Research on Beijing-Tianjin-Hebei ecological and environmental protection cooperative development

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Abstract. China’s rapidly growing urbanization has brought upon setbacks such as resource depletion and environmental pollution. As an important representative of China’s economic development and urban agglomeration, the Beijing-Tianjin-Hebei Urban Agglomeration’s (BTHUA) coordinated development of eco-environmental protection is still in a lagging state, and the restoration process of eco-environmental governance is relatively slow. Based on the analysis of relevant national demographic data, this study evaluates the current status of the BTHUA’s eco-environmental protection program and the main issues it faces with respect to economic development status, pollutant discharge characteristics, related resources distribution characteristics, and technology resources sharing mechanisms. The results show that the current pollutant emissions and the distribution of scientific and technological resources in the BTHUA are both in an unbalanced state, together with the shortage of sharing mechanisms, resulting in a lower efficiency in the coordinated development of the ecological environment protection in BTHUA. Simultaneously, based on the front-end scientific research results, the corresponding countermeasures and scientific suggestions are put forward for the main bottleneck problems, to provide certain theoretical support for the coordinated development of ecological and environmental protection.

1. Introduction
The Beijing-Tianjin-Hebei urban agglomeration (BTHUA) is not only an important part of China’s economic development urban agglomeration, but also a core area to promote the economic development of the country’s crucial cities. It can be seen from Figure 1, Beijing has merged with 11 cities in Tianjin and Hebei provinces to jointly build a regional innovation community, an innovation made to drive China’s economic growth. The urbanization rate of the BTHUA rose from 38.99% in 2000 to 64.94% in 2017, and the urbanization level increased by 66.56% within 17 years[1]. However, with the continuous densification of the population and industry, rapid urban development and industrialization, the BTHUA’s concerns of resource depletion and ecological environment problems are becoming increasingly alarming, and the contradiction between ecological environment protection and urban development is constantly growing, hence eco-environmental protection has gradually become one of the main reasons restricting the BTHUA’s coordinated development. The BTHUA is located in the North of China, and three adjacent component cities constitute a complete regional system in terms of ecological environment[2]. In the process of the BTHUA’s coordinated development, the central cities continue to draw on public ecological resources, and the natural recovery capacity of the ecological resource supply areas cannot meet the needs of the urban economic
development, and the ecological balance is constantly being broken. At the same time, intrinsic factors such as regional topography, climatic conditions, and soil water qualities have led to delayed restoration and reconstruction of the BTHUA’s ecological environment.

![Figure 1. Location and structural characteristics of the BTHUA.](image)

2. Current status of the BTHUA’s eco-environmental protection coordinated development

2.1. Characteristics of the ecological environment of BTHUA

Table 1. Development indicators of the main region in BTHUA, 2017 [6].

| Development indicators | Beijing | Tianjin | Shijiazhuang | Tangshan | Qinhuangdao | Baoding | Zhangjiakou | Chengde | Cangzhou | Langfang |
|------------------------|---------|---------|--------------|----------|-------------|---------|-------------|---------|----------|----------|
| GDP (10^3 million yuan) | 28.01   | 18.55   | 3.40         | 3.21     | 1.01        | 1.36    | 0.71        | 0.40    | 0.87     | 0.86     |
| GDP per capita (10^4 yuan) | 12.90   | 11.92   | 6.99         | 8.92     | 6.12        | 4.49    | 4.10        | 6.06    | 12.08    | 9.11     |
| GDP growth rate (%)    | 6.70    | 3.60    | 8.10         | 6.70     | 7.40        | 7.25    | 6.50        | 7.22    | 7.68     | 11.75    |

