Research Paper

Construction of Multi-Factor Landscape Recreation System Based on the Minimum Cumulative Resistance (MCR) Model

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Abstract

The establishment of a multi-factors ecological landscape recreation system is of great significance in promoting cultural and tourism integration and transforming and developing suburban areas of the city. The Mentougou district of Beijing is rich in natural and historical-cultural resources, with numerous mining areas needing ecological restoration and industrial transformation. Therefore, this study took the Mentougou district of Beijing as the research object, analyzed its historical, cultural, natural reserve, and mining resources, selects typical representatives for three source areas, namely, historical and cultural source areas, natural ecological source areas, and mining source areas, and applies Minimum cumulative resistance(MCR) model to identify and aid in constructing sustainable recreation corridors, thereby forming a multi-factor coupled ecological landscape recreation system. For each element, the following strategies were proposed: the historical and cultural elements should focus on improving accessibility, enhancing the transportation system, and increasing tourability along the route; the natural recreation elements should prioritize protection, establish diverse habitat communities, enhance biodiversity, and limit gray infrastructure development; the mining recreation elements should emphasize cultural and tourism development transformation, and strengthen peripheral supporting facilities construction while ensuring accessibility. Using a quantitative evaluation method, considering the current situation of Mentougou District, this paper constructed a multi-factors recreation system and proposed suggestions for territorial spatial planning tailored to local conditions, aiming to provide a reference for the sustainable transformation and development of Mentougou District and similar regions.

Keywords

Mentougou District; Landscape Recreation System; Minimum Cumulative Resistance Model; Territorial Spatial Planning; Sustainable Transformative Development

1.Intriduction

With the acceleration of urbanization and the transformation of economic structure, the integration of culture and tourism and the transformation and development of urban peri-urban areas have become an important way to promote the sustainable development of the region(Lin et al., 2016, Yu and Song, 2017). Especially in areas rich in natural resources and historical and cultural resources(Li et al., 2021), how to effectively integrate these resources and build an ecological landscape recreation system is not only related to the ecological protection and cultural inheritance of the region, but also the key to realizing economic transformation and social development. Mentougou District in Beijing, as a treasure trove of natural resources and historical and cultural resources(Chen et al., 2020), as well as a concentration of mining areas with urgent needs for ecological restoration and industrial transformation, provides an ideal case for the study(Li et al., 2011).

Mentougou District's natural resources and historical and cultural resources are its unique advantages, but at the same time it faces the dual challenges of ecological restoration and industrial transformation(Yi et al., 2016, Jin et al., 2011, Liu et al., 2009). The establishment of an ecological landscape recreation system aims to promote the integrated development of culture and tourism in the region through the integration of resources such as history and culture, nature reserves and mining areas, and to realize a multi-win situation for economy, society and ecology(Yi et al., 2018). In this study, Mentougou District is selected as the research object, and through an in-depth analysis of the historical and cultural resources, nature reserve resources and mining resources in the region, typical representatives are selected as the three types of source areas, i.e., historical and cultural source areas, natural ecological source areas, and mining source areas, and the Minimum Resistance Model (MCR) is applied to identify and assist in the construction of sustainable recreation corridors to form a multi-factor coupled ecological landscape recreation system. Through the quantitative evaluation method, combined with the current situation of Mentougou District, this paper constructs a multi-factor recreation system and puts forward suggestions for territorial spatial planning according to local conditions. These suggestions are not only applicable to Mentougou District, but also provide a reference for other areas with similar characteristics for sustainable transformation and development. The research in this paper not only helps to promote the integration and transformation development of culture and tourism in Mentougou District, but also provides new perspectives and practical paths for the sustainable development of urban suburban areas.

2. Research framework

First, the Minimum Cumulative Resistance surface for scenic byway construction is obtained by weighted superposition of land use, NDVI, slope, and distance from the road. Then, representative historical and cultural, natural ecological, and mining transformation resource were selected as three types of ecological source sites, and a multilevel scenic recreational path system was constructed on the basis of the minimum resistance surface through the MCR model.

