Comprehensive evaluation and analysis of ecological environment quality of Laoshan Natural Reserve based on Remote Sensing

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Abstract. We used the remote sensing images of 2001, 2005 and 2010, statistics of reservoir water quality, air quality data, precipitation data and population data to evaluate and analyze the ecological environment quality of Laoshan Natural Reserve. In this decade, the ecological environment of tourism scenic area in Laoshan Natural Reserve becomes significantly better than that of the surrounding area, and it is the urban sprawl and increase of cultivated land area that resulted in the reduction of the scenic plants; Reservoir water quality was stable, but PH value and total nitrogen content still did not meet the standards because of the use of the sewage and pesticide fertilizer in the neighborhood; Air quality decreased slightly, however, the situation of acid rain had improved; Residential population continued to grow in Laoshan district and scenic tourists have increased, so human activity has become the main impacting factor of ecological environment of Laoshan Natural Reserve.

1. Introduction
Laoshan Natural Reserve is located in Qingdao, and has the most complex plant species in the same latitude of China. This area possesses a high ecological conservation and scientific research value. In recent years, with the exploitation of the natural reserve and its surroundings, the disturbance by human activities is becoming more and more serious.
In the early 90's of the last century, Strobel etc. evaluated the estuary eco-environment of Virginia¹. Some researchers combined the human ecological footprint model with the ecological system evolution model for evaluation of urban ecosystem². Some used GIS technology to evaluate the effects of agricultural production on the environment of Clay Mona province in Italy³. In China, with the development of remote sensing and GIS technology, the ability of getting, processing, and analysing information can provide information services to monitor the human environment. Liu Zhuang, Xie Zhiren etc. established the evaluation system of eco-environment in Jiangsu province⁴; Ma Ronghua used TM remote sensing data in 1998 to evaluate the ecological types in Hainan province⁵; Zhang Xiuying and Zhao Chuanyan used MCA method for potential eco-environment evaluation research of Loess Plateau⁶; Du Suojun, Yin Yimin etc. evaluated the eco-environment of Zhang Jiagang⁷; Zheng Hongping, Bai Liang etc. evaluated the eco-environment quality of Fujian province and analysed the dynamic changes⁸; Jiang Zhenlan, Sha Jinming etc. built the eco-environment evaluation model in Fuzhou⁹; Chen Tao, Xu Yao etc. evaluated the...
eco-environment quality of Sichuan province and established the local eco-environment comprehensive evaluation system[10].

In conclusion, remote sensing technology has become an important means of study on ecological landscape pattern. In this paper, we used three Landsat-TM images to monitor the Laoshan Natural Reserve from 2001 to 2011, and integrated multi-source data to evaluate the environmental quality synthetically.

2. Study area and data

2.1. Natural environment conditions
Laoshan is located in the northeast of Qingdao city, the south of Shandong peninsula. Its eastern side is close to the yellow sea. It is located in the middle latitudes, which have the continental monsoon climate. Both sides of Laoshan are close to the sea, and the length of the coastline is 87.3 kilometres long. The coastal landscape is almost marine abrasion landform. There are many plant species in the region, such as forest vegetation, economic crops, economic trees, crops, etc.

2.2. Remote sensing data
The remote sensing data used in this paper is Landsat-7 image in 2001, Landsat-5 image in 2005 and Landsat-5 image in 2010. They are as shown in figure 1.

![Figure 1. Remote sensing data](image)

2.3. Other data
We also collected the monitoring data of water quality from four reservoirs in the natural reserve (table 1), the air monitoring data, the statistical data of precipitation and demographic (table 2).

| Table 1. Monitoring data of water quality |
|-----------------------------------------|
| Reservoir | 2001 | 2005 | 2010 |
|-----------|------|------|------|
| Dahedong  | III  | PH, total nitrogen | PH, total nitrogen | II  | total nitrogen |
| Dashicun   | III  | null  | II   | null |
| Quanxinhe  | II   | null  | I    | null |
| Liuqinghe  | II   | total nitrogen | II   | total nitrogen |

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Table 2. Monitoring data of air, precipitation, demographic

| year | SO₂ | CO  | NO₂ | NOₓ | PM₁₀ | pH value in rain | acid rain (%) | quantity |
|------|-----|-----|-----|-----|------|-----------------|--------------|----------|
| 2001 | 0.34| 0.90| 0.013| 0.095| 5.19 | 29.79            | 191881       |
| 2005 | 0.053| 1.3 | 0.025| 0.090| 6.27 | 0.0             | 214634       |
| 2010 | 0.045| 1.3 | 0.025| 0.090| 6.43 | 0.0             | 241818       |

3. Extraction and analysis on the types of landscape ecology

3.1. Landscape ecological types extraction and characteristic analysis

We pre-processed remote sensing image of the three years (2001, 2005, 2010), and used GIS software to make the graph of landscape ecological classification system (figure 2). The ecological classification system is shown in table 3.

Table 3. Ecosystem classification system

| Level 1 class | Level 2 class          |
|---------------|------------------------|
| 1             | Forest                 |
| 2             | Water                  |
| 3             | Plough                 |
| 4             | Artificial surface     |
| 5             | Bare soil              |
|               | Mixed broadleaf-conifer Forest |
|               | Reservoir              |
|               | Canal                  |
|               | Farmland               |
|               | Residence              |
|               | Industrial land        |
|               | Transportation land     |
|               | Bare mountain          |

Figure 2. Extraction results of landscape ecological types

3.2. Analysis of characteristics of landscape pattern

Table 4 is the table of ecosystem landscape area change for ten years in Laoshan Natural Reserve. From the proportion of landscape, we found that forest accounted for maximum, and farmland followed by, while others accounted for smaller and water accounted for minimum. From the situation of area change, we found the area of forest has been reduced during ten years, and the area of residence (including industrial land and transportation land) has increased obviously. The area of farmland is constantly increasing, and the area of water had no change. Setting 2000 to 2005 as the first phase and 2000 to 2005 as the second phase, the area of forest reduced in both phases, but the forest reduction amplitude in the first phase is less than the second phase; the farmland increase...
amplitude in the second phase is obvious higher than that of the first phase; the increased area of residence is the same as farmland, and the increase amplitude in the second phase is higher.

