators closely related to ecology and directly perceivable by humans: greenness, wetness, heat, and dryness. The index does not use subjectively weighted summation to integrate indicators but uses Principal Component Analysis (PCA) to automatically quantify the contribution of each indicator to ecology. The integrated index has good comparability with the Ecological Status Index proposed by the Ministry of Environmental Protection and has been applied to dozens of cities and regions since its proposal.

RSEI can be expressed as a function of the above four indicators:

$$RSEI = f(Greenness, Wetness, Heat, Dryness)$$

They are represented by NDVI, Wet, LST, and NDSI respectively. The formulas are:

$$Wet = c_{1Blue} + c_{2Green} + c_{3Red} + c_{4NIR} + c_{5MIR1} + c_{6MIR2}$$

where $c_i(i = 1, ..., 6)$ are the coefficients of each band in the tasselled cap transformation. The coefficients for Landsat 5 and Landsat 8 images can be found in the literature.

$$NDSI = (MIR1 - NIR)/(MIR1 + NIR)$$

The NDSI index represents dryness because it can enhance exposed surface information including bare soil and buildings. Before PCA integration, the four indicators must be normalized to unify their values to the range [0,1] rather than using traditional weighted summation. The greatest advantage of PCA is that the weights of indicators are not artificially determined but objectively determined according to the contribution of each indicator to each principal component, avoiding errors caused by subjective weighting.

In PCA, the first principal component (PC1) integrates the information of each variable to the greatest extent. Therefore, PC1 was used to couple the above four indicator variables. To facilitate comparison, PC1 was normalized to make its value between [0,1]. To make larger values represent better ecological conditions, RSEI was calculated as:

$$RSEI = PC1[(NDVI, Wet, LST, NDSI)]$$

7. Results and Analysis

The above methods were used to retrieve impervious surface, vegetation, and water information for Xiong' an New Area in 2004 and 2015. Manual threshold debugging was then used for extraction. Due to the large study area, each theme could not be extracted using only one threshold, so a zonal threshold method was used, followed by appropriate manual modification of each thematic extraction result.

7.1 Accuracy Assessment

300 random sample points were used to verify the accuracy of the retrieved impervious surface, vegetation, and water information. At the same time, the MODIS land surface daily temperature product (MOD11A1) on the same day was used to obtain the mean land surface temperature of the study area for comparison with the mean land surface temperature retrieved in this study. Comparing means can maximize the avoidance of differences caused by different spatial resolutions.

The results show that the extracted information has high accuracy. Google Earth was used for reference data, and the comparison results show that the two are relatively close. The reason for some gaps may be that the overpass times of the two satellites are not exactly the same.

Accuracy assessment table
Comparison of retrieved LST with near-synchronous MODIS LST

7.2 Changes in Main Surface Parameters

Statistics of the extracted impervious surface, vegetation, and water information were obtained to analyze the changes in main surface cover types in the study area over the past 11 years. The results show that the change intensity of main surface cover types in Xiong' an New Area in recent 11 years is not large, and the overall development intensity is relatively low. Specifically, impervious surface and water showed increases, while vegetation showed a decrease. From 2004 to 2015, impervious surface increased by 65.2 km^2, vegetation decreased by 46.55 km^2, and water increased by 38.47 km^2.

Land cover changes in Xiong' an New Area from 2004 to 2015

By screen digitizing, the built-up areas of the three counties in the study area were mapped and their areas were counted. The built-up areas of the three counties did not change much during these 11 years. Xiong County, which had the largest increase, only increased by 16.88 km^2, while Rongcheng County, which had the smallest increase, only increased by 1.53 km^2. However, the impervious surface ratios of the three counties are all very high, basically greater than 70%.

Changes in impervious surface, vegetation and water in Xiong County, Anxin County and Rongcheng County from 2004 to 2015

7.3 Ecological Environment Changes

The PCA data of the remote sensing ecological index show that the eigenvalue of PC1 is the largest among the four principal components, exceeding 0.9 in both years, and can well represent the information of the four indicator variables. The contributions of the indicators can be divided into two groups according to their signs: wetness and greenness have the same sign, playing a positive role in ecology; dryness and heat have the same sign, playing a negative role. This is completely consistent with natural ecological conditions.