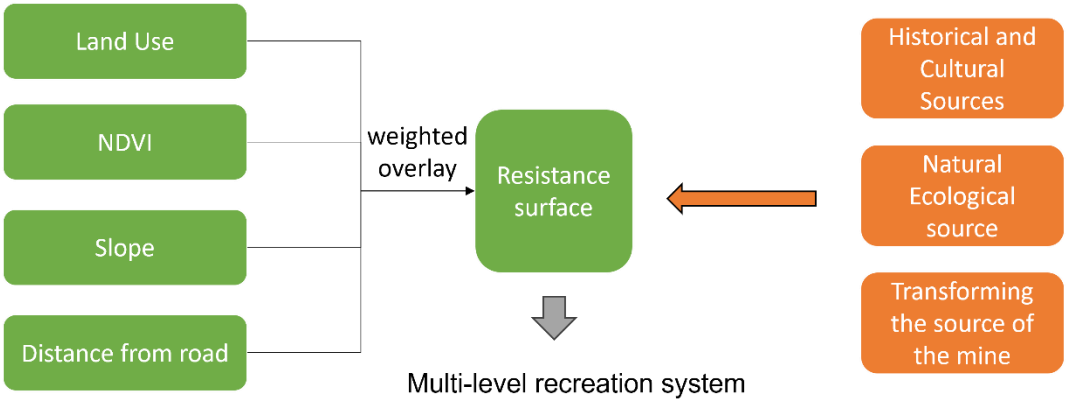

Figure 1. Research framework (source: Author's own drawing)

3. Overview of the study area

3.1.Geographic and Environmental Characteristics of Mentougou District

Mentougou District is located in the southwest part of Beijing, between longitude 115°25 ′ 00" ~ 116°10 ′ 07" ~ north latitude 39°48 ′ 34" ~ 40°10 ′ 37" ~ about 62 kilometers from east to west and 34 kilometers from north to south, with a total area of 1447.85 square kilometers. The total area is 1447.85 square kilometers.

Mentougou District is located in the transition zone from the North China Plain to the Mongolian Plateau, with the terrain high in the northwest and low in the southeast. The terrain skeleton was formed during the Yanshan Movement of the Mesozoic Era, and 98.5% of the total area of Mentougou District is mountainous, with the plain area accounting for only 1.5%. The western part of the mountains is the core part of Beijing's western mountains, which are tall and mountainous, with more than 160 peaks about 1,500 meters above sea level. In the northwestern part, there is the “No.1 Peak in Kyoto”, Lingshan, with an altitude of 2,303 meters, and there are also Hundred Flowers Mountain, Dressing the hair in a bun, and Miaofeng Mountain and other peaks(Chen et al., 2014).

Mentougou District has a mid-latitude continental monsoon climate, with a dry and windy spring, a hot and rainy summer, a cool and wet fall, and a cold and dry winter. The climates of the western mountains and the eastern plains are obviously different, with an average annual temperature of 11.7℃ in the eastern plains and 10.2℃ in the western Jaitang area(Li et al., 2023).

3.2. Overview of Historical and Cultural Resources

Mentougou District is an area in Beijing with a deep historical and cultural heritage, known for its rich red history(Shengjie and Minglv, 2023), folk customs, ancient roads and villages(Ma et al., 2015, Xi and Zhang, 2013), religious temples, the coal industry in western Beijing, geological resources, prehistoric culture, the Great Wall culture(He et al., 2023), farming culture, and glazed culture. These cultural resources not only cover a wide range of historical periods from prehistoric civilization to modern industry, but also include natural landscapes, folk beliefs, traditional handicrafts, and many other aspects, which together constitute the rich and colorful cultural landscape of Mentougou District, making it a typical representative of Beijing's vernacular culture and an important cultural heritage area(Gao, 2020, Yang and Fu, 2017).

