

GIS-Based System Construction of Natural Protected Areas: A Case Study of Shanghai

Dr. Wei Ma

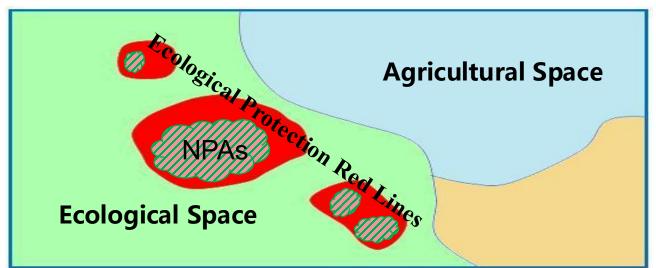
Natural Protected Area Division, Academy of Forest and Grassland Inventory and Planning, National Forestry and Grassland Administration

1 Natural Protected Areas (NPAs)



China is striving to build an institutional framework for the construction of ecological civilization.

- ➤ Based on the "one map" of the **Territorial and Spatial Planning** (TSP), **Ecological Protection Red Lines** (EPRLs) have been delineated.
- In order to explore harmonious coexistence between humans and nature, national and local agencies established **Natural Protected Areas** (NPAs) incorporated into the EPRLs.



The 8th World Conservation Congress (October 9-15) was held in Abu Dhabi, with the theme "Fueling Transformative Conservation" and will formulate the *IUCN Programme 2026-2029*.



1 Natural Protected Areas (NPAs)



Natural protected areas (NPAs) are specific terrestrial and marine regions of certain value designated for scientific conservation, effective management, and rational utilization.

- The escalation of land development intensifies the conservation-development conflict, necessitating an urgent optimization of the spatial layout in NPAs.
- According to 'Guidelines on the establishment of a natural protected areas system dominated by national parks (2019)' and 'Letter on Preliminary Work for Optimizing and Adjusting the Scope and Functional Zoning of Nature Reserves (2020)', the aims, objects, tasks and principles of integration and optimization for NPAs were determined.



中共中央办公厅 国务院办公厅 印发《关于建立以国家公园为主体的 自然保护地体系的指导意见》的通知

> 自然资源部 国家林业和草原局关于做好 自然保护区范围及功能分区优化调整 前期有关工作的函

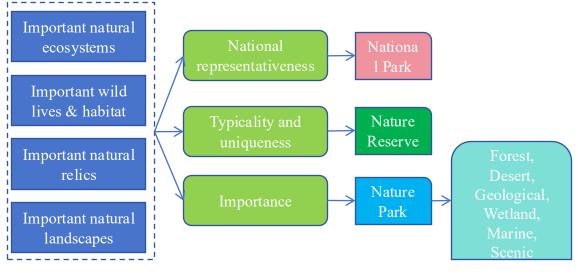
1 Natural Protected Areas (NPAs)



- ➤ Based on identifying various needs such as incorporating key plots into NPAs, resolving conflicting areas, adjusting management zones, consolidating and merging areas, converting types, and downgrading or revoking protected status,
- we strive to improve the **NPAs system with Chinese characteristics**, with national parks as the mainbody, nature reserves as the foundation, and various nature parks as a supplement.

The basic features of different types for NPAs

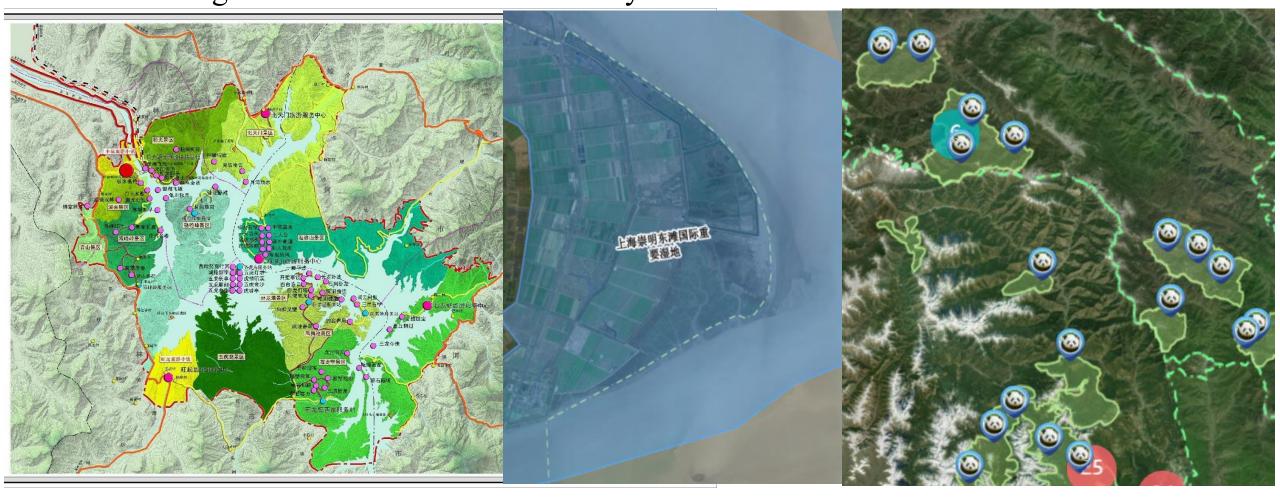
Туре	Protected Objects	Conservation Value	Management Objectives
National Parks	Large-scale natural ecosystems	Possessing national representativeness	Conservation of integrity and authenticity
Nature Reserves	Biodiversity, rare and endangered species, and geological relics	Possessing typicality and special conservation value	Focused protection of key protected objects
Nature Parks	Natural ecosystems, natural relics, and natural landscapes	Possessing important ecological, ornamental, cultural, and scientific values	Integration of focused conservation and sustainable utilization



