Application of remote sensing and GIS technology in urban ecological environment investigation

Qiang Liu

Received: 15 June 2021 / Accepted: 22 July 2021 / Published online: 12 August 2021
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Abstract
The degree of human impact on the environment is closely related to social development. Due to the process of industrialization, economic and social development, and the intensification of human activities, cities are facing serious environmental pollution and ecosystem degradation, which threatens the normal metabolic function and coordinated development of urban ecosystem. These regional ecological and environmental problems seriously threaten the atmosphere, land, and water resources that people rely on for survival and cause great economic losses. The study of the relationship between urbanization and ecological environment is an important part of the study of global environmental change, which is of great significance for the sustainable development of cities and the harmonious development of human and nature. This paper studies the remote sensing image data and night lighting data in the region, and uses appropriate spatial analysis methods in ENVI and GIS to separate the main building areas in the urban center, and quantitatively analyzes the spatial characteristics and the morphological development of urban buildings. Based on GIS and remote sensing technology, combined with pressure state model and analytic hierarchy process, this paper establishes an index system for evaluating urban ecosystem health. Using the method of time, space, quantity, and order of ecological integration, this paper makes a spatial quantitative analysis of geography and obtains the indexes of population disturbance, land reclamation degree, and ecological elasticity. The quantitative measurement of urban population is carried out, and the ecological system, spatial distribution characteristics, and urban evolution law are obtained, as well as the strategies of urban ecosystem in the framework of multi-element communication mechanism.

Keywords Remote sensing · GIS · Urban ecology · Environmental investigation

Introduction
The development of modern industry has made great progress for human society but also brought more and more serious environmental problems, such as greenhouse effect, acid rain, and the decline of biodiversity. With the rapid development of China’s economy, environmental problems are becoming more and more serious. At present, the establishment of ecological civilization has become an important part of the development of China’s socialist cause (Mahatta et al. 2014).

“The overall plan for the reform of ecological civilization system” shows that the construction of ecological civilization affects the sustainable and healthy development of society and must be placed in a prominent position (Zell et al. 2008). The research of urban ecological environment survey based on remote sensing and GIS technology is of great practical significance to improve people’s quality of life and realize the sustainable development of the city. Geographic information system (GIS) was born during the revolution of computer technology. Its establishment has a very far-reaching impact on the scientists of geographic research and related disciplines. Using powerful computer processing function, GIS can collect images or data from satellite or UAV (Manzoor et al. 2015). These are the technical means to collect, store, manage, calculate, analyze, display, and describe geographically dispersed data. In addition to the traditional 3D spatial information, we can also use GIS time scale and spatial scale to analyze and compare the location attribute information changing with time and display the scientific research results

1 School of Architectural Engineering, Chengdu Vocational and Technical College of Industry, Chengdu 610218, Sichuan, China
in the combination of sound, image, and text. Because of the above advantages, the scope of GIS has been extended to cover all aspects of human life (Stokler et al. 2016). This is of great significance to the construction of industry and agriculture, the development of national economy, and the macro-economic decision-making. Most of the research data in this paper are remote sensing data, which record a lot of spectral information about various elements on the surface (Mirza et al. 2007). Various remote sensing platforms, such as satellites or space shuttles, are equipped with sensors to receive information emitted or reflected by the ground objects themselves (Riaz et al. 2014). The main goal of remote sensing research is to decipher all kinds of natural phenomena and geological laws on the ground and determine the relevant remote sensing information through the recovery, processing, analysis, and inversion of remote sensing data (Ramachandra et al. 2011). This paper analyzes the characteristics of spatio-temporal changes in the ecological environment, and uses the core density map and the gray correlation model to show the dynamic evolution rules and the degree of interaction between them, and puts forward political education and political suggestions. In the surrounding areas, the path strategy can be used as a guide for urban sustainable development and ecological environment protection (Pohekar and Ramachandran 2004). In this paper, the spatial distribution characteristics and health level evolution law of each index factor from 2015 to 2020 were quantified by using area discount algorithm, density analysis method, moving window method, comprehensive evaluation model, and other related calculation methods.