Principal component analysis data

The ecological status of Xiong' an New Area is relatively stable, with predominantly good ecological quality. From the statistical data of the two years, the RSEI mean value in 2015 is slightly higher than that in 2004. This is mainly because the vegetation in this area is mainly cultivated land, which is often left bare due to harvest and fallow, directly affecting ecological quality. However, the ecological quality has improved slightly, mainly due to increased wetness and decreased dryness and heat, although greenness has decreased.

Mean values of the four indicators and RSEI in the study area

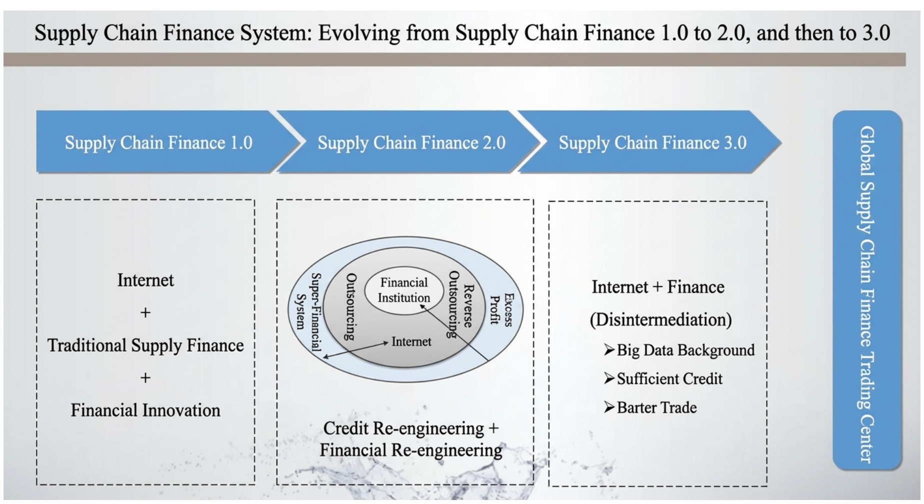

Figure 1: Figure 3

Distribution map of impervious surface, vegetation, and water in Xiong' an New Area

RSEI ecological status maps of Xiong' an New Area in 2004 and 2015

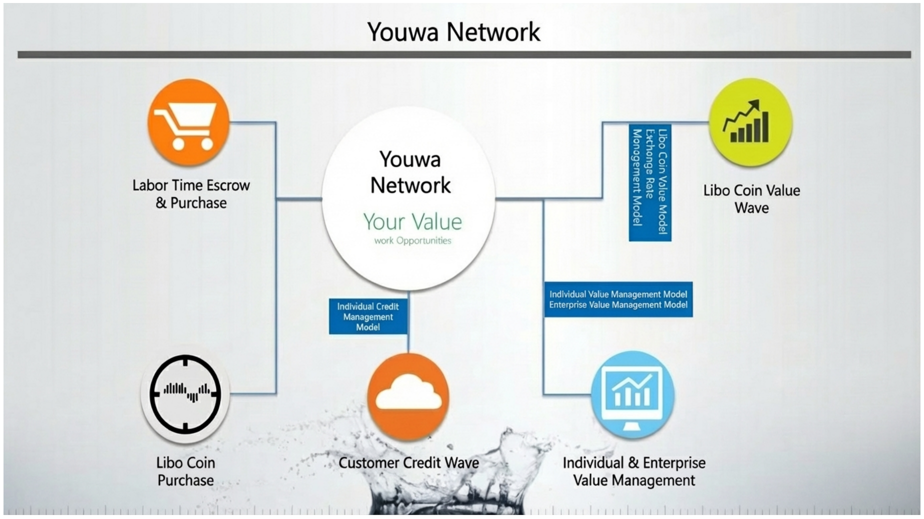

Figure 2: Figure 4

The ecological differences between the two study years can be clearly seen in the figure. The ecological quality in 2004 is not as good as in 2015. There are two reasons: (1) The 2004 image date was more than half a month later than the September 8 image, so in the central-northern part of the area, much cultivated land had been harvested, leaving bare soil. (2) Baiyangdian Lake in the central part was heavily occupied in 2004, with large water areas disappearing. After being interviewed by the Ministry of Environmental Protection in 2015 and given a deadline for treatment, water quality improved significantly, water area increased, and ecological quality of the lake area improved.

