MRV Mechanisms and Data Governance in China's Territorial Spatial Planning System and its Response for Urban Climate Action

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Urban-Act
Integrated Urban Climate Action for Low-Carbon & Resilient Cities

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Registered offices
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GIZ Office China
Tayuan Diplomatic Office Building
1-13-2 14 Liangmahe Nanlu,
Chaoyang District 100600 Beijing, PR China
T +86 10-8527 5180
F +86 10-8532 1405
E giz-china@giz.de
I www.giz.de/china

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The Urban-Act project is implemented on behalf of the International Climate Initiative (IKI) of the Federal Government of Germany. Within the Federal Government, the IKI is anchored in the Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety (BMUKN).

Project Director
Heinrich Gudenus

Head of China Component
Liu Tong

Author
Shanghai Tongji Urban Planning and Design Institute Co., Ltd.

Translation
Enter Consulting (Shanghai) Co., Ltd.

Design
Beijing Zhuochuang Advertising Co., Ltd.

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Abstract

This report examines how China's territorial spatial planning system can support urban climate action through improved Monitoring, Reporting and Verification (MRV) mechanisms and data governance. It defines MRV not as a narrow greenhouse-gas accounting tool, but as a broader planning-governance mechanism linking monitoring, evaluation, policy feedback and dynamic plan maintenance. The report finds that China has already established a strong foundation for planning-based MRV through the One Map System, the China Spatial Planning Observation Network, standardised planning databases, annual assessments and five-year evaluations. These arrangements provide an institutional and digital basis for tracking spatial development, ecological protection, resource efficiency, urban resilience and planning implementation.

However, the current system remains stronger in monitoring effectiveness and efficiency of planning delivery. Climate-related data on emissions, energy use, building operation, transport activity, ecological carbon sinks and climate risks are still fragmented across departments and are not yet fully standardised, spatialised or verified. Drawing on pilot practices in Shanghai, the Yangtze River Delta Ecological Green Integrated Development Demonstration Zone, Jiaxing, Xi'an and Xiamen, as well as comparative lessons from London, New York and Tokyo, the report recommends that the improvement of planning MRV mechanism can include improving assessment feedback, institutionalising cross-departmental coordination, integrating climate data into planning platforms, developing a "spatial governance + climate performance" indicator framework, and linking MRV results with policy and market incentives. The report concludes that territorial spatial planning can become a key institutional platform for measurable, adaptive and coordinated urban climate action.

Glossary of Terms and Abbreviations

Abbreviation/ Term	English Full Term	Chinese Original	Contextual Definition in this Report
MRV	Monitoring, Reporting and Verification	Monitoring, reporting, and verification	In this report, MRV refers to the mechanisms used to monitor, assess, and safeguard the implementation of territorial spatial plans. It is distinct from the term's conventional use in narrow carbon accounting (monitoring, reporting, verification).
"One Map" System	One Map System	"One Map" implementation supervision information system for natural resources management and territorial spatial planning	An integrated online platform covering the entire lifecycle of spatial planning and natural resource management, including survey and monitoring, plan formulation and approval, oversight, diagnostic assessment, law enforcement, and real estate registration.
CSPON	China Spatial Planning Observation Network	Territorial spatial planning implementation monitoring network	A mechanism that leverages the "One Map" system to provide systematic support for the supervision, data aggregation and submission and dynamic monitoring of territorial spatial plan implementation.
TSP	Territorial Spatial Planning	Territorial spatial planning	A comprehensive process of strategically allocating, coordinating, and managing development, protection, and construction activities within territorial space to achieve sustainable development.
SDD	Shanghai Strategic Development Database	Shanghai Urban Development Strategy Database	The foundational data platform used by Shanghai to monitor the implementation of its master plan, track performance indicators and conduct dynamic assessments.
"Five Levels, Three Types, and Four Systems"	Five levels, three types and four supporting systems	Territorial spatial planning system framework	This denotes the spatial planning framework consisting of: five levels (national, provincial, municipal, county and township); three types of plans (master, detailed and special); and four supporting systems (plan formulation and approval, implementation oversight, legislation and policies, and technical standards).
"Annual Monitoring and Five-Year Evaluation"	Annual monitoring and five-year evaluation	Monitoring and evaluation system for urban territorial spatial planning	A key institutional mechanism for the implementation and management of territorial spatial planning. Under the requirement of "Annual Monitoring and Five-Year Evaluation", it provides for regular analysis and assessment of spatial development stage characteristics, as well as the implementation status and effectiveness of territorial spatial plans at all levels and of various types. The purpose is to promptly identify issues and shortcomings in the implementation process, propose countermeasures and recommendations, and support the dynamic adjustment, refinement, and revision of territorial spatial plans.

Abbreviation/ Term	English Full Term	Chinese Original	Contextual Definition in this Report
Ecological Protection Red Line	Ecological Protection Red line	Ecological protection red line	Areas designated in territorial spatial planning that have critical ecological functions, are extremely fragile ecologically, or hold significant potential ecological value, and therefore require mandatory, strict, and permanent protection.
Permanent Basic Cropland	Permanent Basic Cropland	Permanent basic cropland	Arable land designated in territorial spatial planning to ensure national food security and the supply of essential agricultural products, in line with projected socio-economic development and population needs. It is subject to permanent and special protection, and may not be occupied or converted without high-level approval.
Urban Development Boundary	Urban Development Boundary	Urban development boundary	A boundary delineated in territorial spatial planning that defines areas where concentrated urban development and construction are permitted within a given period. It serves as a regulatory instrument to contain uncontrolled urban sprawl, optimise urban functions, and improve spatial quality.
"Three Zones and Three Control Lines"	Three Zones and Three Control Lines	Three zones and three control lines	Denotes the spatial planning framework composed of the "Three Zones" (agricultural, ecological, and urban spaces) and the "Three Control Lines" (Permanent Basic Cropland, Ecological Protection Red Lines and Urban Development Boundaries).
Main Functional Zone	Main Functional Zone	Main functional zone	Spatial units delineated according to resource and environmental carrying capacity, spatial development suitability, socio-economic development levels and strategic positioning. Each zone has a designated primary function and is managed through differentiated policies and coordinated development approaches.
"Three Red Lines and One List"	Three Red Lines and One List	Comprises the Ecological Protection Red Lines, Environmental Quality Thresholds, Resource Utilization Caps, and the Ecological and Environmental Access List	Ecological Protection Red Lines: see definition above. Environmental Quality Thresholds: define regional management and pollutant emission control requirements to safeguard air, water, and soil quality. Resource Utilization Caps: set upper limits on the total consumption, intensity, and efficiency of resource use, including energy, water, and land. Ecological and Environmental Access List: a list that sets out the environmental access requirements for new projects in each region.

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1 Context and Mandate

1.1 Research Background

Against the backdrop of the global climate crisis and China's firm commitment to its "Dual Carbon" goals—peaking carbon emissions by 2030 and achieving carbon neutrality by 2060—cities, as major emission sources and key arenas for climate action, have assumed an increasingly pivotal role. In parallel, China is advancing the reform of its Territorial Spatial Planning (TSP) system, establishing a comprehensive framework of five administrative levels, three plan types and four supporting systems. Integrating climate mitigation, adaptation and resilience into municipal-level territorial spatial master plans and special plans has therefore become an urgent policy priority. Municipal planning must move beyond merely setting climate targets: it needs robust Monitoring, Reporting and Verification (MRV) mechanisms and integrated data management systems that enable the scientific assessment of plan performance and ensure the rigorous implementation of climate action.

The term "MRV" (Monitoring, Reporting and Verification) originates in international frameworks for carbon emissions management. The 2007 UN *Bali Action Plan* formally introduced the requirement for a greenhouse gas (GHG) management system that can be monitored, reported, and verified. Since then, MRV has become a core institutional requirement in international carbon trading and climate governance frameworks. In the field of carbon emissions and climate action management, MRV denotes a systematic framework for tracking GHG emissions, mitigation actions and the effectiveness of climate policies. Specifically, "monitoring" refers to the continuous or periodic collection of emission data from sources using standardised methods and instruments; "reporting" entails the submission of these data to regulatory authorities in standardised formats and according to prescribed procedures; and "verification" involves independent third-party audits that assess the accuracy, consistency, and completeness of the reported data. The core value of MRV lies in ensuring the authenticity, transparency, and effectiveness of climate action through quantifiable, traceable data. MRV is commonly applied in Nationally Determined Contributions (NDCs), carbon markets and corporate carbon accounting, and in practice it has a strong market orientation.

This study extends the application of MRV into the field of territorial spatial planning. Drawing on the systematic management logic of carbon governance, it proposes an integrated, closed-loop mechanism for the formulation, approval, oversight, and dynamic updating of spatial plans. Within the TSP system, the MRV mechanism discussed in this report adopts the terminology of international climate policy while adapting and reconfiguring it to the local context. It specifically refers to an implementation safeguard mechanism embedded within China's Urban Diagnostic Assessment system. In this context, the MRV framework is extended in three distinct ways: **1. Monitoring:** The scope shifts from carbon emission data to the full range of territorial development and protection indicators. This includes, but is not limited to, land-use change, enforcement of Ecological Protection Red Lines and Urban Development Boundaries, changes in blue-green spaces, accessibility of public services, and spatially explicit climate indicators such as carbon intensity and sink capacity. **2. Reporting:** The pathway shifts from corporate submissions to regulatory bodies towards routine government reporting. Municipal governments regularly compile and submit implementation data—primarily in the form of annual monitoring reports and five-year evaluation reports—to higher-level natural resource authorities. **3. Verification:** The method moves from independent third-party audits to a combination of multi-dimensional administrative validation measures, including remote sensing cross-checks, logical consistency checks of data, interdepartmental joint reviews, and technical assessments by external experts.

It is important to note that, unless otherwise specified, throughout this report "MRV" refers strictly to this spatial planning implementation mechanism, not to its original meaning in carbon management. This conceptual borrowing aims to transfer the mature process-control approach of climate governance into the spatial governance system. By establishing an end-to-end, closed-loop management model, this study seeks to provide a clearer framework for the precise monitoring and science-based evaluation of urban climate action.

This research is commissioned and funded by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH under the programme: "Integrated Actions for Low-Carbon and Resilient Territorial Spatial Planning under the Context of Climate Change (Urban-Act)." Urban-Act supports partner countries, including China, in achieving the UN Sustainable Development Goals and their respective Nationally Determined Contributions (NDCs). In China, the programme is implemented in close collaboration with the Ministry of Natural Resources (MNR) and the Ministry of

Ecology and Environment (MEE). Together with academic partners such as Tongji University, the programme advances the integration of climate considerations into territorial spatial planning. Through pilot initiatives in Jiaxing, Xiamen, Xi'an, Shanghai, the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone and the Xiong'an New Area, the programme aims to develop replicable and scalable best practices.

As of May 2025, all municipal-level territorial spatial master plans in China have been officially approved, marking a shift for local governments from the plan-making phase to an implementation, monitoring and evaluation phase. Consequently, assessing and strengthening existing MRV mechanisms and data flows—in order to rigorously track and effectively manage urban climate action—is now a central challenge for urban governance. This study addresses this challenge by providing a systematic analysis and concrete, operational recommendations.

1.2 Research Objectives

This study aims to achieve the following three core objectives:

Assess Existing Mechanisms: Conduct a comprehensive assessment of the MRV mechanisms, data architectures and operational practices currently in use in pilot cities' municipal master plans. Assess their effectiveness in supporting urban climate action, and identify systemic strengths, data gaps, inconsistencies, and institutional bottlenecks in cross-level integration.

Propose Optimization Solutions: Drawing on empirical findings, develop actionable policy, institutional and technical recommendations to strengthen municipal MRV mechanisms and climate data-sharing protocols, thereby breaking down silos and enabling seamless cross-departmental coordination and data interoperability.

Develop an Indicator Framework: Create a robust climate-action monitoring and evaluation indicator framework that is operational at the municipal level, yet standardised sufficiently to support data aggregation and macro-level reporting at the national level.

1.3 Research Content

To meet these objectives, this study is organised around four main work streams:

1) Assessment of Municipal Spatial Planning MRV Mechanisms and Climate Responsiveness:

- Map the territorial spatial planning frameworks, MRV architectures and data requirements at both national and municipal levels.
- Analyse the current data integration and sharing workflows between the Ministry of Natural Resources (MNR) and municipal governments, and horizontally among municipal departments.
- Evaluate the spatial planning systems in the pilot regions (Shanghai and the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone), focusing on climate-related elements in master and special plans (e.g. GHG emissions, land-use footprints, resilience metrics), operational MRV mechanisms, and the collection and use of climate-relevant evaluation data.
- Identify critical data gaps, operational inconsistencies and structural bottlenecks that undermine current MRV implementation.

2) Development of Optimization Strategies for MRV and Data-Sharing:

- Formulate specific recommendations for harmonising climate data within spatial planning processes.
- Design structural improvements to the MRV framework—including institutional realignments, digital tools, and data platforms—to enable systematic tracking of urban climate actions.
- Outline pragmatic pathways for climate data sharing, exploring interoperability with existing MNR databases and national digitalisation initiatives.

3) Optimization of the Monitoring and Evaluation Indicator Framework:

- Propose a municipal-level indicator matrix, with metrics grouped under climate mitigation, adaptation and resilience, and supported by clear evaluation criteria.

4) Compilation of Comprehensive Research Reports and Knowledge Products:

- Consolidate all analyses, assessments and recommendations into a rigorously structured, evidence-based comprehensive report.
- Develop concise, high-impact presentation materials that synthesise key findings and core strategic recommendations for executive stakeholders.

1.4 Technical Approach

This study follows a structured, sequential methodology comprising policy and literature review, status assessment, case studies, issue identification, strategy development, and consolidation of outputs. The workflow is organised as follows:

- **Policy and Literature Review:** Systematically review national and municipal policy frameworks, planning regulations, technical guidelines, and the relevant literature to establish a robust analytical baseline.
- **Status Assessment:** Use content analysis to examine the MRV protocols and data requirements embedded in current municipal master plans and special plans.
- **Case Studies:** Conduct in-depth analyses of representative pilot regions (Shanghai and the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone) to investigate operational dynamics, institutional arrangements, and tailored policy responses to climate change.
- **Strategy Development:** Synthesise diagnostic findings to formulate evidence-based optimisation strategies and actionable recommendations.
- **Consolidation and Output Generation:** Integrate all findings and strategic insights into a coherent narrative, culminating in the final report and associated deliverables, in accordance with the prescribed project outline.

2 Current Municipal Territorial Spatial Planning: MRV Mechanisms and Climate Responsiveness

2.1 The Territorial Spatial Planning System and Implementation Oversight Framework

Since the launch of the reform and opening-up policy, China has experienced rapid urbanisation and industrialisation, entering a phase of large-scale greenfield development. During this period, a range of planning frameworks provided essential support for urban growth, resource protection and the rational use of natural resources. However, as the national development paradigm shifted, the legacy planning system progressively revealed systemic weaknesses—including overlapping content, inconsistent plan formulation standards and insufficient horizontal coordination—that rendered it increasingly inadequate for the governance demands of the new era. For many years, a landscape of "parallel plans" prevailed, marked by multiple coexisting regimes: urban and rural planning administered by construction authorities; land-use planning overseen by land administration bureaus; and socio-economic development planning together with Main Functional Zone planning led by the Development and Reform Commissions (DRCs). The division of responsibilities was as follows: Main Functional Zone Planning: Focused on creating a comprehensive policy framework for spatial development and protection, prepared primarily at the national and provincial levels. Urban and Rural Planning: Encompassed city and town system planning (national/ provincial), city planning (municipal/ county), and town, township and village planning. City and town planning were further divided into master plans and detailed plans, aimed chiefly at regulating urban construction space. Land-Use Master Planning: Operated across five levels—national, provincial, municipal, county and township (town)—with a core emphasis on farmland protection and the intensive, economical use of land resources. Because these departments lacked unified coordination on plan formulation standards, land-use classification, data infrastructure and approval procedures, discrepancies frequently arose. Problems such as overlapping content, conflicting indicators and contradictory boundaries severely eroded the coherence and authority of spatial governance. Moreover, in the field of ecological and environmental protection, an equally fragmented institutional landscape existed: environmental protection agencies were responsible for environmental planning; water resource authorities for water and flood control planning; forestry bureaus for forest land protection and use; and the oceanic administration for marine functional zoning. As these special plans operated under separate administrative systems without a unified spatial coordination mechanism, they exemplified a governance pattern typically characterised as "multi-headed administration and dispersed responsibilities".