3.2. Overview of Ecological Resources

Mentougou District of Beijing is rich in nature reserve resources(Tian et al., 2022), and the following is an overview of the major nature reserve resources in the region(Li, 2023):

a. Beijing Hundred Flowers Mountain National Nature Reserve: Located in the western part of Mentougou District, with a total area of 21,743.1 hectares, the reserve is the largest nature reserve in Beijing, and one of only two national nature reserves in the city. The main protection objects of the reserve are the ecosystems of secondary deciduous broad-leaved forests and rare and endangered species and their habitats in the stony mountains of North China in the warm temperate zone.

b. Beijing Xiaolongmen National Forest Park: located in Qingshui Town, Mentougou District, with a total area of 1,595 hectares, it is dominated by natural broad-leaved forests, deciduous broad-leaved mixed forests, temperate coniferous forests, larch forests and deciduous broad-leaved scrubs, with a forest coverage rate of 91%, and with the highest peak of the main peak, Dongling Mountain, standing at an altitude of 2,303 meters.

c. Tianmen Mountain National Forest Park: located in Mentougou District, covering an area of 669.41 hectares, with the main peak at an altitude of 550 meters, the park has majestic mountains, strange peaks and rocks, and deep forests and valleys, and belongs to the Taihang Mountains.

d. Geological Park: Mentougou District has many geological relics, and most of the representative strata in North China are exposed in the territory of Mentougou, and many stratigraphic units were firstly researched in the territory of Mentougou and named in accordance with the geographical name of Mentougou. Geological relics in Mentougou District include seven categories, including geological (body and layer) sections, geological structures, paleontological fossils, mineral rocks and deposits, geomorphological landscapes, water body landscapes and environmental geological relic landscapes.

e. Other Nature Reserves: Mentougou District has several other levels of nature reserves, including municipal and district-level nature reserves, forest parks and wetland parks.

With its unique geographic location and rich natural resources, Mentougou District has become an important ecological conservation area and an important area for biodiversity protection in Beijing. These nature reserves not only provide habitats for wildlife, but also valuable resources for scientific research, education and ecotourism(Jian et al., 2009).

3.3. Overview of mine resources

The mining resources of Mentougou District in Beijing have a long history of exploitation and rich mineral resources. Mentougou District is located in the western mountains of Beijing, and is known as the “cradle of China's geological work”, where geological research was carried out earlier, and since the founding of the State, the mining departments of various regions have systematically carried out regional geological surveys and mineral census and exploration work in Mentougou District(Yu-Xin et al., 2016).

In recent years, Mentougou District has made active efforts to promote ecological protection and green transformation in the ecological conservation area, and to promote synergistic development in the region, including the closure of mines and sand and gravel factories, etc., the promotion of ecological restoration and treatment of abandoned mines, as well as the development of green industries and cultural tourism brands.

With the changes in urban development and positioning, Mentougou District has begun to transform into a green ecological conservation area, ending its long history of mining.In 2019, Mentougou completely ended its thousands of years of coal-mining history with the shipment of the last load of coal from the Qianjuntai mine(Xu-sheng et al., 2009). This transformation marks an important step in ecological protection and sustainable development in Mentougou District.

West Beijing, “a line of four mines” and the surrounding area by the Men-Da line railroad strung Wangping mine, Datai mine, Muchengjian mine and Qianjuntai mine, four coal mines shut down and withdrawn from production and the rural areas along the composition of the regional tourism resources, the railroad mining heritage is prominent features. Wangping Mine, as the first station of the “four mines”, is the pilot project for the synergistic development of the “four mines in one line” and the surrounding areas.

4. Ecological source area identification

The scope of my study is the Mentougou District of Beijing.Mentougou District has a long history ,with a large number of historical and cultural resources, including historical and cultural villages, Great Wall ruins and so on. The district is also rich in natural resources, including several scenic spots and nature reserves. At the same time, Mentougou District is rich in coal mining resources, leaving behind many coal mining sites that are undergoing transformation and upgrading. How to integrate these resources to create a multi-level scenic recreational path system is the focus of our study.