Maps showing suspended sediment and chlorophyll concentrations in Baiyangdian Lake

7.4 Analysis of Interaction Between Surface Parameters and Ecological Environment

Analyzing the interaction between land cover types and ecological environment is an important prerequisite for predicting the impact of Xiong' an New Area development on the ecological environment. Using the 2015 data, statistical regression methods were employed to quantitatively analyze the interaction between land cover types and ecological environment to predict the potential impacts of upcoming new area construction on regional ecology and thermal environment.

The normalized impervious surface (NDISI), vegetation (NDVI), and water (MNDWI) thematic images were sampled using a 2 km grid. Remote sensing ecological index (RSEI) was used as the dependent variable for stepwise regression analysis with the three major land cover types, yielding the following

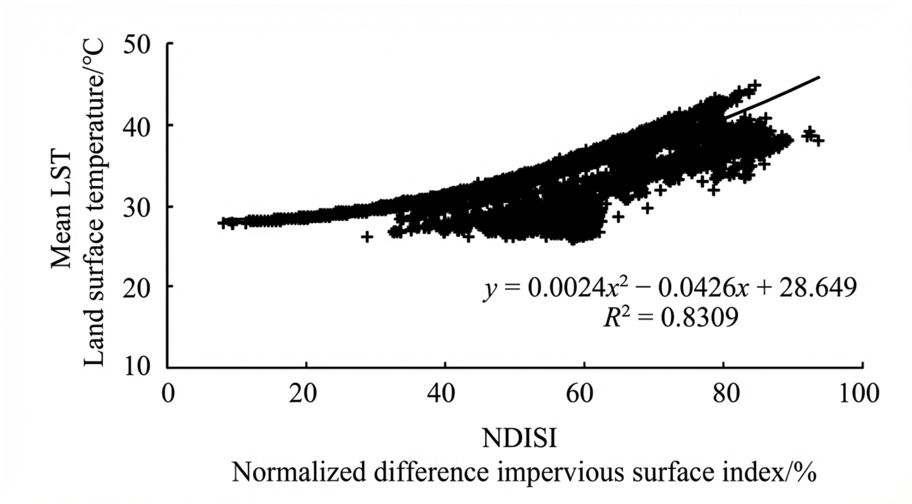

Figure 3: Figure 5

relationship equation:

$$RSEI = -0.011NDISI + 0.006NDVI + 0.002MNDWI + 0.524(R^2 = 0.999)$$

The equation shows that all three land cover types passed the significance test (P < 0.001) and were retained as important factors affecting regional ecological quality. The entire equation also has high consistency. From the signs of the coefficients, NDISI is negative, indicating that impervious surface has a negative effect on ecology, while NDVI and MNDWI are positive, indicating that vegetation and water have positive effects. From the absolute values of the coefficients, the coefficient of NDISI (0.011) is greater than the sum of vegetation and water (0.006 + 0.002), indicating that impervious surface has the most obvious impact on ecology, greater than the combined impact of vegetation and water.

A 3D scatter plot composed of RSEI and its most influential factor, impervious surface, and vegetation shows high scatter aggregation with relatively uniform thickness, presenting a rod shape that is thin at the top and thick at the bottom. This indicates that the ecology of the area is relatively balanced. The thicker lower part of the scatter plot indicates that there are slightly more areas with poor ecology than with excellent ecology, but there is no significant wedge shape seen in other areas.

When the proportion of impervious surface area increases by 1%, the RSEI will decrease by 24.76%. Because the vegetation area in the study area far exceeds the water area, the increase in impervious surface will mainly occupy vegetation. Assuming vegetation and water areas decrease proportionally according to their current ratio, when impervious surface proportion increases by 25%, RSEI will drop significantly from the original 0.639 to 0.481.

Regional surface development and construction will cause changes in the regional thermal environment. The Ministry of Environmental Protection officially issued the national environmental protection standard "Technical Specification for Evaluation of Ecological Environment Status" in 2015, which for the first time introduced urban thermal environment indicators, making them important indicators for evaluating urban ecological environmental quality alongside water quality and noise. Large-scale urban expansion-induced urban heat island effects have attracted worldwide attention. Many studies have shown that impervious surface is the most important factor increasing land surface temperature.