Materials and methods

Data source

In this paper, we use the remote sensing images from the “Landsat” series of optical earth observation satellites. The remote sensing information source of the earth resources satellite of the multispectral imager and thematic mapper is transmitted from the satellite with the most stable image, the most widely used range and the longest transmission time. Landsat TM has seven frequency bands with a resolution of 30 m, excluding the long-wave infrared range with a resolution of 120 m, as shown in Table 1.

In the process of exploring the evolution of land use in the city center, this paper will select a series of Landsat remote sensing images covering the city center. Landsat 5tm data was used in 2017, and Landsat 8 data was used in 2018 and 2020. The lane number is 127 and 128, and the line number is 32. The selected images are all images with good imaging quality and less than 2% cloud cover in summer in the study area.

Data preprocessing

Since the date of the acquired remote sensing image data is the same in each period, the state of the reflection surface coverage is not very different, which reduces the error caused by the seasonal inconsistency. Before interpreting the image, atmospheric and geometric corrections are carried out, and then envi5.3 pixel-based maximum likelihood method is used to monitor and classify the image. Land use in the study area can be divided into seven categories: garden land, construction land, woodland, water, cultivated land, grassland, and unused land. By randomly and evenly sampling 50 samples in the region of interest to verify the accuracy, the accuracy of kappa interpretation is maintained. The accuracy of classification is more than 75% in 4 years, which meets the requirements of land use classification accuracy in this paper.

Urban ecosystem health assessment model

Health is a relative concept. The assessment of urban ecosystem health focuses on the spatial differences of ecosystem health rather than establishing absolute health standards. In order to more intuitively express and analyze the results of urban ecosystem health assessment, this paper will use the relative assessment method to rank the assessment methods.

On the basis of previous studies and considering the actual conditions of the study area, such as the natural environment and the level of socio-economic development, this paper divides the state of urban ecosystem into five levels. The specific classification of urban ecosystem health status and related state values is shown in Table 2.

This study uses PSR model and analytic hierarchy process to determine the weight of each scoring indicator, which aims to classify the importance of health status and urban ecosystem status, and finally create a system to evaluate the health status of urban ecosystem, as shown in Table 3.

Population damage rate model: the population damage rate is calculated according to the ratio of the construction land area to the total land area of the area, which is used to express the pressure and stress caused by human activities in the city. The more the population is disturbed, the greater the impact of human activities on the natural surface of the region and the greater the pollution of the ecosystem. The design model is shown in formula (1):

$$PD = CLA / LA$$

\(PD\) is the degree of population destruction, \(CLA\) is the construction land area, and \(LA\) is the total land area.

Land reclamation coefficient model: land reclamation coefficient is calculated according to the ratio of cultivated land area to total land area in the region, which reflects the utilization degree of land resources and the ability of land to
continue to provide resources. The higher the degree of land reclamation, the greater the load of land and the greater the impact on the ecosystem; the design model is shown in formula (2):

\[
LRR = \frac{CA}{LA}
\]

LRR is the land reclamation rate, CA is the area of the area, and LA is the total land area.

Population density model: population density is calculated based on the ratio of population to total land area in a given area, which is used to represent the population density in a city. The higher the population density, the greater the population load and the greater the load on the ecosystem, the calculation model is shown in formula (3):

\[
PD = \frac{PQ}{LA}
\]