Mentougou has 3 Chinese Famous Historical and Cultural Villages, 12 Chinese Traditional Villages and 14 Beijing Traditional Villages. Famous ancient villages include Cuanji Village, Lingshui Village, Sanjiadian Village, Liulichu Village and Yanhecheng Village, etc. These ancient villages show the unique beauty of Beijing's ancient towns and villages with their long history and unique cultural heritage. Meanwhile, Mentougou is the place where religion is concentrated in Beijing, with hundreds of Buddhist temples, the most famous of which are Tanzhe Temple and Jingtai Temple. Taoism has also left a deep mark in Mentougou, such as Tongxian Guan and Jade Emperor Temple. Mentougou also has prehistoric cultural relics such as the “Donghulin Man” site, and rich resources of the Great Wall, which is an important part of the Great Wall culture. Therefore, this paper selects traditional villages, prehistoric cultural sites, Ming Great Wall sites and religious and Buddhist temples as the historical and cultural sources of this paper, totaling 33 sites.

Mentougou District is rich in nature reserves, including the Beijing Hundred Flowers Mountain National Nature Reserve, the Beijing Xiaolongmen National Forest Park and the Beijing Tianmenshan National Forest Park. These nature reserves not only provide important habitats for wild animals and plants, but also valuable resources for scientific research, education and eco-tourism, and are important nature reserve resources in Mentougou District and even in Beijing. In this paper, a total of nine natural ecological sources, such as scenic areas and nature reserves, were selected in the Mentougou area according to ecosystem types.

The closure and restoration of abandoned mines is an important step in Mentougou District's transition from traditional coal mining to green ecology. Mentougou District has successively closed all 270 township coal mines and more than 500 non-coal mines and sand and gravel factories in the district. Ecological restoration and management of abandoned mines is also ongoing to restore the natural environment and ecological functions of these areas. Therefore, 11 abandoned mines were selected as source sites in this paper.