In 2017, the total population of the BTHUA reached 112.48 million people, with a year-on-year increase of 0.4%; the GDP of the BTHUA area reached 805 billion yuan, that’s an increase of 7.05% compared to 2016. The GDP per capita increased from 58058.6 yuan in 2013 to 71625.29 yuan in 2017[1], with an average annual growth rate of 5.39%. Rapid growth in the GDP and GDP per capita marks the positive evolution of the BTHUA city cluster and thereby proves that it is in the process of rapid urbanization. Table 1 shows the economic production indicators of the BTHUA’s main regions in 2017. According to the development and economic scale of major cities, the main regions can be divided into three types: (1) Rich cities: Beijing, Tianjin, Shijiazhuang, and Tangshan; (2) Developed cities: Qinhuangdao, Baoding; (3) Undeveloped cities: Zhangjiakou, Chengde, Cangzhou and Langfang. Compared to 2011[3], Qinhuangdao and Baoding have experienced rapid economic development in the past decade, while Cangzhou and Langfang have both had slower economic developments. The imbalance in the major regions’ economic development is another factor restricting the coordinated development of the BTHUA.
Figure 2 illustrates the changes in the GDP of the BTHUA’s secondary and tertiary industries from 2013 to 2017. As can be seen from the figure, the tertiary industry GDP of Beijing and Tianjin has increased significantly over the years while the secondary industry’s growth trend remains flat, which shows that while the tertiary industry in Beijing and Tianjin is developing rapidly, the ecological space of the secondary industry is compressed to a certain extent, which somewhat promotes the green replacement process of the industry[4]; On the other hand, the GDP of Hebei’s secondary industry, which is dominated by manufacturing and construction, has been increasing year by year. The growth tendencytrend of the tertiary industry that has been squeezed is far lower than that of Beijing and Tianjin. Regional ecological environment spaces continue to shrink, directly increasing the burden of regional ecological and environmental protection coordinated development.

![Graph showing GDP changes](image)

**Figure 2.** Regional GDP and the changes of the secondary and tertiary industries in the BTHUA.

Based on the above characteristics, there is a large gap in economic levels among the three regions, leading to inconsistent main objectives and realizations of collaborative ecological environment management. The BTHUA has shown an accelerated growth trend in terms of population concentration, spatial planning, and economic scale. Nevertheless, the acceleration of urbanization and industrialization has, to a certain extent, led to the destruction of energy, land, space and natural resources, neglected residents’ sense of ecological benefits in the face of direct interests, and the controversy between urban development and the ecological environment has deepened.

2.2. **Pollutant emission of the BTHUA**

The rapid urbanization and industrialization of the BTHUA has led to increasing pressure being exerted on resource consumption and the ecological environment. Urban agglomerations face a myriad of sustainable development challenges[5], including air pollution, solid wastes production, water pollution, ecosystem degradation and shortage of natural resources[6-7]. The total amount of wastewater discharged in Hebei in 2017 was as high as $253.7 \times 10^3$ million tons (Figure 3a), accounting for 53.11% of the total wastewater discharged from Beijing, Tianjin and Hebei; Beijing’s total wastewater treatment capacity was 6.876 million t/d, and its recycling rate was 60.6%, while the recycling rate in Hebei was only 24.8%, and the wastewater treatment capacity was hence relatively insufficient. The total nitrogen and ammonia emissions from the sewage discharged by Hebei are relatively elevated, accounting for 10.7% and 15.5% of the total pollutant emissions, respectively. On the other hand, Hebei’s emission of air pollutants is much higher than that of Beijing and Tianjin (Figure 3b). Among them, the total annual emissions of SO$_2$ and NO$_x$ are as high as $6 \times 10^5$ tons and
1.056 million tons respectively, that’s 30 times and 7.3 times Beijing’s emissions; Tianjin and Hebei have relatively high emissions of industrial source pollutants, with $1.6 \times 10^5$ tons and $1.152 \times 10^5$ tons, respectively. Hebei’s high-carbon industries and winter coal-fired heating are the main sources of atmospheric pollutants[8]. After years of investment in management, Beijing has acquired better control of air pollutant emissions, which might also be potentially related to the distribution and migration characteristics of polluting enterprises. Regarding the generation and treatment of municipal solid wastes, although the volume of domestic solid waste removal and transportation in Beijing in 2017 was quite high (9248 million tons), the harmless treatment rate was as high as 99.99% (Figure 3c). Incineration-based domestic waste treatment plants are mostly concentrated in Hebei (53), which adds a huge burden on secondary pollutant discharge and treatment in Hebei. It can be seen that a large number of pollutants discharged in Hebei and the excessive amount of polluting enterprises are one of the important factors affecting the coordinated development and ecological protection of the BTHUA.