Table 1 Parameters of Landsat series satellite sensors

| Sensor                    | Band name       | Types             | Wavelength      | Resolution/ m |
|---------------------------|-----------------|-------------------|-----------------|---------------|
| Thematic plotter of Landsat-2 | Band1           | Blue band         | 0.93–0.22       | 30            |
|                           | Band2           | Green band        | 0.23–0.19       | 30            |
|                           | Band3           | Red band          | 0.19–0.18       | 30            |
|                           | Band9           | Near infrared     | 0.71–0.92       | 30            |
|                           | Band2           | Shortwave infrared | 1.29–1.71       | 30            |
|                           | Band1           | Long-wave infrared | 10.30–12.1      | 30            |
|                           | Band7           | Shortwave infrared | 2.13–2.31       | 30            |
| Landsat8-OLI              | Band1           | Blue band         | 0.932–0.922     | 30            |
|                           | Band2           | Blue-green band   | 0.910–0.922     | 30            |
|                           | Band3           | Green band        | 0.232–0.110     | 30            |
|                           | Band9           | Red band          | 0.190–0.190     | 30            |
|                           | Band2           | Near infrared     | 0.72–0.802      | 30            |
|                           | Band1           | Shortwave infrared | 1.110–1.710     | 30            |
|                           | Band7           | Shortwave infrared | 2.900–2.900     | 30            |
|                           | Band8           | Micron panchromatic | 0.100–0.780    | 12            |
|                           | Band9           | Shortwave infrared | 1.910–1.990     | 30            |
| TIRS                      | Band10          | 10.2             | 10.7–11.3       | 100           |
|                           | Band11          | 12.0             | 11.1–12.1       | 100           |

Table 2 Health classification and state implication of urban ecosystem

| Health classification | Health status   | Ecosystem characteristics                                                                 |
|-----------------------|-----------------|------------------------------------------------------------------------------------------|
| First level           | Very healthy    | The system is stable and vigorous, the ecological structure is reasonable and there are  |
|                       |                 | no abnormalities, the ecosystem is under external pressure and has perfect functions and |
|                       |                 | is in a sustainable development state                                                      |
| Level 2               | Health          | The system is relatively stable and vigorous, the ecological structure is reasonable    |
|                       |                 | and no abnormalities, and the ecosystem is under less external pressure and has         |
|                       |                 | relatively complete functions and is in a state of sustainable development               |
| Level 3               | Sub-health      | The system is stable and has a certain vitality, the ecological structure is             |
|                       |                 | reasonable but some of them are abnormal, and the ecological system can perform basic  |
|                       |                 | ecological functions under greater external pressure and is in a sustainable state      |
| Level 4               | Unhealthy       | There are defects in the system structure, low vitality, and many abnormalities in the  |
|                       |                 | ecological structure. The ecosystem is subject to external pressure and degradation and  |
|                       |                 | is in an uncoordinated state                                                            |
| Level 5               | Morbid          | The system structure is unreasonable, the vitality is low, and there are many            |
|                       |                 | ecologically abnormal areas. The ecosystem is under huge external pressure and          |
|                       |                 | severely deteriorated and is in an extremely uncoordinated state                        |
PD is the population density, PQ is the population, and LA is the total land area.

Normalized vegetation index (NDVI) is obtained by statistical calculation of the difference between near-infrared reflectance and red reflectance as the sum of the two, taking into account the vegetation growth and vegetation degree in the region. The higher the NDVI index is, the better the vegetation condition is and the denser the spatial distribution of vegetation is; the design model is shown in formula (4):

$$NDVI = \frac{NIR - R}{NIR + R}$$

In the formula, NDVI is the normalized vegetation index, NIR is the near infrared reflectance, and R is the red reflectance.

The higher the diversity index is, the more complex the regional land use is, and the higher the degree of fragmentation is. The design model is shown in formula (5):

$$SHDI = -\sum_{i=1}^{m} (p_i) \ln(p_i)$$

In formula (5), PI is the ratio of the area of type I to the total area of the landscape, and M is the ratio of the total number of species in the landscape.

The average patch area index is a complex measure of the number and area of landscape types, reflecting the spatial shape and level of detail of landscape types. It can be used to compare the aggregation or fragmentation of different landscapes; the design model is shown in formula (6):

$$Area_{min} = \frac{A}{N} \times 10^{-4}$$

In the formula, A is the total area of a given landscape type in the area, and N is the number of sites of a given landscape type. The size of Area_min can reflect the aggregation and fragmentation of terrain.