Therefore, regression analysis was further used to study the relationship between impervious surface and land surface temperature. The relationship between impervious surface and land surface temperature in this area is not a simple linear relationship but a quadratic polynomial relationship, indicating that the temperature increase in high-proportion impervious surface areas is significantly greater than in low-proportion areas.

According to the quadratic polynomial equation in Figure 7, when impervious surface proportion is less than 30%, the temperature increase is less than 2-3°C. However, when impervious surface proportion exceeds 70% (high-proportion area), the land surface temperature reaches 37.51°C, which is 5.15°C higher than the average land surface temperature of the entire study area (31.36°C) at the time of satellite overpass. Therefore, the warming effect in high-proportion impervious surface areas must receive sufficient attention.

3D scatter plot
[FIGURE:7] Regression analysis of impervious surface (NDISI) and land surface temperature (LST)

Since temperature is comprehensively affected by the three major surface cover types, to examine their comprehensive impact on land surface temperature, land surface temperature was further regressed with impervious surface, vegetation, and water, yielding the following equation:

$$LST = 0.176NDISI - 0.108NDVI - 0.021MNDWI + 33.528(R^2 = 0.828)$$

NDISI passed the $P < 0.001$ significance test, NDVI passed $P < 0.003$, and MNDWI also passed significance tests, indicating they are all factors affecting land surface temperature. From the coefficients, NDISI is positive while NDVI and MNDWI are negative, indicating that impervious surface has a warming effect while vegetation and water have cooling effects. From the absolute values of the coefficients, the impact of impervious surface on land surface temperature is also greater than the sum of vegetation and water, making it the most important factor causing land surface temperature rise. When impervious surface

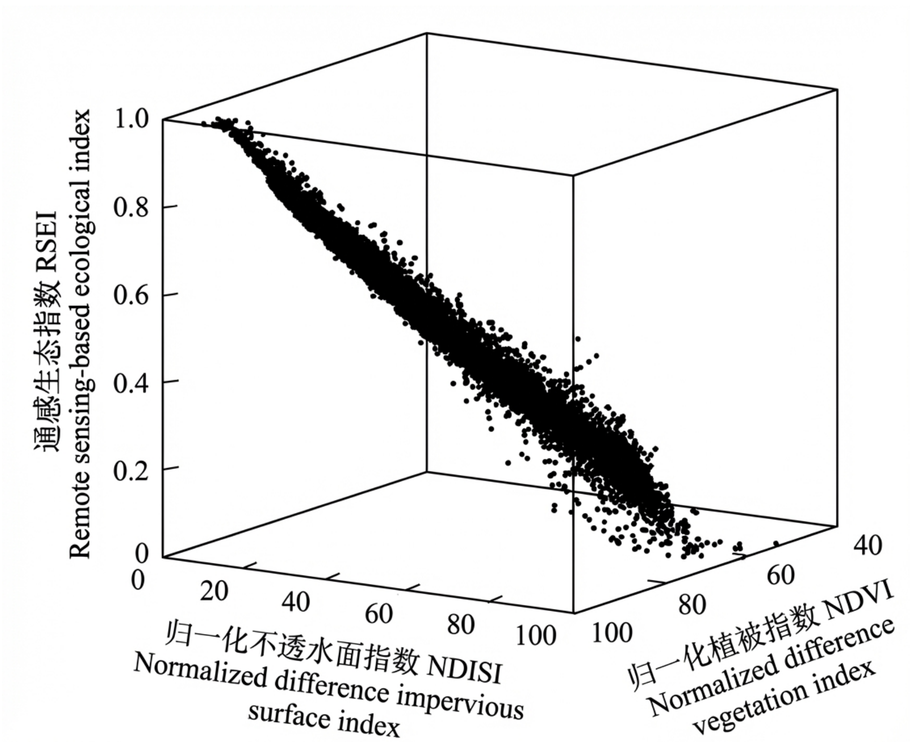

Figure 4: Figure 6

area proportion increases by 1% (with vegetation and water areas decreasing accordingly), land surface temperature will rise by 2.78°C. Therefore, new area development will also face serious regional warming challenges.

