IFLA AAPME Awards 2024
Award Categories - Analysis and Planning (Unbuilt Category)

Project Title

Optimisation and Construction of Green Space Network in Beijing Driven by Carbon Sink Capacity

Project Statement

Since industrialization, global carbon emissions have surged, triggering a series of climate and environmental issues. The United Nations Intergovernmental Panel on Climate Change (IPCC) emphasized in its 2023 report that the adverse climate impacts are more profound than previously anticipated. China, the largest carbon emitter, has launched a dual carbon goal policy to address this imminent global environmental crisis and achieve net-zero emissions. Thus, this project focuses on the low-carbon green space planning of the Beijing Plain area, thoroughly studying the evolving urban green space patterns and layout challenges within the low-carbon target framework. Based on the current situation research and data analysis, the project objectively optimizes the existing green space, which is significant for promoting sustainable, low-carbon urban development.

Project Narrative and Contents

1.Background

Project Address : Plain Areas, Beijing, China
City&Country : Beijing, China
Research Size in SqKM : 6,628.23 SqKM

Urban green spaces are closely related to carbon absorption. In today's context of increasingly severe carbon dioxide emissions, addressing green space layout issues with a low-carbon goal is crucial for sustainable urban development. Currently, China is the world's highest carbon-emitting country, with Beijing being one of the second batch of low-carbon cities in China. The plain area serves as the primary spatial carrier of human activities, concentrating high energy consumption and high carbon emissions. Therefore, the Beijing Plain area was selected, supplemented by data analysis, to optimize its green space network.

2.Research Methods

This project studied the plain areas of Beijing by calculating the Net Primary Productivity (NPP) and annual carbon sequestration using land cover data from the years 2000, 2010, and 2020. Landscape indices were employed to reflect the green space morphology, analyzing the correlation between changes in these indices and green space carbon sink. The results indicated that LPI (Largest Patch Index), AI (Aggregation Index), PLADJ (Percentage of Like Adjacencies), and COHESION (Patch Cohesion Index) have a high correlation with green space carbon sink. These factors, considered carbon sink potential factors, were combined with ecological potential factors and weighted accordingly to select areas with high carbon sink capability and ecological value as high potential source points.

Additionally, by assessing the land use, carbon sink, and ecological sensitivity, a resistance surface was constructed. Here, impervious surfaces, areas with low carbon sink and low sensitivity were assigned the highest resistance values. In contrast, forested areas and regions with high carbon sink and high sensitivity were assigned low resistance values. Finally, the Minimum Cumulative Resistance (MCR) model was utilized to generate the optimal paths connecting the source points. Based on these paths, field investigations, and the urban planning of Beijing, including constructing the first and second green belts, the optimal paths were adjusted to construct a green corridor to enhance carbon sink capacity in the plain areas of Beijing.

Project Narrative and Contents

3.Analyses and Strategies

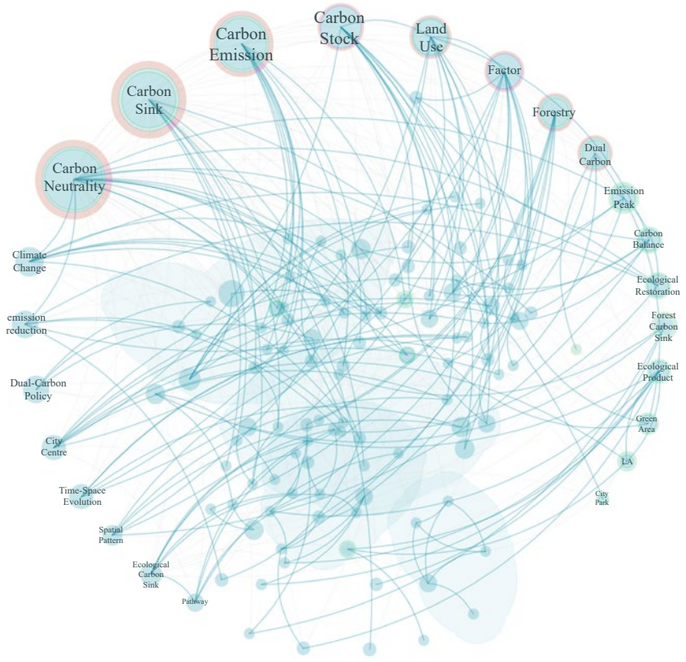
Based on the current situation, high carbon sink areas, and dense corridor zones are mainly concentrated in the first and second green belts of Beijing and suburban river areas, including the Olympic Forest Park and Summer Palace areas, extending southward to the Wenyu River area, Chaobai River area, Yongding River area, and the southeastern Taihu Wetland area. Therefore, a three-tier planning framework has been proposed: "Core Carbon Sink Area," "Planned Corridor Area," and "cropland Control Area. Simultaneously, 6 "Core Carbon Sink Circles," 27 "Major Carbon Sink Areas," and 11 "Green Space Addition Area" have been established. The "Core Carbon Sink Circles" will control the entire corridor, implementing targeted protection measures. The "Planned Corridor Area" extends from the Core Carbon Sink Area and can be used protectively. The "Cropland Control Area" restricts the rapid expansion of urban built-up areas. The carbon sink capacity of the 27 "Major Carbon Sink Areas" will be enhanced to strengthen the regional control of the corridors. The 11 " Green Space Addition Area " located at corridor breakpoints, will improve corridor connectivity. These areas are key to optimizing and updating the green space pattern in the Beijing Plain and achieving the dual carbon goals. Additionally, based on the current conditions of the corridor coverage areas, they have been classified into four types: forest-dominated, water-dominated, cropland-dominated, and urban-dominated. Specific strategies for increasing carbon sinks have been proposed for each type.

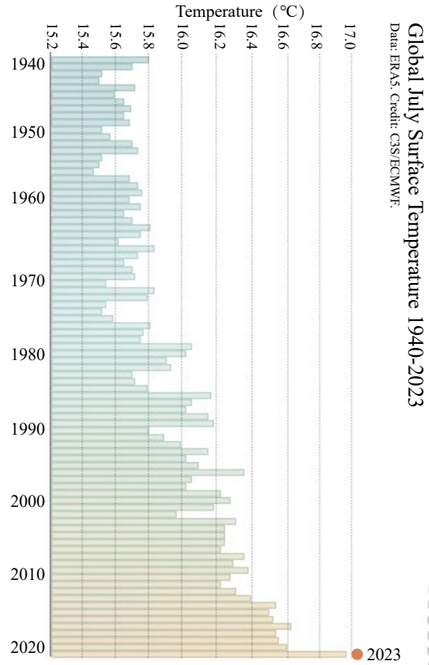
4. Signiffcance of the Project

The planning has established a comprehensive green network system, integrating and grading green spaces in the plain area, optimizing their morphology, and enhancing their quality. Based on ecological corridors, this green network system aims to improve green space carbon sequestration capacity while considering urban development strategies. Relying on the ArcGIS cost connection algorithm, it provides robust data support for urban decarbonization and significantly optimizes urban green space patterns. This method differs from traditional urban planning, offering suggestions and insights for low-carbon urban development and providing innovative strategies to achieve dual-carbon goals. Furthermore, this planning model can serve as a reference for green space planning in the North China region.

Analysis of Existing Literature and Data | Backgrounds

Literature Keywords





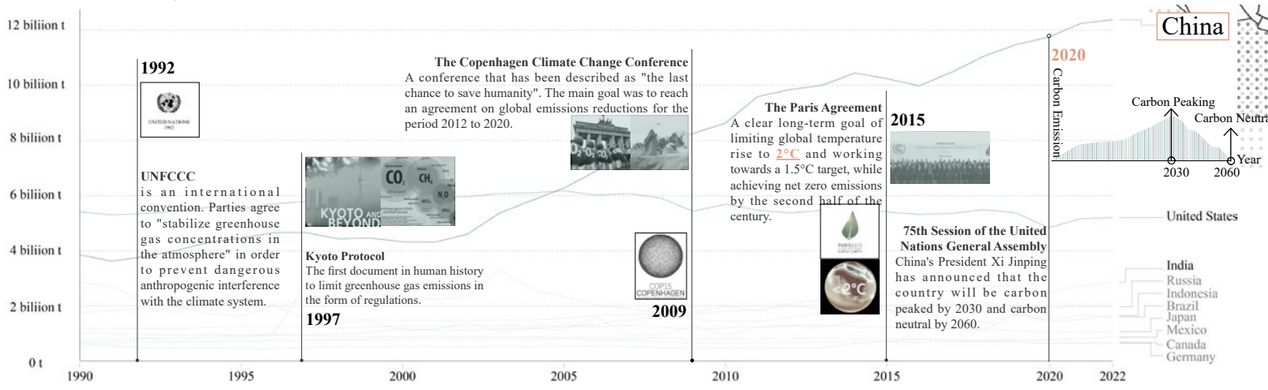
Climate Change 2023 | *The synthesis report of the Sixth Assessment Report released by the Intergovernmental Panel on Climate Change (IPCC)*

The adverse climate impacts are already more profound and extreme than expected.