Figure 3. Emissions of major pollutants in the BTHUA in 2017[10-13].
2.3. Governance funds and research institutions

Table 2. Environmental pollution control investment situation of the BTHUA in 2017[13].

| Investment project (10$^2$ million yuan) | Beijing       | Tianjin     | Shijiazhuang | Tangshan     |
|----------------------------------------|---------------|-------------|--------------|--------------|
| Total investment in environmental      | 9539.0        | 665.4       | 71.2         | 605.8        |
| pollution control                       |               |             |              |              |
| Investment in environmental            | 6085.7        | 640.0       | 44.3         | 311.9        |
| infrastructure construction            |               |             |              |              |

Another major contradiction is reflected in the investment in ecological protection and the cost of governance. Considering the increase in pollutant emissions during the BTHUA’s coordinated development, the cost of governance and the investment in environmental infrastructures construction have increased rapidly. As can be depicted from Table 2, the total investment in environmental governance of the BTHUA in 2017 was 134.24 billion yuan, accounting for 14.07% of the country’s total investment in ecological and environmental governance, of which Beijing and Hebei had higher investment amounts of 569.83 and 605.8 billion yuan respectively. 569.83 billion yuan of fixed assets investment in public facilities such as water conservancy and environment, accounting for 6.94% of the country’s total investment, of which Hebei’s environmental fixed asset investment was the highest, reaching 355.42 billion yuan[13]. Beijing’s various investments in environmental pollution treatments are in a relatively high position (Figure 4), and Hebei, the major pollutant discharge area, has invested only 48.73% of Beijing’s environmental infrastructure, and environmental investment accounts for only 1.68% of the GDP; in addition, the Beijing, Tianjin and Hebei region has a highly invested in the cost of pollutants processing, reaching 9.754 billion yuan and 2.453 billion yuan in sewage treatment and solid wastes treatment, accounting for 18.74% and 8.33% of the country’s overall level, respectively.

**Figure 4.** Ecological and environmental protection related investment situation of the BTHUA in 2017[14].

2.4. Enterprise and resource distribution

Universities and research institutes are the core driving forces for the development and innovation of science and technology. As can be seen from Figure 5a, in 2015, there were 234 research institutes and universities in Beijing[9], while Hebei and Tianjin only had 104 and 80 of those respectively[10-12]. The total fixed assets of the city’s scientific research institutions and universities are also much higher than the total in both Tianjin and Hebei. On the other hand, due to the continuous migration and concentration of large and medium-sized enterprises in Hebei, the distribution of industrial institutions and fixed assets investment in the BTHUA is primarily concentrated in the Hebei region (Figure 5b).
As of 2016, the number of industrial institutions in Hebei has become twice that of Beijing, while the number of environmental protection institutions is only 70% that of Beijing. The industrial production process is the main source of pollutants, and the unreasonable industrial and environmental protection industry structure is currently one of the main explanations for this level of environmental pollution in Hebei.

Beijing has outstanding resource advantages in terms of the foundation of national-level scientific laboratories and test bases. According to the statistics, in 2015, the BTHUA region had a total of 1051 research and experimental bases above the designated size (Figure 5c), including 89 national-level engineering experimental bases, of which Beijing has 81, accounting for 91.01% of such resources, while the Hebei Province has only one National-level Engineering Technology Research Center. There are 136 national laboratories and other national-level bases, of which Beijing’s accounts for 91.18% of the total. Due to the extensive demand for scientific research experiments and the shortage of large-scale experimental apparatus, the utilization rate of large-scale scientific instruments in Hebei Province is as high as 102.2% (Figure 5d). Consequently, Beijing has abundant scientific and technological resources and a high-end scientific instruments foundation. The utilization rate of large-scale scientific instruments has remained fairly constant at about 80%, which is considered a suitable equilibrium between resources and demand. There is a clear scale difference in the distribution of industrial and environmental protection enterprises between these three regions. The development of scientific and technological resources such as large-scale scientific equipment and national laboratories is unbalanced, and the gap is large.

**Figure 5.** Development of eco-environmental institutions in BTHUA.
2.5. Resource sharing situation
Judging from the sharing of large-scale scientific instruments and equipment in the BTHUA and large-scale instruments and equipment in national laboratories, the current share of external instruments and equipment in these three places is relatively low. As can be seen in Figure 6, the total amount of large scientific instruments being shared among these three provinces and cities in 2015 was 16341 (sets), of which the total number of external sharing instruments was 8479 (sets), accounting for 43.0% of the total, while the total number of instruments used exclusively or the total number of large-scale instruments shared within the unit is 7862 (sets) [14]. Even though from these three cities and provinces’, the external sharing ratio of Beijing’s large-scale scientific instruments and equipment reaches the highest among the three regions, including internal sharing, the proportion of large-scale scientific instruments participating in sharing is only 82.2%, which is the three regions’ lowest. The sharing rates of large instruments in Tianjin and Hebei are 85.5% and 85.8%, respectively. Under the condition of relatively scarce scientific and technological resources, the share of total resources in Tianjin and Hebei is about three percentage points higher than that in Beijing. The proportion of large instruments not shared in Beijing is as high as 17.8%, which is also the key to the current problem of sharing scientific and technological resources in the three regions of Beijing, Tianjin and Hebei and improving their sharing capabilities.