The interplay between NPAs types, protected objects, and distinctive attributes



Geographic Information Systems (GIS) technology has played an increasingly important role in the field of NPAs, such as NPAs planning, natural resource survey and biodiversity monitoring, which advancing the construction of the NPAs system.



2 GIS + NPAs



During the system construction of NPAs, conventional

functions were employed, supplemented by specialized ones.

□ Conventional Functions

- > Standardizing data formats
- Unify the use of the CGCS2000 (China Geodetic Coordinate System 2000) **coordinate system**
- Standardize the use of shp (Shapefile) or gdb (File Geodatabase) **vector data formats**
- Identify the **layers** required for the entire workflow
- Specify the type, code, value, and other attributes of the **attribute fields**
- to construct a vector database for NPAs

国家林业和草原局自然保护地管理司关于印发 《全国自然保护地整合优化预案数据汇交指引》的通知

《王国日然体》也正日况自娱来级加记又拍打》的遗址						
名称	类型	内容				
■ B_LIAONING_FQTZ.shp	Shapefile					
■ B_LIAONING_TCBK.shp	Shapefile	[合优化预案(经过省级批复审核过的*zip,rar,7z,pdf)				
■ B_LIAONING_TRBK.shp	Shapefile	-自然保护地整合优化分述报告(经过省级批复审核过				
■ B_ZHH_LIAONING_BJ.shp	Shapefile					
■ B_ZHH_LIAONING_GNQ.shp	Shapefile					
■ B_ZHQ_LIAONING_BJ.shp	Shapefile	:量数据*(zip 格式,包含 shp 格式数据,2000 国家大地坐				
■ B_ZHQ_LIAONING_GNQ.shp	Shapefile					

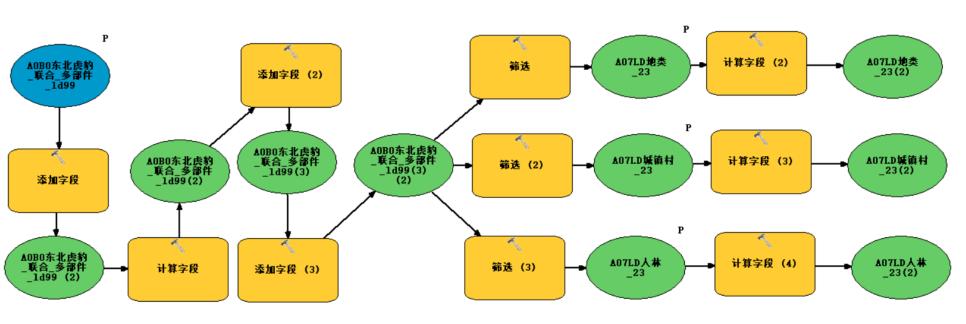






□ Conventional Functions

- > Rapid calculation and statistics
- Meeting the computational and statistical needs of massive data across more than 30 provincial-level administrative units nationwide, involving multiple batches, various types, and diverse requirements.