Impervious surface levels with corresponding LST

7.5 Prediction of Ecological and Thermal Environment Effects of Xiong' an New Area Planning

The upcoming new area construction will cause major changes in the area' s surface and thus impact the regional ecological environment. Therefore, integrating ecological concepts into planning is an important prerequisite for future new area planning. Remote sensing spatial information technology can predict the impact of new area planning and provide a scientific basis for the green ecological planning and construction of the new area.

Since Xiong' an New Area is still in the planning stage and the only planning indicators disclosed by the media are population targets and new area area, this paper mainly indirectly estimates the increased impervious surface area based on population indicators and new area area. According to the plan, the population will reach 2.5 million, the population density will reach 1250 people/km^2, and the long-term planning area will reach 2000 km^2. The construction of the new area will significantly increase the population and density of the area, which will inevitably impact the area' s ecological environment.

This section uses the area' s 2015 land surface temperature mean and impervious surface area as baselines, then uses formulas (17) and (18) to predict the ecological and thermal environment effects of the increased impervious surface area. The prediction results are shown in Table 8.

From the prediction results, if the proportion of new impervious surface area to total new area is 25%, the impervious surface area of the new area will increase significantly to 500 km^2, which will inevitably have obvious impacts on the area's ecology and thermal environment. This will cause the area' s ecological quality to decline by 9.79% (RSEI decreasing from 0.639 to 0.576), and the average land surface temperature to rise by 1.1°C (from 31.4°C to 32.5°C), meaning the ecological quality level will drop from good to medium.

If the proportion of impervious surface in the new area is further increased, the decline in ecological quality and increase in land surface temperature will be even greater. The Chinese Academy of Social Sciences predicted the area' s population 上限 would be 5 million, which is 2.5 million higher than the current planning scheme. This would inevitably lead to further increases in impervious surface area and greater negative impacts on ecological quality and land surface temperature.

If the proportion of impervious surface area in the new area is controlled at 20%, the ecological quality of the new area would instead increase by 2.5% and land surface temperature would decrease by 0.3°C. This is mainly because the

20% impervious surface proportion is lower than the current 21.04% impervious surface proportion in the area.

The above predictions were made based on the existing surface cover distribution pattern of the area. From the 2015 image, whether in urban built-up areas or farmland, the impervious surface density is very high. To improve the model prediction results, Xiong' an New Area can adopt low-impact green ecological technologies for scientific planning.

Prediction of ecological quality and thermal environment changes responding to potential population growth in Xiong' an New Area

---

8. Conclusions

The construction of Xiong' an New Area is a major national initiative. Rational planning and construction of a green ecological new area is an important symbol of the success of new area construction. This study shows that although the areas of the three major surface cover types in Xiong' an New Area have changed over the past 11 years, the change intensity is not large and the ecological status is generally stable with a slight increase. The overall development intensity of the area is not large, and the ecological quality is good. However, because the surface green cover is mainly cultivated land, the ecological status is easily affected by seasonal changes in crops. The impervious surface ratio in the built-up areas of the area is very high, with all three county towns having impervious surface ratios exceeding 70%, causing the average land surface temperature of built-up areas to exceed the average land surface temperature of the entire study area by 2-3°C. The urban thermal environment of Xiong' an New Area is not optimistic.

All three major surface cover types in Xiong' an New Area affect regional ecological quality and thermal environment, with impervious surface having the greatest impact—exceeding the combined impact of vegetation and water—and showing negative effects. Since the construction of the new area will bring large increases in impervious surface, controlling the proportion and density of impervious surface will be the primary issue to consider in new area planning. This study reveals that impervious surface and land surface temperature have a quadratic polynomial relationship in this area, and the temperature increase in high-proportion impervious surface areas will be several times higher than in low-proportion areas. Therefore, new area planning must strictly control high-proportion impervious surface.

Based on the quantitative relationship models between the three major surface cover types and regional ecological quality and thermal environment obtained in this study, predictions were made for the impacts of the new area' s planned population size and new area on ecological quality and thermal environment. If the proportion of new impervious surface area to new area is 25%, it will cause the area' s ecological quality to decline by 9.79% and land surface temperature to rise by 1.1°C. However, if the impervious surface proportion is controlled at 20%, the new area' s ecological quality will instead increase by 3.6% and land surface temperature will decrease by 0.3°C.