Table 4. Decade change table of ecosystem landscape area

| Type      | 2001       | Percentage (%) | 2005       | Percentage (%) | 2010       | Percentage (%) |
|-----------|------------|----------------|------------|----------------|------------|----------------|
| Forest    | 26316.28   | 56.10          | 21605.05   | 51.87          | 23524.12   | 50.01          |
| Plough    | 11749.77   | 26.04          | 12618.78   | 27.96          | 13239.73   | 28.15          |
| Water     | 1132.47    | 2.51           | 1184.03    | 2.62           | 1179.97    | 2.51           |
| Residence | 5926.22    | 15.35          | 7920.48    | 17.55          | 9093.42    | 19.33          |

3.3. Analysis of change driving mechanism

The area of forest in the Laoshan Natural Reserve trended to reduce in this decade, but the decreasing rate has been declining, which shows that people are paying attention to the survival condition of the natural vegetation in the Laoshan Natural Reserve and have already begun to take some measures to protect the vegetation. As can be seen from the table, the effect of forest protection turned out to be good enough after 2005. The surrounding areas of Laoshan scenic spot had a certain degree of urban sprawl. Residence, industrial land, transportation land, and farmland increased in a certain extent. The increase inevitably reduced the area of natural vegetation, but the area of water reduced little. The main factor that influenced the ecological landscape change has always been the human activities. From the population data of Laoshan Natural Reserve, we can found the population of Laoshan Natural Reserve rendering out the trend of continuous growth during ten years. The population density growth results in the needs of more human housing and food, and the area of residence, industrial land, transportation land, and farmland are constantly increasing. All this leads to the natural vegetation in natural reserve under threat. In the 10 years from 2000 to 2010, the increase of the area of residence and farmland is at the cost of large areas reducing of vegetation resources. Therefore, the most important factor that effects ecological landscape conversion of Laoshan Natural Reserve is human’s driving force.

4. Comprehensive assessment of eco-environment quality

We comprehensively evaluated and analysed the eco-environmental quality of Laoshan Natural Reserve with the information of precipitation, air quality, reservoir water quality, and population change.

(1) Analysis of reservoir water quality

We trimmed the reservoir water quality data of Laoshan Natural Reserve -- the water quality of Dashicun reservoir is standard, but the PH value and total nitrogen are excessive; the water quality of Dahedong reservoir belongs to a good level; the water quality of Liuqinghe reservoir is good, but the total nitrogen is excessive; the water quality of Quanxinhe reservoir achieves class I standard. Overall the water quality in study area is good and all achieve class II standard of surface water (GB3838-2002). But some overweight indicators reflect the local reservoir water has a certain level of pollution. Among them, the exceeding PH value is the reason for the surrounding dam and reservoir construction; the exceeding total nitrogen shows that the reservoir water quality has been the situation of the eutrophication in a certain extent, which is mainly caused by human factors. From population variation of Laoshan Natural Reserve from 2000 to 2010, we can find that due to the increase of the population, the pollution around the reservoir increased. The wastewater emissions, the use of nitrogen fertilizer and pesticide have caused a certain degree of pollution. In addition, the fish and shrimp fed by farmers in the reservoir can also make the nitrogen content of water over top. The rapid development of tourism leads to the increase of restaurant wastewater, and rainfall will also carry the total nitrogen.

(2) Analysis of air quality
According to the datum, the air quality of Laoshan Natural Reserve in 2001 is good. The content of SO$_2$, CO, NO$_2$, and PM$_{10}$ were not overweight. Four kinds of air-monitoring index in 2005 and 2010 were not overweight too, and they have decreased compared with those of 2001. Overall, the air quality of Laoshan Natural Reserve is better, and the local vegetation contributes a lot. In 2001, the impact of PM$_{10}$ in the air became serious for air environmental. Through the survey we found it’s because of the circulating fluidized boiler of the nearby high-tech company that was put into operation in November. That indicates the human activities have a great influence on the composition of air.

(3) Analysis of precipitation quality
The precipitation monitoring data of Laoshan Nature Reserve be obtained in this study mainly used to test the PH value and the rate of acid rain. We found that the PH value of total precipitation is less than the standard of acid rain (5.60) in 2001, and the PH value is greater than 5.19 in 2005 and 2010, which not belong to the scope of the acid rain.

5. Conclusions
(1) In this study, we processed remote sensing images of three years (2001, 2005, 2010) in the Laoshan Natural Reserve, and classified the landscape ecosystem, then we analysed ecological landscape characteristics. Research shows that the eco-environment of tourism scenic spots in Laoshan Natural Reserve is much better than that of the surrounding areas, but the urban expansion of surrounding areas and the increase of cultivated land area have a harmful effect on the eco-environment of scenic spots to a certain extent, such as the decrease of vegetation in scenic spots, and more importantly, the influence for air quality.

(2) The PH value of reservoir water and total nitrogen in the Laoshan Natural Reserve are overweight. The main reason is the sewage discharge and excessive use of pesticide nitrogen fertilizer by nearby residents. In addition, feeding fish and shrimp in the reservoir has a certain impact as well. Through analysed factors such as air quality, population changes, we concluded that the most important factor of eco-environment changes in Laoshan Natural Reserve is the producing practice of human.

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