Application of Model Builder of the representative GIS software ArcMap





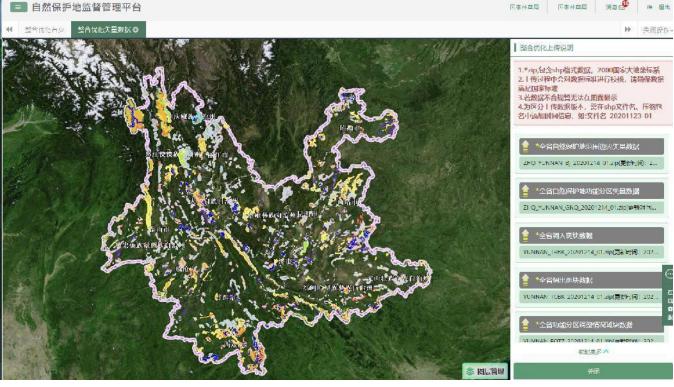




□ Conventional Functions

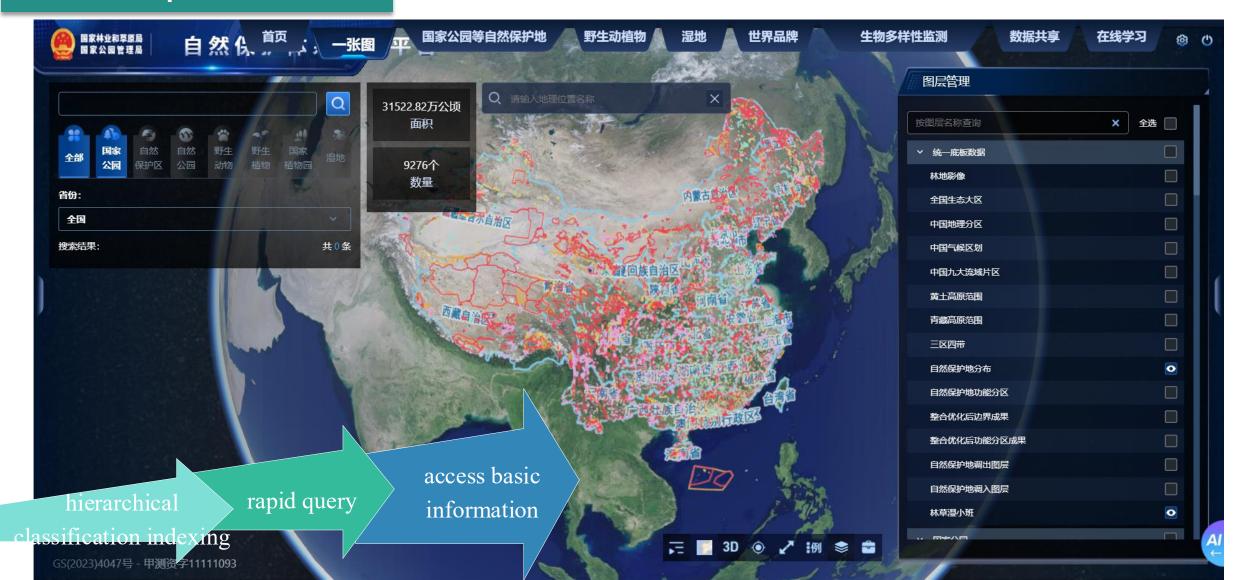
- > Diverse presentation of results
- Develop an **online platform** to host an integrated map supported by a unified data framework. The platform will facilitate online browsing, consultation, and review, supported by hierarchical classification indexing and rapid query functions.







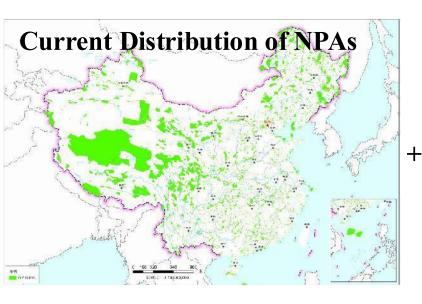
NPAs online platform



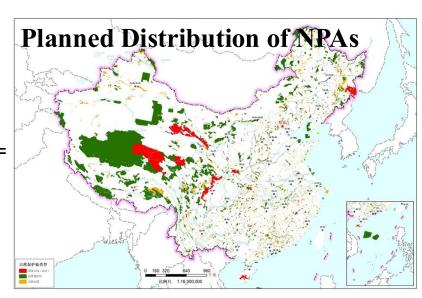


To address spatial planning issues in NPAs—such as overlapping, fragmentation, and coverage gaps—the use of individual tools and integrated model/tool sets from ArcMap was demonstrated. Key specialized functions, including identification, erase, intersect, merge, and split, were applied to accomplish data collection and integration, statistical processing, analysis, and evaluation.

- **□** Specialized functions
- > Identifying conservation gaps





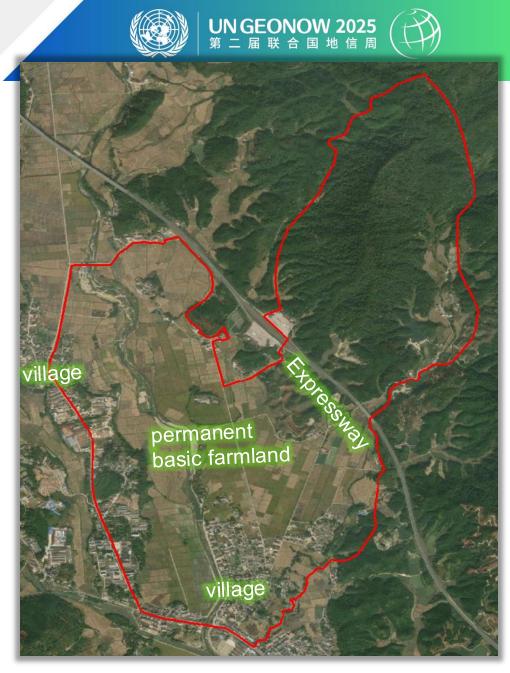


2 GIS + NPAs

□ Specialized functions

- > Identifying contradictions and conflicts
- Agricultural Space: Within national nature reserves, there exist approximately **1.5 million** hectares of cultivated land, including over **900,000** hectares of permanent basic farmland.
- Urban Space: The national scenic and historic areas encompass more than **200** urban built-up areas, over **1,300** designated towns and townships, and in excess of **7,300** administrative villages, with a total affected population surpassing **10 million**.
- Development Zones
- Mineral Tenements
- Project Facility Sites
- Commercial Plantations