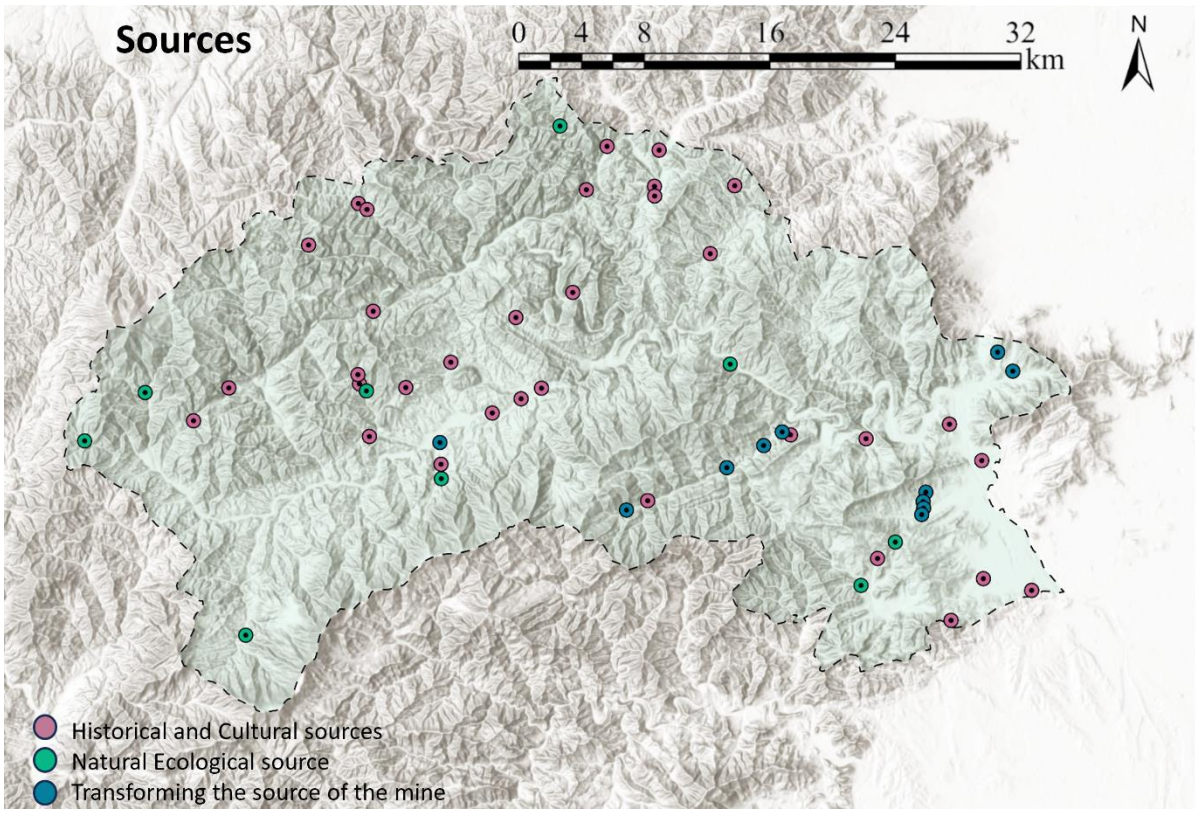

Figure 2. Three source landings (source: Author's own drawing)

5. Construction of Ecological Landscape Recreation Corridor Based on Minimum Resistance Model (MCR)

Referring to the results of previous research, and using AHP analysis, each type of indicator was assigned(Figure 3) and weighted to arrive at the final resistance surface for the construction of the Scenic Byway.

Table 1 Resistance surface construction weighting table

Type	1	2	3	4	5	Weight
Land Use	Water	Forest	Grassland	Farmland	Construction land Unused land	0.423
NDVI	0.85~1	0.78~0.85	0.65~0.78	0.5~0.65	0~0.5	0.332
Slope	≥25	15~25	8~15	3~8	0~3	0.115
Distance from road	≥160	120~160	80~120	40~80	0~40	0.13