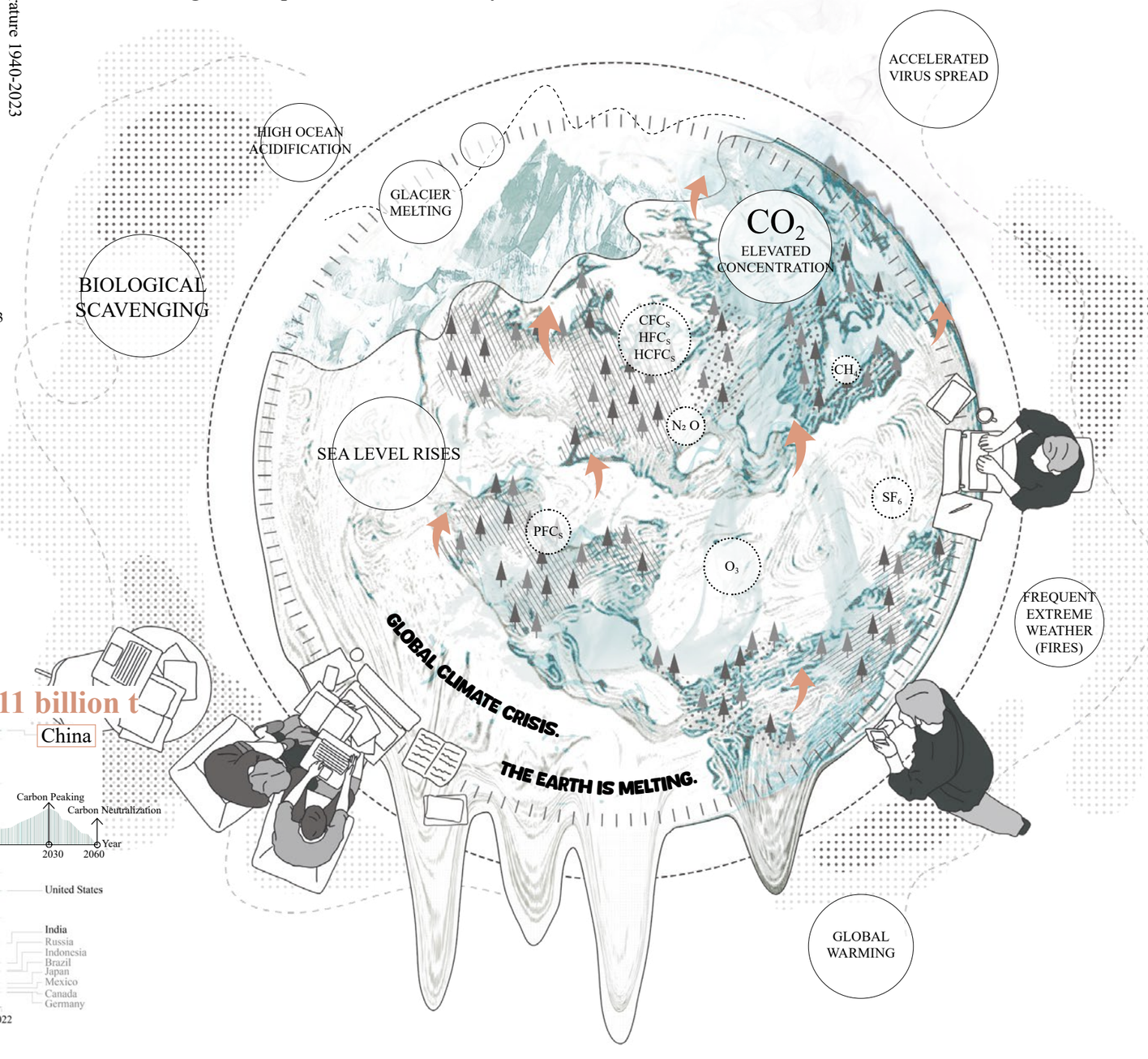
Nature | *Identifying where nature-based solutions can offer win-wins for carbon mitigation and biodiversity across knowledge systems*

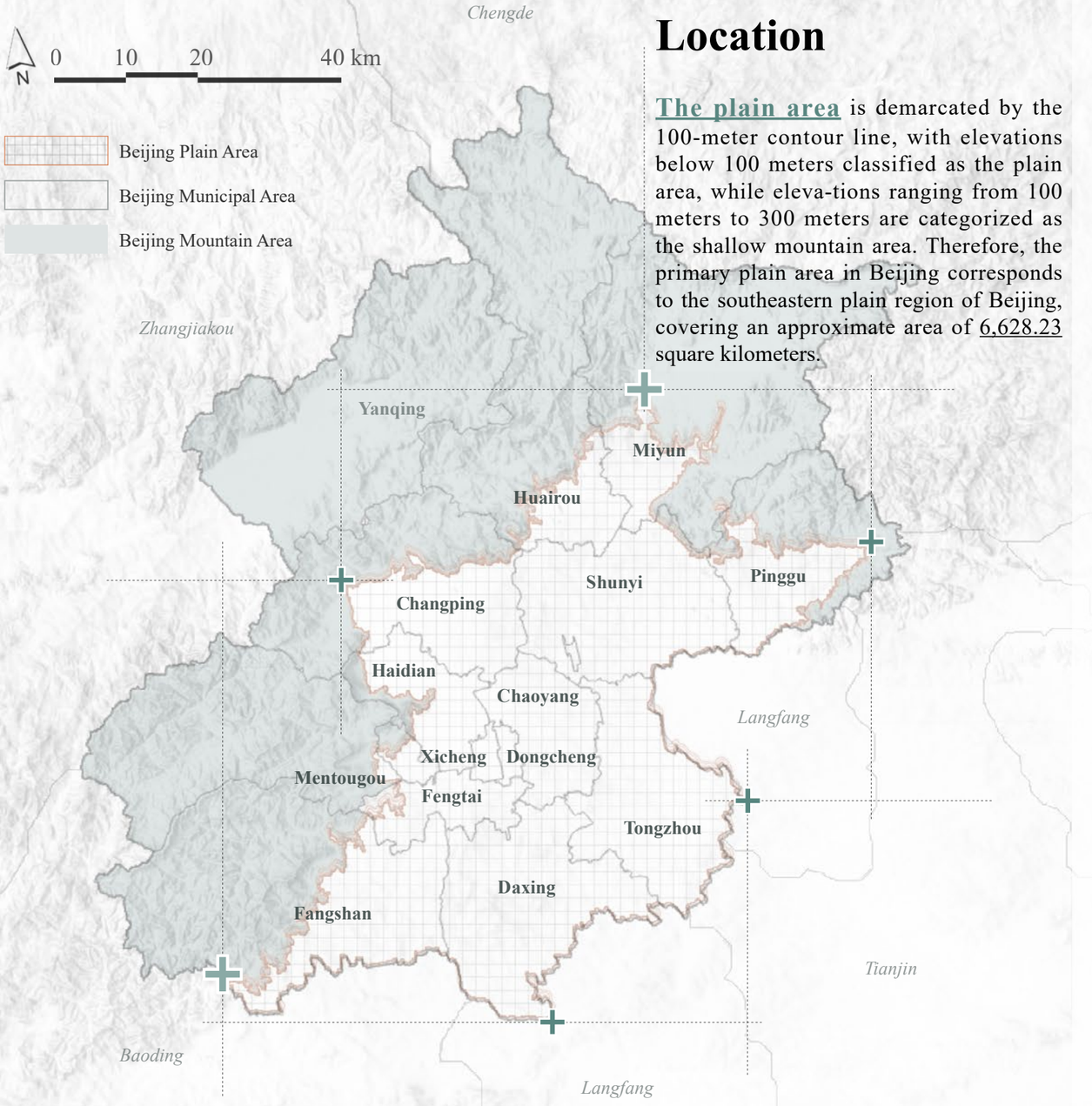
Recent studies call for research into the interplay between biodiversity, climate adaptation and mitigation as well as environmental justice outcomes in order to keep global warming within the desired 1.5 degrees Celsius global mean temperature increase, halt global biodiversity loss, and promote human well-being.

Annual CO_2 Emissions | 1990 to 2022



With human industrialization, carbon dioxide emissions in the atmosphere have increased, leading to an ecological crisis as the global climate continuing warm. In this context, improving the morphology and quality of urban green spaces can enhance the effectiveness of carbon sinks on land and water and also help to improve biodiversity. Therefore, from the perspective of carbon sinks, we excavate areas with high potential for carbon sinks, spatially optimize them, and protect them in tandem with the surrounding green spaces to form a perfect green corridor of potential carbon sinks, to strengthen the carbon sink capacity of the whole region and protect its biodiversity.





Location

The plain area is demarcated by the 100-meter contour line, with elevations below 100 meters classified as the plain area, while eleva-tions ranging from 100 meters to 300 meters are categorized as the shallow mountain area. Therefore, the primary plain area in Beijing corresponds to the southeastern plain region of Beijing, covering an approximate area of 6,628.23 square kilometers.

The second batch of 29 pilot low-carbon cities

- Centrally-administered Municipality
- Province-level Region
- Prefecture-level City

Beijing

2012 China's Second Batch of Low-Carbon Pilot Cities

To implement a low-carbon economy in cities, including low-carbon production and low-carbon consumption, to establish a resource-saving and environmentally friendly society, and to build a benign and sustainable energy ecosystem.

2023 Beijing Ranks First in National Low-Carbon City Pilot Assessment

Actively implementing the "dual-carbon" strategy, the intensity of carbon emissions has continued to decline, and the city's total carbon emissions have been effectively controlled.

The plain area

A Major Producer of Carbon Sources

The plain area is a major spatial carrier of human activity and a concentration of high energy consumption and carbon emissions.

Resilience Spaces

Beijing Plain area is a concentrated area of urban carbon sources, so it has higher research value. Compared to the mountainous areas of Beijing, the green spaces in the plain area used as urban construction land and its spatial pattern system are more resilient, making it easier for functional regulation and urban land use control.

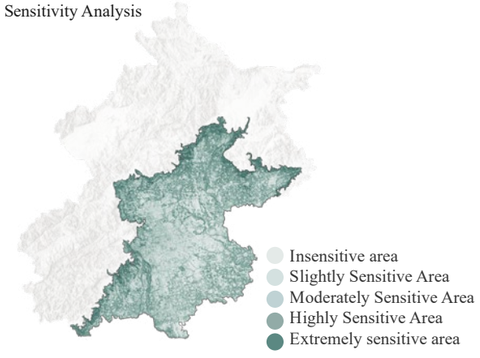
Analysis of current situation

1.Highly sensitive areas are mainly protected and are suitable for development and construction without destroying ecological resources.

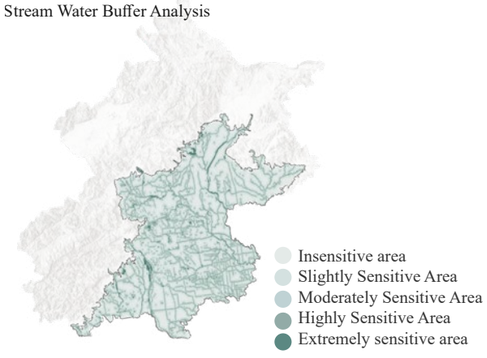
2.It should comply with the urban characteristics of traditional and modern civilization, and strengthen the penetration and integration of green open space between the inner city and the peripheral countryside.

3.Based on the current traffic roads, the future can be guided to increase green belts on both sides of the roads to connect the green space of the city and form the layout of ecological corridors.