Maxingshan Forest Park

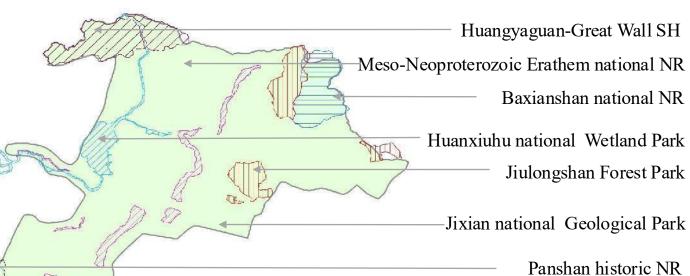


□ Specialized functions

Detecting overlapping plots

NPAs commonly exhibit issues of overlapping boundaries.

Spatial analysis reveals that over 4,800 NPAs (more than 50% of the NPAs total) are involved in regional spatial overlap.



-Jixian national Geological Park

Jiulongshan Forest Park

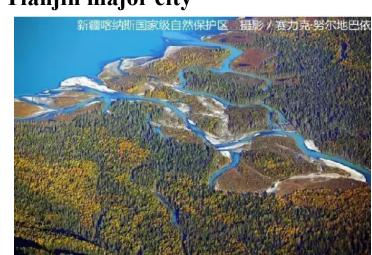
Panshan historic NR

Panshan national SH

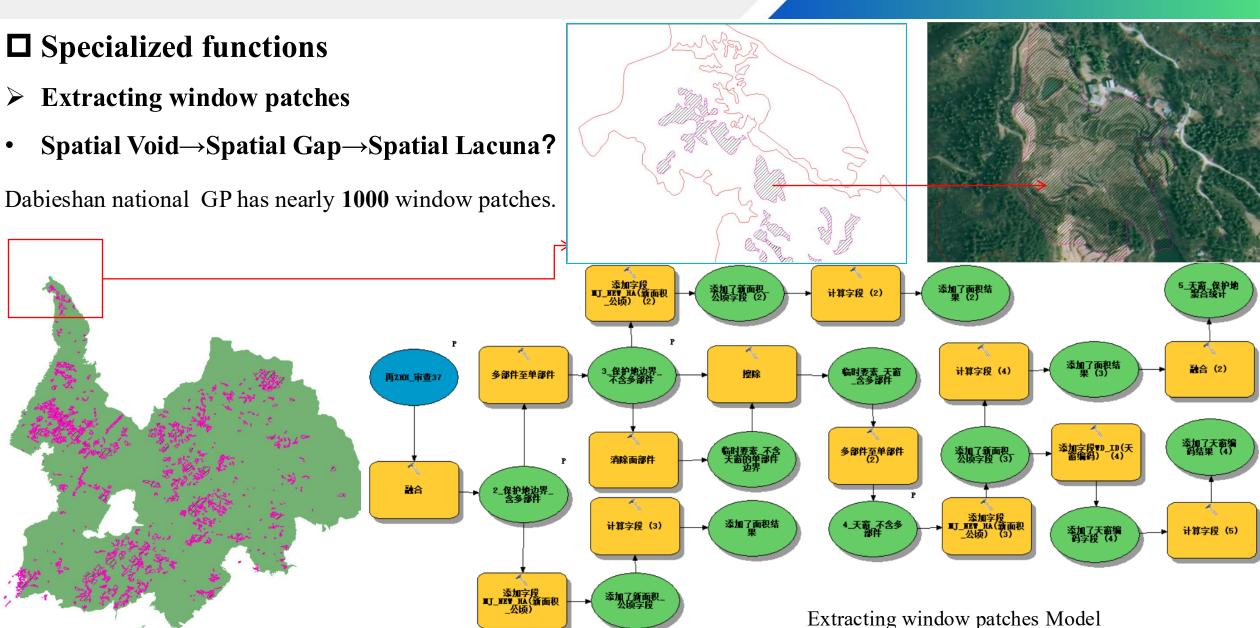
8 NPAs in Jizhou, Tianjin major city













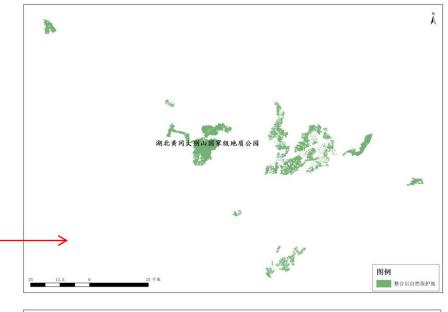
□ Specialized functions

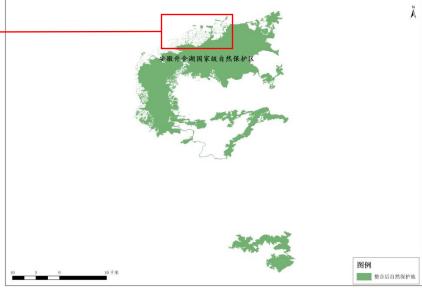
> Calculating the number of isolated patches

On average, each NPAs in the country has 6 fragmented and independent patches, with Geological Parks having the highest average of 17 patches and nature reserves averaging 10 patches.

Dabieshan national GP has nearly 1700 fragmentations.







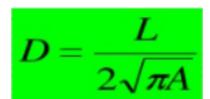


□ Specialized functions

> Assessing fragmentation levels

The **shape index** measures the complexity of a patch's shape by calculating the deviation between its perimeter and the circumference of a circle with an equivalent area.

Specifically, the D-value represents the ratio of the patch's perimeter to the circumference of a circle of equal area. A ratio of 1 indicates a perfect circular shape, while higher values signify a more irregular and developed patch boundary.

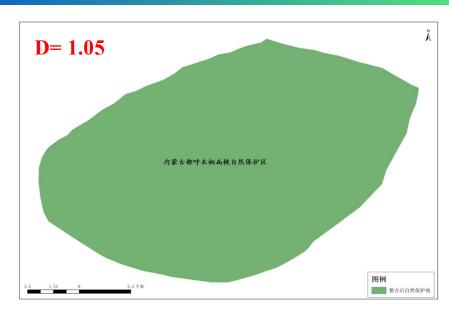


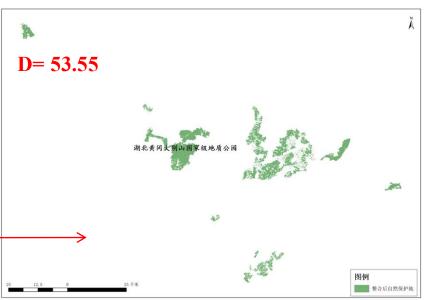
D - Shape Index (a measure of patch complexity)