|       | No Sharing | Internal Sharing | External Sharing |
|-------|------------|------------------|------------------|
| Hebei | 12.9       | 47.7             | 40.1             |
| Tianjin | 13.4      | 51.2             | 35.4             |
| Beijing | 11.6      | 33.8             | 54.6             |

Figure 6. Resource sharing of large-scale instruments in BTHUA.

3. Factors restricting the development of ecological environmental protection

3.1. Unbalanced discharge of pollutants, large investment in treatment costs
It can be found from the BTHUA’s eco-environmental pollutant discharge in recent years that the internal pollutant discharge value in Hebei is pretty high and affects BTHUA’s region ecological environment quality, which is mainly reflected in the discharge of sewage and polluted gas. In addition, the emissions of high-carbon industrial pollutants, as well as the structural layout and degree of development of other polluting industries, have a decisive impact on the quality of the air environment in BTHUA. Beijing, Tianjin, and Hebei are contiguous in geographical distribution, and form a complete ecologic environmental regional system. These three cities’ ecological activities heavily affect the environmental quality of the entire ecological area. Although the intensity of governance and related cleaning technologies have been continuously improved in recent years. Owing to the accumulation of excessively polluting enterprises and treatment plants, as well as the concentrated migration of pollution sources, Hebei is still in a state of severe pollution. As a result, the
development process of urbanization is restricted, and the quality of urbanization, the carrying capacity of the ecological environment, and the capacity for sustainable development are reduced. Eco-environmental construction requires a large amount of capital investment, but the continuous increase in pollutant emissions has led to rising governance costs in the BTHUA in recent years, which has created greater pressure on ecological construction while allocating investment flows. Therefore, under the double pressure, the process of BTHUA coordinated development is more difficult, and the BTHUA coordinated development of ecological and environmental protection has therefore become a high-input and energy-consuming project.

3.2. Unbalanced distribution of institutions and scientific and technological resources
From the perspective of the number of related institutions and investment in fixed assets, Beijing, as my country’s technological and cultural innovation center and economic development driving zone, has a good scientific and technological resource base. Due to their own development restrictions, Tianjin and Hebei have a large gap between Beijing’s science and technology resource base and fixed investment. As of 2016, the number of industrial institutions in Hebei is twice that of Beijing, and the number of environmental protection institutions is only 70% of Beijing; due to the large demand for scientific research and the shortage of large experimental instruments, the utilization rate of large scientific instruments in Hebei Province is as high as 102.2%, while the utilization rate of Beijing-related scientific instruments remains around 80%, reaching a good relationship between resources and demand; Beijing’s total fixed assets in universities and scientific research institutions are 146.69 billion yuan, while Hebei and Tianjin are only 39.27 billion yuan and 30.18 billion yuan. Most industrial and high-pollution companies migrate to Hebei, and Hebei’s environmental protection-related investment and technological development conditions are relatively inadequate, resulting in a large number of pollutants produced in Hebei each year, due to the lack of technology and related systems, it is unable to meet the governance needs, which affects Ecological and environmental protection development of urban agglomerations.

3.3. Shortage of information technology sharing mechanism
At this stage, the three regions have not yet established a perfect cross-regional science and technology resource sharing system, and the efficiency of science and technology resource sharing in each region is relatively low. Beijing, Tianjin and Hebei each deal with internal matters within the region with jurisdiction as the boundary, and each management of ecological environmental resource sharing The forum is “fragmented” and divided far away, there are many shortcomings in the coordination mechanism, and there is a great contradiction between economic development and ecological and environmental protection. In terms of scale in 2015, the proportion of large instruments not shared in Beijing is as high as 17.8%. In the state of relatively scarce scientific and technological resources, Tianjin and Hebei share a total resource sharing ratio of about three percentage points higher than that of Beijing. The key to the sharing of regional scientific and technological resources. Although various regions have introduced relevant reward and compensation mechanisms to improve the sharing efficiency of science and technology resources, due to the far division of the management system and the regional differences in the reward and compensation mechanisms, it is impossible to form a coordinated science and technology resource sharing mechanism, which restricts Beijing, Tianjin and Hebei. Sharing efficiency of local science and technology resources.