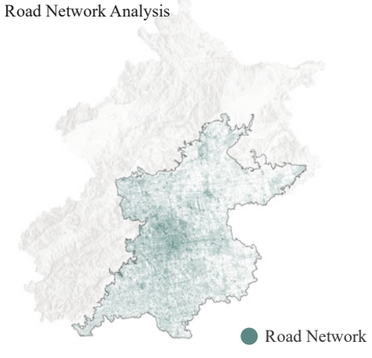
Sensitivity Analysis



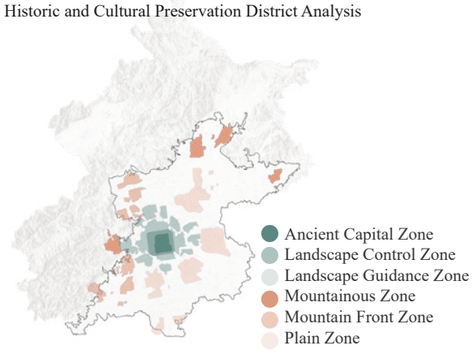
Stream Water Buffer Analysis



Road Network Analysis



Historic and Cultural Preservation District Analysis



Methodology and Research

Zero Emission ⟷ *Urban Spatial Patterns*

Purpose

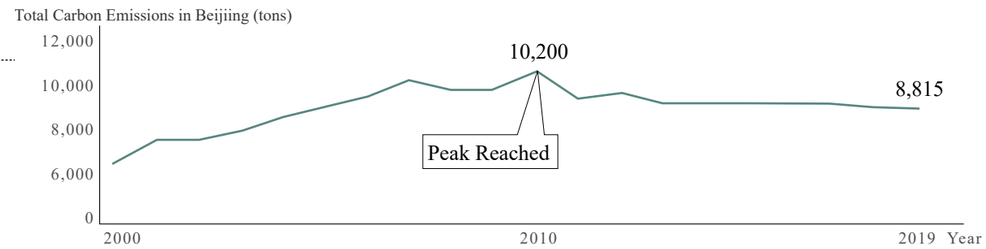
Optimize

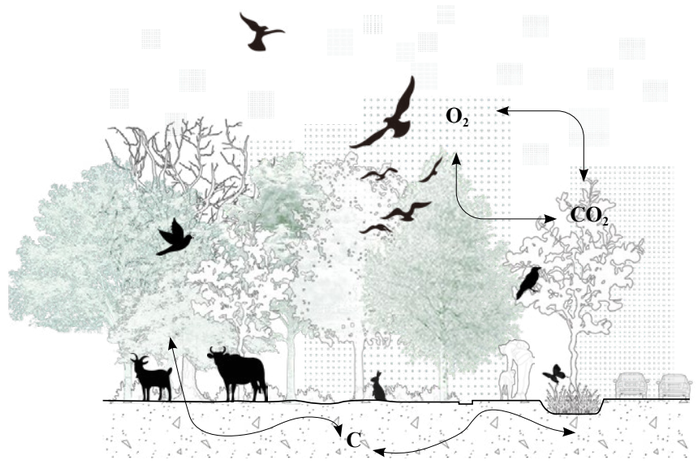
Biodiversity Conservation

Carbon Emission

- Building Land
- Industrial Land
- Transportation Area

According to data derived from the "*China Carbon Accounting Database*," after peaking in 2010, carbon emissions in Beijing had somewhat decreased by 2019, with total emissions rising slightly between 2000 and 2019, resulting in effective carbon emission control.





After controlling carbon emissions, it is necessary to further enhance the carbon sink capacity of the ecosystem, optimize the urban pattern, and form complete **green corridors** with high carbon sink capacity. The steps are as follows:

Carbon Sink — *Urban Green Space*

1. Measurement of Carbon Sinks in Green Spaces of the Plain Area
2. Validating the Correlation Between Changes in Green Space and Carbon Sinks in the Plain Area
3. Generation of Corridors Based on Potential High Carbon Sink Areas

Biodiversity corridors

Urban green space in its current state: commercial office areas, parks, rivers, greenways, neighborhoods

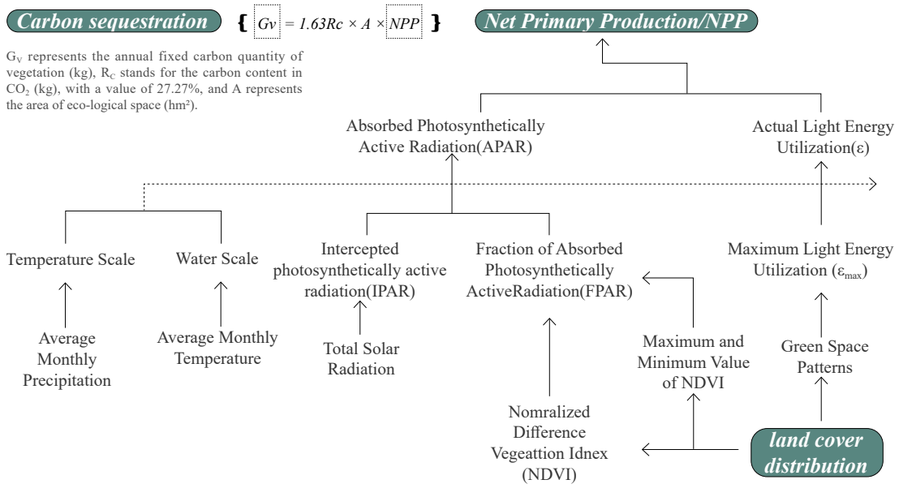
Field trip to Beijing Plain Areas

The construction of green space is being promoted in an orderly manner

The forest coverage rate of the first green area has reached 31.8%, and 109 city parks have been built, initially building a ring of city parks in the center of the capital city; the forest coverage rate of the second green area has reached 38.9%, which is significantly higher than that of the city's plain area, and 44 large-scale country parks have been built.

Implementing the Requirements of Beijing's Urban Master Plan and Thinking about Optimizing the Green Space of Beijing in the Future

·Step1:Measurement of Carbon Sinks in Green Spaces of the Plain Area

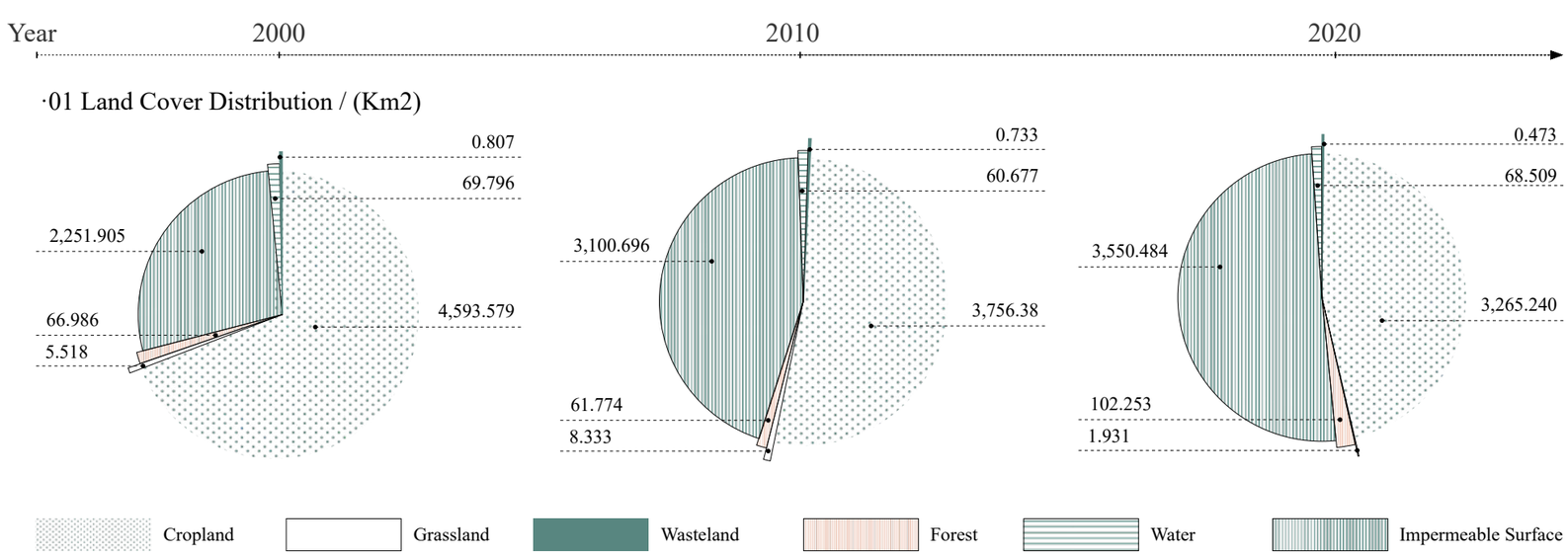


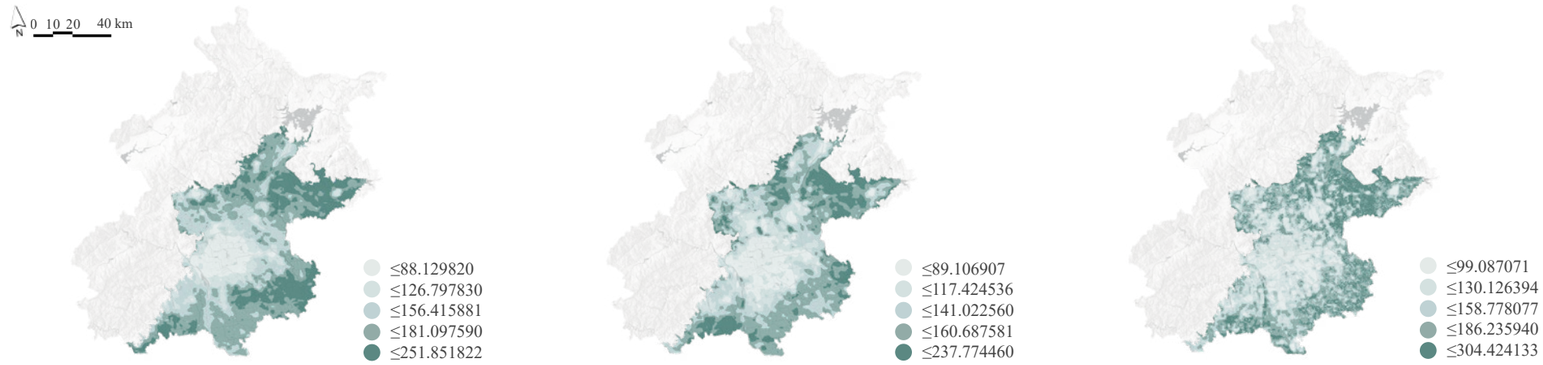
Analyzing the time series perspective by comparing classified ecological space land use data from 2000 to 2010 and then to 2020 reveals notable changes in land use and landscape cover over the past two decades: grassland and cropland areas have experienced declines while forest land and impermeable surface areas have witnessed increases.