Against this backdrop, "multi-plan integration" reform was placed on the national agenda. In 2014, a coalition of four central authorities—the National Development and Reform Commission (NDRC), the Ministry of Land and Resources, the Ministry of Environmental Protection and the Ministry of Housing and Urban-Rural Development—launched cross-ministerial multi-plan integration pilots at the municipal and county levels. The initiative aimed to break down institutional silos by merging previously fragmented planning domains—specifically, socio-economic development mandates, urban-rural spatial layouts, cadastral land-use allocations and environmental protection baselines. The ultimate goal was to establish a highly integrated spatial governance framework for each jurisdiction, operationalised through a single, comprehensive planning instrument and governed by one unified, spatially aligned geospatial blueprint. In 2015, the *Overall Plan for Reform of the Ecological Civilization System* explicitly called for a spatial planning framework that is "nationally unified, mutually coherent and hierarchically managed". These exploratory reforms laid the foundation for the institutional restructuring of 2018. In March 2018, the *Plan for Deepening Reform of Party and State Institutions* was promulgated, creating the Ministry of Natural Resources (MNR). The MNR consolidated responsibilities previously scattered across eight entities: the former Ministry of Land and Resources; the urban-rural planning management functions of the Ministry of Housing and Urban-Rural Development; the Main Functional Zone planning duties of the NDRC; the water resource survey and ownership registration functions of the Ministry of Water Resources; the grassland resource survey and registration functions of the Ministry of Agriculture; the forest and wetland resource survey and registration functions of the State Forestry Administration; the mandates of the State Oceanic Administration; and the duties of the State Bureau of Surveying and Mapping. This consolidation achieved unified planning management authority at the institutional level, effectively ending the long-standing paradigm of "multi-headed administration" and providing the essential institutional foundation for a unified, authoritative, and efficient Territorial Spatial Planning

(TSP) system. In May 2019, the CPC Central Committee and the State Council issued the *Opinions on Establishing and Supervising the Implementation of a Territorial Spatial Planning System*, which formally instituted the "Five Levels, Three Types and Four Systems" framework: Five Levels: Correspond to the five administrative tiers—national, provincial, municipal, county and town/township—ensuring that spatial governance responsibilities are aligned with administrative competences. Three Types: Comprise master plans, detailed plans and special plans. The master plan provides a comprehensive arrangement for the entire territorial space and serves as the basis for detailed plans and the foundation for special plans. Four Systems: Consist of four supporting pillars—plan formulation and approval, implementation oversight, legislation and policies, and technical standards—which together define procedures, establish channels for full-process implementation oversight, and provide legal and technical rigour, thereby ensuring a closed-loop management chain from initial planning through to final implementation.

As of May 2025, territorial spatial master plans at the national, provincial, municipal and county levels have largely been approved, marking the fundamental establishment of the Territorial Spatial Planning (TSP) framework. With the main plan-making phase now largely complete, the strategic focus has shifted from achieving comprehensive spatial coverage to enforcing dynamic, whole-lifecycle implementation oversight. In May 2025, Zhang Bing, Chief Planner of the Ministry of Natural Resources (MNR), stressed the need to "accelerate the digital transformation of spatial governance, moving from 'static administration' to 'smart governance'." This paradigm shift rests on two main pillars: Digital infrastructure, which speeds up the roll-out of the integrated "One Map" system and the China Spatial Planning Observation Network (CSPON) to deliver comprehensive data coverage, dynamic updating and intelligent spatial control; Institutional frameworks, which require the rigorous execution of urban diagnostic assessments, dynamic updating and continuous oversight feedback loops. Institutionally, the MNR took the first step in June 2021 by issuing the *Urban Diagnostic Assessment Guidelines for Territorial Spatial Planning*, establishing the initial framework for the urban diagnostic assessment system. In 2025, the General Office of the MNR revised these guidelines, issuing the *Urban Diagnostic Assessment Guidelines for Territorial Spatial Planning (2025 Revision)*. At the same time, the Ministry put in place a regular diagnostic assessment mechanism, explicitly designating these assessments as the core instrument for implementation oversight and steering the system towards standardised, refined and routine operation. In parallel, the formal release of the *Technical Guidelines for the Construction of the Territorial Spatial Planning Implementation Monitoring Network* in December 2025 introduced a scenario-based approach to governance. Building on the existing four-level (national, provincial, municipal, and county) digital "One Map" implementation supervision platforms for natural resource management and territorial spatial planning, the guidelines provide for the construction of a comprehensive spatial monitoring network characterised by seamless vertical integration and horizontal inter-agency coordination. Under this unified architecture, administrative responsibilities are clearly stratified: The national level leads on macro-level monitoring, strategic oversight and overarching inter-ministerial coordination. The provincial level drives strategic transmission and regional coordination, acting as the critical link that translates national directives into sub-national action. The municipal and county levels focus on operational execution and high-precision governance, anchoring data workflows in real-world applications. At the same time, the framework encourages local authorities to draw on their specific territorial needs to pioneer tailor-made, context-specific application scenarios, thereby progressively expanding and enriching the operational repertoire of smart spatial governance.

As the foundational tool of national spatial governance, the TSP system provides systematic, spatially explicit institutional safeguards for low-carbon development. On the one hand, the cross-functional convergence of the natural resources and territorial spatial planning "One Map" infrastructure with CSPON creates a unified digital backbone. This integrated spatial data infrastructure (SDI) enables the precise spatial quantification of carbon sources and sinks, predictive scenario simulations, and continuous dynamic monitoring. On the other hand, the ongoing operation of the statutory spatial monitoring and evaluation (M&E) framework provides an institutional channel for embedding carbon-efficiency metrics directly into the annual urban diagnostic indicator matrix. This integration bridges the gap between administrative performance and climate targets, making it possible to spatially harmonise, visually display and dynamically correlate actual plan implementation with measurable carbon-mitigation outcomes.

Under the "Five Levels, Three Types and Four Systems" framework, the "One Map" implementation supervision information system forms a vertically integrated and horizontally connected data governance architecture, enabling the cascading upward submission of data from the township level to the national level. **National level:** The Ministry of Natural Resources (MNR) is responsible for the construction, operation, and maintenance of the national "One Map" implementation supervision information system. The MNR sets the top-level design for territorial spatial planning, formulates technical standards, and performs macro-monitoring functions. It is also responsible for examining and approving the master plans

of major cities subject to State Council approval (e.g., Beijing, Shanghai). **Provincial level:** Provincial natural resource authorities are responsible for the construction, operation, and maintenance of their respective provincial "One Map" systems. Their duties include organising the formulation, examination, and approval of provincial-level territorial spatial master plans, and supervising and guiding plan implementation in subordinate municipal and county jurisdictions. These systems connect vertically with the national system through standardised data portals, ensuring that planning data, approval information and monitoring results are transmitted upwards level by level. **Municipal and county levels:** Municipal and county-level natural resource authorities are responsible for the construction and routine maintenance of "One Map" systems within their jurisdictions. Their mandates include organising the formulation and approval of their own territorial spatial master plans, and carrying out the detailed, localised implementation of annual diagnostic assessments. These systems extend downward to the township level, ensuring full territorial coverage.

Within this multi-level MRV network, inter-agency responsibilities are clearly defined: Natural resources departments act as the lead agency for the MRV system, responsible for building and maintaining the "One Map" platform, aggregating and submitting diagnostic assessment indicators, and supervising and verifying plan implementation. Development and Reform Commissions (DRCs) provide data on national economic and social development and macro-economic indicators (such as energy consumption and carbon emissions), and take part in target alignment during the five-year evaluation process. Ecological and environmental departments supply data concerning the "Three Red Lines and One List", environmental quality monitoring and carbon emission accounting, and participate in special assessments related to climate change. Housing and urban-rural development departments provide data on urban construction, building energy consumption and municipal infrastructure operation. Transport departments supply data on transport infrastructure planning, construction and operation. Water resources departments provide data on water resource use, flood control and drainage. Statistical departments furnish basic statistical data on population and economic development. All departments are required to provide the relevant data to the natural resources departments in accordance with their established administrative functions. The natural resources departments then consolidate these data into the "One Map" system for spatial integration and comprehensive analysis. During the verification phase, natural resources departments use remote sensing and other technical means to validate key binding indicators; this is supplemented by inter-departmental joint reviews for cross-verification, thereby ensuring data authenticity and consistency. Through this multi-level, multi-department collaborative MRV network, a comprehensive monitoring and full-process control mechanism has been put in place—spanning from the national to the local level, and from macro-strategic oversight to micro-level implementation.

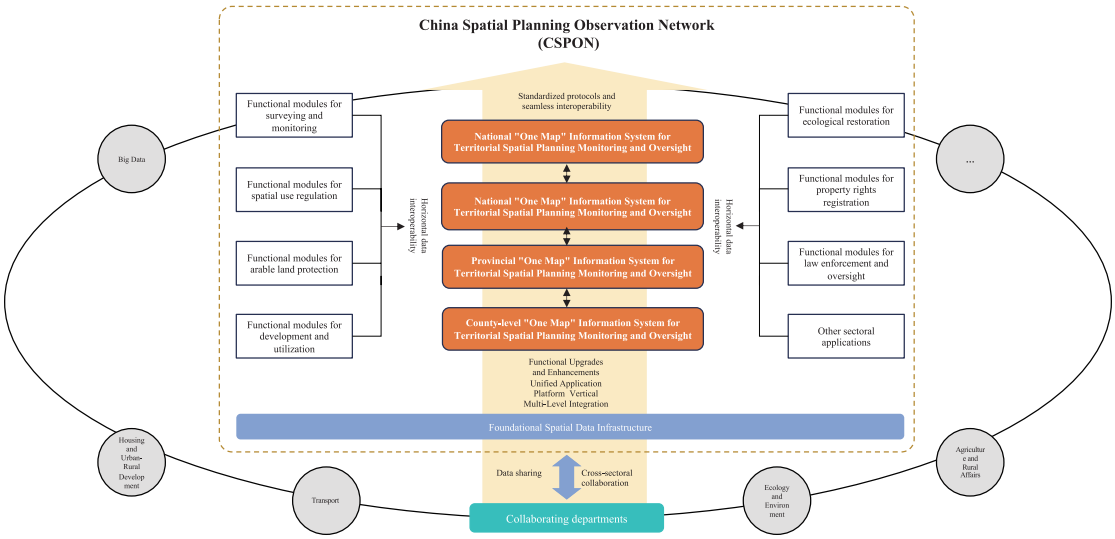


Figure 1: Architecture of the Multi-Level "One Map" Implementation Supervision System and the Inter-Departmental Collaboration Framework
Source: Work Plan for the Construction of the National Territorial Spatial Planning Implementation Monitoring Network (2023–2027)

2.2 Municipal Territorial Spatial Planning Systems, MRV Mechanisms, and Climate Responsiveness

2.2.1 Master Plan Preparation, Approval, and the MRV Mechanism

2.2.1.1 The Strategic Role of the Master Plan and the Preparation/ Approval Framework

The municipal territorial spatial master plan serves as a spatial development blueprint and strategic roadmap aligned with China's "Two Centenary Goals". It is the core spatial policy instrument for putting into practice the new development philosophy, advancing efficient spatial governance, and promoting both high-quality development and higher living standards. As the overarching framework for guiding spatial conservation, development, use, restoration and all construction activities within the municipal territory, the master plan is comprehensive, strategic, coordinated, foundational and legally binding. Within the "Five Levels, Three Types and Four Systems" framework, the municipal master plan occupies a pivotal intermediate position: it must systematically interpret and concretise top-level national mandates while providing the essential regulatory basis for drafting lower-level detailed plans and special plans, and for managing territorial space through zoning and development controls.

Since 2020, the Ministry of Natural Resources (MNR) has continuously refined the technical standards for municipal territorial spatial master plans, issuing a series of policy directives and industry benchmarks to provide full-process standardised guidance for plan formulation, cartographic presentation, database development and implementation oversight. In September 2020, the MNR issued the *Guidelines for the Preparation of Municipal Territorial Spatial Master Plans (Trial)* (hereinafter the "*Guidelines*"). As the first technical foundation for municipal planning, the Guidelines emphasise a "Multi-Plan Integration" approach and set out clear requirements in five areas: general provisions, baseline studies, core planning content, public participation, and review procedures. By requiring an equal emphasis on strategic direction and strict baseline enforcement, the Guidelines established a unified technical roadmap and mandated foundational assessments such as evaluations of resource and environmental carrying capacity, spatial development suitability, and the use of baseline data from the Third National Land Resource Survey. In March 2021, the MNR released the *Cartographic Specifications for Municipal Territorial Spatial Master Plans (Trial)* and the *Database Specifications for Municipal Territorial Spatial Master Plans (Trial)*. These specifications aim to standardise the cartographic representation and database construction of municipal master plans, thereby ensuring the consistency, comparability and transferability of planning outputs and creating the technical foundation for the subsequent "One Map" implementation oversight system, data aggregation and submission and dynamic updating.

Institutionally, the municipal people's government bears the ultimate responsibility for formulating the master plan, while the municipal natural resource authorities carry out the operational work. This includes collecting baseline data, conducting thematic studies, drafting spatial proposals, facilitating public participation and managing the approval submission process. The formulation process requires close inter-agency collaboration: sectoral authorities—including those responsible for development and reform, housing and urban-rural development, transport, ecology and environment, water resources, and culture and tourism—provide sector-specific data and strategic input. The Municipal Territorial Spatial Planning Committee is tasked with reviewing and deliberating on the planning outputs. As regards approval, the master plan is reviewed and adopted by the municipal people's government before being submitted to the provincial people's government for final approval (master plans for major cities designated by the State Council must be submitted to the State Council for approval). Municipal natural resource authorities are responsible for preparing the submission dossiers, while provincial natural resource authorities carry out the technical review and final compliance audit.

2.2.1.2 The MRV Mechanism in Master Planning

As China's spatial planning paradigm shifts from a focus on plan formulation and approval to implementation oversight, the establishment of a robust Monitoring, Reporting and Verification (MRV) mechanism is not merely a technical safeguard; it is the central pillar for achieving precise governance of urban climate action. Within the operational MRV mechanism for municipal territorial spatial planning, each department has a clearly defined set of responsibilities.

As the logical starting point of the mechanism, the monitoring phase centres on building a dynamic data baseline by drawing on high-frequency, multi-dimensional spatial sensing technologies. China has now institutionalised a routine reporting regime based on annual monitoring and five-year evaluations. Annual monitoring focuses on tracking and diagnosing progress against mandatory planning indicators and key annual tasks, with the aim of identifying short-term urban operational issues and providing timely early warnings.

Five-year evaluations, by contrast, constitute systematic performance reviews; they must be aligned with the national economic and social development plan and provide a comprehensive audit of phased progress towards long-term planning objectives. In June 2021, the Ministry of Natural Resources issued the *Urban Diagnostic Assessment Guidelines for Territorial Spatial Planning* (TD/T 1063-2021). Applicable to cities at the prefectural level and above nationwide, this standard established a routine monitoring and evaluation mechanism based on annual monitoring and five-year evaluations. By requiring regular analysis of urban development stages and the effectiveness of territorial spatial master plan implementation, the standard marked the formal establishment of the urban health check and evaluation system for territorial spatial planning in China. In May 2025, the General Office of the Ministry of Natural Resources revised and issued the *Diagnostic Assessment Guidelines for Territorial Spatial Planning (2025 Revision)*. The revised *Guidelines* are closely aligned with China's latest reform mandates to accelerate the transformation of urban development models and introduce systematic adjustments across three dimensions—livability, resilience and smart governance: **1. Prioritizing urban safety and resilience:** The *Guidelines* introduce new indicators such as the overlap area between flood-retention zones and urban development boundaries, the area of agricultural land within a 20-kilometre radius of the urban core, and the number of water sources. The assessment scope is also expanded to include the renovation of ageing gas pipeline networks, the provision of e-bike parking facilities, and construction waste disposal sites. **2. Strengthening guidance for high-quality development:** The revision adds content on identifying spatial conflicts and assessing spatial assets and the revitalisation of existing stock, with the aim of refining planning and management policies in a targeted manner. **3. Making neighbourhood-level assessment mandatory:** Assessment of the 15-minute community life circle has been upgraded to a mandatory requirement for all cities. This includes detailed tracking of pedestrian accessibility to primary and secondary schools, eldercare facilities, cultural and sports facilities, health centres, fresh food markets and football pitches. **4. Adapting to digital and intelligent transformation:** To meet the needs of the digital and intelligent transformation of territorial spatial governance, the total number of indicators was streamlined. The MNR now provides 60 per cent of the indicator data, leaving local authorities to report only 40 per cent. Supported by newly deployed digital reporting tools, the entire workflow—data input, calculation, visualisation and analysis—is completed online, substantially reducing the administrative burden on grassroots governments. The indicator framework of the revised *Guidelines* retains the structure of the 2021 edition. Content relevant to climate change is concentrated primarily within the green and low-carbon dimension, with specific indicators including land consumption, water consumption and energy consumption per unit of GDP, as well as the share of green transport modes. For annual monitoring, the municipal natural resources department acts as the lead agency. It is responsible for organising the annual territorial spatial monitoring, acquiring basic data through technical means such as satellite remote sensing and aerial photography, and conducting spatial analysis via the "One Map" system. Sectoral departments, based on the allocation of responsibilities within the indicator framework, are each responsible for the collection, review and submission of monitoring data in their respective domains. For example: the ecological and environmental department provides environmental quality and carbon emission data; the housing and urban-rural development department provides building energy consumption and urban construction data; the transport department provides traffic operation data; and the water resources department provides water resource use data. The municipal statistics bureau is responsible for providing basic demographic and economic statistics. The five-year evaluation is coordinated and led by the municipal government and specifically organised by the municipal natural resources department, with the participation of district-level governments and relevant municipal departments. Independent third-party professional institutions are also engaged to conduct independent assessments and technical reviews. After deliberation by the Municipal Planning Committee, the evaluation report is submitted to the municipal people's government for final approval and then reported upwards to the provincial natural resources department in accordance with established procedures (for cities whose master plans are approved by the State Council, the report is submitted directly to the MNR). During the dynamic plan updating phase, the municipal natural resources department proposes plan adjustment recommendations based on the diagnostic assessment results. These adjustments are implemented after deliberation by the Municipal Planning Committee and approval by the municipal people's government, ensuring the continuous refinement and effective implementation of the plan.