The evenness index can represent the evenness of different types of landscape distribution and the universality of landscape composition; the design model is shown in formula (7):

$$SHEI = -\sum_{i=1}^{m} \left[ \frac{S_i P_i}{M} \right] \ln \left( \frac{S_i P_i}{M} \right)$$

In the formula, PI is the ratio of the area of type I to the total area of the landscape, and M is the ratio of the total number of species in the landscape.

Environmental sustainability refers to the ability of ecosystems to self-regulate, resist, and resist external disturbances, reflecting the potential of regional ecosystem stability and environmental challenges. The degree of environmental sustainability mainly depends on the type of regional land cover, and elasticity can be measured by changing the type of land use; the design model is shown in formula (8):

$$ECO_{res} = \sum_{i=1}^{m} (S_i P_i)$$

In this paper, weighted grid spatial coverage analysis is used to calculate health stress, condition, response, and overall ecosystem scores; the mathematical model is shown in formula (9):

$$S = \sum_{i=1}^{n} W_i R_i$$

where s is the evaluation value of ecosystem health, Wi is the weight value of evaluation index i, Ri is the standardized result of calculating evaluation index i, and N is the number of indicators.

Results

Analysis of urban ecosystem stress assessment results

In this paper, part of the construction land is extracted from the land use type data and is divided into five evaluation levels
using the natural breaks method. As shown in the figure, the greater the disorder of population, the higher the level and spatial distribution of disorder of population, as shown in Figure 1.

Figure 1 shows that from the overall situation of spatial distribution, the population interference degree of the study area has the characteristics of less interference from north to South and more interference from the center. The first and second levels of low disturbance mainly exist in mountainous areas. The types of internal land use are mainly forests and pastures, which are rich in ecological resources and far away from the densely populated central area of the city. Therefore, the disturbance intensity of human activities is relatively low, which is in the fourth and fifth levels of disturbance. The main city of economic development, the area is mainly built-up area, the urban land area is large, the population is dense, and the intensity of human intervention is very high.

The ecosystem health pressure index reflects the pressure of an area on the ecosystem. This paper focuses on the comprehensive influence of the index, population chaos, reclamation rate, and population density. ArcGIS-weighted analysis coverage tool is used to analyze spatial grid cells, in which land reclamation disturbance and population density are expressed in space. Finally, according to the classification standard and spatial distribution of urban ecosystem health, it is divided into five levels. As shown in Figure 2, the stress estimates are obtained.

**Analysis of urban ecosystem status assessment results**

In this paper, fragstats4.2 program is used to express the results of uniformity index measurement in space. The results were standardized in ArcGIS platform, and the spatial results were divided into five levels according to the scoring standard. The more uniform the index is, the lower the ranking is, and the higher the level is, the larger the space of annual evenness index, as shown in Figure 3.

As shown in Figure 3, the homogeneity index under study shows the high and low characteristics of the central and southern regions and the lower in the north, in terms of the overall spatial distribution. The first and second layers with low homogeneity index are distributed in the suburbs far away from each built-up area. The landscape design of this part of the area is less affected by urbanization, and the land is composed of one or more species. The main types of landscape are forest landscape, and the landscape area is divided into groups and uneven distribution. The unified areas with higher fourth and fifth index are mainly distributed in each area adjacent to the urban development. Due to the impact of urbanization, the human development level in these areas is very high. Large land is divided into several types of land and landscape advantages. The land use is decreasing, land use types are becoming rich and balanced, and the uniformity of landscape is also improving. The analysis of the spatial and temporal change trend of the distribution of homogeneity index shows that the degree of landscape homogeneity will continue to increase in each area near the urban center from 2015 to 2020. Combined with the implementation of the remote area environmental space control and the ecological territory policy of the internal forest landscape control, the degree of the policy has increased, and the trend of agglomeration is presented, and the homogeneity of the overall landscape has declined.
ArcGIS platform is used to distribute and calculate area fraction for different land use types and elastic PI and normalize the results. Finally, the results are expressed in space and divided into five grades according to the evaluation criteria. The lower the evaluation level, the more spatial distribution of ecological elasticity, the greater the ecological elasticity, as shown in Figure 4.