Spatial and Temporal Distribution of Green Space Carbon Sinks in the Plain Area

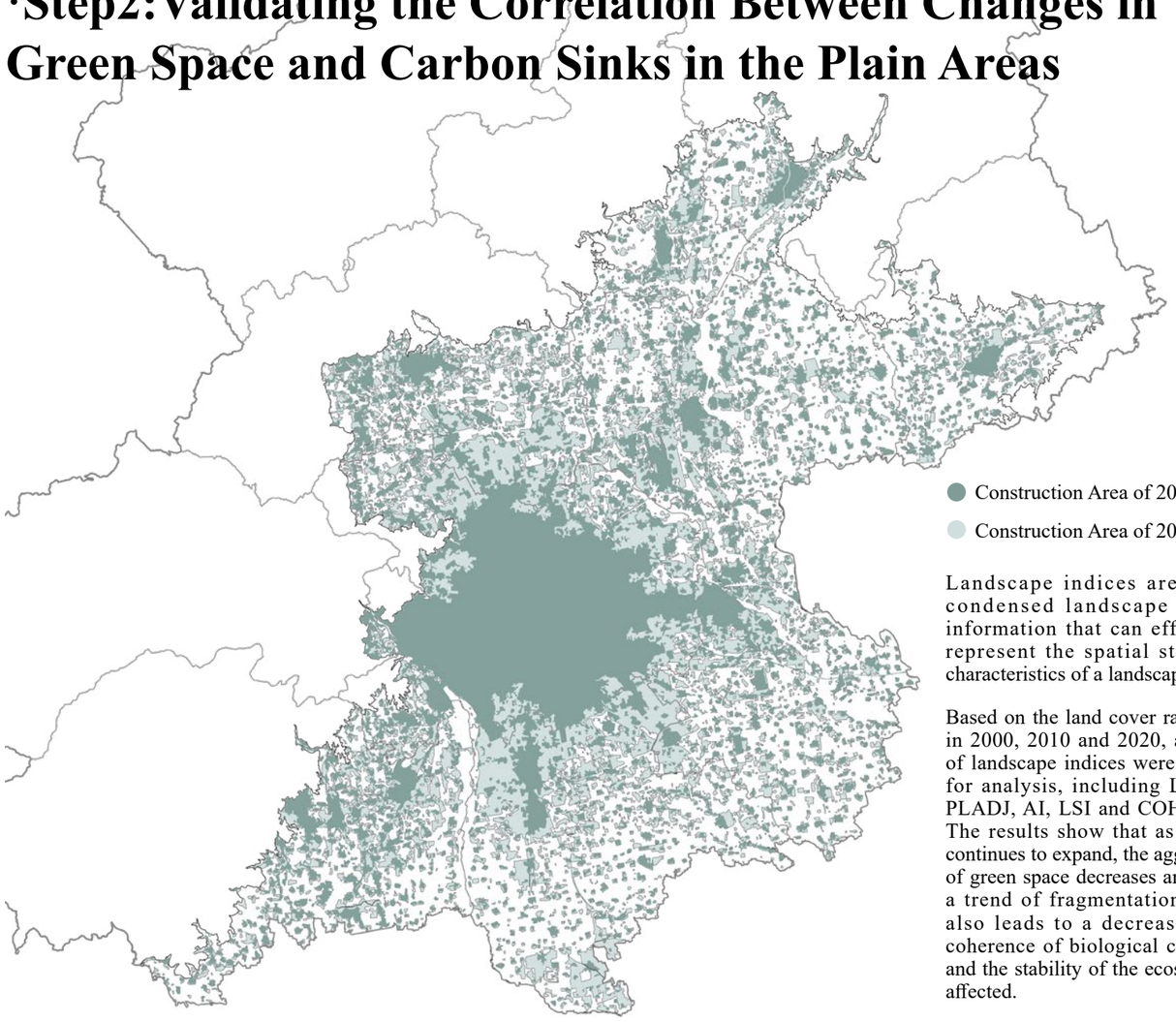
Spatial perspective:
Compared with the shallow mountainous areas , the value of the central urban areas is lower due to high levels of urbanization and intense land development activities within this central zone.Conversely, peripheral shallow mountainous regions boast excellent ecological foundations leading to higher levels of vegetation net primary productivity there.

Temporal perspective:
The number from 2000 to 2020 shows an overall increasing trend. Notably though within the central urban region itself afforestation projects along with planning and construction initiatives for green partitions have yielded positive outcomes towards improving overall urban landscapes while also transforming parts of lowest-value areas into lower-value ones.





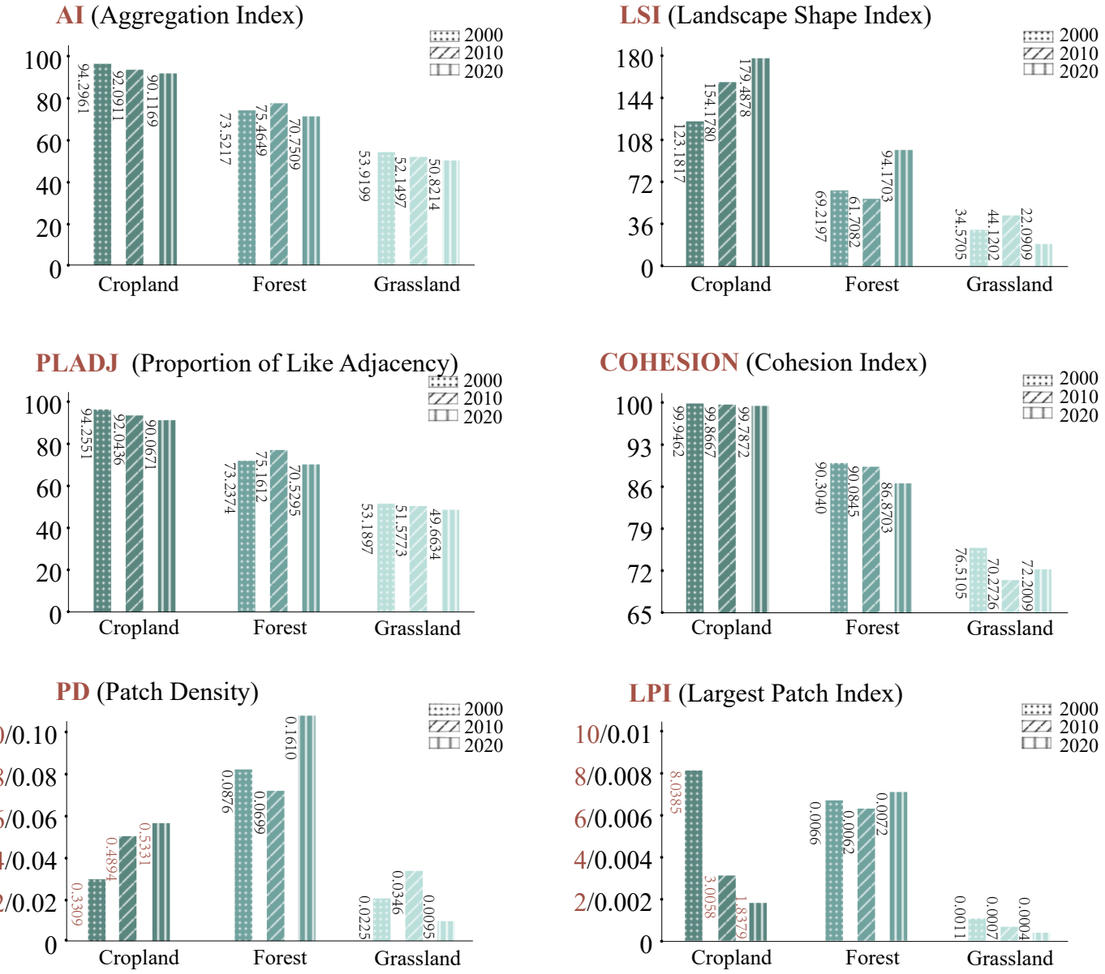
·Step2:Validating the Correlation Between Changes in Green Space and Carbon Sinks in the Plain Areas



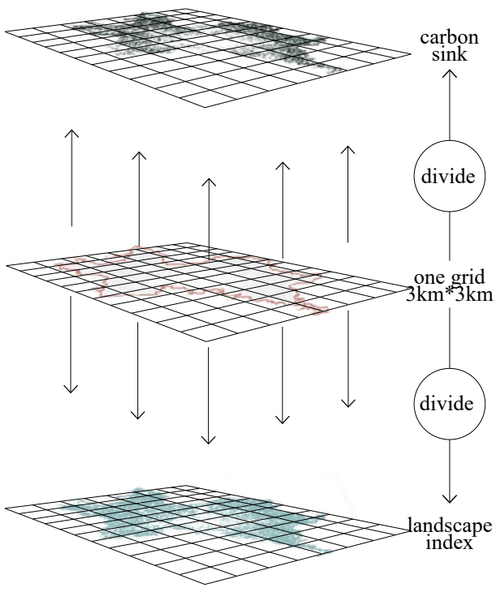
Landscape indices are highly condensed landscape pattern information that can effectively represent the spatial structural characteristics of a landscape.

Based on the land cover raster data in 2000, 2010 and 2020, a variety of landscape indices were selected for analysis, including LPI, PD, PLADJ, AI, LSI and COHESION. The results show that as the city continues to expand, the aggregation of green space decreases and shows a trend of fragmentation, which also leads to a decrease in the coherence of biological corridors, and the stability of the ecosystem is affected.

Calculation of the Landscape Index



Validating the Correlation



Construction of a 3km*3km grid array with region-wide coverage

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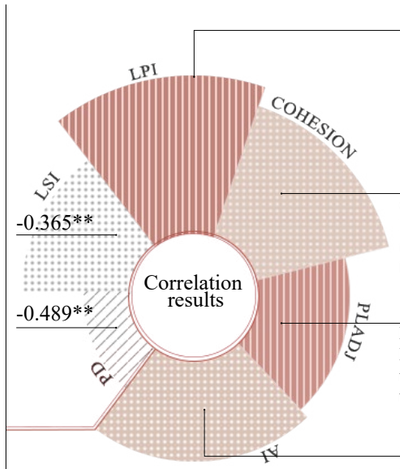
Getting the mean value of carbon sequestration and landscape index in each grid

↓

727 data sets obtained

↓

Correlation of carbon sequestration with each landscape index analyzed using SPSS tool



High Correlation

LPI: 0.827**

LPI (Largest Patch Index)

The proportion of the largest patches of a certain type to the overall area can reflect the degree of concentration of patches and the dominant type of landscape.

COHESION: 0.773**

COHESION (Cohesion Index)

Reflecting the degree of aggregation of patches of the same landscape type, the higher the value, the higher the degree of cohesion of patches.