In the reporting phase, the municipal people's government bears the primary responsibility for the assessment. Using digital reporting tools, it submits the diagnostic reports and assessment results online to the provincial and national natural resources departments. This bottom-up reporting mechanism encompasses not only macro-level indicators such as forest coverage and energy consumption per unit of GDP, but also progressively integrates micro-level performance metrics such as the coverage rate of the 15-minute community life circle and the share of green transport modes, thereby forming a clearly tiered, multi-dimensional information feedback chain.

Verification constitutes the critical safeguard that ensures the authority and authenticity of the MRV mechanism. To prevent data misreporting or statistical bias, the verification process typically combines administrative review with third-party assessment. The MNR and provincial authorities use the China Spatial Planning Observation Network (CSPON) to conduct logical consistency checks of the submitted data, and use technical means such as remote sensing cross-checks to verify the authenticity of spatial indicators. In parallel, formal opinions are sought from the relevant departments to obtain their consensus. Additionally, independent third-party professional institutions are engaged to conduct technical assessments, such as expert reviews, which provide an objective and impartial validation of the outcomes. The reporting process is finalised only after the consent of the people's government at the corresponding level has been obtained. Only monitoring and evaluation outcomes that have successfully passed this verification stage can proceed to complete the reporting process.

At the operational level, the smooth functioning of the MRV mechanism relies on cross-departmental coordination. The Municipal Planning Committee or the municipal planning authority serves as the overarching coordinating body, responsible for facilitating data sharing and operational alignment among the relevant functional departments. During the plan formulation phase, MRV requirements are embedded into the design of the indicator framework, with the data sources, calculation methods and responsible departments explicitly defined for each metric. During implementation, the binding force of MRV results is strengthened by incorporating mandatory indicators into the performance appraisal systems for Party and government leaders. This mechanism ensures that issues identified during monitoring are directly fed back into the plan updating and dynamic adjustment processes, thereby creating a virtuous cycle of "monitoring–evaluation–feedback–updating".

Despite these advances, the current MRV implementation mechanism has scope for improvement in its responsiveness to climate change. At present, monitoring prioritises spatial forms, land-use status and related energy consumption. The system is not yet sufficiently capable of capturing dynamic data that directly reflect climate action performance, such as carbon emission intensity and community thermal comfort. With the widespread adoption of big data and the accelerating evolution of digital and intelligent technologies, future efforts can deepen the integration of artificial intelligence and big data analytics within the verification phase, thereby increasing the degree of automation in data processing and reducing uncertainties arising from human intervention. At the same time, exploring more open data-sharing protocols to dismantle inter-departmental information silos is a key pathway towards enhancing the scientific rigour and operational feasibility of the MRV mechanism for municipal territorial spatial planning. By continuously refining this mechanism, cities can embed the logic of climate governance more effectively into spatial governance systems, thereby providing robust data support and institutional safeguards for achieving high-quality development and high-level protection.

2.2.1.3 Technical Support for the Master Plan's MRV Mechanism

At present, the MRV mechanism within municipal territorial spatial planning is supported primarily by the China Spatial Planning Observation Network (CSPON) and the Natural Resource Management and Territorial Spatial Planning "One Map" Implementation Supervision Information System (hereinafter the "One Map" system). By establishing a full-lifecycle, closed-loop management pathway, these platforms turn abstract governance objectives into a digital management process that is visible, comprehensible and manageable.

The municipal "One Map" system is the core digital platform underpinning the territorial spatial planning MRV mechanism. Its primary function is to integrate diverse planning outputs, regulatory elements and monitoring data onto a single spatial base map, thereby enabling full-lifecycle digital management—from plan formulation and approval through to implementation oversight. Specifically, the "One Map" system performs the following functions: **1. Planning output management:** It digitises and archives the outputs of various plans—including master plans, detailed plans and special plans—and supports online cross-referencing and parallel review for Multi-Plan Integration. **2. Spatial regulation analysis:** It carries out spatial analysis and early-warning assessments for core regulatory elements, such as ecological protection red lines, permanent basic cropland and urban development boundaries. 3**. Monitoring and evaluation support:** It provides spatially explicit data and analytical tools for annual monitoring and five-year evaluations. **4. Administrative approval assistance:** It embeds planning control requirements into approval workflows—such as land-use pre-approvals for construction projects and the issuance of site selection opinions—thereby enabling map-based approval.

As regards institutional responsibilities, at the national level the Ministry of Natural Resources (MNR) formulates nationally unified database standards, cartographic specifications and data aggregation requirements, thereby achieving vertical integration with municipal systems through CSPON and the "One Map" network. Sectoral

authorities—including development and reform, housing and urban-rural development, ecology and environment, transport, water resources, and culture and tourism—are responsible for aggregating spatially relevant data from their respective sectors into the "One Map" system in accordance with unified standards. Provincial natural resources departments provide technical guidance to municipal systems and disseminate standard specifications, ensuring interconnectivity and uniform data standards across all municipalities within the province. The municipal "One Map" system itself is constructed and operated by the municipal natural resources department. Specific technical support bodies affiliated with the department, such as plan formulation and information centres, undertake the system's day-to-day development, data updating and operational maintenance. The Municipal Big Data Administration (or the Municipal Government Services and Data Management Bureau) is responsible for coordinating the government data resource sharing platform and for providing technical support to interface the "One Map" system's data with other e-government systems. The municipal finance bureau is responsible for securing funding for system construction and maintenance.

With regard to construction standards, the municipal "One Map" system must strictly adhere to a series of technical specifications issued by the MNR: the *Database Specifications for Municipal Territorial Spatial Master Plans (Trial)* defines the database structure, field definitions and coding rules; the *Cartographic Specifications for Municipal Territorial Spatial Master Plans (Trial)* standardises cartographic representation formats; and the *Technical Guidelines for the Construction of the Territorial Spatial Planning Implementation Monitoring Network*, issued in December 2025, explicitly define the functional architecture, technical pathways and interface specifications of the "One Map" system. In terms of spatial reference, the system uniformly adopts the 2000 National Geodetic Coordinate System and the 1985 National Height Datum. For data formats, it uses the MNR's unified land and sea use classification for territorial space. The foundational base map is updated annually using the outcomes of the Third National Land Resource Survey and annual change survey data, while sectoral data are submitted at regular intervals in line with their respective update cycles. Through unified technical standards and standardised development procedures, the authority, accuracy and interoperability of the municipal "One Map" system are reliably ensured.

2.2.2 Specialized Climate-Related Plans and Their MRV Mechanisms

In 2018, the *Plan for Deepening Reform of Party and State Institutions* consolidated previously dispersed ecological and environmental regulatory functions, creating a unified ecological and environmental management system and establishing the Ministry of Ecology and Environment (MEE). The MEE's core responsibilities encompass the full chain of ecological and environmental protection, with its central mandate being the uniform exercise of regulatory and administrative law enforcement over all types of ecological and urban-rural pollution discharges. The ecological and environmental zoning control system—centred on the "Three Red Lines and One List" (the Ecological Protection Red Lines, Environmental Quality Thresholds, Resource Use Caps and the Ecological and Environmental Access List)—is a key instrument for implementing differentiated, location-specific regulation and for advancing the modernisation of ecological and environmental governance.

In terms of institutional design, the *Interim Provisions on the Management of Ecological and Environmental Zoning Control*, issued by the MEE in 2024, explicitly stipulate that zoning control schemes are developed at the provincial and municipal levels, each with distinct priorities. The provincial scheme focuses on macro-level coordination: it is responsible for defining the overall "Three Red Lines" targets for the province and its constituent municipalities, establishing the spatial distribution of the three categories of eco-environmental control units (priority protection, key control and general control), and allocating control indicators down to the municipal level. It also formulates the ecological and environmental access list for the province and its key regions. The municipal scheme focuses on local implementation: building on the provincial scheme, it further refines the specific boundaries, numbers and area shares of each control unit within the municipality, and formulates highly specific ecological and environmental access lists for the entire municipality and for each individual unit, ensuring that control requirements are effectively enforced.

With regard to technical support, the *Technical Guidelines for Ecological and Environmental Zoning Control: General Outline* (HJ 1430-2025), formally implemented on 1 March 2026, established a comprehensive "1+N" technical standards system. The "1" refers to the General Outline, which serves as the overarching document and sets out the fundamental principles, the composition of the technical standards system, working procedures and the overall requirements for ecological and environmental zoning control. For the first time, these guidelines incorporated the groundwater environment, the

acoustic environment, the synergistic management of pollution reduction and carbon mitigation, and heavy-metal environmental risk management into the control framework. They also explicitly defined the requirements for linkage with existing instruments, such as Environmental Impact Assessments (EIA) and pollutant discharge permits.

In operational terms, the ecological and environmental zoning control system has established a full-lifecycle, closed-loop management framework comprising annual tracking, five-year evaluation and dynamic updating: Annual tracking: The implementation of the scheme is dynamically monitored on a yearly basis, focusing on changes in ecological and environmental quality and compliance with control requirements, thereby providing a basis for timely early warnings and adjustments. Five-year evaluation: Every five years, a systematic evaluation of control effectiveness is conducted in alignment with the evaluations of the national economic and social development plan and the territorial spatial plan, generating proposals for optimisation and adjustment. Dynamic updating: During the scheme's period of operation, dynamic updates may be undertaken when new laws or regulations are enacted, when ecological protection red lines are legally adjusted, or when the national economic and social development plan or territorial spatial plan undergoes changes. However, such updates must strictly respect the mandatory baselines: ecological functions must not be degraded, environmental quality must not be allowed to decline, and resource and environmental carrying capacities must not be exceeded.

In practice, the zoning control scheme places strong emphasis on precise "admission management" for enterprises and projects, directly serving environmental decision-making. In its implementation pathway, it forms a complete closed loop of "source control—process simplification—post-event supervision" together with EIAs and pollutant discharge permits. This provides an institutional channel through which macro-level emission reduction targets can be cascaded down to specific enterprises, and through which actual emissions can be monitored and verified.

As regards departmental responsibilities, the MRV operation of the ecological and environmental zoning control scheme requires close inter-agency collaboration across multiple phases: Scheme formulation phase: The competent ecology and environment department works together with the relevant departments—including development and reform, industry and information technology, natural resources, housing and urban-rural development, transport, water resources, agriculture and rural affairs, and forestry and grassland—to ensure information sharing, application and supervision in their respective fields. The natural resources department provides the spatial control base map data (including ecological protection red lines, permanent basic cropland and urban development boundaries) to guarantee spatial consistency with territorial spatial plans. The development and reform department provides macroeconomic data on industrial structural adjustment and on the control of total energy consumption and energy intensity. Plan publication phase: The approved ecological and environmental zoning control scheme is publicly released by the government at the corresponding level, and the control outcome data are simultaneously submitted and aggregated into the "One Map" system. Plan monitoring phase: Ecology and environment departments at all levels draw on a city-wide automatic ecological and environmental monitoring network—which includes air quality monitoring stations, surface water quality monitoring sections and soil environment monitoring sites—to carry out routine monitoring. This focuses on tracking indicators such as total pollutant emissions, environmental quality changes and carbon emission intensity. In parallel, the natural resources department uses the "One Map" system to conduct spatial monitoring of land-use changes within the control units, with a view to promptly identifying illegal development activities. Plan evaluation phase: The municipal ecology and environment department organises an annual tracking evaluation of the scheme's implementation and compiles an annual tracking evaluation report. Every five years, a systematic evaluation of control effectiveness is conducted alongside broader spatial and socio-economic evaluations. After formal opinions have been sought from the departments of development and reform, natural resources, housing and urban-rural development, and water resources, the evaluation results are submitted to the higher-level ecology and environment department. Dynamic update phase: In the event of legal or regulatory adjustments, changes to ecological protection red lines, drinking water source protection areas or nature reserves, or amendments to the territorial spatial plan, the municipal ecology and environment department, together with the relevant departments, carries out the dynamic update of the control scheme. Critically, they must ensure that ecological functions are not compromised and that environmental quality does not decline.

2.3 Collection, Sharing, and Integration of MRV-Related Data in Territorial Spatial Planning

2.3.1 Data Collection, Sharing, and Integration in Planning MRV

2.3.1.1 Data Collection, Sharing, and Integration for the Territorial Spatial Master Plan MRV

As a cornerstone of territorial spatial planning, data collection and application at the municipal level are highly systematic and standardised. In accordance with the *Guidelines for the Preparation of Municipal Territorial Spatial Master Plans (Trial)*, the current round of municipal master plans is centred on creating a unified base map and baseline data. Built on the outcomes of the Third National Land Resource Survey and strictly following national technical specifications—such as the land and sea use classification for territorial space and the delineation of urban development boundaries—the framework uniformly adopts the 2000 National Geodetic Coordinate System and the 1985 National Height Datum as its spatial reference. This produces a working base map with consistent coordinates, aligned sheet edges and seamless vertical integration. Coastal regions supplement this with additional base maps and baseline data for marine areas and islands within their jurisdiction. The data collection process draws together authoritative outputs from foundational surveying and mapping as well as geographic condition monitoring. It systematically aggregates data from a wide range of domains, including natural resources, ecology and environment, economy and industry, population and society, history and culture, infrastructure, urban and rural development, regional coordination, disaster risk, soil and water pollution, and marine spatial protection and use. At the same time, it captures key data such as relevant planning outputs, land-use approval records and permanent basic cropland control information. Where necessary, supplementary surveys and multi-dimensional basic data analyses are carried out, thereby providing comprehensive and accurate data support for plan formulation and safeguarding its scientific rigour and binding regulatory force.

According to the *Urban Diagnostic Assessment Guidelines for Territorial Spatial Planning*, diagnostic assessments are built around an indicator framework of 6 primary categories, 21 secondary categories and 110 specific indicators. Within this framework, ecological indicators—such as forest coverage rate, retained forestland area and grassland area—directly reflect a city's carbon sink capacity and baseline ecological conditions. Meanwhile, metrics such as land, water, and energy consumption per unit of GDP, together with the recycling rate of municipal domestic waste, the treatment rate of rural domestic waste and the share of sustainable mobility, collectively indicate resource use efficiency and the prevalence of low-carbon lifestyles. The data sources for these indicators are highly diverse. The foundational base map relies chiefly on the outcomes of the Third National Land Resource Survey. Sectoral statistical data are drawn from annual bulletins and operational records of the departments responsible for development and reform, housing and urban-rural development, transport, water resources, agriculture, and forestry and grassland. As required by the 2025 Revision of the Guidelines, the municipal planning monitoring and assessment system has undergone a comprehensive digital transformation. The Ministry of Natural Resources (MNR) now supplies around 60 per cent of the indicator data through a centralised platform, leaving the remaining 40 per cent to be reported by local governments on the basis of local circumstances. In administrative terms, the municipal natural resources department acts as the lead agency for data aggregation and database development, responsible for building the "One Map" implementation supervision information system. The relevant functional departments, in line with their respective mandates, handle the collection and preliminary review of their sector-specific data, ensuring the consistency of cross-departmental data flows.