Figure 4 shows that, from the overall situation of spatial distribution, ecological elasticity has the following characteristics: high in the north and low in the south. The first and second levels of ecological elasticity are mainly distributed in important land and less dangerous areas. There are many forest resources in this part of the study area, and forests play an extremely important role in maintaining the elasticity of the regional ecosystem. At the same time, the resources of other countries that contribute less to environmental elasticity account for a relatively small share. The ecological elasticity of this area is high, and the areas with low level 4 and level 5 ecological elasticity are mainly distributed in the areas with less important land and more dangerous land. The analysis of the temporal and spatial changes of the distribution of environmental elasticity shows that the environmental elasticity will continue to decline from 2015 to 2020.
Ecosystem health indicators reflect the status and changes of regional ecosystem, as well as the natural structure and environmental factors. This paper focuses on the health indicators of urban ecosystem, including NDVI, diversity index, average plot area index, evenness index, and ecological elasticity. The results of the five index factors of the index are spatially represented by ArcGIS-weighted coverage analysis tool to spatially distribute the spatial grid units of NDVI index, diversity index, average plot area index, evenness index, and ecological elasticity. According to the evaluation criteria, the evaluation results are expressed and finally divided into five levels, and the health status of urban ecosystem is evaluated. The spatial distribution is shown in Figure 5.

The statistical analysis of the assessment results of urban ecosystem health shows that there is a significant difference between the north and the south from 2015 to 2020, and it is getting worse year by year. Health assessment is divided into four levels and five levels, and the scope is gradually expanded from south to north.

Analysis of urban ecosystem response assessment results

In this paper, GIS is used to delimit the land use area from the forest area of the region. According to the classification criteria of urban ecosystem health, the results can be divided into five categories. The lower the grade, the larger the forest area. The spatial distribution is shown in Figure 6.

Figure 6 shows that from the general spatial distribution pattern, there are significant differences between the high and low values of forest coverage. The forest area is mainly distributed in the north, the first and second layers of the forest area. The coverage is mainly distributed in the northeast, mainly in mountainous areas, and the fourth and fifth sparse forest areas are mainly distributed in the central and southern regions. Based on the analysis of temporal and spatial changes of forest coverage distribution, the implementation of eco-environmental spatial control policy from 2015 to 2020 led to a relatively small decline in the area forest coverage, but there is still a trend of forest resources reduction in territorial control areas.

GDP per capita is an indicator of regional economic development, which can reflect a person’s response to the improvement of urban environment. In this paper, China grid data set is used for the spatial distribution of one kilometer GDP, and the results are divided into five levels according to the evaluation criteria to evaluate the state of the ecosystem. The higher the per capita GDP, the lower the estimated level and spatial distribution of per capita GDP, as shown in Figure 7.

As can be seen from Figure 7, in terms of the overall situation of spatial distribution, per capita GDP is usually at a high level, but there are still spatial differences. Among them, there are central and sub-regions with higher per capita GDP, and the per capita GDP is mainly distributed between the economically developed urban centers and peripheral areas; the fourth and fifth level regions with lower per capita GDP are mainly located far away from urban development. It can be seen that people’s overall response to the ecological environment is increasing year by year, but the per capita GDP in some areas is still at a low level, which cannot meet the good coordination between the environmental ecological resources and the required capital.

Analysis of comprehensive evaluation results of urban ecosystem

According to the statistical analysis of urban ecosystem health response assessment results, it can be seen from Table 4 that
the significant difference between them was in 2015. The third level area is located in the North far away from the city center, mainly in the city center and surrounding areas, and the fourth and fifth level areas are mainly located in the areas far away from the city center and suburbs.