L - Patch Perimeter (the total boundary length)

A - Patch Area

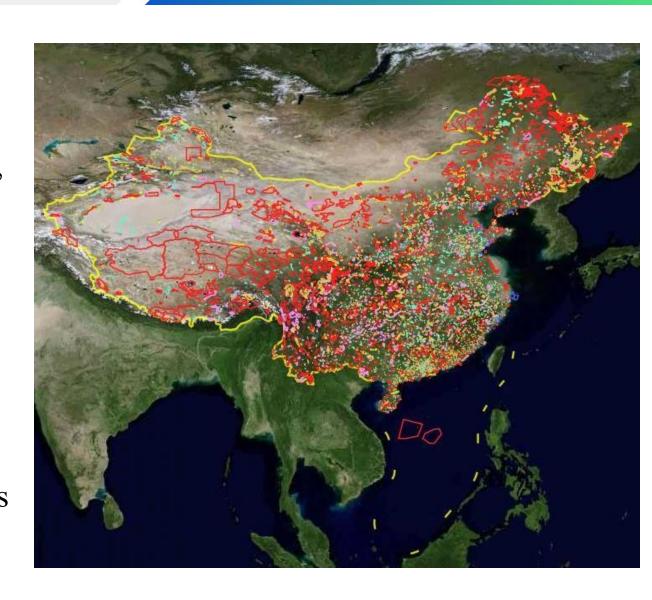
Dabieshan national GP has the highest shape index of 53.55.







- ➤ Based on GIS, one of the core "3S" technologies in surveying and mapping geoinformation technology, relevant spatiotemporal data such as protected objects, baseline resources, and conflict areas are integrated.
- This enables the quantitative processing of geospatial data in NPAs and the construction of a "One Map" system for visual representation.
- Through spatial statistical analysis, it supports applications in spatial planning, targeted data services, and decision-making for NPAs.



3 Shanghai NPAs



Our research had provide a reference for critical national initiatives such as *Planning of Spatial Distribution of National Parks* and *National Protected Areas Development Plan (2021–2035)*, and also promote the construction and development of ecological protection red line adjustment and evaluation and territorial space planning.

Taking Shanghai as an example, thereby accomplishing the goals of spatial optimization and system construction for NPAs.



3.1 Natural ecological conditions

UN GEONOW 2025 第二届联合国地信周

- Shanghai is located in the alluvial plain of the Yangtze

 River Delta, where the terrain slopes gently from west to
 east.
- The city is building a 'beach-bay-lake-island' ecological foundation to enhance biodiversity and sustainability.
- Notably, this water city boasts abundant wetland and wildlife resources, covering approximately 70,000

hectares.