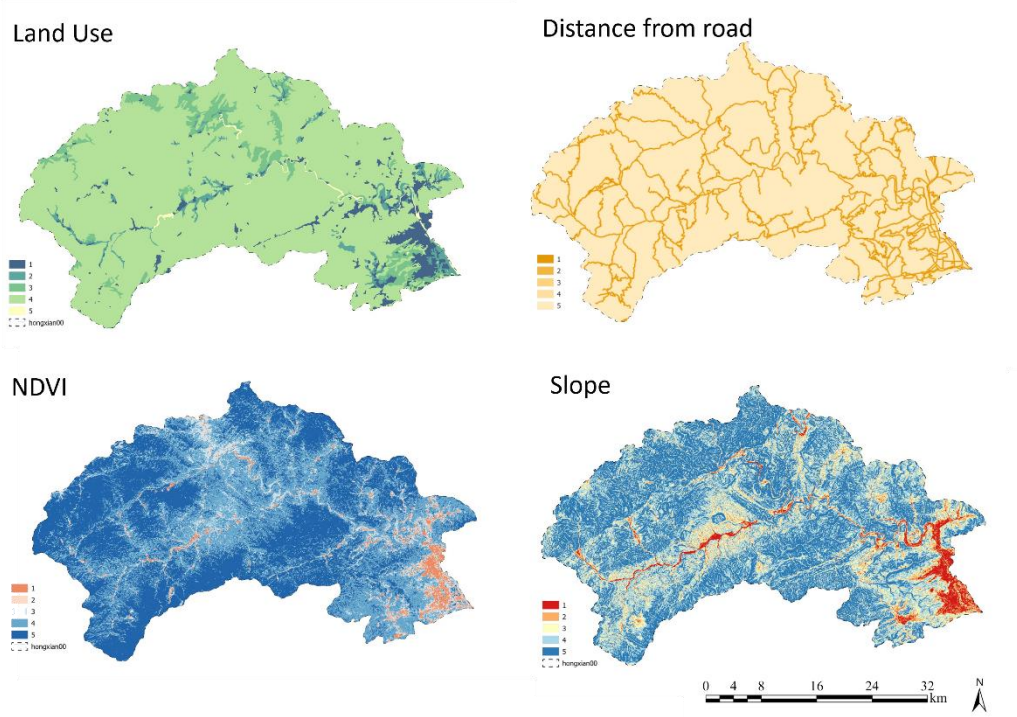

Figure 3. Basic geographic data (source: Author's own drawing)

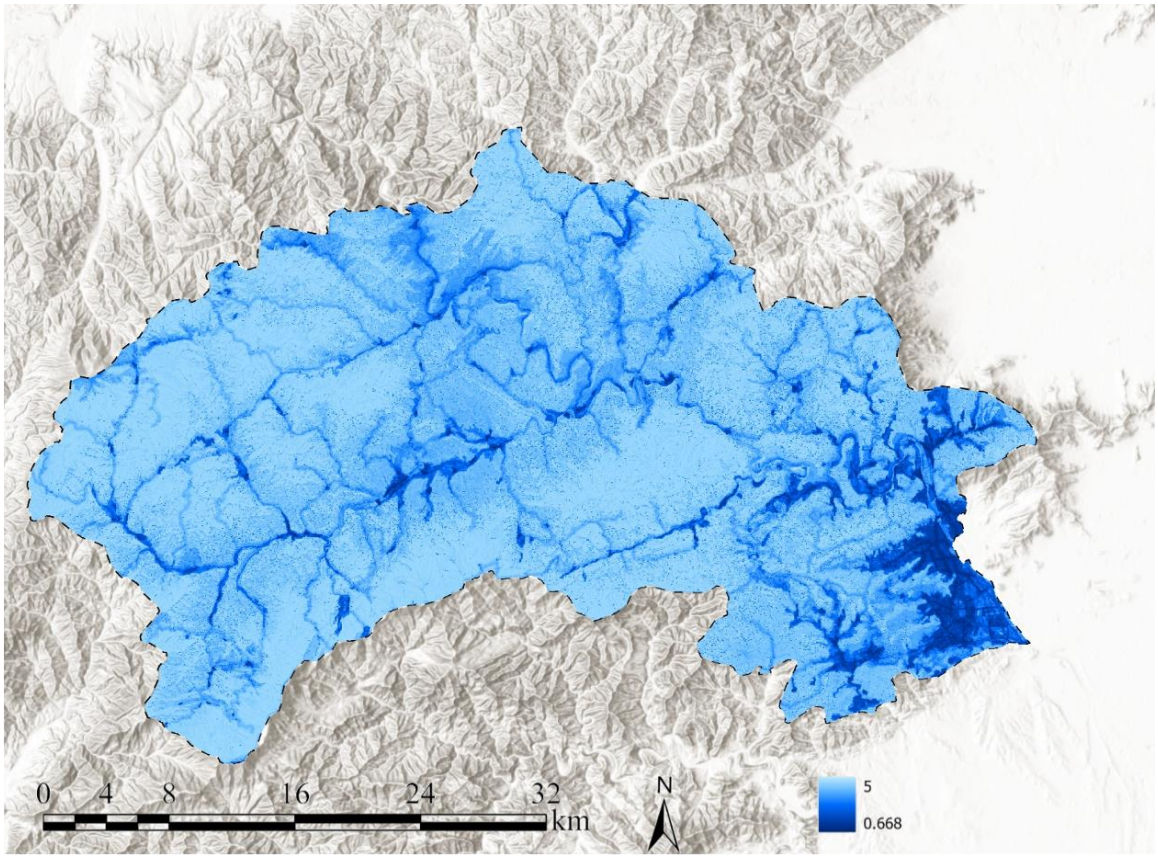

Figure 4. Resistance surface generation results (source: Author's own drawing)

Finally, the resistance surface was generated(Figure 4), and the smaller the value in the graph, the smaller the resistance value here, proving that it is easier to generate recreational paths; conversely, the larger the value, the larger the resistance value here, proving that it is more difficult to generate recreational paths.