The urban ecosystem health stress assessment, health assessment, and response assessment were carried out on the GIS platform, and the weighted coverage analysis tool was used for spatial expression. Finally, according to the classification standard and spatial distribution, it can be divided into five levels. As shown in Figure 8, a comprehensive assessment of the state of urban ecosystem is obtained.

**Discussion**

**Research progress of urban ecosystem health**

**Study on the concept of urban ecosystem health**

Since the Canadian IDRC project was launched, domestic and foreign scientists have conducted in-depth and systematic research on the health of urban ecosystem. The health of urban ecosystems has also been improved. Colin pointed out that urban ecosystems include the complex relationship between people in cities and their environment. Therefore, a healthy
urban ecosystem includes the health of natural environment, built environment, residents, and society. Hancock combines the internal and external links of urban system and integrates environmental, social, and economic factors into the conceptual framework of urban ecosystem health. Li Heng et al. introduced the natural ecology and energy flow of the socio-economic system into the urban ecosystem health system and discussed the change of the urban ecosystem health status. Wang Suxia pointed out that in the process of urbanization, urban ecosystem can develop healthily to achieve the coordination and balance among urban people, economy, and society. Li et al. have confirmed that the water quality of urban rivers is closely related to human activities, and several factors must be considered when studying the ecosystem status of urban rivers. Fu Bojie and others have discussed that it is necessary to carry out multidisciplinary, comprehensive research combining nature with social economy to deal with the changes caused by complex factors when studying regional ecology and ecological problems (Adnan et al. 2012). Kathleen et al. hypothesized that in most environmental studies, human factors are considered to be an inherent negative impact, thus ignoring the interaction between human and natural factors. The combination of human and natural system can effectively solve the problem of ecosystem health in megacities. Pickett and others emphasized that urban ecosystem research covers biology, sociology, and architecture and pointed out that urban ecology research not only focuses on biological communities, but also all social ecosystems.

Application status of urban ecosystem health assessment

In recent years, interdisciplinary research has been included in urban ecosystem health assessment. More and more scientists try to study and analyze urban ecosystem health assessment from different perspectives. Based on reductionism and system theory, Wang Xiaoyue and others established a diagnostic model and index system of “urban diseases” to evaluate the health status of urban areas. Qin combines the concepts of medicine and human health to diagnose the importance of urban circulatory system and reproductive system health. Based on attribute theory, Qin studies the criteria for evaluating urban ecosystem health.

Table 4: Analysis results of urban ecosystem health response assessment from 2005 to 2020

| Years | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
|-------|---------|---------|---------|---------|---------|
| Area /km² | Proportion % | Area /km² | Proportion % | Area /km² | Proportion % | Area /km² | Proportion % | Area /km² | Proportion % |
| 2005  | 2050.91 | 28.31 | 811.32 | 11.15 | 1139.15 | 15.15 | 1829.15 | 25.52 | 1311.91 | 18.35 |
| 2010  | 1825.13 | 25.00 | 798.32 | 10.95 | 1271.35 | 17.39 | 1910.91 | 21.95 | 1932.15 | 19.91 |
| 2015  | 1112.91 | 23.91 | 119.85 | 9.31 | 1317.39 | 19.35 | 2193.15 | 29.15 | 1350.91 | 18.90 |
| 2020  | 1793.51 | 29.51 | 198.79 | 9.21 | 1979.51 | 20.15 | 2171.15 | 30.95 | 1191.23 | 15.91 |
The introduction of mathematical modeling method provides an effective and convenient research method for the study of urban ecosystem health assessment. Su et al.’s analysis model of data set is used to assess the state of urban ecosystem. Li Mengjie and others used fuzzy mathematics model to evaluate the state of urban ecosystem in Nanjing. Xiao Tao and others used probabilistic neural network model to evaluate the health status of urban lake system seasonally (Aras et al. 2004). Chen et al. used projection tracking model and real coding algorithm to calculate the health status of urban ecosystem. Zhang Baosheng et al. used unsafe measurement model to measure multi-index matrix and evaluated and analyzed the health status of Baotou ecosystem. Zhou et al. established the framework of urban ecosystem health assessment model based on emergence analysis model and evaluated and analyzed the health status of urban ecosystem. Ma Shuangshuang et al. used fractal theory to calculate the fractal dimension of the system and quantify the health level and trend of urban ecosystem. Based on the PSR model, He Xin et al. used Moran index to measure the spatial differentiation of urban-rural ecosystem state in grid cells. Prasetya et al. used hierarchical analysis process to study the health indicators of urban coastal ecosystem and the main variables affecting ecosystem health.