PLADJ: 0.795**

PLADJ (Proportion of Like Adjacencies)

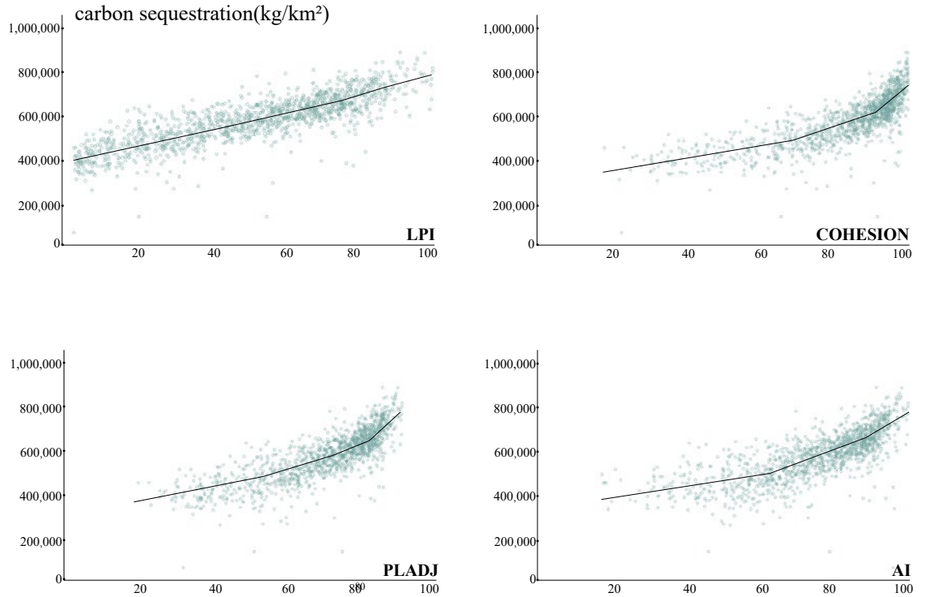
Percentage of adjacent identical landscape types to total adjacent landscapes. Indicates how discrete the landscape is.

AI: 0.734**

AI (Aggregation Index)

Indicates the degree of discrete patches in the landscape area, the larger the value, the more the patches of the same type are aggregated, and the structure is compact.

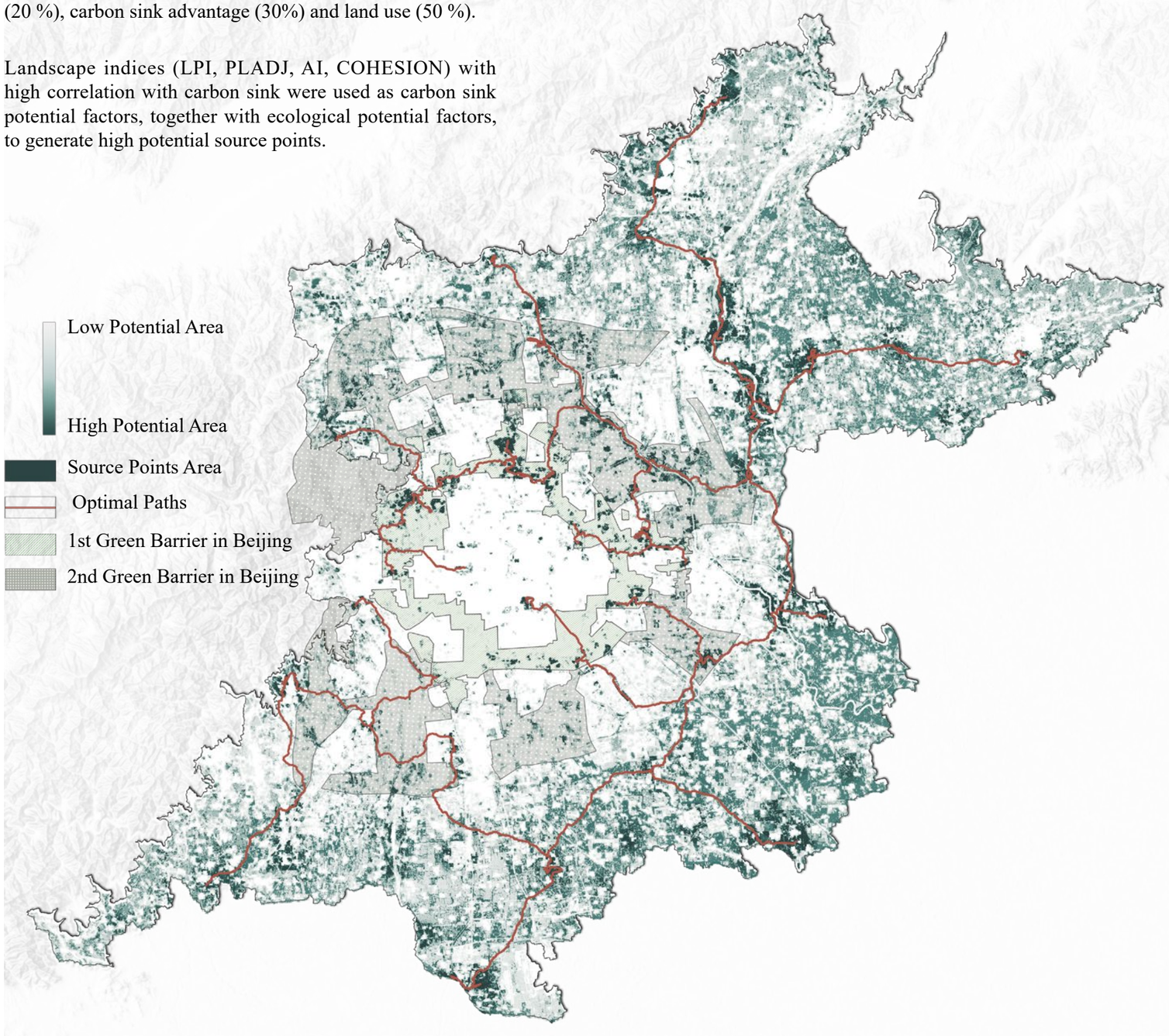
**: At the 0.01 level (2-tailed), the correlation was significant.



·Step3: Generation of Corridors Based on Potential High Carbon Sink Areas

The selection of source points considered the factors of carbon sink potential (60%) and ecological potential (40%), and the resistance surface considered ecological advantage (20 %), carbon sink advantage (30%) and land use (50 %).

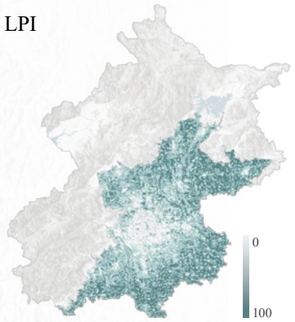
Landscape indices (LPI, PLADJ, AI, COHESION) with high correlation with carbon sink were used as carbon sink potential factors, together with ecological potential factors, to generate high potential source points.