6. Recreation system planning

6.1 Recreation System

Using the cost connectivity tool inside ArcGIS, the resistance surfaces were calculated with the three source land categories to arrive at the final recreation system(Figure 4).

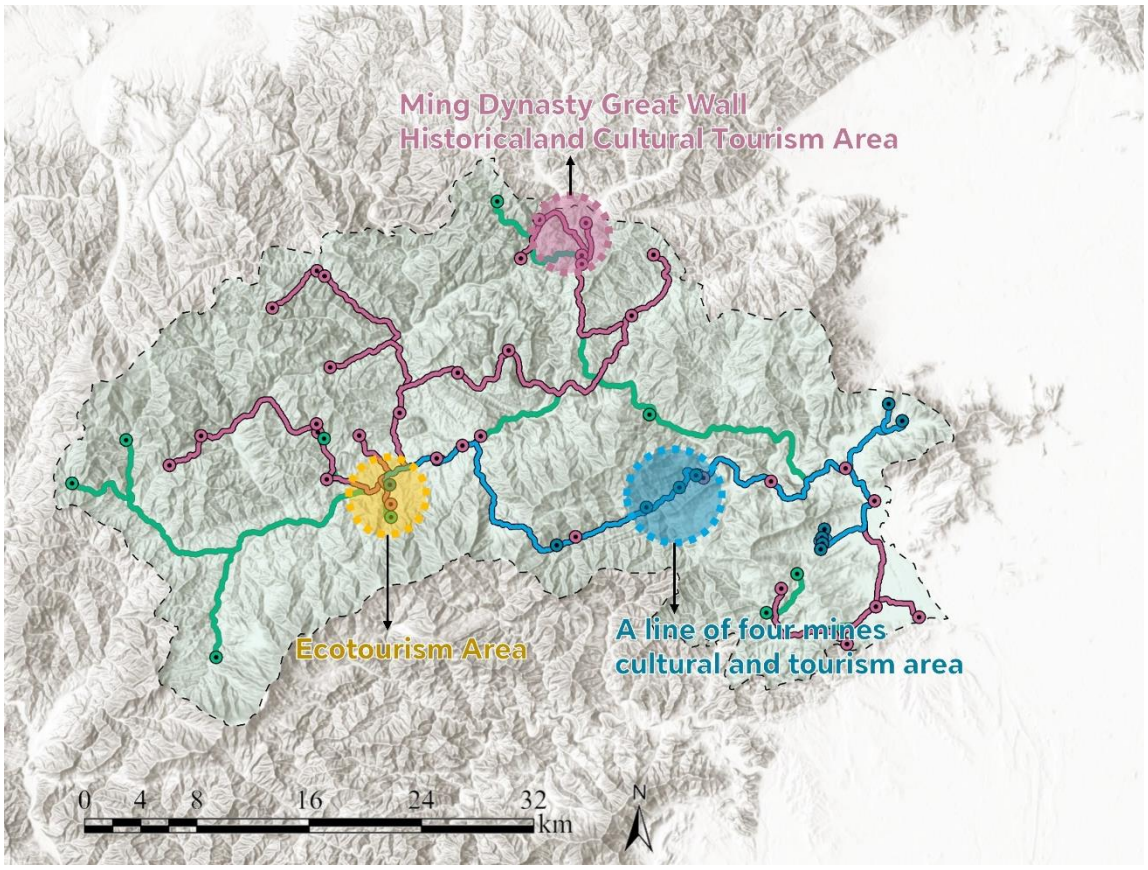

Figure 5. Recreation System Planning (source: Author's own drawing)