Strategies for urban ecosystem health in primary and secondary areas

The first and second health levels of urban ecosystem occupy a large share in the study area, mainly distributed in Conghua District, Zengcheng District, Huadu District, Baiyun District, and the north of Huangpu District. They are important water reserves, and the landscape type is mainly forest. Because of the difficulty of restoring and restoring the ecological environment of these areas after human destruction and destruction, they are important areas for the protection of ecological resources; the management countermeasures in this field mainly include the following aspects.

Strictly layout of urban development space

In order to restrain the development trend of the city to the north, the strategy of environmental priority and strict control is being implemented. In industrial and urban areas, the water protection zone, the restoration of water quality of Baini River, and the water division of Zengcheng river area must be strictly controlled. The development and use are used to ensure the environmental security of the territory, and scientific development efforts are set up according to the environmental sustainability of metropolitan areas, such as development intensity, population distribution, and suitability of land development, while other areas should be carefully developed according to the red line of environmental protection and environmental management and control (Basir et al. 2013).

Strict control of pollution control in the area

The main management and control of industrial and domestic pollution caused by human factors, strengthening pollution detection and control and monitoring mechanism, improving the collection and purification rate of industrial and domestic pollution, and preventing industrial and domestic pollution from discharging into key and sensitive environment.
Strengthen the protection and construction of regional ecological belt

The multi-level and multi-functional network structure of regional ecological network is constructed by making full use of the extensive ecological functions of existing forest, natural reserve, green artificial forest, and protective forest. Carry out all urban environmental planning; strengthen the protection and restoration of landscape, forest, field and lake in the northern part of ecological barrier; increase the area of natural vegetation; strengthen water and soil conservation; improve the development of regional environmental safety mode; update and plant high-quality forest species; and form forest belt network and forest protection system with ecological function and protection benefit (Castillo et al. 2016).

Strategies for urban ecosystem health

There are three levels of urban ecosystem distribution, mainly in Huadu District, Baiyun District, Conghua District, Zengcheng district south, Huangpu District North, Nansha District and other surrounding areas.

Improve the construction of urban ecological isolation zone

The third-level healthy area is a special area. When the inland ecosystem of a certain area is damaged, it will develop in an unhealthy direction, especially into a scattered and small third-level healthy area, which is vulnerable to the influence of the surrounding larger area (Cebecauer and Suri 2016). Therefore, this paper should recognize the sustainable development of the city and strive to improve the construction of regional ecological isolation areas, such as datanwei Baiyunshan huolushan ecological isolation zone, huadushan green isolation zone, and nanshagang Expressway Green isolation zone.

Strengthen the construction of urban green sustainable development

We should implement strategic urban expansion, prevent blind urban expansion, reduce the abuse of land resources in development zones, and improve the reserve capacity of land resources, adjust the industrial structure by using the regional environmental conditions, and reduce the economic development mode from the height of attention to the minimum. An effective model will be transformed into an intensive and efficient model. Investment in new energy technologies such as wind, solar, and biomass energy is increasing to reduce the damage to the original natural ecology.