Multi-source data are deeply integrated within the "One Map" system. Once converted into spatially explicit form, these data change from isolated statistical figures into decision-support parameters with geographic attributes. During the annual monitoring of the municipal master plan, analysing fluctuations in monitoring indicators helps reveal spatial scales, layout patterns and change trends, thereby diagnosing issues in plan implementation. For instance, tracking pedestrian accessibility to primary and secondary schools, eldercare facilities, cultural and sports facilities, and health centres within the 15-minute community life circle allows a direct assessment of the equity of public service distribution. In terms of climate responsiveness, the real-time monitoring of resilience indicators—such as the overlap area between flood-retention zones and urban development boundaries, or the number of secured water sources—effectively gauges a city's capacity to manage extreme climate risks.

Table 1: Data Sources for Climate Change Response Indicators in Master Plan Monitoring and Evaluation

Secondary Category	Indicator Items
Water Security	Total water consumption[1]; annual per capita water consumption[1]; depth of shallow groundwater table; proportion of groundwater meeting Class I–III quality standards; number of water sources[1]
Food Security	Permanent basic cropland protection area; proportion of high-standard farmland within permanent basic cropland; construction land area within permanent basic cropland; forest and grassland area within permanent basic cropland; current arable land area; agricultural land area within the urban boundary and a 20-km peri-urban radius
Ecological Security	Ecological protection red line area; area of urban and rural construction land within the ecological protection red line; arable land area within the ecological protection red line; area of land used for ecological functions within the ecological protection red line; proportion of terrestrial protected areas relative to total terrestrial land area; retained water area; wetland protection rate[1]; retention rate of natural continental coastlines[1]
Cultural Security	Natural and cultural heritage sites (count) [1]
Stormwater & Flood Security	Area of overlap between flood-retention zones and urban development boundaries[1]; proportion of permeable surfaces in urban areas; compliance rate of flood-control embankments[1]; number of urban waterlogging points
Municipal Security	Coverage area of distributed clean energy facilities[1]
Public Health Security	Number of hospital beds in medical and health institutions per 1,000 people[1]; area of land reserved for public health emergency preparedness[1]; 2-km coverage rate of Grade II and above hospitals
Urban Resilience	Per capita emergency shelter area; 5-minute coverage rate of fire and rescue services; number of ultra-high-rise buildings; area with annual ground subsidence > 50 mm[1]; number of geological disaster hazard points

Note: 1 denotes indicators reported by local authorities; the remainder are centrally provisioned by the MNR (including indicators derived from smart-scenario calculations).

Source: Urban Diagnostic Assessment Guidelines for Territorial Spatial Planning (2025 Revision)

In summary, data collection and application in municipal territorial spatial planning have evolved into a closed-loop system led by natural resources departments and supported by cross-departmental collaboration. Through the organic integration of standardised indicator frameworks, authoritative data sources and clearly allocated responsibilities, data flows underpin the entire lifecycle from plan formulation and approval to monitoring and evaluation. Empowered by digital and smart tools, this governance model not only improves the precision and timeliness of planning administration but also lays a sound foundation for the quantitative tracking and science-based evaluation of urban climate action. Going forward, as data-sharing frameworks are further refined and digital platforms become more deeply integrated, data will act as an increasingly powerful driver of the modernisation of urban spatial governance and the achievement of China's "Dual Carbon" goals.

2.3.1.2 Collection of MRV-Related Data for Specialized Plans

Within municipal special plans and their associated monitoring and evaluation frameworks, data on climate change and environmental protection are generally collected in accordance with the technical standards established by the ecological and environmental authorities. Taking ecological and environmental zoning control as an example, data collection is governed by the *Technical Guidelines for Ecological and Environmental Zoning Control: General Outline* (HJ 1430-2025), and centres on the core framework of the "Three Red Lines and One List" (Ecological Protection Red Lines, Environmental Quality Thresholds, Resource Utilization Caps and the Ecological and Environmental Access List). The indicator data cover not only traditional metrics—such as total pollutant emissions, surface water environmental quality and the proportion of days with good or excellent ambient air quality—but also, for the first time, newly incorporated dimensions, including the synergistic management of pollution reduction and carbon mitigation, the groundwater

environment, the acoustic environment, and heavy-metal environmental risk management. These data are drawn primarily from the city-wide automated ecological and environmental monitoring network, the pollutant discharge permit management system, environmental impact assessment (EIA) approval records for construction projects, and pollution source census results.

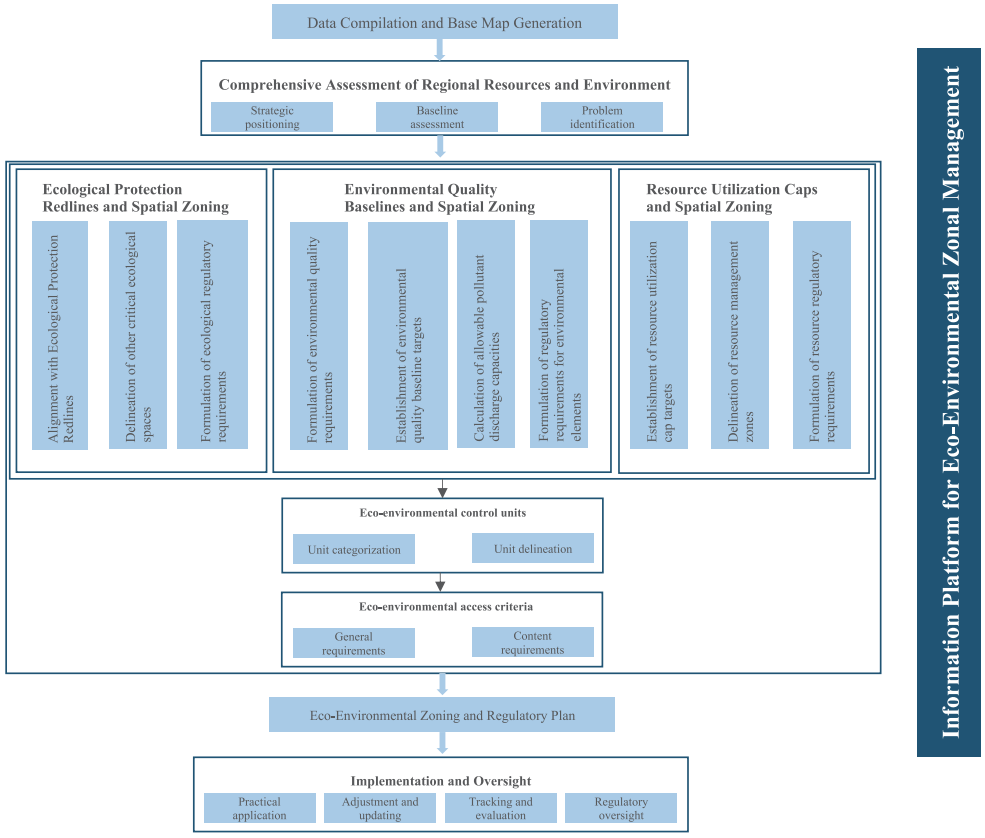


Figure 2: Technical Workflow for Ecological and Environmental Zoning Control
Source: Technical Guidelines for Ecological and Environmental Zoning Control: General Outline (HJ 1430–2025)

As the lead authority for ecological and environmental zoning control, the ecological and environmental department has put in place a full-lifecycle management system comprising annual tracking, five-year evaluation, and dynamic updating. This ensures that the data accurately reflect changes in environmental quality and compliance with regulatory requirements[1]. The aggregated multi-source data play a critical guiding role in plan implementation. During the plan formulation phase, spatial analysis of variables such as greenhouse gas emission intensity and the spatial distribution of carbon sinks supports the scientific delineation of priority protection, key control, and general control units, thereby enabling differentiated admission management. During the implementation oversight phase, these data are seamlessly integrated into the territorial spatial planning "One Map" system. This integration provides an institutional mechanism for translating macro-level emission reduction targets into actionable enterprise-level obligations and for enforcing precise market-entry controls.

1 The Opinions of the General Office of the CPC Central Committee and the General Office of the State Council on Strengthening Ecological and Environmental Zoning Control explicitly state that, in principle, the ecological and environmental zoning control scheme is to remain stable. It is to be systematically adjusted every five years in alignment with the evaluations of the national economic and social development plan and the territorial spatial plan. Where an update is strictly necessary within this five-year period, a dynamic update is to be carried out in accordance with the principle that the body that issued the scheme is responsible for updating it. Such an update must be based squarely on full alignment with the national economic and social development plan and the territorial spatial plan, and the updated scheme must simultaneously be filed for the record with the ecology and environment department at the next higher level.

2.3.2 Data Integration Between the Ministry of Natural Resources and Prefecture-Level Cities

Data integration between the Ministry of Natural Resources (MNR) and prefecture-level cities has moved beyond the simple aggregation of planning outputs towards the close integration of operational workflows. Through harmonised digital infrastructure, standardised periodic evaluation protocols and strengthened full-lifecycle implementation oversight, data flows have become the vital link between macro-level policy and micro-level governance. This digital and intelligent transformation provides a solid technical foundation for cities to tackle climate change and achieve sustainable development. As these integration mechanisms mature, data will continuously feed into spatial governance, driving a fundamental shift in urban management from "static regulation" to "smart governance".

2.3.2.1 Foundational Architecture and Collaborative Operational Mechanisms

Data integration between the MNR and prefecture-level cities is a cornerstone of China's nationally unified territorial spatial planning system. At its core lies the use of the China Spatial Planning Observation Network (CSPON) and the "One Map" system to create a vertically coordinated mechanism. This approach breaks down long-standing information silos between levels of government and puts in place a data governance framework that relies solely on natural resource survey and monitoring data as the single authoritative baseline.

To ensure scientific rigour and standardisation in data integration, the MNR has formulated strict database standards, cartographic specifications, and data aggregation requirements. When submitting data, prefecture-level cities must comply fully with the unified coordinate systems, classification standards and coding rules. By applying consistent standards to the outcomes of the Third National Land Resource Survey, annual change survey data and planning outputs at all levels, the system achieves seamless spatial alignment of data across the four administrative levels: national, provincial, municipal, and county. At the same time, prefecture-level cities are required to upload completed master plans, detailed plans, and special plans—together with all documents produced during the approval process—to the ministerial database in real time. This integrates local planning into the national "One Map" system and enables digital archiving of the entire planning lifecycle.

In annual monitoring and routine oversight, the Ministry and prefecture-level cities operate according to a clearly structured division of responsibilities. In line with the *Urban Diagnostic Assessment Guidelines for Territorial Spatial Planning (2025 Revision)*, the ministerial platform draws together satellite remote sensing data, demographic big data and sectoral statistics to provide around 60 per cent of the monitoring indicator data to prefecture-level cities. This reduces the burden of data collection at the local level and ensures consistent national evaluation benchmarks. Prefecture-level cities then report the remaining 40 per cent of locally specific indicators, based on their actual circumstances. This two-way exchange successfully strikes a balance between authoritative macro-level oversight and precise local urban governance. In addition, the ministerial platform uses remote sensing verification techniques to cross-check the locally reported data for key binding indicators—such as the Ecological Protection Red Lines and urban development boundaries—thereby ensuring the rigorous enforcement of baseline controls.

2.3.2.2 The Progressive Refinement of Data Integration and Emerging Challenges

The depth of data integration is evident not only in the centralisation of static outputs but, more importantly, in the oversight of the dynamic implementation process. Through a vertically integrated monitoring network, the MNR is able to directly track how spatial-use controls are being implemented at the municipal level. Where local actions breach binding planning constraints—such as the unauthorised conversion of cropland—the system automatically triggers an early warning and feeds the relevant information back to the local natural resources department for immediate verification and corrective action. This real-time feedback mechanism has markedly improved the responsiveness of spatial governance. In addition, by drawing on scenario simulations and big data analytics, the ministerial platform supplies prefecture-level cities with comprehensive urban operational evaluation reports, helping local governments to optimise spatial layouts and resource allocation.

In the context of climate change mitigation, data integration is rapidly becoming more granular. Data sharing between the MNR and prefecture-level cities has broadened to encompass the spatially explicit assessment of carbon sources and sinks, shifts in the energy mix, and the distribution of resilient infrastructure. By embedding climate-response indicators into the annual monitoring framework, the national government can accurately track regional progress in the synergistic reduction of pollution and carbon emissions. Data reported by prefecture-level cities—such as forest coverage rates and the share of blue-green spaces—are processed through ministerial-

level algorithms and transformed into a scientific evidence base for assessing progress towards China's Nationally Determined Contributions (NDCs). This form of spatially explicit accounting delivers the traceable and auditable data support essential for achieving the national "Dual Carbon" goals.

Despite these significant advances, the data integration process still faces a number of interconnected challenges in practice. Because of deeply entrenched technical and institutional silos between departments, the real-time sharing of sectoral data—for instance, from development and reform, housing and urban-rural development, and ecology and environment—with the natural resources system is still subject to delays. In certain prefecture-level cities, the frequency and accuracy of data updates still fall short of national requirements, resulting in insufficient granularity in vertical data alignment. Looking ahead, as the *Technical Guidelines for the Construction of the Territorial Spatial Planning Implementation Monitoring Network* are implemented more fully, data integration will progressively move towards an operational model that is more intelligent and more precise. By incorporating artificial intelligence algorithms and distributed database technologies, the MNR and prefecture-level cities can build a data ecosystem that is more efficient, more transparent, and truly closed-loop. This ecosystem will serve as a core driver of the modernisation of China's territorial spatial governance system and its overall governance capacity.

3 MRV Implementation Pathways in Territorial Spatial Planning of Pilot Cities/ Regions

3.1 Shanghai: MRV and Climate Change Response in Megacity Planning

Located at the mouth of the Yangtze River, Shanghai is one of China's most important megacities and the centre of the world-class Yangtze River Delta city cluster. According to the 2025 Statistical Bulletin on Shanghai's National Economic and Social Development, the city's gross domestic product (GDP) reached RMB 5,670.8 billion in 2025, an increase of 5.4 per cent over the previous year, and its permanent resident population at year-end stood at 24.85 million. Shanghai covers an administrative area of roughly 6,340.5 square kilometres and consists of 16 districts; it is characterised by a high concentration of population and economic activity. In terms of its designated national role, Shanghai is positioned as an international centre for the economy, finance, trade, shipping, and science and technology innovation. It also performs vital functions in support of the Yangtze River Economic Belt, the integrated development of the Yangtze River Delta, and the national strategy of opening up. Globally, Shanghai is classified by the Globalization and World Cities Research Network (GaWC) as an Alpha+ world city and consistently ranks between fifth and tenth in the Global Financial Centres Index (GFCI 38). In 2025, container throughput at the Port of Shanghai exceeded 55.06 million TEUs, maintaining its position as the world's busiest port for the sixteenth consecutive year.

This highly concentrated and deeply globally integrated development pattern presents multiple challenges for Shanghai's spatial planning and implementation management. Balancing growth with strict constraints: Shanghai must sustain its global city functions and economic competitiveness while rigorously controlling the size of its population and its total construction land. The *Shanghai Master Plan (2017–2035)* (hereinafter *Shanghai 2035)* explicitly requires negative growth in the total amount of planned construction land. It calls for the four bottom lines—population size, construction land, the ecological environment and urban safety—to be strictly maintained. By 2035, the permanent population is to be capped at around 25 million and total construction land limited to no more than 3,200 square kilometres. Paradigm shift in governance: Shanghai is under pressure to transform itself by shifting from greenfield expansion to the regeneration of existing stock, from project-based construction to whole-process governance, and from one-off plan approval to dynamic implementation evaluation. The plan itself emphasises the establishment of a spatial reservation mechanism (strategic land reservation) and a dynamic assessment and adjustment mechanism to respond to the uncertainties inherent in urban development. Integrating safety and climate resilience: The imperatives of climate change, resource and environmental constraints, and the safe functioning of a megacity require Shanghai to embed low-carbon development, resilience building, ecological space protection and infrastructure safety into the monitoring system for spatial plan implementation.