A three-tiered system of scenic byways was eventually derived. Based on the distribution institutions of the scenic byways and source areas, we have selected three areas as transportation hubs and service scenic areas for the multi-level recreation system. Including (1) Ming Dynasty Great Wall Historical and Cultural Tourism Area: Establishment of historical and cultural excursion scenic spots centered on the ruins of the Ming Dynasty Great Wall. (2) Ecotourism Area: Establishment of leisure and excursion scenic spots centered on historical and cultural villages and natural ecological areas. (3) A line of four mines cultural and tourism area :Establishment of “one line, four mines” cultural tourism tour area with Wangping Coal Mine as the core.

6.2 Planning Strategies

For the historical and cultural tourism system, we constructed the Ming Dynasty Great Wall Historicaland Cultural Tourism Area in the north. The following planning strategies are also proposed for this recreation system:

- Enhance infrastructure such as public transit, bus systems, and slow-moving trails such as cycling.
- Preservation and utilization of various historical and cultural villages.
- Establishment of a hub of historical and cultural scenic spots centered on the Ming Dynasty Great Wall.

Besides,the following strategies are proposed for the natural ecological recreation system:

- Establish a red line for ecological protection and strictly limit development.
- Establishment of diverse habitats and ecological landscapes.
- Build a system of natural science signage.

The strategies for targeting the transformation of mining areas are:

- Strengthen the construction of hotels and other supporting facilities to form a complete service system.
- Through planning and design, the abandoned mining area is transformed and upgraded, which can be changed into a cultural and creative park.
- Treatment of abandoned mine sites through ecological restoration.

7. Conclusion and outlook

In this paper, a multi-factor coupled ecological landscape recreation system was successfully constructed by comprehensively analyzing the historical and cultural resources, natural reserve resources and mining resources in Mentougou District, Beijing. By applying the Minimum Resistance Model (MCR), this study identifies and assists in the construction of sustainable recreation corridors, effectively connecting historical and cultural sources, natural ecological sources and mining sources to form a comprehensive recreation network. Specific strategies are proposed for different elements: for the historical and cultural elements, accessibility is enhanced and the transportation system is improved; for the natural recreation elements, protection is the main focus and the development of grey infrastructure is restricted; and for the mining recreation elements, the transformational development of culture and tourism and the construction of peripheral supporting facilities are emphasized. Through the quantitative evaluation method, combined with the actual situation of Mentougou District, this paper not only constructs a multi-factor recreation system, but also puts forward suggestions for territorial spatial planning in line with the local reality.

These results provide a scientific basis and practical guidance for the integration and transformation of culture and tourism in Mentougou District, and help promote the sustainable development of the regional economy. The implementation of this study not only protects and utilizes the natural resources and historical and cultural resources of Mentougou District, but also promotes ecological restoration and industrial transformation, and provides a new path for the sustainable development of suburban areas.

Future research can explore and expand on the following aspects: community participation and benefit sharing: strengthen community participation, ensure that local residents can obtain practical benefits from the recreation system, realize benefit sharing, and enhance the sense of access and satisfaction of the community.

Innovative application of ecological restoration technologies: Explore and apply new ecological restoration technologies, especially in the ecological restoration of mining areas, in order to improve the restoration efficiency and effectiveness. Development of cultural tourism products: Combine the history, culture and natural resources of Mentougou District to develop more attractive cultural tourism products and enhance the tourism experience. Improvement of policies and regulations: Research and propose relevant policies and regulations to provide legal support for the construction and management of the ecological landscape recreation system. Cross-regional cooperation: Explore the mode of cooperation with other regions, share resources and jointly build a regional ecological landscape recreation system. Climate Change Adaptation: To study the impacts of climate change on the ecological landscape recreation system and formulate corresponding adaptive management measures. The depth of these studies can further promote the sustainable development of Mentougou District and similar areas, and provide more references and lessons for the transformation and development of urban suburban areas.

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