References

[1] Kennedy R E, Andréfouët S, Cohen W B, Gómez C, Griffiths P, Hais M, Healey S P, Helmer E H, Hostert P, Lyons M B, Meigs G W, Pflugmacher D, Phinn S R, Powell S L, Scarth P, Sen S, Schroeder T A, Schneider A, Sonnenschein R, Vogelmann J E, Wulder M A, Zhu Z. Bringing an ecological view of change to Landsat-based remote sensing. Frontiers in Ecology and the Environment, 2014, 12(6): 339-346.

[2] Willis K S. Remote sensing change detection for ecological monitoring in United States protected areas. Biological Conservation, 2015, 182: 233-242.

[3] Remote sensing analysis of ecological changes triggered by emerging island-type city construction: A case study of Pingtan Comprehensive Experimental Zone in Fujian. Chinese Journal of Applied Ecology, 2015, 26(2): 541-547.

[4] Mensah F, Adanu S K, Adanu D K. Remote sensing and GIS based assessment of land degradation and implications for Ghana' s ecological zones. Environmental Practice, 2015, 17(1): 3-15.

[5] Du P J, Xia J S, Du Q, Luo Y, Tan K. Evaluation of the spatio-temporal pattern of urban ecological security using remote sensing and GIS. International Journal of Remote Sensing, 2013, 34(3): 848-863.

[6] Analysis of urban heat island effect based on changes in urban surface parameters. Acta Ecologica Sinica, 2011, 31(14): 3890-3901.

[7] Behlings R, Bochow M, Foerster S, Roessner S, Kaufmann H. Automated GIS-based derivation of urban ecological indicators using hyperspectral remote sensing and height information. Ecological Indicators, 2015, 48: 218-234.

[8] Xu H Q, Lin D F, Tang F. The impact of impervious surface development on land surface temperature in a subtropical city: Xiamen, China. International Journal of Climatology, 2013, 33(8): 1873-1883.

[9] Baoding Municipal Bureau of Statistics. Baoding Economic Statistical Yearbook 2016. (2016-11-01) [2017-05-16]. http://navi.cnki.net/KNavi/YearbookDetail?pcode=CYFD&pykm=YB

[10] Chavez P S Jr. Image-based atmospheric corrections-Revisited and improved. Photogrammetric Engineering & Remote Sensing, 1996, 62(9): 1025-1036.

[11] Ramsey R D, Wright Jr D L, McGinty C. Evaluating the use of Landsat 30m Enhanced Thematic Mapper to monitor vegetation cover in shrub-steppe

environments. Geocarto International, 2004, 19(2): 39-47.

[12] Barsi J A, Schott J R, Hook S J, Raqueno N G, Markham B L, Radocinski R G. Landsat-8 thermal infrared sensor (TIRS) vicarious radiometric calibration. Remote Sensing, 2014, 6(11): 11607-11626.

[13] Jiménez-Muñoz J C, Cristóbal J, Sobrino J A, Sòria G, Ninyerola M, Pons X. Revision of the single-channel algorithm for land surface temperature retrieval from Landsat thermal-infrared data. IEEE Transactions on Geoscience & Remote Sensing, 2009, 47(1): 339-349.

[14] Jiménez-Muñoz J C, Sobrino J A, Skoković D, Mattar C, Cristóbal J. Land surface temperature retrieval methods from Landsat-8 thermal infrared sensor data. IEEE Geoscience & Remote Sensing Letters, 2014, 11(10): 1840-1843.

[15] Sobrino J A, Jiménez-Muñoz J C, Soria G, Romaguera M, Guanter L, Moreno J, Plaza A, Martinez P. Land surface emissivity retrieval from different VNIR and TIR sensors. IEEE Transactions on Geoscience & Remote Sensing, 2008, 46(2): 316-327.

[16] Nichol J. An emissivity modulation method for spatial enhancement of thermal satellite images in urban heat island analysis. Photogrammetric Engineering & Remote Sensing, 2009, 75(5): 547-556.

[17] Xu H Q. Analysis of impervious surface and its impact on urban heat environment using the normalized difference impervious surface index (NDISI). Photogrammetric Engineering & Remote Sensing, 2010, 76(5): 557-565.

[18] Xu H Q. Modification of normalised difference water index (NDWI) to enhance open water features in remotely sensed imagery. International Journal of Remote Sensing, 2006, 27(14): 3025-3033.