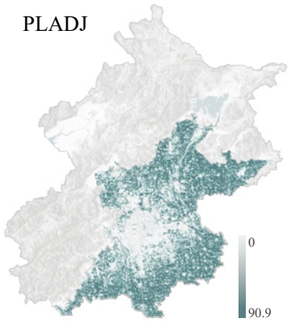
Source Point Selection

60% Carbon Sink Potential Factors

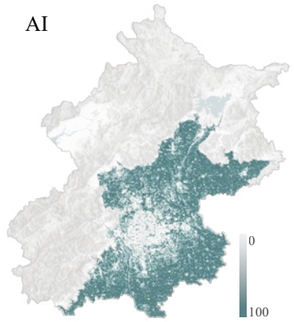
LPI



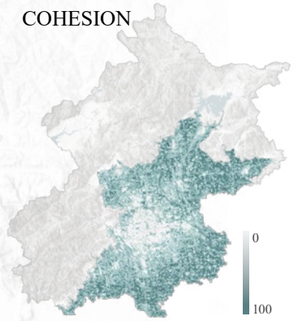
PLADJ



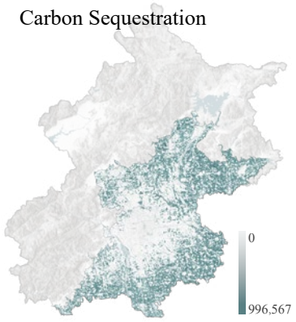
AI



COHESION

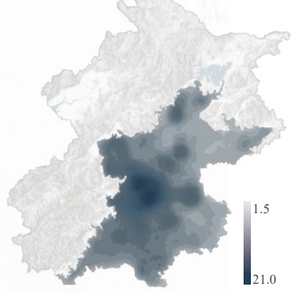


Carbon Sequestration

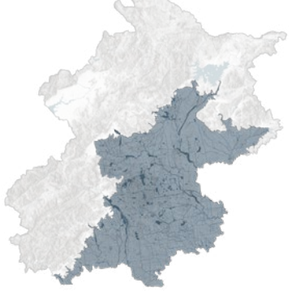


40% Ecological Potential Factors

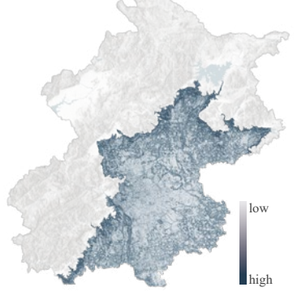
Road Density



Distribution of Parks And Rivers

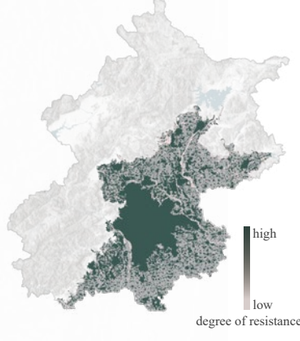


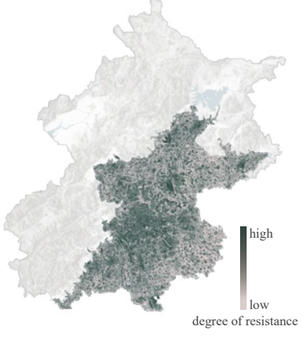
Ecological Sensitivity

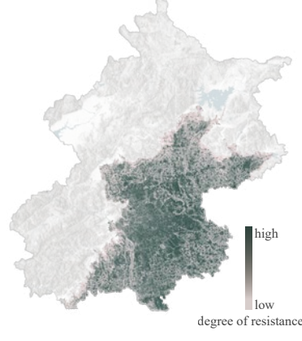


Resistance Surface Construction

50% Land Cover **30%** Carbon Sink Advantage **20%** Ecological Advantage



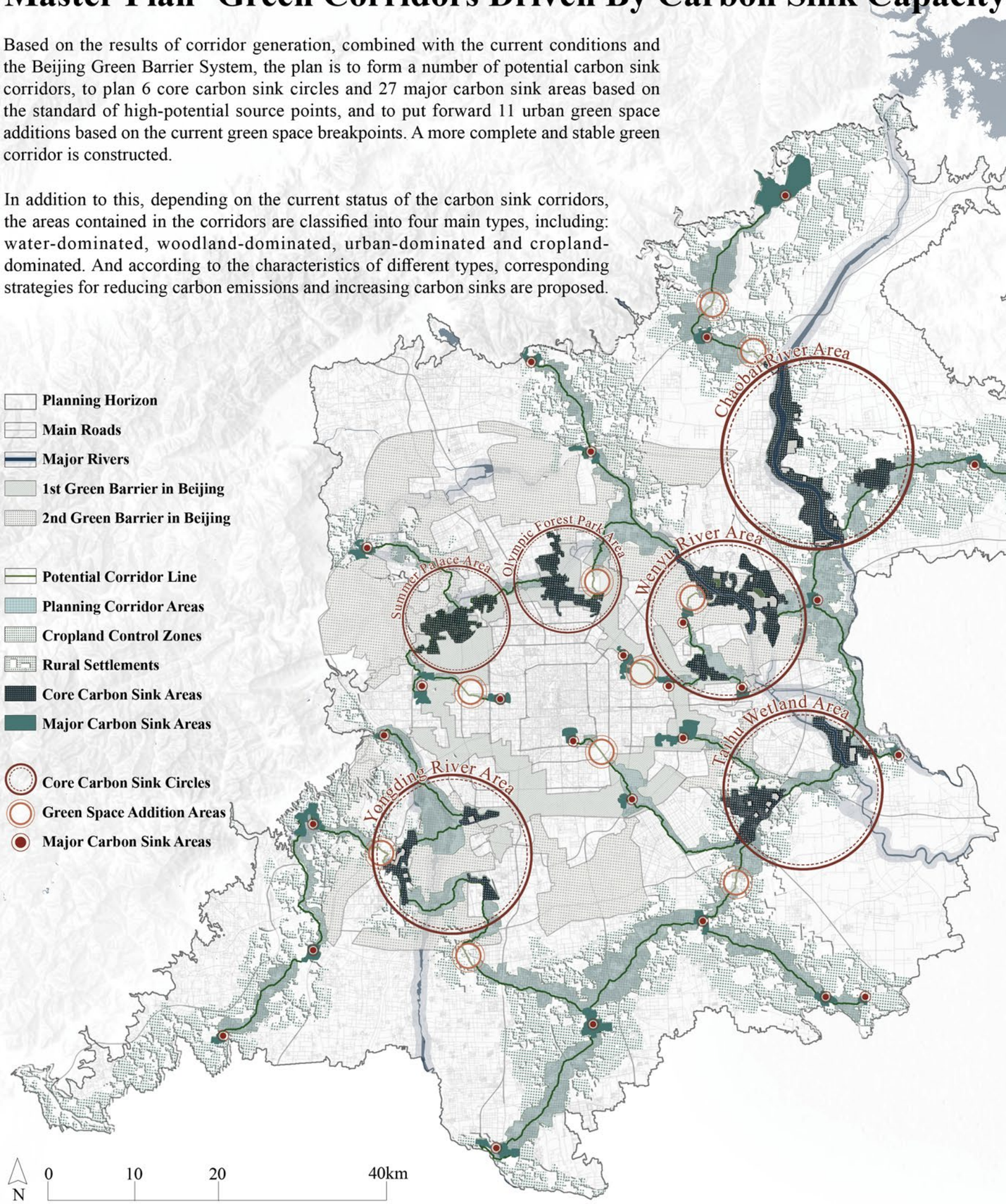


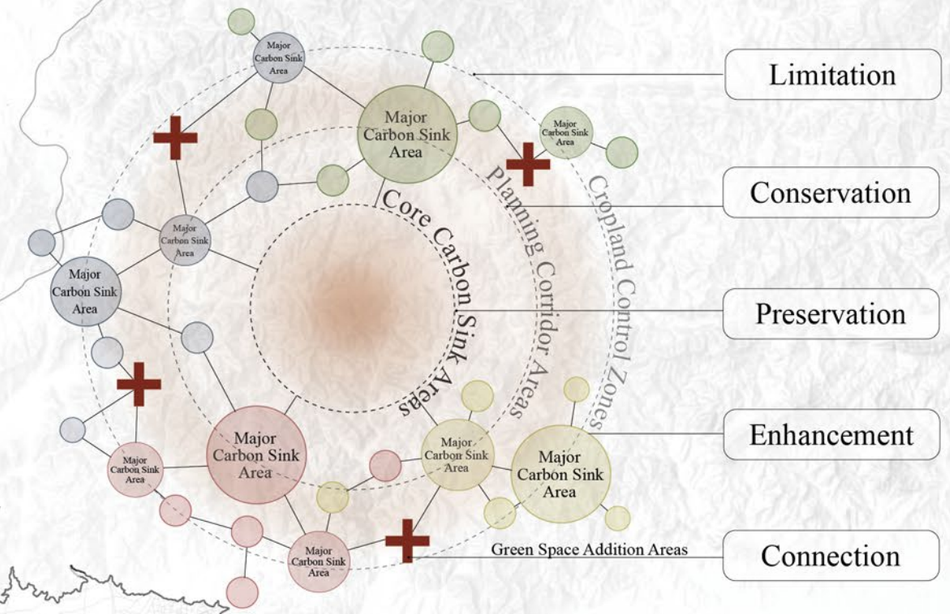


Master Plan- Green Corridors Driven By Carbon Sink Capacity

Based on the results of corridor generation, combined with the current conditions and the Beijing Green Barrier System, the plan is to form a number of potential carbon sink corridors, to plan 6 core carbon sink circles and 27 major carbon sink areas based on the standard of high-potential source points, and to put forward 11 urban green space additions based on the current green space breakpoints. A more complete and stable green corridor is constructed.

In addition to this, depending on the current status of the carbon sink corridors, the areas contained in the corridors are classified into four main types, including: water-dominated, woodland-dominated, urban-dominated and cropland-dominated. And according to the characteristics of different types, corresponding strategies for reducing carbon emissions and increasing carbon sinks are proposed.





