Assessment and Trend Analysis of Ecological Environment Condition in Beijing during the 13th Five-Year Plan

Yuzheng Zhang [1, *]

[1] The Experimental High School Attached to Beijing Normal University, Beijing, China

* Corresponding author: travis_gilbert@stu.centralaz.edu

Abstract: On the basis of the technical criterion issued by the Ministry of Ecology and Environment of China in 2015, we analyze the changes in the Biological Richness Index, Vegetation Coverage Index, Water Network Denseness Index, Land Stress Index, Pollution Load Index, and their sub-indexes to evaluate the ecological environment quality in Beijing during the 13th Five-Year Plan period and examine how it changed. We use the data from the official website and the ArcGIS tool to calculate each indicator. The findings suggest that compared with the 12th Five-Year Plan period, the ecological circumstances in Beijing overall improved during the 13th Five-year Plan period, of which treatment of the water and air pollutants substantially improved; biodiversity, plant coverage, and land stress marginally better; and the situation of the waterbody roughly remains constant. The findings of this research can be used as a reference for Beijing's future environmental preservation and substantiable development planning.

Keywords: Beijing, Ecological Environment, Ecological Index, Thirteenth Five-year Plan.

1. Introduction

The ecological environment is a general term for the quantity and quality of natural resources that affect human survival and development. Based on ecological theory, ecological environment quality is to analyze the status and changing trend of ecological environment quality at a certain time and space scale according to certain evaluation criteria, to reflect the quality of the ecological environment and its suitability for human survival and economic and social development [1].

Ecological environment quality is closely related to social development. In order to guarantee the regional ecological environment, it is necessary to strengthen the related work of ecological environment quality assessment.

In 2015, the Ministry of Environmental Protection revised and implemented the Technical Criterion [2] on the basis of the environmental assessment standard in 2006 [3]. The criterion standard can reflect regional eco-environmental quality, so as to compare eco-environmental quality in time and space dimensions. Many scholars have used the Criterion to evaluate the ecological environment conditions on at a regional scale [4-10].

In 2016, the government published the environmental protection plan for the 13th Five-Year Plan period of Beijing and determined the guideline of ecological environmental governance from 2016 to 2020.

We will use the criteria in the Technical Criterion [2] to evaluate and summarize the ecological environment quality and the trend of ecological environment change in Beijing during the 13th Five-Year Plan period.

2. Overview of Beijing Ecology Environment

Beijing locates in the north of the North China Plain, with the Yanshan Mountains in the north and the Taihang Mountains in the west, and the Bohai Sea in the east. Beijing has 16,410 square kilometers area, of which 40% of the plain area and 60% of the mountainous area. Beijing locates in a typical semi-humid continental monsoon climate zone, with hot summer, cold winter, and short spring and autumn, causing an uneven distribution of precipitation which concentrated in July and August.

Beijing has more than 200 rivers, most of which originate from the northwest mountains and flow east; has no natural lakes, but built 85 reservoirs concentrated in the western and northern suburbs.

The vegetational form in Beijing is mainly temperate deciduous broad-leaved forest supplemented by temperate coniferous forest and other vegetation. Those vegetational forms vary with height.

Beijing's ecological environment has been gradually improved: the environmental background value was generally consistent, the biological richness decreased slightly, the coverage degree of vegetation and water network was improved, the degree of land stress increased, and the degree of carrying pollutants was significantly improved.

3. Method

We analyze the Ecological Index (EI) of Beijing from 2015 to 2020 and obtained the changing trend of Beijing's ecological environment since 2015.

Ecological Index is determined by Biological Richness Index, Vegetation Coverage Index, Water Network Denseness Index, Land Stress Index, Pollution Load Index, and Environmental Restriction Index.

3.1. Biological Richness Index (BRI)

Biological Richness Index is determined by Biodiversity Index (BI) and Habitat Quality Index (HQ), and can be calculated as Equation (1).

$$BRI = \frac{BI+HQ}{2} \tag{1}$$

Since biodiversity in an area is generally consistent for relatively long periods, the fluctuation of Biodiversity Index is small. Therefore, in the absence of updating Biodiversity Index, the fluctuation of Biological Richness Index could be reflected by the fluctuation of habitat quality index. The weights of Habitat Quality Index for each habitat type are listed in Table.1, and HQ can be calculated by Equation (2).