The *Shanghai 2035* master plan explicitly calls for proactive responses to climate change and for building Shanghai into a more adaptable and resilient eco-city. As early as the start of 2008, Shanghai was included in the Low-Carbon City pilot project jointly launched by the World Wide Fund for Nature (WWF) and China's Ministry of Construction. In 2011, Shanghai's total carbon emissions reached a temporary peak of 220 million tonnes before entering a slow decline; emissions have since stabilised at roughly 200 million tonnes, achieving a gradual decoupling of carbon emissions from GDP growth. *Shanghai 2035* further integrates green and low-carbon concepts into the overall urban planning framework and proposes low-carbon strategies and indicators across a range of sectors in order to promote low-carbon urban development in a comprehensive manner. The significance of the Shanghai case therefore goes beyond merely illustrating the planning experience of a developed metropolis. At a more fundamental level, it demonstrates how target setting, spatial regulation, project delivery, and monitoring and evaluation mechanisms can be integrated into the entire lifecycle of territorial spatial planning under conditions of high density, tight constraints, and multi-objective governance.

3.1.1 Shanghai's Territorial Spatial Planning System and Overall MRV Mechanism

(1) **The Territorial Spatial Planning System**

In accordance with the *Opinions of the CPC Shanghai Municipal Committee and the Shanghai Municipal People's Government on Establishing a Territorial Spatial Planning System and Supervising Its Implementation*, Shanghai has put in place an integrated plan formulation and approval system that carefully aligns spatial and

temporal dimensions. Along the spatial dimension, the framework is structured into three tiers: master plans, unit plans and detailed plans. The master plan tier encompasses the Shanghai Territorial Spatial Master Plan, the master plans for the Pudong New Area and the various suburban districts, as well as special plans prepared at the master-plan level. The unit plan tier includes unit plans for the main urban area, master plans for new towns, and unit plans for specific policy zones. The detailed plan tier consists of regulatory detailed plans, village plans for rural suburban units, and special plans adopted at the detailed-planning level. Along the temporal dimension, the system incorporates near-term territorial spatial plans and annual implementation plans, which serve as the essential basis for the phased delivery of the master plan. Overall, Shanghai's plan formulation and approval architecture can be systematically summarised as "two dimensions (spatial and temporal), three tiers (master, unit and detailed), and four types (master, unit, detailed and special plans)".

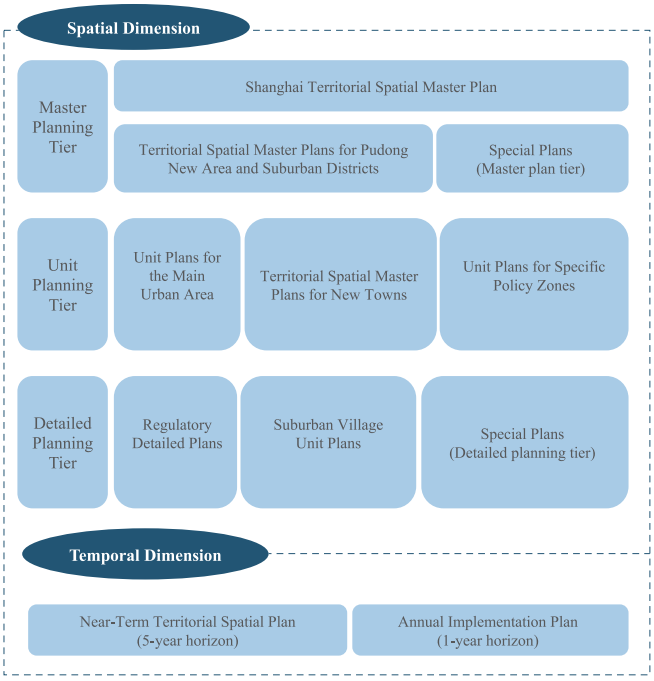


Figure 3: Shanghai Territorial Spatial Planning Preparation Framework
Source: Compiled based on the Opinions of the CPC Shanghai Municipal Committee and the Shanghai Municipal People's Government on Establishing and Supervising the Implementation of Shanghai's Territorial Spatial Planning System

At the master plan tier, the Shanghai Territorial Spatial Master Plan is organised and prepared by the Shanghai Municipal People's Government and submitted to the State Council for approval. The current statutory plan is the *Shanghai Master Plan (2017–2035)* (hereinafter *Shanghai 2035*), which was formally approved by the State Council in 2017. To guide the formulation of Shanghai 2035, the municipal Party committee and government set up a dedicated leading group to provide strategic direction and overall coordination. The Shanghai Municipal Bureau of Planning and Natural Resources (formerly the Shanghai Municipal Bureau of Planning and Land Resources) acted as the lead agency, responsible for the detailed drafting work. The process involved extensive inter-agency collaboration: a broad group of municipal departments participated actively by supplying critical data, discussing key issues, and carrying out major thematic studies and specialist research. These agencies included the Development and Reform Commission, the Commission of Economy and Informatization, the Commission of Commerce, the Transportation Commission, the Housing and Urban-Rural Development Management Commission, the Bureau of Ecology and Environment, the Tax Service, the Landscaping and City Appearance Administrative Bureau, the Education Commission, the Health Commission, the Civil Affairs Bureau, the Sports Bureau, the Administration of Culture and Tourism, the Emergency Management Bureau, the Public Security Bureau, the Agriculture and Rural Affairs Commission, the Marine Bureau, the Bureau of Statistics, the Housing Security and Building Administration Bureau, the Human Resources and Social Security Bureau, and the Finance Bureau. In addition, all 16 district governments in Shanghai were fully involved in the plan's preparation.

Shanghai applies a tiered management structure for its territorial spatial special plans. Special plans at the master-plan level focus primarily on sectors with significant spatial implications, including infrastructure, the ecological environment, public services, historic and cultural heritage conservation, marine spaces, and industrial development. These are jointly prepared by the competent sectoral authorities (or the relevant district governments) and the Municipal Bureau of Planning and Natural Resources, and are then submitted to the municipal government for approval. Climate-responsive special plans embedded within this framework include the *Shanghai Action Plan for Climate Change Adaptation (2024–2035)*, the *Shanghai Implementation Plan for Climate Change and Health Adaptation (2025–2030)*, and the *Shanghai Implementation Plan for Synergistic Pollution Reduction and Carbon Mitigation*.

(2) The Overall MRV Mechanism

Guided by the requirements set out in the *Opinions of the CPC Central Committee and the State Council on Establishing a Territorial Spatial Planning System and Supervising Its Implementation*, Shanghai has successfully established—and continues to refine—a full-lifecycle mechanism for plan monitoring, evaluation, and dynamic updating.

The current *Shanghai 2035* master plan explicitly requires the establishment of a robust plan maintenance system and the institutionalisation of dynamic monitoring, periodic evaluation, and timely updating procedures. Drawing on the Shanghai Strategic Development Database (SDD) as its core digital platform, the system tracks and monitors all target indicators set out in the master plan in order to continuously assess progress towards the plan's goals.

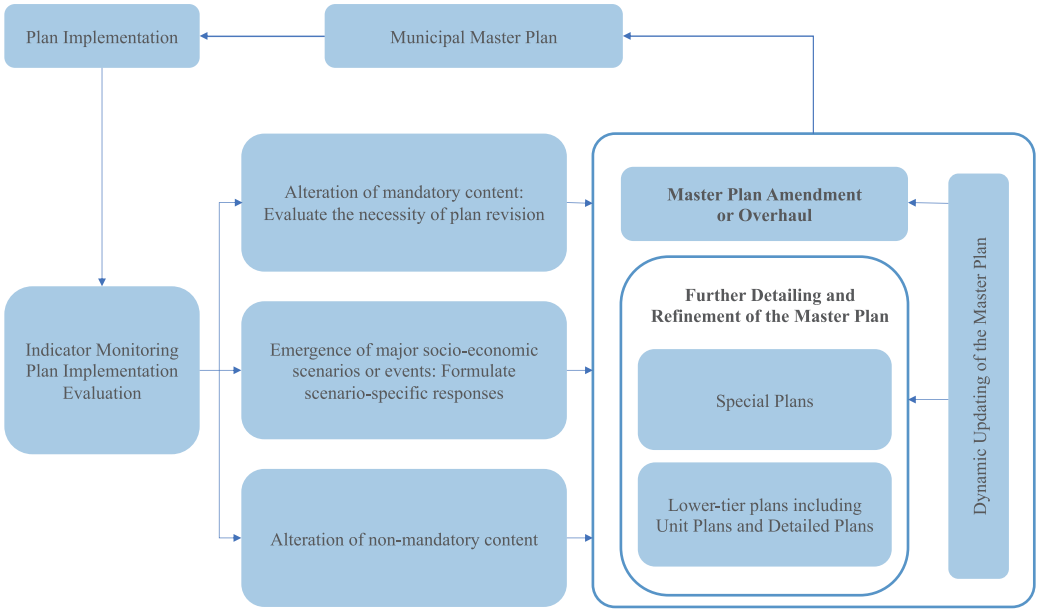


Figure 4: The "Monitoring—Evaluation—Maintenance" Mechanism of the Shanghai Master Plan
Source: Report on the Shanghai Master Plan (2017–2035)

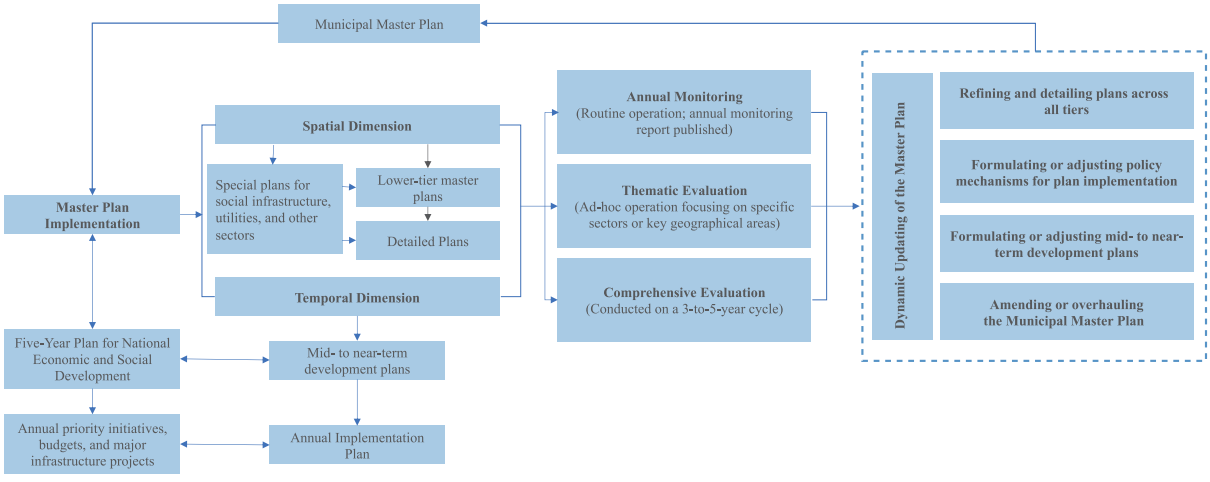


Figure 5: Operational Framework for the Implementation Monitoring, Evaluation, and Dynamic Maintenance of the Shanghai Master Plan
Source: Jin Zhongmin, Chen Lin, and Tao Yingsheng (2019). "Research on Technical Methods for Monitoring the Implementation of the Master Plan of a Megacity's Territorial Spatial Planning—A Case Study of Shanghai." Shanghai Urban Planning, 4(2019): 8.

Following its approval by the State Council in 2017 and its official release in 2018, *Shanghai 2035* introduced routine annual monitoring and evaluation procedures. This put in place a regular assessment cycle based on an annual monitoring and five-year evaluation loop.

(3) Annual Monitoring

Annual monitoring is, in principle, conducted once a year. Its primary focus is to track changes in planning indicators, monitor progress on key planning tasks, assess the overall "vital signs" of the city's annual performance, and identify short-term issues that require immediate corrective action. In 2018, the Shanghai Municipal Bureau of Planning and Natural Resources carried out the first annual monitoring exercise for *Shanghai 2035* (Figure 6). Closely following the master plan's internal logic of "objectives (indicators)—strategies—mechanisms", the annual monitoring framework was designed to track the 97 core indicators set out in *Shanghai 2035*. By analysing fluctuations in these indicators, the assessment identifies spatial scales, layouts, and development trends, thereby diagnosing implementation bottlenecks, examining their root causes and formulating targeted proposals for refinement.

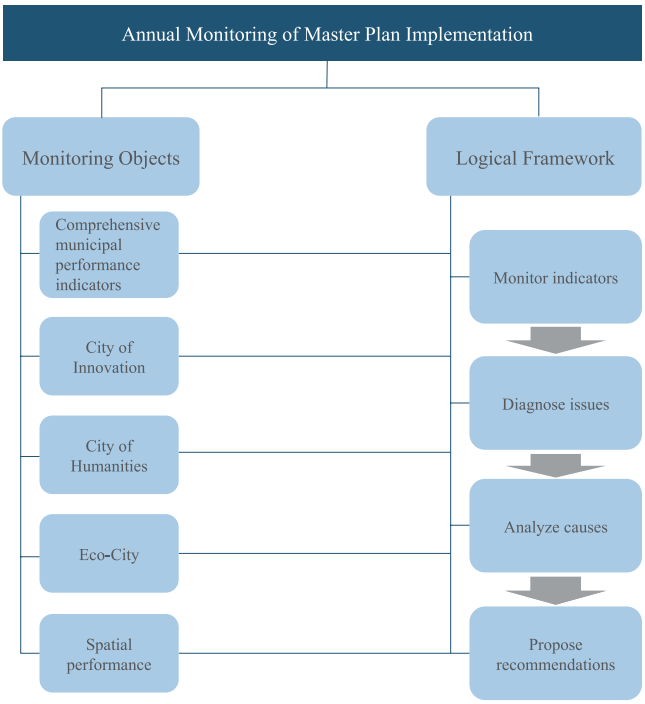


Figure 6: Operational Framework for the Implementation Monitoring, Evaluation, and Dynamic Maintenance of the Shanghai Master Plan
Source: Jin Zhongmin, Chen Lin, and Tao Yingsheng (2019). "Research on Technical Methods for Monitoring the Implementation of the Master Plan of a Megacity's Territorial Spatial Planning—A Case Study of Shanghai." Shanghai Urban Planning, 4(2019): 8.

The deliverables of the annual monitoring process typically include: One comprehensive research report (incorporating annual monitoring samples); One monitoring indicator table; One integrated urban performance diagnostic map; One public satisfaction survey report; Several special thematic monitoring reports. These reports provide a comprehensive account of indicator monitoring results and plan implementation progress, examine key issues and their underlying causes, and offer actionable recommendations for the dynamic updating of the master plan. In line with the latest directives of the Ministry of Natural Resources (MNR), the annual monitoring report is to be finalised by the third quarter of each year. Following review and approval by the Municipal Bureau of Planning and Natural Resources, the data are aggregated and submitted online to the MNR via the national territorial spatial planning implementation monitoring network (CSPON). At the same time, the findings are filed for the record with the Municipal Planning Committee, the Municipal Government and the Standing Committee of the Municipal People's Congress to ensure rigorous administrative oversight.

(4) Five-Year Evaluation

The five-year evaluation is conducted every five years to systematically assess the effectiveness of master plan implementation, ensure alignment with the national economic and social development plan and near-term development priorities, and provide an evidence base for the dynamic updating of the master plan. In 2023, the General Office of the Shanghai Municipal People's Government issued the *Work Plan for the Five-Year Implementation Evaluation of the Shanghai Master Plan (2017–2035)*, formally launching the exercise. The evaluation follows a tiered administrative structure of municipal-level coordination and district-level implementation, together with a dual-track framework combining comprehensive evaluation and special evaluation. In addition to assessing the master plan itself, the exercise simultaneously evaluates the implementation of the *Shanghai Territorial Spatial Near-Term Plan (2021–2025)*, district master plans and land-use master plans, central-city unit plans, and the relevant municipal special plans.