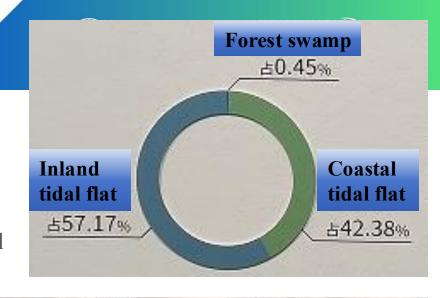


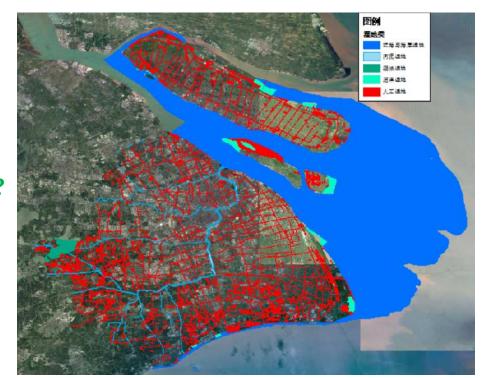




3.1 Natural ecological conditions

- Wetlands consist of 86.5% offshore and coastal wetland, 8.5% artificial wetland, and 5.0% other inland natural wetland (rivers, lakes, and marshes).
- About 91% of the wetlands are located on beaches of Chongming and Pudong.





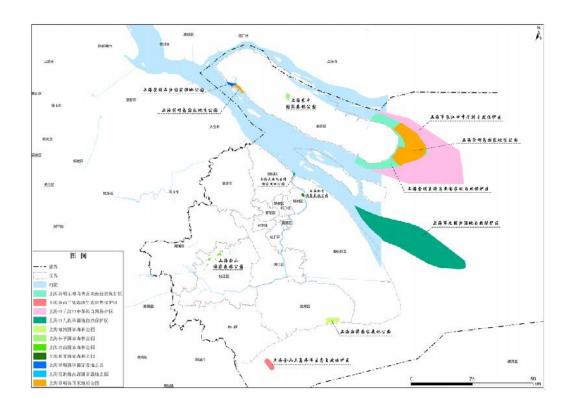


How to protected them?

3.2 Current situation of NPAs



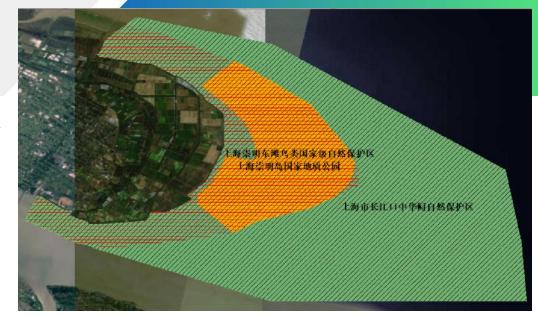
- Shanghai has established a total of 11 NPAs, including 4 nature reserves, 4 forest parks, 1 geological park, and 2 wetland parks.
- NPAs in our country protect important natural resources and typical ecological environments and are divided into three types: National Park, Nature Reserve and Nature Park.

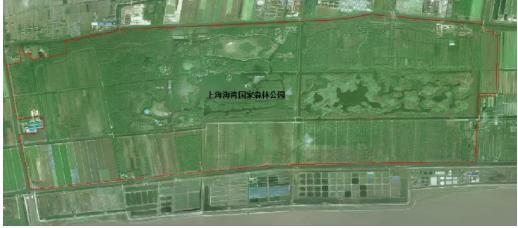


NO.	Туре	Name	Grade
1		Chongmingdongtan birds	National
2	Nature reserve	Jiuduansha wetland	National
3		Jinshansandao ocean	Sub-national
4		Changjiangkou-Chinese sturgeon	Sub-national
5	Geological park Chongmingdao		National
6		Dongping	National
7	Forest park	Gongqing	National
8		Haiwan	National
9		Sheshan	National
10	Watland nauk	Wusongpaotaiwan	National
11	Wetland park	Chongmingxisha	National

3.2 Current situation of NPAs

- There is an obvious problem of **overlap among several NPAs** in Shanghai. For example, the Chongming Yangtze River Estuary and Chinese Sturgeon Nature Reserve completely overlaps the Chongming Dongtan Bird Nature Reserve. This also affects the Chongming Geological Park (Dongtan subarea).
- The spatial scope needs to be **adjusted and optimized**. For instance, some areas with high ecological value remain unprotected by NPAs, while some conflicting zones are mistakenly included.
- The NPAs system and planning proposed in the Shanghai Integrated and Optimized Natural Protected Areas (2024) had limitations, particularly its insufficient alignment with the Shanghai Urban Master Plan (2017-2035). This is evident in the lack of national parks and inadequate protection of wetland resources.