Table.1. Weights of Habitat Quality Index

Type	Woodland (woo)	Grassland (gra)	Wetland (wet)	Farmland (far)	Construction land (con)	Unutilized Land (unu)
weight	0.35	0.21	0.28	0.11	0.04	0.01

$$HQ = A_{bio} * \frac{0.35*woo+0.21*gra+0.28*wet+0.11*far+0.04*con+0.01*unu}{\text{total area}} \tag{2}$$

A_{bio} is the normalization coefficient of HQ, and the reference value is approximate 511.264. Through the ArcGIS tool, we get the area of each land type in Beijing, and the Habitat Quality Index of Beijing was obtained by multiplying the area by weight and normalization coefficient. Since the BI is not available, we use HQ to approximate BRI. Calculation results are shown in Table.2.

Table.2. Calculation Results of Biodiversity Richness Index

year	2015	2016	2017	2018	2019	2020
BRI (HQ)	45.28	45.36	45.51	45.59	45.70	45.81

3.2. Vegetation Coverage Index (VCI)

$$VCI = A_{veg} * \frac{\sum_{i=1}^{n} p_i}{n} \tag{3}$$

Vegetation Coverage Index can be calculated by Equation (3). In the equation, A_{veg} is the normalization coefficient of VCI and the reference value is approximate 0.012; P represents the maximum monthly mean value of NDVI; n represents the number of pixels in the investigated area. By using the ArcGIS tool, we get the mean value of NDVI from 2015 to 2020. According to the calculation, the VCI is shown in Table.3.

Table.3. Calculation Results of Vegetation Coverage Index

year	2015	2016	2017	2018	2019	2020
VCI	86.72	87.11	87.84	88.63	89.59	89.80

3.3. Water Network Denseness Index (WNDI)

We will use the ratio of river length, water area, and water resource amount to the total area to calculate the Water Network Denseness Index.

$$WNDI = \frac{A_{riv} * river\ length + A_{lak} * water\ area + A_{res} * water\ resource}{3 * total\ area} \quad (4)$$

In Equation (4), A_{riv} is the normalization coefficient of river length and the reference value is approximate 84.370, A_{lak} is the normalization coefficient of water area with a reference value of 591.791, A_{res} is the normalization coefficient of water resource and reference value is 86.387. It obtains the data of river length, water area, and water resources from the official website of Beijing Government. Through calculation, we get the Water Network Denseness Index from 2015 to 2020 in Beijing. The results are shown in Table.4.

Table.4. Calculation Results of Water Network Denseness Index

year	2015	2016	2017	2018	2019	2020
river length	2284.6	2423.7	2433.5	2475.9	2364.2	2338.8
water area	468.64	468.89	469.14	469.4	469.65	469.9
water resource	2676	3506	2977	3546	2436	2576
WNDI	14.24	15.94	15.03	16.11	13.97	14.18

3.4. Land Stress Index (LSI)

The weights of Land Stress Index are listed in Table.5.

Table.5. Weights of Land Stress Index

Type	Severe Erosion (severe)	Moderate Erosion (moderate)	Construction land (construction)	Other Stress (other)
weight	0.4	0.2	0.2	0.2

Thus, the calculation equation of LSI is:

$$LSI = A_{ero} * \frac{0.4 * severe + 0.2 * moderate + 0.2 * construction + 0.2 * other}{total\ area} \quad (5)$$

A_{ero} is the normalization coefficient of LSI and the reference value is approximate 236.044.

This paper gets the data on land stress from *Beijing Bulletin of Soil and Water Conservation* and *Beijing Environmental Statement*, and calculate the Land Stress Index. Since the data of other stress in Beijing from 2015 to 2020 is not available, we use the latest value of other stress, which is approximate 1.00, to reflect them. Since several data of construction areas are not available, we use the interpolation method to estimate those values. The calculation results are listed in Table.6.

Table 6. Calculation Results of Vegetation Coverage Index

Year	2015	2016	2017	2018	2019	2020
severe	183.34	135.14	86.95	38.75	5.65	2.09
moderate	449.02	332.53	216.04	99.55	27.37	12.10
construction	2887.97	3030.40	3152.83	3285.26	3417.69	3550.12
LSI	10.66	10.43	10.19	9.96	9.95	10.26

3.5. Pollution Load Index (PLI)

The Pollution Load Index is determined by the discharge of pollutants in water and air in the investigated region, and weights are as Table.7.