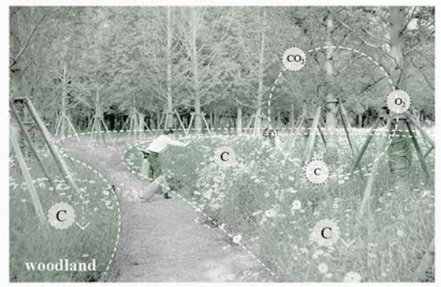
6 Core Carbon Sink Circles

11 Green Space Addition Areas

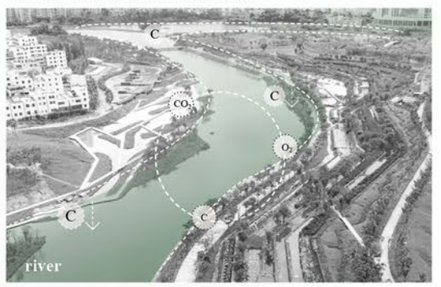
27 Major Carbon Sink Areas

Four Main Types

Woodland-dominated Areas



Water-dominated Areas

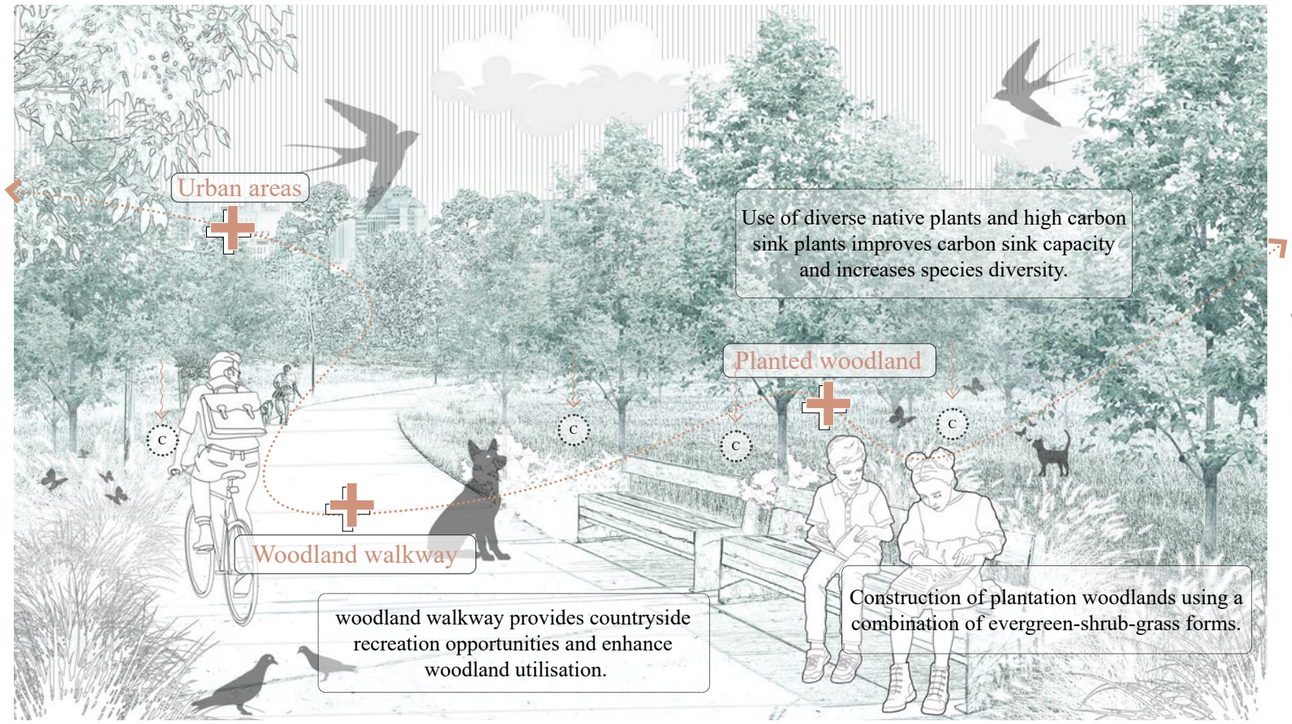


Cropland-dominated Areas

Urban-dominated Areas

Planning Strategies

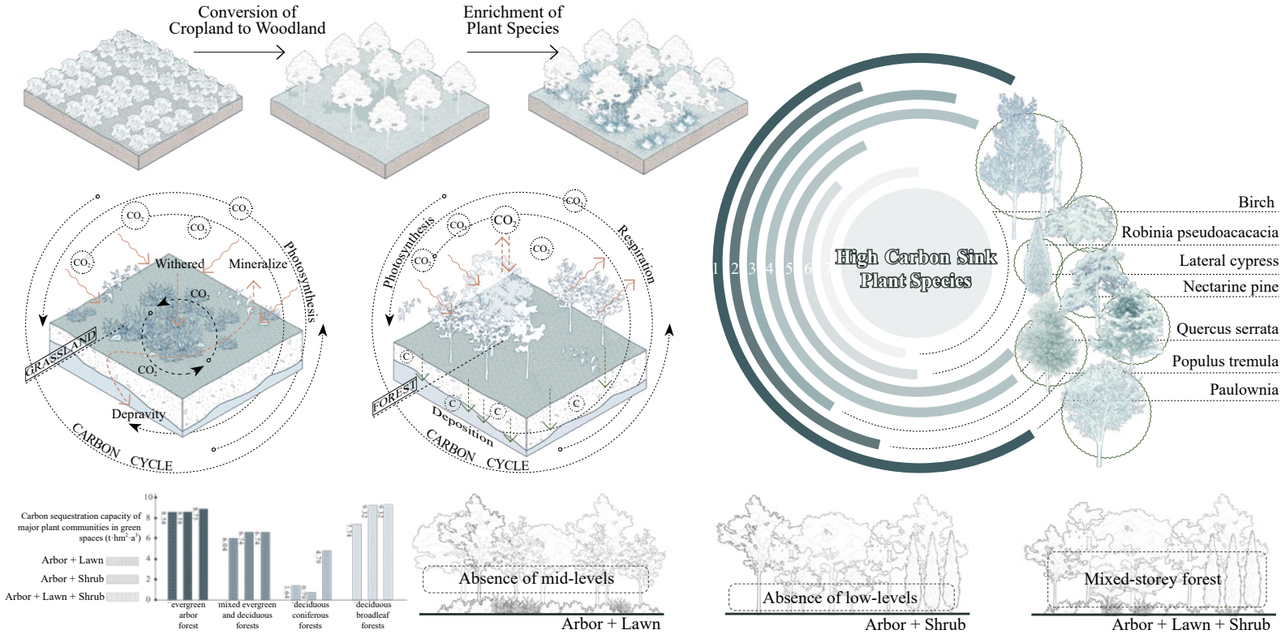
01. Woodland-dominated Areas



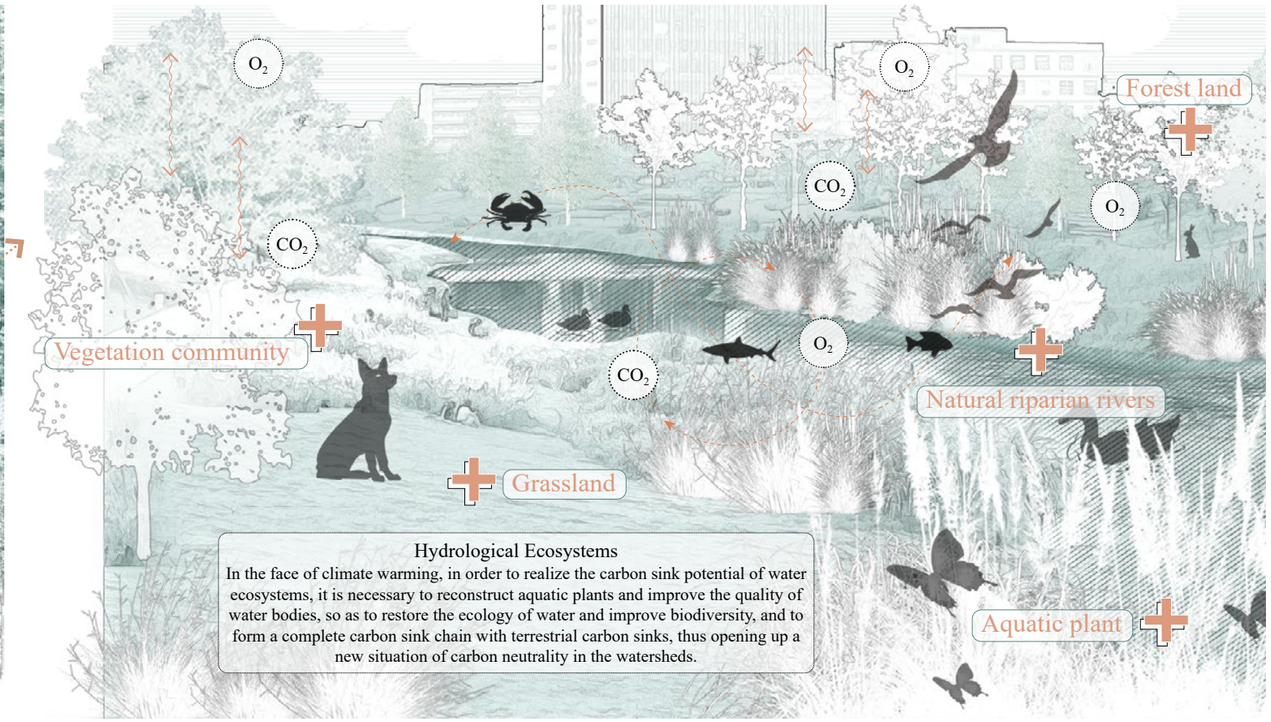
Enhance the carbon sequestration capacity of plants on the corridor:

1. Select high carbon sink plant species, consisting mainly of broadleaf species, large-breasted trees, and low-maintenance shrubs.
2. Build a multi-level plant community. Increasing the proportion of high carbon sequestering tree species and medium planting density can improve photosynthesis efficiency, thus enhancing plants' ability to sequester carbon and release oxygen.

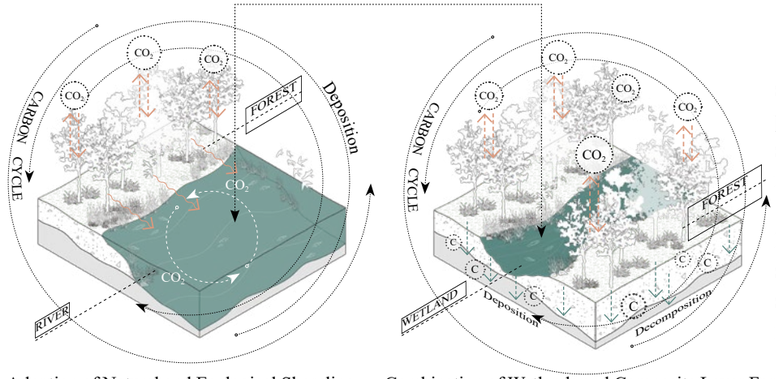
Plains Afforestation Programme



02. Water-dominated Areas



Conservation of Aquatic Species



Adoption of Natural and Ecological Shoreline.

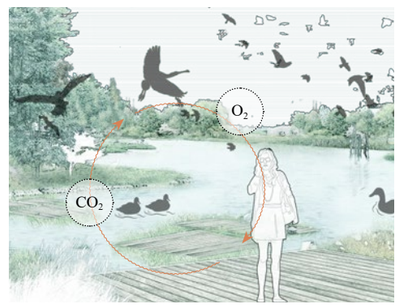
Combination of Wetlands and Composite Layer Forests.

1. In the river area, the use of natural shoreline to increase the area of green space, promote the combination of blue and green space, and optimize the combination of the river and the city form.

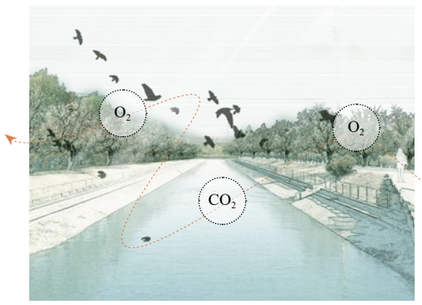
2.Protecting wetland areas, expanding the size of green patches and enhancing carbon sequestration capacity, incorporating mixed forests and increasing biodiversity.