3.4. Shortage of sharing mechanisms
At this stage, the three areas of Beijing, Tianjin, and Hebei each take jurisdiction as the boundary to deal with regional internal issues. The sections of ecological environment protection are “fragmented” and far apart; there are many shortcomings in the coordination mechanism and there is a major conflict between economic development and ecological environment protection. Under the layout of coordinated eco-environmental management among the cities in BTHUA, cooperation and exchanges
should be strengthened, awareness of sharing, and collaborative governance capabilities should be equally strengthened. These three cities should be unified.

At the same time, the BTHUA is yet to establish a perfect concept of cross-regional scientific and technological resource sharing. The long-term mechanism for resource sharing can be established in order to strengthen the exchange of technologies and resource sharing between these three places; use next-generation information technologies to establish a platform for sharing scientific and technological information and technical resources, boost the interconnection of ecological constructions and coordinated development in various places; Instill regionalized environmental governance methods and ecological environmental protection compensation mechanisms to promote the coordinated development of the ecological protection program in Beijing, Tianjin and Hebei.

4. Conclusions

The core of the BTHUA eco-environmental coordinated development is to build and improve the three regions’ eco-environmental coordinated development system. The coordinated urban-rural spatial pattern of production is one of the main tasks of the BTHUA coordinated development. Beijing, Tianjin and Hebei should be used as a community of shared destiny to coordinate planning, comprehensive management and resource sharing; based on the long-term effective ecological environment mechanism and resource sharing mechanism, and under the guarantee of perfect coordinated policies, jointly promote the BTHUA ecology Environmental protection construction.

5. Suggestions

5.1. Strengthening organizational management and optimize top-level design

Combine the top-level design of the country with the actual situation in Beijing, Tianjin and Hebei, set up a special management office and a leading group, implement the long-term development plan for the ecological environment of BTHUA, explore effective new paths for coordinated development, and reasonable Plan the top-level design of BTHUA eco-environmental protection development, and build a long-term effective mechanism for the coordinated development of the ecological environment system.

5.2. Optimizing industrial layout and promote overall coordination

Taking Beijing as the center of the functional industry field, clarifying the responsibility system of each region, fully linking the planning policy and the ecological environment mechanism, strictly implementing the requirements of the “Opinions on Strengthening the Construction of Key Platforms for BTHUA Industrial Transfer”, upgrading the regional industrial structure and optimizing the region. The industrial layout, with Xiongan New District as the traction, will relocate environmental protection enterprises and scientific and technological resources to the south of Hebei to a certain extent, transfer some high-quality environmental protection scientific and technological resources to ecological conservation areas, and accelerate the formation of a more reasonable spatial layout.

5.3. Establishing a scientific and technological resource sharing mechanism

Formulate award and supplementary mechanisms and guarantee mechanisms for the sharing of scientific and technological resources in the region, strengthen the technical exchange and resource sharing of the three places, and promote the three regions to maintain long-term mutual contact, mutual penetration and mutual complementation; provide policy guarantee for cross-regional scientific and technological resource consultation and solicitation business And support, encourage R&D institutions, industrial parks, scientific laboratories, engineering technology centers and other relevant institutions to provide cross-regional service projects and provide corresponding government subsidies according to the nature of their services; by optimizing the distribution model of environmental protection science and technology resources in the region, the technology chain, Full integration of industrial chain and commercial chain.
5.4. Establishing a resource sharing service platform

Construct a comprehensive new platform, as shown in Figure 7. On the basis of the existing platform, the use of a new generation of information technology to expand the establishment of scientific and technological information and technical resources sharing platform to strengthen the interconnection of ecological construction and coordinated development in various places, to avoid the “independent” phenomenon of resource information. Construct a comprehensive new platform, as shown in Figure 7. Starting from the innovation needs of small and medium-sized enterprises and related industries in the BTHUA, we will integrate the dispersed ecological and environmental protection technology resources in the urban agglomeration, and promote the sharing of ecological and environmental protection technologies in various regions through the online and offline connection of resource pools. Coordinated distribution with the environmental protection industry provides a good platform support for further cooperation in information sharing, technology sharing, equipment sharing and output sharing among the three places.

![Diagram](image)

**Figure 7.** The structure of BTHUA’s eco/environmental technology service platform.

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