The evaluation is overseen by the Shanghai Municipal Planning Committee, while its Office (the Shanghai Municipal Bureau of Planning and Natural Resources) manages overall coordination. District governments, relevant municipal departments and associated bodies take part jointly, forming a collaborative operating model that combines expert advisory input, inter-departmental coordination, municipal–district synergy, independent third-party assessment, regional cooperation, and public participation. The Municipal

Planning Committee provides overall leadership, offering guidance and taking decisions on major strategic issues. The Office of the Municipal Planning Committee (the Shanghai Municipal Bureau of Planning and Natural Resources) coordinates the evaluation process, organises the various tasks, refines technical requirements, monitors indicator data (in conjunction with the Municipal Statistics Bureau), and consolidates the outputs of district governments and municipal departments into a single overarching evaluation result. District governments prepare district-level evaluation reports and compile data for their respective jurisdictions in strict accordance with the *Shanghai 2035* master plan's requirements. Municipal departments—including the Bureau of Ecology and Environment, the Housing and Urban-Rural Development Administration Commission, the Transportation Commission, the Landscaping and City Appearance Administrative Bureau, the Commission of Economy and Informatization, the Big Data Center and the Commission of Commerce—carry out data collection and special evaluations within their respective sectors. Independent third-party institutions conduct the comprehensive evaluation of *Shanghai 2035* to ensure objectivity. The Expert Committee provides technical advice, methodological validation, and rigorous review of the evaluation reports. The relevant regional coordination bodies are responsible for organising and coordinating assessments relating to their respective geographical areas; for example, the Yangtze River Delta Regional Cooperation Office is responsible for coordinating those evaluations under *Shanghai 2035* that relate to Yangtze River Delta integration, the Shanghai Metropolitan Area and cross-boundary areas adjoining Shanghai. The public and civil society organisations participate primarily through opinion gathering, feedback mechanisms and the articulation of stakeholder concerns.

With regard to the content of the evaluation, the five-year assessment builds on the requirements set out in the *Urban Diagnostic Assessment Guidelines for Territorial Spatial Planning*. Following the principle of maintaining continuity in the implementation of a long-term plan, the assessment measures progress against the objectives, strategies, and key priorities of *Shanghai 2035*, with particular attention to four areas: strategic objectives and tasks, regional coordination, spatial structure, and priority sectors (Table 2).

Table 2: Key Areas of the Five-Year Implementation Evaluation of Shanghai 2035

Evaluation Area	Evaluation Content
Objectives and Tasks	Assess progress toward the overall and sub-objectives established in Shanghai 2035, analyze the implementation progress of the indicator system, evaluate the advancement of the territorial spatial near-term plan, and summarize key achievements and shortcomings.
Regional Coordination	Anchored by the themes of "integration" and "high-quality development," analyze Shanghai's role as the leading growth engine within the Yangtze River Delta city cluster across three spatial dimensions: the Yangtze River Delta urban agglomeration, the Shanghai Metropolitan Area, and adjacent cross-boundary zones.
Spatial Pattern	Assess the implementation of the "networked, multi-centered, cluster-based, and intensive" spatial system, as well as the strategic spatial pattern characterized by "core-city radiation, coordinated advancement of the two wings, growth driven by new towns, and North-South transformation" established in Shanghai 2035. Focus heavily on spatial baseline controls, spatial structure, and key development areas.
Key Sectors	Focusing on high-quality urban development, systematically assess seven priority areas: urban-rural integration, industrial functions, heritage conservation and urban regeneration, housing and public services, safety and resilience, green and low-carbon development, and implementation assurance mechanisms.

Source: Compiled based on the content of the Notice issued by the General Office of Shanghai Municipal People's Government on Printing and Distributing the Work Plan for the Five-Year Implementation Evaluation of Shanghai Master Plan (2017-2035)

In terms of outputs, Shanghai's master plan evaluation has produced a "1+2+N" results framework. The "1" refers to a single overarching report: the *Five-Year Implementation Evaluation Report of the Shanghai Master Plan (2017–2035) (2017–2022)*. The "2" consists of two thematic reports: an independent third-party evaluation report and an annual monitoring report[2]. The "N" comprises a series of supporting reports, including: (i) sectoral assessment reports prepared by the municipal departments responsible for specialised policy areas, assessing implementation against the master plan, near-term action plans and relevant municipal sectoral plans; (ii) local assessment reports prepared by district governments and relevant agencies, assessing implementation against the master plan, district-level master plans, central urban area unit plans and near-term plans; and (iii) a public satisfaction survey report.

Upon completion, the *Five-Year Implementation Evaluation Report of the Shanghai Master Plan (2017–2035) (2017–2022)* is submitted to the Shanghai Municipal Planning Commission for review. Following deliberation by the Shanghai Municipal Government, the report is formally submitted to the Ministry of Natural Resources in accordance with the prescribed approval procedures.

(5) Data Support

In line with the requirements of "one unified base map, one unified standard, one unified plan and one unified platform", the Shanghai Municipal Bureau of Planning and Natural Resources has developed the "One Map" implementation supervision information system for natural resource management and territorial spatial planning, building on the existing Shanghai Strategic Development Database (SDD). The system creates a unified spatial base map and brings together city-wide, three-dimensional and high-precision geospatial data on a single digital platform. Building on this, data from multiple government departments are combined with socio-economic statistics, urban management information and spatio-temporal datasets to form a comprehensive digital platform for monitoring plan implementation and urban development. The system was largely completed and entered operation in 2021. It enables routine, dynamic monitoring of spatial, environmental and development-related indicators across the city and provides a key data basis for the monitoring and evaluation of territorial spatial planning.

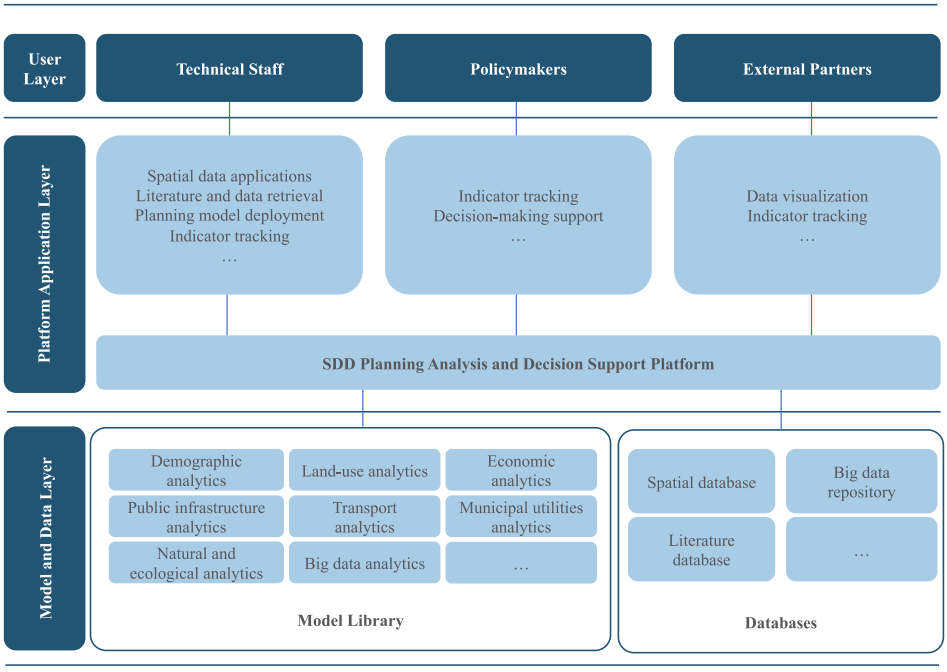


Figure 7: Architecture of the Shanghai Strategic Development Database (SDD) Platform
Source: Report on the Shanghai Master Plan (2017–2035)

2 According to the Ministry of Natural Resources' assessment requirements, a separate annual diagnostic assessment is not conducted in years when a five-year evaluation is undertaken. Accordingly, Shanghai completed the annual diagnostic assessment as part of the five-year evaluation process.

(6) Public Participation and Social Feedback Mechanisms

Beyond technical monitoring, departmental reporting and administrative verification, public participation serves as an important complementary mechanism within Shanghai's territorial spatial planning MRV framework. During both the preparation and the implementation of *Shanghai 2035*, Shanghai was among the first Chinese cities to explore a more open and participatory approach to planning. Public participation does not directly involve conducting carbon emissions accounting or verifying spatial indicators; rather, it provides valuable feedback grounded in residents' day-to-day experience of urban life and city operations, thereby helping to offset the limitations of relying solely on spatial data and sectoral statistics.

During the annual monitoring stage, Shanghai gathers citizens' subjective assessments of public service facilities, transport, the ecological environment, community life circles, and urban safety and resilience through public satisfaction surveys, online questionnaires, and social consultation exercises. Together with planning-indicator monitoring, remote-sensing analysis and departmental statistics, these inputs form the evidence base for the annual monitoring exercise. They help identify implementation issues that are difficult to capture through technical indicators alone—such as the perceived accessibility of public services, the everyday use of green space, the quality of the walking and cycling environment, and residents' sense of safety in their communities during extreme weather events.

During the five-year evaluation stage, public participation is further embedded in the overall evaluation mechanism. Under the collaborative model that brings together expert advisory input, inter-departmental coordination, municipal–district collaboration, independent third-party evaluation, regional coordination and public participation, the public and civil society organisations contribute primarily through the collection of opinions and concerns, satisfaction surveys and social feedback. These inputs are compiled into a public satisfaction survey report, which forms part of the "1+2+N" evaluation output system and provides a reference for plan updating and subsequent policy adjustment.

From an MRV perspective, public participation in Shanghai performs three main functions. First, in the monitoring stage, it introduces residents' perception data, helping to ensure that the assessment of plan implementation does not focus exclusively on spatial form and construction indicators but also takes account of people's lived experience of urban quality, resilience and low-carbon living conditions. Second, in the reporting stage, it incorporates social feedback into the evaluation output system through instruments such as the public satisfaction survey report. Third, in the verification and dynamic updating stages, public oversight and social feedback increase the transparency of issue detection and the responsiveness of the planning system. Overall, Shanghai's public participation mechanism represents a shift from traditional planning disclosure towards a social feedback mechanism that spans the entire plan implementation process. That said, its role in climate-action MRV remains largely supplementary, feedback-oriented and supervisory in nature. Going forward, there is still considerable scope to link public perception data, community-level climate-risk feedback and low-carbon behaviour data more systematically with the territorial spatial planning monitoring platform.

Figure 8: Public Survey Interface for the Annual Monitoring of the "Shanghai 2035" Master Plan
Source: Official Account of Shanghai Municipal Bureau of Planning and Natural Resources

3.1.2 Climate Change Response within the MRV Framework of the Master Plan

(1) Climate Change Response in *Shanghai 2035*

Among the urban visions set out in *Shanghai 2035* is the goal of building an "Ecological City", which calls for Shanghai to "continuously enhance its adaptive capacity and resilience and become a benchmark for the green, low-carbon, safe and sustainable development of international megacities". Following the plan's "objective–indicator–strategy" logic, the Ecological City objective is linked to nine associated targets. The indicator most directly relevant to climate change is the rate of reduction of total carbon emissions from the peak level. At the strategic level, Section 1 of

Chapter 7, Ecological Environment and Urban Safety, is dedicated to climate change response and covers four areas: green and low-carbon development, responding to sea-level rise, responding to extreme climate impacts, and mitigating the urban heat island effect.

The overall objective of green and low-carbon development is for both total carbon emissions and per-capita carbon emissions in the city to peak by 2025. By 2035, total carbon emissions are to be 5 per cent lower than the peak level, and energy consumption per RMB 10,000 of GDP is to be kept below 0.22 tonnes of standard coal equivalent. The strategy focuses on optimising the energy mix, reducing energy consumption in industry and buildings, and promoting green transport. It also aims to further increase the share of renewable energy in primary energy supply. By 2035, all eligible projects are to be delivered as prefabricated buildings, all newly built civil buildings are to meet green building standards, and the share of green travel modes across the city is to reach around 85 per cent.

Measures to address sea-level rise cover four areas: land subsidence control, flood prevention and drainage, stormwater drainage and sponge city development, and river and lake systems and water conservancy. For land subsidence control, the plan proposes controlling groundwater extraction and establishing dedicated monitoring networks for land subsidence and groundwater conditions, with the aim of limiting average annual land subsidence to less than 6 mm by 2035. For flood prevention and drainage, the emphasis is on consolidating and improving Shanghai's overall flood-control arrangements and raising flood-control and drainage standards. For stormwater drainage and sponge city development, the plan seeks to optimise the layout of the drainage system and specify rainstorm return-period standards, including a minimum five-year return period for the main urban area and new towns. The sponge city targets require that by 2020 more than 20 per cent of the built-up urban area should meet sponge city requirements, rising to more than 80 per cent by 2035. For river and lake systems and water conservancy, the plan aims to raise the municipal river and lake water surface ratio to around 10.5 per cent and to improve the integrated water management framework across different management zones.

The response to extreme climate impacts focuses on strengthening the monitoring and assessment of sea-level changes and various climate-related hazards, and on establishing early-warning and emergency-response mechanisms for extreme climate events. It also includes developing ecological corridors and biodiversity conservation networks to improve ecosystem quality and stability; constructing coastal shelterbelt systems to provide buffer space against natural hazards; and strengthening the resilience of major urban infrastructure, large-scale engineering projects, buildings, and lifeline systems to extreme climate impacts.

Measures to mitigate the urban heat island effect mainly include preserving ventilation corridors in the main urban area, developing ecological buffer zones, wedge-shaped green spaces, and waterfront corridors, controlling building heights in key areas, and promoting vertical greening and rooftop solar installations throughout the main urban area.

Beyond these climate-specific measures, climate change considerations are integrated across *Shanghai 2035*. Other components of the plan, including the optimisation of ecological spatial patterns, transport strategies, and urban safety and resilience measures, also contribute to climate change mitigation and adaptation objectives.

(2) Climate-Change Content in the Monitoring and Evaluation of *Shanghai 2035*

- **Annual Monitoring**

Shanghai 2035 establishes a monitoring indicator system comprising seven dimensions and 97 indicators (Figure 9), of which 30 are core indicators (Figure 10). Among the 97 indicators, those relevant to the Urban-Act programme are mainly concentrated in the "Safety and Resilience" dimension, including 11 indicators under "lower-carbon resource use" and six indicators under "more effective safety assurance". These 17 indicators include not only the corresponding indicators from the target indicator system, but also some of the goals and requirements set out in the plan's climate-change-response provisions. However, of the 30 core monitoring indicators, only the rate of reduction of total carbon emissions from the peak level is included, while indicators such as the share of sponge city construction area are not. Following the Ministry of Natural Resources' unified roll-out of annual monitoring and five-year evaluations for territorial spatial planning, Shanghai has brought the monitoring and evaluation requirements of Shanghai 2035 into line with the ministerial framework and has organised its monitoring and evaluation content around four dimensions: the indicator system, spatial structure, strategic tasks and key areas.