Table.7. Weights of Pollution Load Index

Type	Chemical Oxigen Demand (COD)	Ammonia Nitrogen (NH3)	Sulfur Dioxide (SO2)	Smoke and Dust (SAD)	Nitric Oxide (NOX)	Solid Pollutants (SOL)
weight	0.2	0.2	0.2	0.1	0.2	0.1

$$PLI = \frac{0.2*A_{COD}*COD+0.2*A_{NH3}*NH_3}{total\ annual\ precipitation} + \frac{0.2*A_{SO2}*SO_2+0.1*A_{YFC}*SAD+0.2*A_{NOX}+0.1*A_{SOL}*SOL}{total\ area} \quad (6)$$

A_{COD}, A_{NH3}, A_{SO2}, A_{YFC}, A_{NOX}, and A_{SOL}, are normalization coefficients of discharge of COD, NH_3, SO_2, smoke and dust, nitric oxides, and solid pollutants discarded, separately. According to official statistics from Beijing Environmental Statement and the government official website, we get Pollution Load Index from 2015 to 2020. Table.8 shows the results of the calculations.

Table.8. Calculation Results of Pollution Load Index

year	2015	2016	2017	2018	2019	2020
PLI	30.83	25.05	21.86	20.66	20.83	15.78

3.6. Environmental Restriction Index (ERI)

Environmental Restriction Index is an adjusting index of Ecological Index. It is adjusted based on the occurrence of different levels of environmental events, ecological damage, environmental pollution, and other problems.

Because the data on environmental emergencies and environmental pollution caused by ecological destruction in Beijing is not available, we will not use the Environmental Restriction Index to adjust the Ecological Index of Beijing.

3.7. Ecological Index (EI)

The equation of ecological index is calculated as Equation (7).

$$EI = 0.35 * BRI + 0.25 * VCI + 0.15 * WNDI + 0.15 * (100 - LSI) + 0.10 * (100 - PLI) + (ERI) \quad (7)$$

Through calculation, we get the annual EI as Table.9.

Table.9. Calculation Results of Ecological Index

year	2015	2016	2017	2018	2019	2020
EI	59.98	60.98	61.43	61.97	61.91	62.49

4. Discussion

From 2015 to 2020, Biological Richness Index is overall unchanged but has an increasing trend, Vegetation Coverage Index increases from 86.72 to 89.80, Water Network Denseness Index and Land Stress Index are floated around 15 and 10 separately, and Pollution Load Index decreases significantly. The statistics indicate that pollutants treatment has been greatly improved; biodiversity, vegetation coverage, and land stress have been slightly improved; and the water situation remains the same.

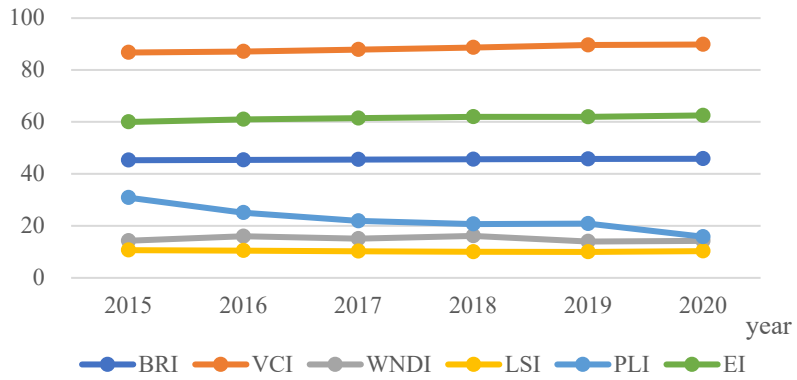

Figure 1. Change of index of Beijing ecological environment condition

Table.10. Changing Value of Environmental Indexes

year	EI	BRI	VCI	WNDI	LSI	PLI
change	2.51	0.53	3.08	-0.07	-0.39	-15.05

Since EI values are roughly 60, the ecological environment in Beijing still needs to be improved. The Ecological Index in 2020 increased by 2.51 compared with 2015, which shows a slight improvement in ecological environment. This changing trend suggests that with the continuous promotion of ecological and environmental work in Beijing during the 13th Five-Year Plan period, the ecological and environmental conditions in Beijing have been continuously improved.

5. Conclusion

This paper uses the evaluation criteria in the Technical Criterion [1] to analyze and evaluate the ecological environment quality of Beijing during the 13th Five-Year Plan period of China, and summarize the current eco-environmental situation and changing trend s of Beijing in this period. The findings suggest that Beijing's ecological environment is at a good level but could still be better; ecological conditions in Beijing have improved slightly in this period; pollution treatment has improved significantly, biological resources, vegetation coverage, and land stress have all improved slightly, and the water situation has remained stable.

Some parts of this study still need improvement. Firstly, statistics for biodiversity should be collected to make more accurate calculation results of Biological Richness Index. Secondly, environmental emergencies and ecological damage data should be collected to calculate Environmental Striction Index. These improvements can reflect ecological environment quality and changing trends more accurately and comprehensively so that the evaluation results can be more consistent with the actual situation.

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