1 Natural Shoreline & Blue-green Fusion

2 Ecofloating Island & Blue-Green Integration

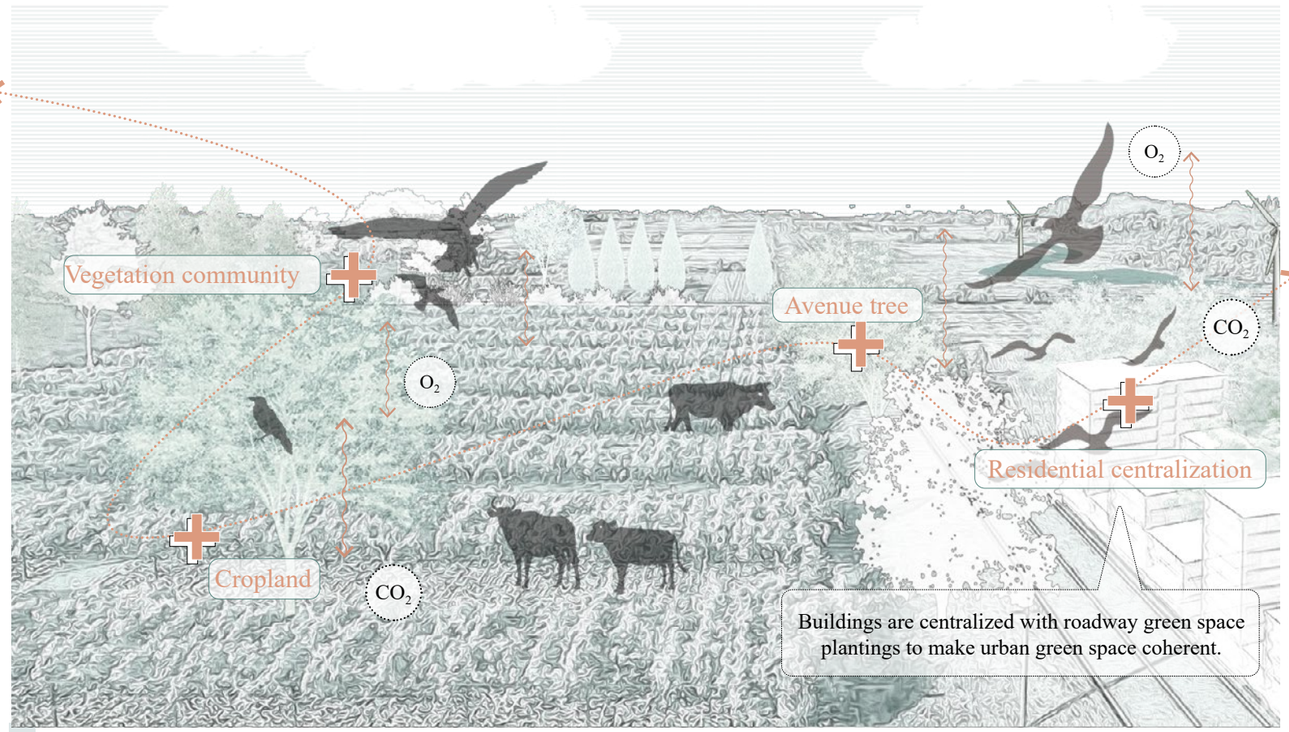


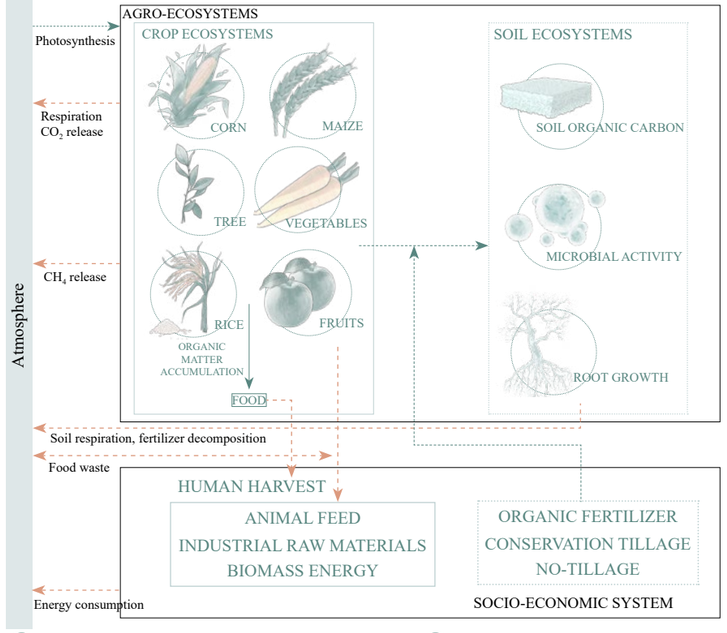
3 Priority Protection&Restoration of Ecosystems



Planning Strategies

03. Cropland-dominated Areas

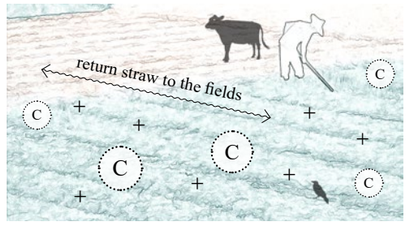




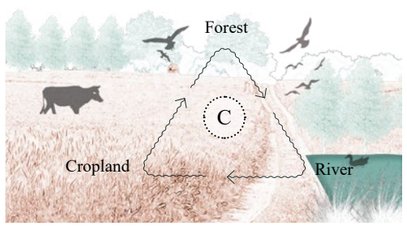
Cropland Ecosystems

The carbon sink function of cropland ecosystems includes carbon sequestration in crop biomass and soil carbon sequestration, and it is of great significance in analyzing the global carbon cycle and restoring biodiversity in cropland to increase the organic carbon content of the soil and ensure the integrity of the cropland through methods such as returning straw to the field.

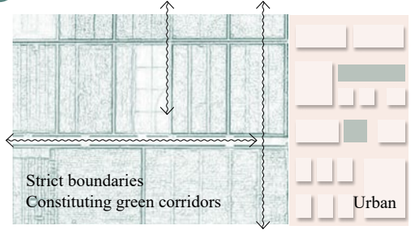
1 Increase in Organic Carbon



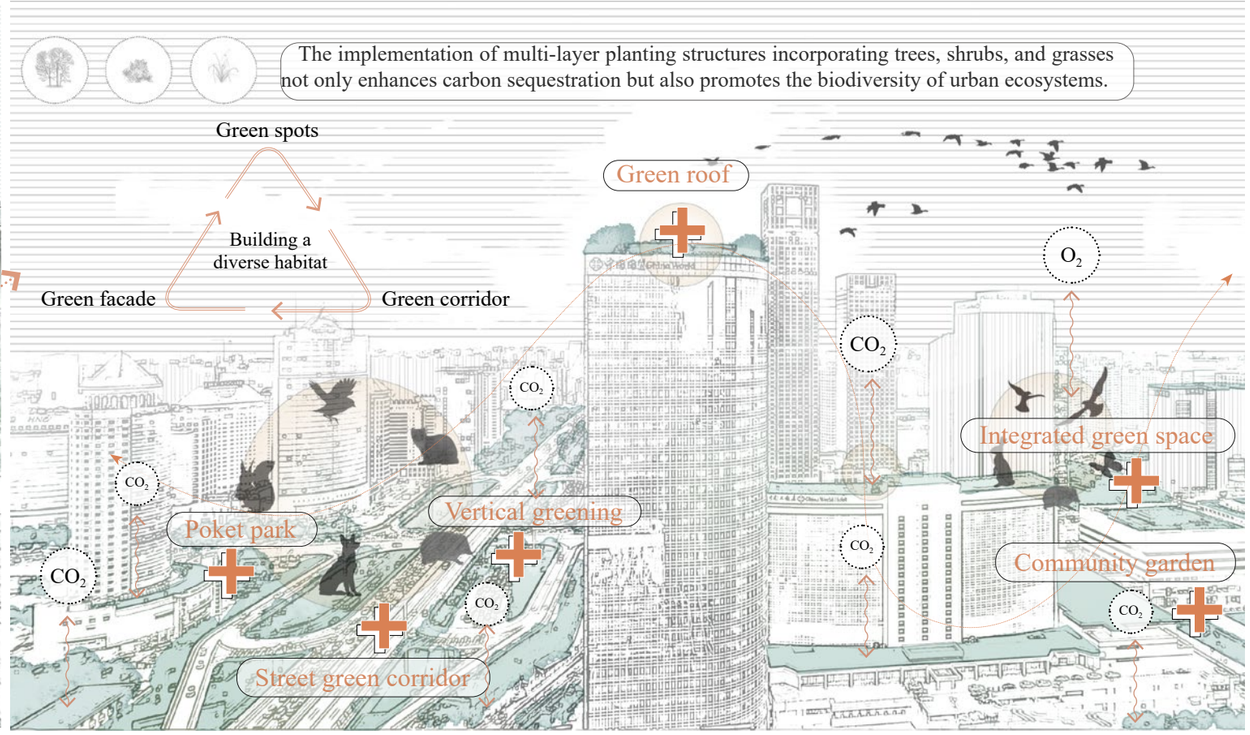
2 Compounding Operations to Reduce Emissions

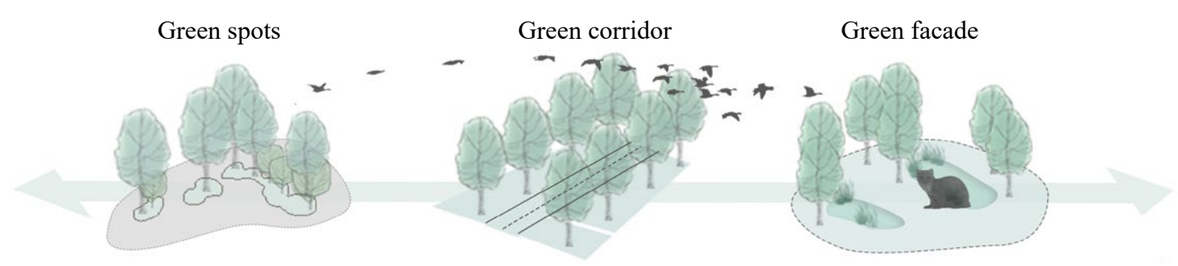


3 Centralized and Formation of Ecological Corridors

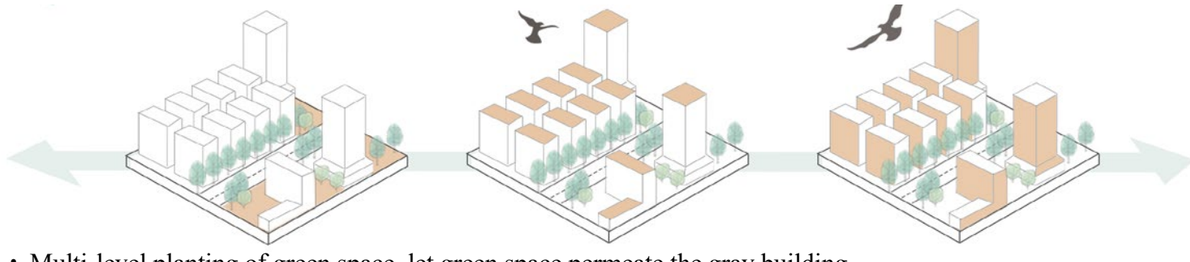


04. Urban-dominated Areas



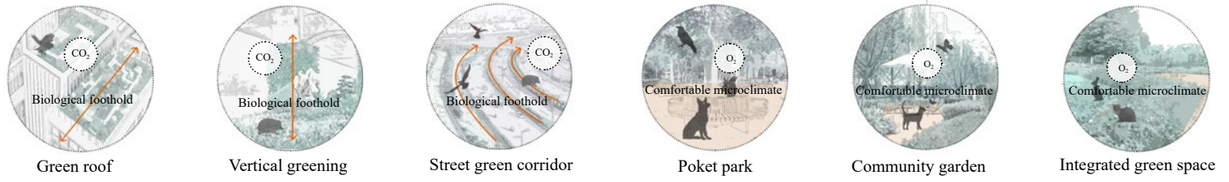


• Green plants as a medium, series continuity of green space.To protect the existing carbon sink green space and urban living environment.



• Multi-level planting of green space, let green space permeate the gray building.

Scene Display



Planning Benefits and Regional Promotion

Representative Planning Models

Combining data analysis and field research, the plan aims to form a green network system based on ecological corridors, orientated towards the enhancement of carbon sinks and taking into account urban development strategies.

As the core city, Beijing's planning model is an important reference for the entire North China region, especially the Beijing-Tianjin-Hebei region, and can become the pioneer cities in promoting low-carbon actions.

Interactive Green Space System