Citywide Comprehensive Operational Indicators		Permanent resident population (10,000 persons) Urban population (10,000 persons) Share of population aged 60 and above in total permanent residents (%) Number of foreign expatriates/nationals (10,000 persons) Total area of construction land (km^2) Urban construction land area (km^2) Construction land consumption per unit of GDP (ha/RMB 100 million) Scale of strategic spatial reserves (km^2) Total municipal GDP (RMB trillion) Local government revenue (RMB 100 million) Overall labour productivity (RMB 10,000/person) Economic structure (proportion of primary, secondary, and tertiary sectors) Land price indices for residential, office, and commercial uses (RMB 10,000/m^2)
Innovation and Vitality	Strengthened core functions of a global city	Gross expenditure on R&D (GERD) as a share of municipal GDP (%) Number of multinational corporation (MNC) R&D headquarters (entity) Value-added of the financial sector as a share of municipal GDP (%) Share of financial sector employees in the total workforce of the main urban area (%) Proportion of cultural sector employees in the total employed population (%) Area of industrial land designated for advanced manufacturing within industrial bases (km^2) Number of internationally influential cultural festival and sports event brands (brand) Number of MNC Asia-Pacific headquarters (entity)
	A more open international hub	Annual inbound international passenger arrivals (10,000 person-trips) Ratio of inbound to outbound passenger flows (%) Air passenger transit rate (%) Annual air passenger throughput (100M person-trips) Air cargo and mail throughput (10,000 tonnes) Water-to-water transshipment rate (%) International container transshipment rate (%)
	An optimized environment for talent and entrepreneurship	Proportion of the prime working-age population with tertiary education (%) Jobs-housing balance index Average commute time (minutes) Proportion of rental housing held by the government, institutions, and enterprises in new housing supply (%) Proportion of small- and medium-sized units in new housing supply (%) Number of higher education and vocational training institutions (excluding high schools and compulsory education) per 100,000 population (%)
Cultural Charm and Humanities	Enhanced 15-minute community life circles	15-minute walking distance coverage of community public service facilities (health, elderly care, education, culture, and sports) (%) Number of leisure, welfare, and learning facilities per 10,000 elderly residents (entity) Implementation rate of park and green space construction (%) Implementation rate of land designated for cultural and sports facilities (%) Implementation rate of land designated for social welfare and elderly care facilities (%) Per capita urban housing floor area (m^2/person) Citizen satisfaction score for community cultural activities (score out of 100)
	A more captivating urban space	5-minute walking distance coverage of public open spaces (green spaces and plazas $\geqslant$ 400 m^2) (%) Total length of primary greenways (km) Total road network density (km/km^2) Proportion of ecological and recreational shorelines to the total shoreline (%) Coverage rate of wireless data networks ($\geqslant$ 100 Mbps) (%) Number of museums, libraries, performance venues, and art galleries per 100,000 population (entity) Area of historical and cultural conservation blocks (km^2) Number of historically protected streets/alleys and waterways (entity) Citizen satisfaction score for the cityscape and urban landscape (score out of 100)

Environmental Sustainability	A more livable ecological environment	Proportion of ecological land (including green spaces and plazas) in the total municipal land area (%) Ratio of river and lake water surface area (%) Per capita park and green space area (m^2/person) Forest coverage rate (%) Proportion of construction land within planned municipal-level ecological corridors (%) Annual average PM2.5 concentration (μg/m^3) Proportion of days with good or excellent air quality Direct landfill rate of untreated municipal waste (%) Environmentally sound treatment rate of municipal solid waste (%) Coverage rate of areas meeting environmental noise standards (%) Urban and rural wastewater treatment rate (%) Water quality compliance rate of centralized drinking water sources (%) Water quality compliance rate of water functional zones (%)
Safety and Resilience	Lower-carbon resource use	Reduction rate of total carbon emissions relative to the peak level (%) Share of renewable energy in primary energy supply (%) Share of clean energy in energy consumption (%) Green building compliance rate for newly built civil buildings (%) Share of green travel modes (%) Number of motor vehicles (10,000 vehicles) Reuse rate of reclaimed water (%) Water consumption per RMB 10,000 of GDP (m^3/RMB 10,000) Water consumption per RMB 10,000 of industrial value added (m^3/RMB 10,000) Annual total water use (100 million m^3) Energy consumption per RMB 10,000 of GDP (tonnes of standard coal equivalent/RMB 10,000)
	More effective safety assurance	Response time meeting fire and pre-hospital emergency call requirements (minutes) Emergency shelter area per capita (m^2) Population served per fire station (10,000 persons/station) Share of distributed energy in total municipal energy supply (%) Annual average land subsidence in the city (mm) Self-sufficiency rate for locally supplied vegetables and food (%)
Spatial performance	Transport Guidance	Rail transit station coverage rate in new towns with a population over 100,000 (%) Proportion of land area within a 600m radius of rail transit stations inside the UDB (%) Public transport modal share (%) Average operating speed of urban trunk bus routes (km/h)
	Land Use	Proportion of urban redevelopment land in the annual land supply (%) Population density of new cities and towns (10,000 persons/km^2) Ratio of idle land area to the average annual land supply over the past five years (%) Ratio of idle land area to the average annual land supply over the past five years (%) Economic output intensity per unit of industrial land (RMB 100M/km^2) Area of districts with completed urban renewal assessments in the current year (ha)
	Spatial Regulation	Scale of construction land within the Urban Development Boundary (UDB) (km^2) Cumulative scale of construction land reduction outside the UDB (km^2) Permanent basic cropland protection task (10,000 mu) Arable land retention area (10,000 mu) Area of land designated for land banking (ha) Area of successfully banked land (ha) Total area of supplied state-owned construction land (ha) Total area of supplied state-owned construction land (ha)

Figure 9: Monitoring Indicator System Defined in Shanghai 2035
Source: Report on Shanghai Master Plan (2017–2035)

No.	Indicator	Unit	2020 Target	2035 Target
1	Permanent resident population	10,000 persons	⩽ 2,500	Around 2,500
2	Total area of construction land	km^2	3,185	3,200
3	Construction land area per unit of GDP	ha/RMB 100M	⩽ 9.1	⩽ 4.2
4	Gross expenditure on R&D (GERD) as a share of municipal GDP	%	4	Around 5.5
5	Value-added of the financial sector as a proportion of GDP	%	⩾ 15	Around 18
6	Proportion of cultural sector employees in the total employed population	%	8	Around 10
7	Area of industrial land designated for advanced manufacturing within industrial bases	km^2	150	150
8	Annual inbound international passenger arrivals	10,000 persons	900	Around 1,400
9	Air passenger transit rate	%	⩾ 15	Around 19
10	Jobs-housing balance index	—	⩾ 80 (Main City Area); ⩾ 70 (Integration-oriented town clusters); ⩾ 100 (Comprehensive development town clusters)	⩾ 95 (Main City Area); ⩾ 73 (Integration-oriented town clusters); ⩾ 115 (Comprehensive development town clusters)
11	Proportion of rental housing held by the government, institutions, and enterprises in new housing supply	%	⩾ 20	⩾ 20
12	15-minute walking distance coverage of community public service facilities (health, elderly care, education, culture, and sports)	%	80	Around 99
13	5-minute walking distance coverage of public open spaces (green spaces and plazas ⩾ 400 m^2)	%	⩾ 70	Around 90
14	Total length of primary greenways	km	1,000	Around 2,000
15	Total road network density	km/km^2	10.0 (Central Activity Zone) 8.0 (Central City)	10 (Central Activity Zone) 8 (Main City Area New Towns)
16	Number of museums, libraries, performance venues, and art galleries per 100,000 population	Entity	0.625 (Museums); 2.0 (Libraries); 1.0 (Performance venues); 3.0 (Art galleries)	1.5 (Museums); 4.0 (Libraries); 2.5 (Performance venues); 6.0 (Art galleries)
17	Area of historical and cultural conservation blocks	km^2	Regular assessment and comprehensive protection of areas where architectural forms, spatial patterns, and streetscapes fully reflect Shanghai's historical and regional cultural characteristics, continuously expanding the conservation scope	
18	Water surface ratio of rivers and lakes	%	⩾ 10.1	Around 10.5
19	Per capita park and green space area	m^2/person	⩾ 8.5	⩾ 13.0
20	Forest coverage rate	%	⩾ 18	Around 23
21	Annual average PM2.5 concentration	Ug/m^3	Around 42	Around 25
22	Direct landfill rate of untreated municipal waste	%	Essentially 0	0
23	Water quality compliance rate of water functional zones	%	78	100
24	Reduction rate of total carbon emissions from the peak	%	—	5
25	Per capita emergency shelter area	m^2/person	⩾ 0.5	⩾ 2.0
26	Population served per fire station	10,000 persons/ station	14	<10
27	Rail transit station coverage rate in new towns with a population over 100,000	%	70	Around 95
28	Public transport modal share	%	30	Around 40
29	Permanent basic cropland protection task	10,000 mu	249	150
30	Arable land retention target	10,000 mu	282	180

Figure 10: Core Monitoring Indicators Defined in Shanghai 2035

Source: Jin Zhongmin, Chen Lin, and Tao Yingsheng (2019). "Research on Technical Methods for Monitoring the Implementation of the Master Plan of a Megacity's Territorial Spatial Planning—A Case Study of Shanghai." Shanghai Urban Planning, 4(2019): 8.

Table 3: Safety and Resilience Indicators in the Monitoring Indicator System of Shanghai 2035

Indicator Theme	Indicator Items
Lower-carbon resource use	Reduction rate of total carbon emissions relative to the peak level (%) Share of renewable energy in primary energy supply (%) Share of clean energy in energy consumption (%) Green building compliance rate for newly built civil buildings (%) Share of green travel modes (%) Number of motor vehicles (10,000 vehicles) Reuse rate of reclaimed water (%) Water consumption per RMB 10,000 of GDP (m^3/RMB 10,000) Water consumption per RMB 10,000 of industrial value added (m^3/RMB 10,000) Annual water use (100 million m^3) Energy consumption per RMB 10,000 of GDP (tonnes of standard coal equivalent/RMB 10,000)
More effective safety assurance	Response time meeting fire and pre-hospital emergency call requirements (minutes) Emergency shelter area per capita (m^2) Population served per fire station (10,000 persons/station) Share of distributed energy in total municipal energy supply (%) Annual average land subsidence in the city (mm) Self-sufficiency rate for locally supplied vegetables and food (%)

Source: Report on the Shanghai Master Plan (2017–2035)

Annual monitoring focuses on indicators with explicit target values. For each indicator, the assessment compares the annual value with the baseline and the target, gauges the extent to which targets are being achieved, and analyses recent trends. It also summarises key patterns in indicator performance across the different categories and provides recommendations for subsequent monitoring and evaluation.

- **Five-Year Evaluation**

The five-year evaluation of *Shanghai 2035* addresses climate change response primarily through two areas: the objectives and tasks section, and the green and low-carbon thematic area within the key sectors.

The objectives and tasks section covers the target indicators and monitoring indicators set out in the master plan—such as the rate of reduction of total carbon emissions from the peak level and the share of green travel modes—as well as the mandatory evaluation indicators for cities whose master plans require State Council approval under the relevant regulations. The evaluation results indicate that these indicators are performing well.

The green and low-carbon thematic area focuses on the implementation of the master plan with regard to the energy mix, industrial energy consumption, transport energy consumption and green buildings. Overall, implementation progress in these areas has been good.

3.1.3 Climate-Related Specialised Plans and Their MRV Content

According to Shanghai's five-year implementation evaluation plan for its master plan, the assessment of special plans is incorporated into the overall evaluation of the master plan. The results contribute both to the master-plan evaluation and to the thematic reports on special-plan evaluation.

3.2 The Yangtze River Delta Eco-Green Integrated Development Demonstration Zone: Cross-Regional MRV Practice and Response to Climate Change

3.2.1 Territorial Spatial Planning System and Overall MRV Mechanism

The Yangtze River Delta Eco-Green Integrated Development Demonstration Zone is a cross-provincial platform for institutional innovation that was established after the integrated development of the Yangtze River Delta was elevated to a national strategy. In November 2018, at the first China International Import Expo, the central government announced its support for integrated development in the Yangtze River Delta and its elevation to a national strategy. In May 2019, the *Outline of the Yangtze River Delta Regional Integrated Development Plan* proposed the creation

of the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone (hereinafter the "Demonstration Zone"), calling for it to pioneer the translation of ecological strengths into economic and social development advantages, and to move from project-level coordination towards institutional innovation for regional integration. As existing reports also note, the Demonstration Zone plays an important role in exploring pathways and providing a model for eco-green integrated development across the Yangtze River Delta.

In October 2019, the National Development and Reform Commission issued the *Overall Plan for the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone* (hereinafter the "Overall Plan"). In November of the same year, the Demonstration Zone was formally inaugurated. It is not a new administrative district, but a regional collaborative governance platform that spans Shanghai, Jiangsu and Zhejiang. Its territory mainly comprises Qingpu District in Shanghai, Wujiang District in Suzhou, Jiangsu Province, and Jiashan County in Jiaxing, Zhejiang Province—the "two districts and one county" (Figure 11). The earlier *Overall Plan* proposed a total area of about 2,300 square kilometres, including around 350 square kilometres of water area; the subsequent territorial spatial master plan further specified a planned area of about 2,413 square kilometres. The *Overall Plan* positions the Demonstration Zone as a "strategic breakthrough point" for integrated development in the Yangtze River Delta, stressing that it should generate replicable and scalable experience in cross-administrative joint construction and sharing, the coordinated development of ecological civilisation and economic and social development, institutional innovation and green development.

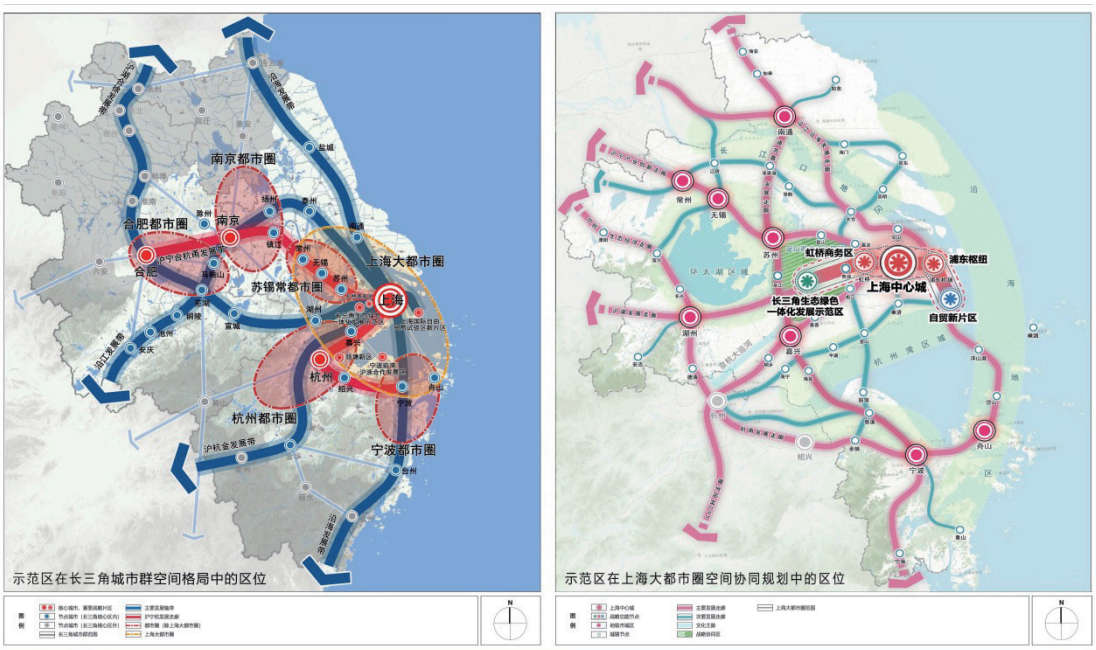


Figure 11: Location of the Demonstration Zone
Source: Territorial Spatial Master Plan of the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone (2021–2035)

The Yangtze River Delta Eco-Green Integrated Development Demonstration Zone is therefore of significant case-study value for this research. On the one hand, it represents the first cross-provincial territorial spatial master plan practice in China to be approved by the State Council; the plan is explicitly required to serve as the basis for planning, construction, and governance in the Demonstration Zone and to be strictly implemented through the territorial spatial planning "One Map" system. On the other hand, the Demonstration Zone explicitly calls for the establishment of a unified territorial spatial planning system, promotes the linkage of master, unit, and detailed plans, and requires the two provinces and one municipality to jointly formulate, approve and issue the relevant plans, while at the same time building a unified planning management information platform. This makes it a valuable case for examining cross-regional MRV mechanisms in territorial spatial planning, coordinated environmental monitoring, cross-boundary data integration and the assessment of climate-action implementation.

The spatial governance entities in the Demonstration Zone include the "three tiers and eight parties"—namely Jiangsu, Zhejiang and Shanghai; Suzhou and Jiaxing; and Qingpu, Wujiang and Jiashan—as well as national-level coordination bodies such as the Leading Group for the Integrated Development of the Yangtze River Delta and the Hongqiao Business District Administrative Committee. Multiple levels of government and diverse actors are thus closely interwoven in the governance structure. To address this, the Demonstration Zone has established a three-tier regular regional consultation platform consisting of a Council, a Construction Executive Committee (hereinafter the "Executive Committee") and a Development Company (Figure 12). The Council is chaired on a rotational basis by the executive vice-governors or executive vice-mayors of the governments of the two provinces and one municipality, and is mainly responsible for studying and determining the Demonstration Zone's development plan, institutional innovation agenda, reform matters, major projects, support policies and coordination arrangements; it reports to the Party committees and governments of the two provinces and one municipality. It also actively explores market-oriented and socially inclusive governance mechanisms, for instance through an entrepreneurs' alliance and the broad participation of well-known domestic and international entrepreneurs, leaders of international organisations, and representatives of research institutions and think tanks in the governance of the Demonstration Zone. The Executive Committee, as the implementing body of the Council, is mainly responsible for researching, formulating, and advancing the Demonstration Zone's development plan, institutional innovation agenda, reform matters, major projects and support policies. The Development Company—the Yangtze River Delta Integrated Demonstration Zone New Development and Construction Co., Ltd.—serves as the development and construction entity of the Demonstration Zone and operates as a market-oriented investment and operational platform.