[19] Wentz E A, Anderson S, Fragkias M, Netzband M, Mesev V, Myint S W, Quattrochi D, Rahman A, Seto K C. Supporting global environmental change research: A review of trends and knowledge gaps in urban remote sensing. Remote Sensing, 2014, 6(5): 3879-3905.

[20] Tullis J A, Jensen J R, Raber G T, Filippi A M. Spatial scale management experiments using optical aerial imagery and LIDAR data synergy. GIScience & Remote Sensing, 2010, 47(3): 338-359.

[21] Zhang X P, Pan D L, Chen J Y, Zhan Y Z, Mao Z H. Using long time series of Landsat data to monitor impervious surface dynamics: A case study of the Zhoushan Islands. Journal of Applied Remote Sensing, 2013, 7(1): 073515.

[22] Application and prospect of remote sensing technology in impervious layer extraction. Geomatics and Information Science of Wuhan University, 2016, 41(5): 569-577, 703-703.

[23] Creation and application of urban remote sensing ecological index. Acta Ecologica Sinica, 2013, 33(24): 7853-7862.

[24] Remote sensing evaluation of ecological environment quality in Changbai Mountain Nature Reserve. Progress in Geography, 2016, 35(10): 1269-1278.

[25] Remote sensing evaluation index for regional ecological environment changes. China Environmental Science, 2013, 33(5): 889-897.

[26] Dynamic monitoring and analysis of ecological environment quality in Weinan City based on remote sensing ecological index model. Chinese Journal of Applied Ecology, 2016, 27(12): 3913-3919.

[27] Analysis of ecological changes in Nanjing based on remote sensing ecological index. Geospatial Information, 2017, 15(2): 58-62.

[28] Monitoring and evaluation of ecological changes in Yongding mining area based on remote sensing ecological index. Remote Sensing for Land & Resources, 2016, 35(5): 200-207.

[29] Assessment of vegetation coverage change and its ecological effects in typical red soil erosion areas of southern China: A case study of Changting County, Fujian Province. Resources Science, 2015, 30(6): 917-928.

[30] Ecological change assessment based on remote sensing index: A case study of Changning City. Remote Sensing for Land & Resources, 2014, 26(4): 145-150.

[31] Crist E P. A TM tasselled cap equivalent transformation for reflectance factor data. Remote Sensing of Environment, 1985, 17(3): 301-306.

[32] Kearney M S, Rogers A S, Townshend J R G. Developing a model for determining coastal marsh health. // Third Thematic Conference on Remote Sensing for Marine and Coastal Environments. Seattle, Washington: Environmental Research Institute of Michigan, 1995: 527-537.

[33] Baig M H A, Zhang L F, Shuai T, Tong Q X. Derivation of a tasselled cap transformation based on Landsat 8 at-satellite reflectance. Remote Sensing Letters, 2014, 5(5): 423-431.

[34] Kloiber S M, Brezonik P L, Olmanson L G, Bauer M E. A procedure for regional lake water clarity assessment using Landsat multispectral data. Remote Sensing of Environment, 2002, 82(1): 38-47.

[35] Xu H Q. Multi-spectral and multi-temporal remote sensing analysis of water color changes in the sea area around Xiamen. Acta Scientiae Circumstantiae, 2006, 26(7): 1209-1218.

[36] Baoding Municipal People' s Government. 2015 Baoding Environmental Quality Bulletin Released. (2016-06-03) [2017-05-16]. http://bd.hebnews.cn/2016-06/03/content_{5547899}.htm.

[37] Quantitative analysis of the relationship between urban impervious surface and related urban ecological elements. Acta Ecologica Sinica, 2009, 29(5): 2456-2462.

[38] Spatio-temporal evolution of urban surface thermal landscape pattern: A case study of Changchun City. Acta Ecologica Sinica, 2017, 37(10): 3264-3273.

[39] Study on thermal environment of Beijing and its relationship with impervious surface based on TM images. Ecology and Environmental Sciences, 2013, 22(4): 639-643.

[40] Xiong' an New Area population should not exceed 2.5 million. (2017/8/12) [2017-8-23]. http://news.163.com/17/0812/14/CRL5KQ6B00018AOR.html.