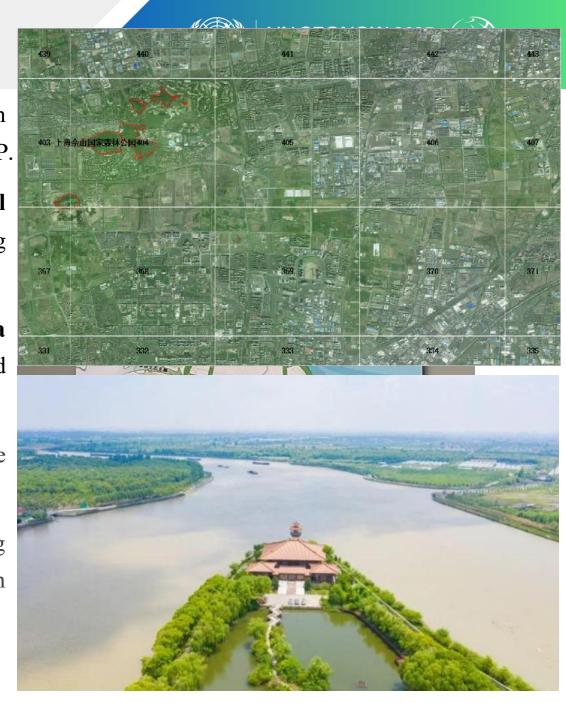


× National Park

- **√** Nature Reserve
- √ Nature Park (only 1 WP, no GP, OP and SP; how to integrate urban-rural park system?)

The spatial planning and system construction of NPAs form the foundation for assessing and adjusting the EPRL and TSP.

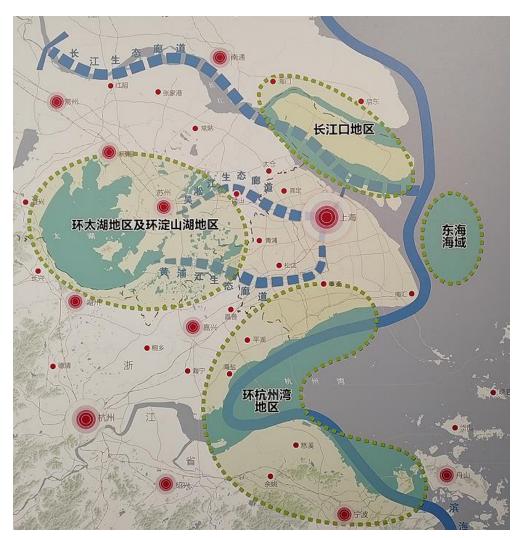
- The work was conducted in compliance with the overall requirements: maintaining protected areas, ensuring protection intensity, and preserving protection quality.
- The working methods include material collection, data analysis, preliminary plan, field inspection, evaluation and demonstration, and the final output.
 - ■Remote sensing images are used to analyze the resource conditions across 677 grids of 4x4 square kilometers.
 - ■Key hotspots were surveyed, including Chongming Island, the Huangpujiang River, Dianshanhu Lake, Sun Island, Sheshan, and Tianmashan.





> Spacial framework

- It was necessary to establish connections to a coastal ecological protection belt, three ecological corridors (the Yangtze River, Wusong River, and Huangpu River), and four sensitive ecological areas, including the East China Sea, the Yangtze River estuary, Taihu Lake, and Dianshanhu Lake, along with their surrounding areas and the Hangzhou Bay region.
- The "Three Districts and Three Lines" outcomes served as the foundation for various levels of TSP. These include the Yangtze River estuary and coastal beaches, ecological conservation areas, ecological corridors, and eco-space in the main urban area.
- The NPAs system was planned in the vast **ecological space** to consolidate the construction of an ecological city.



Ecological coordination map of Shanghai and nearby Shanghai areas



- > Classifying&Grading system
- (1)National park (NP)

The Chongming Dongtan Bird National NR + Chongming Yangtze
River Estuary and Chinese Sturgeon NR+ Chongming GP (Dongtan subarea) were integrated into =

△ Chongming Island—Changjiang Estuary National Park

- ➤ Chongming island has witnessed the formation and evolution of the Yangtze River estuary and its sea-land transformation.
- > a world-class ecological island, a International Important Wetland(2002), a World Nature Heritage Site(2024)

(2) Nature reserve (NR)