Coping strategies of urban ecosystem health levels 4 and 5

In the study area, the fourth and fifth health levels of urban ecosystem accounted for the largest proportion. They are mainly distributed in the central part of the urban development center, including Tianhe, Yuexiu, Liwan, Haizhu, Panyu, and other areas. These areas are characterized by high population density and average population density, small area, large landscape fragmentation, low vegetation coverage, and low ecological elasticity. As a result, the ecosystem in this area is subject to external pressure and degradation. The management countermeasures in this field mainly include the following aspects.

Reasonable planning of urban green space system

The interior of the unhealthy area is affected by impervious soil, the average vegetation area is small, the degree of fragmentation is high, and the impact on the environment can be ignored. Therefore, it is necessary to plan urban green space system reasonably, improve green space, and connectivity (Georgiou and Skarlatos 2016). As part of this response strategy, new urban areas should be built to maximize and develop urban green space system. In addition, the scarcity of land and the high cost of rebuilding the old city make it difficult to build green space in the old city. The green space planning of the old city mainly adopts the methods of “separate greening,” “three-dimensional greening,” and “disaster reduction greening.”

Reasonable evacuation of population and function in central urban area

Resource scarcity and high-density pollution seriously affect the health and stability of urban ecosystem. The high population density in the city center is mainly due to the concentration of high-quality public resources and support facilities, which can provide employment opportunities and enhance the ability of income level (Lee et al. 2009). The construction of public resources and supporting facilities around and far away from the urban center should be strengthened, which can reduce the working time, improve the employment level and the quality of life of residents, so as to evacuate the number of people in the city and the central area, and achieve the goal of population outflow.

Control the intensity of urban construction

Because the unhealthy areas are mainly built-up land and the ecological structure is highly unbalanced, the coordinated and optimized development is the core of urban construction and development, so as to avoid the disordered development
caused by the market and the uncontrolled expansion of urban green protection. Prevention and control of water objects in adjacent areas to avoid new man-made damage.

Conclusion

In recent years, the pace of global urbanization is gradually accelerating, and the degree of urbanization in China continues to grow. By the end of 2020, China’s urbanization rate will reach 60.60%. According to the development law of S-type urbanization, China’s urbanization rate has reached the stage of rapid development. The rapid urbanization has brought many problems, but also stimulated China’s social and economic development. Chinese cities are now facing environmental challenges, such as air pollution, energy shortage, garbage disaster, and environmental degradation. Excessive urbanization also disturbs the cycle of urban primitive ecosystem and affects the social and economic development of the city in varying degrees. With the coordinated development of environmental benefits, “urban disease” is becoming more and more serious. With the development of economy, people begin to realize the importance of environment. Many fast-growing countries have to invest a lot of money to manage the environment. However, with the gradual reduction of natural resources and the deterioration of the ecological environment, human survival is also threatened. Ecosystem health research combines the relationship between the health status of regional natural ecosystem, social and economic health status, and human health status, and systematically studies the path and process of ecosystem unrest pressure, so as to discover regional ecosystem and focus on regional complex ecosystem. The focus of ecosystem health research is to solve the health mechanism, health standards in regional ecosystem, natural ecosystem, and socio-economic system and to provide new solutions for the coordinated development of environmental management and urban subsystem. In this paper, environmental is used to preprocess the remote sensing images in four time periods to eliminate the influence of various errors on the data. Supervised classification method is used to explain the urban land use, using remote sensing images to study the region, using ArcGIS, SPSS, Excel and other software, using various indicators to analyze and evaluate the spatial morphological characteristics. Based on GIS and RS technology, this paper takes the city as the research object, combines the PSR model and AHP analysis method, and finally uses the difference comparative analysis to determine the changes of the ecosystem health status in the city. In the past 5 years, through the multi-factor coupling mechanism to optimize the urban health management strategy, in order to better understand the sustainable and dynamic development of urban health.

Acknowledgements

No. [2019]60 of the Scholarship Fund for Teachers of Vocational Colleges, China Scholarship Council, Ministry of Education.

Declarations

Conflict of interest The authors declare that they have no competing interests.

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