√ Jiuduansha Wetland National NR

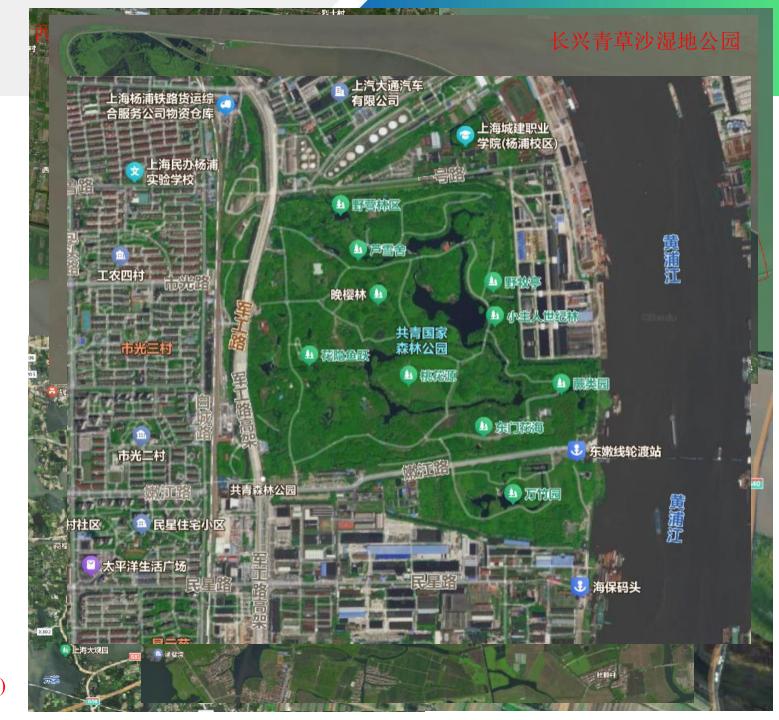
√ Jinshan Three Islands and Marine Local NR

Chongming Dongtan Bird National NR
Chongming Yangtze River Estuary and Chinese Sturgeon NR



- > Classifying&Grading system
- (3)Nature park (NK)
- ①Wetland park (WP)
- √ Chongming Xisha National WP
- × Wusong Paotaiwan National WP (overlap with military land and urban development areas and also limited protection value)
- △ Dianshanhu WP (the largest natural lake in Shanghai)
- △ Chongming Beihu WP (has been incorporated into Shanghai Territorial Spatial Planning)
- → Changxing Qingcaosha WP (reservoir)
- → Qingpu Qingxi WP (country park)
- ②Forest park (FP)
- √ Chongming Dongping FP, Fengxian Haiwan FP,

 and Songjiang Sheshan FP
- × Gongqing National FP (overlap withurban development areas and also limited protection value)



- > Classifying&Grading system
- 3 Geological park (GP)
- × Chongming Island GP (Dongtan subarea)
- √ Chongming Island GP (Xisha subarea) → Chongming Newborn Island GP (in the junction of the Yangtze River, the Yellow Sea and the East China Sea)
- **4**Ocean park (OP)
- △Pudong Coastal Ocean Park (rich in muddy coastal tidal flat resources and typical coastal salt marsh ecosystem)
- (5) Scenic and Historic Interest Area (SH)
- → Qingpu Sun-Island (transitioned from a resort area, integrating the Zhujiajiao Important Wildlife Habitat, and expanding peripheral rivers, wetlands and forests)
- > Adjustment and optimization of scope
- + Additional areas of forests, wetlands, and seas have been replenished as supplements
- Conflict zones with urban development areas and artificial forests should be removed



3.4 Conclusion

16 natural protected areas established in Shanghai through 5 targeted actions (establishment, revocation, integration, transition, adjustment).

- NPAs are categorized into 3 main kinds:
 - □National Park (NP)
 - □Nature Reserve (NR)
 - □Nature Park (NK)

•5 types of NKs include:Forests, Wetlands, Oceans, Geological, Landscape and Famous scenery

The planning maintained the authenticity, systematicness and integrity of the ecosystem in NPAs, and ensured the sustainable and stable ecological functions.



	第二届联合国地信周						
	Type	Current	Action	Planned			
i	National	0		1			
	Nauonai Park			Chongming Island—Changjiang			
	1 al K			Estuary			
	Nature Reserve	4		2			
		Chongmingdongtan bird	integration				
		Changjiang Estuary-Chinese	integration				
		sturgeon	inicgration				
		Jiuduansha wetland	adjustment	Jiuduansha wetland			
		Jinshansandao ocean	adjustment	Jinshansandao ocean			
-	Nature Park	7		11			
		1		1			
	Geological	Chongming Island (Dongtan area)	integration	_			
		Chongming Island (Xisha area)	adjustment	New island			
	Forest	4		3			
		Gongqing	revocation				
		Dongping	adjustment	Dongping			
		Haiwan	adjustment	Haiwan			
,		Sheshan	adjustment	Sheshan			
		2		5			
		Wusongpaotai	revocation				
		Chongmingxisha	adjustment	Chongmingxisha			
	Wetland		establishment	Beihu			
			establishment	Dianshanhu			
			establishment	Qingcaosha			
			transition	Qingxi			
	Ocean	0		1			
			establishment	Pudong Coastal			
	scenic &historic	0		1			
			transition	Qingpu Sun-Island			
	Total	11		16			





Thanks

Wei Ma bmawei@163.com