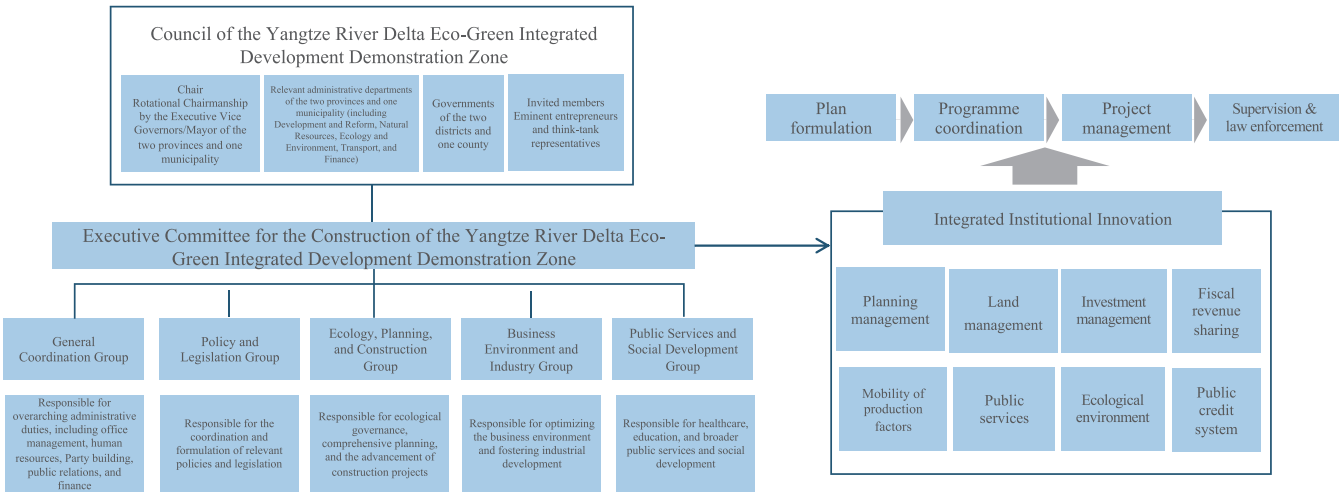


Figure 12: Governance Structure of the Demonstration Zone
Source: Zheng Degao, Sun Juan, Liu Di, et al. "The Governance Logic and Planning Response of the Yangtze River Delta Integrated Demonstration Zone." City Planning, 2023, 47(09): 45–55.

In spatial planning terms, the Demonstration Zone is located at the junction of the two provinces and one municipality, in the bowl-shaped depression of the Taihu Basin. The terrain is flat, with a dense network of lakes and waterways, creating an urban-rural spatial pattern in which small and medium-sized towns are the main drivers of development. The area's high-quality yet fragile ecological base, coupled with rapid development, exposes it to a range of climate and environmental risks. In response, the Demonstration Zone has established a distinctive spatial planning, implementation and monitoring system that spans Shanghai, Jiangsu and Zhejiang, and the design and operation of its MRV mechanism are notably pioneering and experimental.

The Demonstration Zone has put in place a "1+1+N+X" planning system comprising master plans, special plans, and detailed plans. The first "1" refers to the *Territorial Spatial Master Plan of the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone (2021–2035)*—the first cross-provincial territorial spatial master plan

in China to be approved by the State Council—which provides top-level design and binding constraints for the entire area. The second "1" refers to the territorial spatial plan for the pilot start-up area. "N" represents special plans in key fields such as ecology and environment, integrated transport and near-zero carbon development. "X" refers to detailed plans for key areas such as Water Town Living Room. In 2024, this system was further refined into a three-tier arrangement consisting of the master plan for the entire Demonstration Zone, the unit plan for the pilot start-up area, and detailed plans for co-built areas, to ensure that planning objectives and control requirements are cascaded down step by step.

In the planning preparation mechanism, the Demonstration Zone emphasises the pioneering role of regional integration and governance, and follows the basic principle of cross-regional coordination. To ensure consistency, the master plan and special plans for the Demonstration Zone are jointly formulated, approved, and issued by Shanghai, Jiangsu and Zhejiang. Detailed plans are jointly prepared by the Executive Committee together with the governments of Qingpu District, Wujiang and Jiashan. This joint formulation and review mechanism ensures unified technical standards and the mutual recognition of legal effect.

With regard to implementation, for cross-provincial co-built areas such as Water Town Living Room, the Demonstration Zone has introduced an innovative "five-in-one" management model: one blueprint for the entire area, one platform for implementation management, one entity for development, one set of standards for quality, and integrated governance to drive development. This provides the organisational support needed for unified planning implementation supervision and data collection within the MRV mechanism. To ensure the effective implementation of cross-regional plans, the Executive Committee has been granted provincial-level project management authority. It is responsible for the unified management of cross-regional projects and for the approval, verification and filing of projects within the pilot start-up area. The Executive Committee has also been authorised, jointly with the governments of the two districts and one county, to exercise approval authority for the regulatory detailed plan of the pilot start-up area. As a result, the Executive Committee functions not only as a coordinating body but also as an implementing body with substantive planning management powers, enabling it to directly track, manage and report on plan implementation and thereby strengthen the verification and oversight functions of the MRV mechanism.

In terms of data support, the Demonstration Zone has initiated the pilot construction of unified digital infrastructure—namely, the territorial spatial planning implementation monitoring network for the Demonstration Zone and the two provinces and one municipality. This forms the physical and technical core of the entire MRV mechanism. Its aim is to break down data barriers and establish a cross-regional territorial spatial basic information platform (the "One Map" platform), which also serves as the Demonstration Zone's unified planning management platform. The platform uses periodic natural resources survey data, such as annual land-use change survey data, as a dynamic base layer and integrates spatially relevant data from multiple departments—including development and reform, transport, and ecology and environment—to create a territorial spatial digital base layer with full-area coverage, three-dimensional representation, and unified standards. This platform is not only the "base map" for plan formulation and approval, but also the single authoritative data basis for subsequent monitoring and evaluation activities, and it is embedded throughout the entire planning–construction–governance cycle. During the plan formulation stage, planning outputs and control elements—such as land-use boundaries and planning indicators—are digitised and archived, supporting online parallel review under the "multi-plan integration" approach and ensuring from the outset that planning outputs are computable and monitorable. During the construction stage, the system tracks the full chain of project information—from permitting and construction through to completion acceptance—with the aim of digitally comparing the control requirements set out in the planning blueprint against actual works and enabling online supervision of "map-based construction". During the governance stage, the spatial and temporal big data aggregated by the system serve on the one hand to support internal government decision-making, and on the other hand to explore ways of providing information services to the public, thereby enhancing transparency and enabling more refined governance.

3.2.2 Climate Change Response within the MRV Framework of the Master Plan

(1) The Territorial Spatial Master Plan and Its Climate-Change-Related Content

In February 2023, following State Council approval, the governments of Shanghai, Jiangsu and Zhejiang jointly issued the *Territorial Spatial Master Plan of the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone (2021–2035)*. The Demonstration Zone master plan does not replace the respective territorial spatial master plans of the "two districts and one county"; rather, it addresses

those cross-boundary spatial matters and issues where integration is strategically most critical and where the most pronounced bottlenecks occur—in other words, the matters where only joint action can build on strengths and overcome weaknesses, such as the coordinated protection of ecological spaces that extend across administrative boundaries. In the spatial strategy, "ecological priority and green, low-carbon development" is established as the primary principle, with a clear emphasis on strengthening resilience and adaptive capacity to climate change.

The scope of the Demonstration Zone master plan encompasses the whole area of Qingpu District in Shanghai, Wujiang District in Suzhou, Jiangsu Province, and Jiashan County in Jiaxing, Zhejiang Province (hereinafter the "two districts and one county"), and covers a total area of approximately 2,413 square kilometres (Figure 13). The pilot start-up area encompasses the whole area of Jinze, Zhujiajiao, Lili, Xitang and Yaozhuang Towns, covering a total area of about 660 square kilometres. The planning coordination area comprises the Hongqiao main urban area (excluding Qingpu District), Wangjiangjing and Youchegang Towns in Xiuzhou District of Jiaxing, and Dianshan Lake, Jinxi and Zhouzhuang Towns in Kunshan, with a total area of about 486 square kilometres. The plan has a short-term horizon to 2025, a long-term horizon to 2035, and a long-range outlook to 2050.

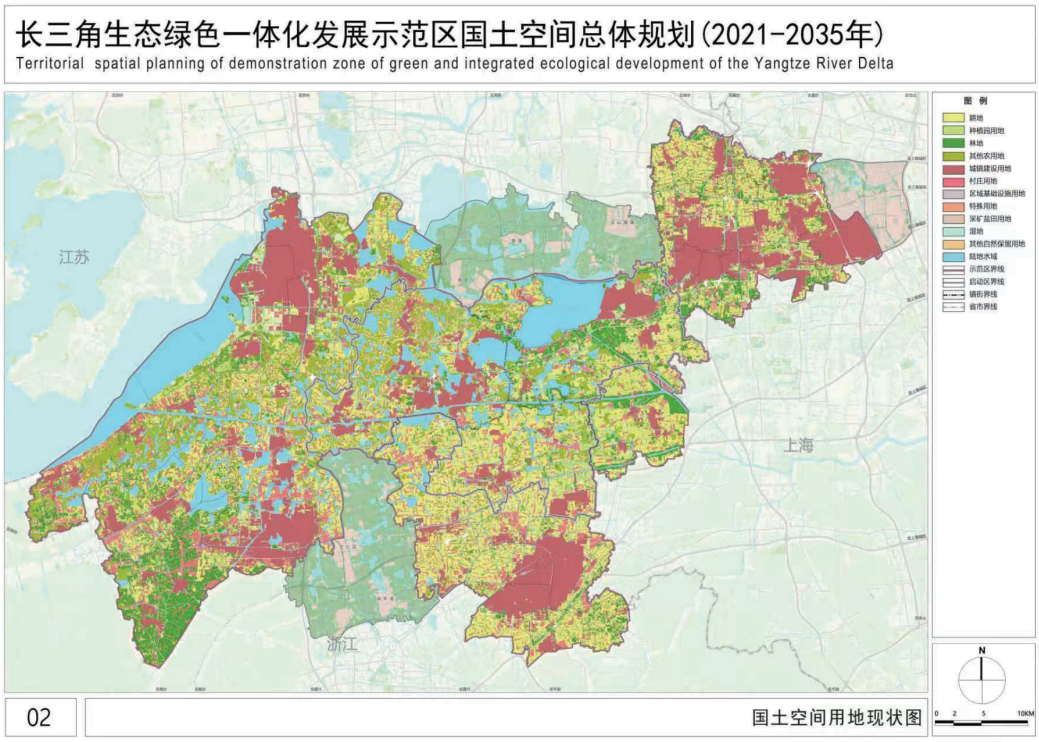


Figure 13: Spatial Scope and Current Land Use of the Demonstration Zone Master Plan
Source: Territorial Spatial Master Plan of the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone (2021–2035)

The plan sets out an overarching vision of a "world-class exemplar of water-town human settlement civilisation" and establishes five sub-objectives: "harmony between humanity and nature", "integrated functions and landscape quality across the whole area", "synergistic progress of the innovation chain and industrial chain", "resonance of Jiangnan charm and small-town character", and "shared public services and infrastructure". Around these five sub-objectives, the plan defines 25 indicators, as set out below.

Table 4: Evaluation Indicator System in the Territorial Spatial Master Plan of the Demonstration Zone

Objective Dimension	No.	Indicator Name (unit)	2020 Baseline (Demonstration Zone)	2025 Target (Demonstration Zone)	2035					Indicator Type
					Demonstration Zone	Qingpu District	Wujiang District	Jiashan County	Planning Coordination Area	
Harmony between humanity and nature (9 indicators)	1	Share of blue-green space (%)	–	≥66	≥66	–	–	–	–	Indicative
	2	Ecological protection red line area (km²)	–	≥143.32 (214,969 mu)	≥143.32 (214,969 mu)	≥21.97 (32,944 mu)	≥115.09 (172,635 mu)	≥6.26 (9,390 mu)	–	Binding
	3	Ratio of river and lake water surface area (%)	20.3	≥20.61	Steadily increasing				–	Indicative
	4	Control width for clear-water green corridors (m)	–	(Class I Clear-Water Ecological Corridor) Urban sections: 30 m management zone and 60 m protection zone; Rural sections: 80 m management zone and 200 m protection zone; Countryside sections: 300 m management zone, 1,000 m protection zone, and 2,000 m core monitoring zone					To be implemented by reference	Indicative
	5	Forest coverage rate (%)	8.6	≥10	≥12	–	–	–	–	Indicative
	6	Coverage rate of protection for important habitats (%)	–	≥80	100				To be implemented by reference	Indicative
	7	Compliance rate of water quality in designated water functional zones (%)	–	≥95	100				To be implemented by reference	Indicative
	8	Arable land retention area (10,000 mu)	–	≥76.60	≥76.60	≥17.73	≥30.78	≥28.09	–	Binding
	9	Permanent basic cropland protection task (10,000 mu)	–	≥66.54	≥66.54	≥15.24	≥26.76	≥24.54	–	Binding

Objective Dimension	No.	Indicator Name (unit)	2020 Baseline (Demonstration Zone)	2025 Target (Demonstration Zone)	2035					Indicator Type
					Demonstration Zone	Qingpu District	Wujiang District	Jiashan County	Planning Coordination Area	
Integrated function and scenic quality across the whole area (7 indicators)	10	Total construction land area (km²)	819.3	≤815.0	≤803.6	≤228.8	≤405.0	≤169.8	–	Binding
	11	Population size (10,000 persons)	346.6	≤360	≤380	≤130	≤160	≤90	–	Indicative
	12	Area of urban development boundary (km²)	–	≤647.6 (971,400 mu)	≤647.6 (971,400 mu)	≤185.5 (278,300 mu)	≤319.8 (479,700 mu)	≤142.3 (213,400 mu)	–	Binding
	13	Expansion coefficient of the urban development boundary	–	≤1.21	≤1.21	≤1.16	≤1.22	≤1.30	–	Binding
	14	Share of construction land within urban development boundaries (%)	–	75–85					To be implemented by reference	Indicative
	15	GRP per unit of construction land (RMB 100 million/km²)	4.8	≥8	15				To be implemented by reference	Indicative
	16	Per capita park green space area (m²/person)	–	≥10	≥15				To be implemented by reference	Indicative
	17	Length of backbone greenways (km)	–	≥500	≥700	≥180	≥370	≥150	–	Indicative
Synergistic progress of innovation and industrial chains (1 indicator)	18	Share of manufacturing and R&D land within urban and rural construction land (%)	35.4	Around 30	≥22	–			To be implemented by reference	Indicative

Objective Dimension	No.	Indicator Name (unit)	2020 Baseline (Demonstration Zone)	2025 Target (Demonstration Zone)	2035					Indicator Type
					Demonstration Zone	Qingpu District	Wujiang District	Jiashan County	Planning Coordination Area	
Resonance of Jiangnan charm and small-town character (3 indicators)	19	Area of historic and cultural blocks (including character-conservation areas) (ha)	684.8	≥684.8	≥684.8	≥423.1	≥261.7	–	–	Binding
	20	Share of living and ecological shorelines along backbone rivers and major lakes (%)	–	≥80	≥90				To be implemented by reference	Indicative
	21	Baseline control height for new buildings (m)	–	Urban areas: ≤ 50; Town centres: ≤ 30; Villages: ≤ 12					To be implemented by reference	Indicative
Shared public services and infrastructure (4 indicators)	22	Density of internal urban road network (km/km²)	6	Around 7	≥8				–	Indicative
	23	Water consumption per RMB 10,000 of GRP (m³/RMB 10,000)	–	≤25	≤20				–	Binding
	24	Annual stormwater runoff control rate in urban areas (%)	–	≥70	≥ 75 (more than 80% of the built-up urban area is required to meet the target)				To be implemented by reference	Indicative
	25	Area of integrated urban-rural community service facilities per 100 households (m²)	–	≥50	≥75				To be implemented by reference	Indicative

Source: Territorial Spatial Master Plan of the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone (2021–2035)

(2) MRV Implementation Pathway of the Territorial Spatial Master Plan

The *Territorial Spatial Master Plan of the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone (2021–2035)* establishes a monitoring and evaluation mechanism comprising annual monitoring, five-year evaluation, and special evaluations in key areas. It produces annual monitoring reports and five-year implementation evaluation reports, and requires that the core indicators of the plan be incorporated into the performance appraisal and evaluation system.

In May 2023, the Demonstration Zone Executive Committee and the Territorial Spatial Planning Research Center of the Ministry of Natural Resources formally put in place an annual monitoring and evaluation mechanism for the Demonstration Zone and officially launched the relevant work. The core of the Demonstration Zone's MRV mechanism is an operating model of "Executive Committee-led coordination, full participation by the three tiers and eight parties across the two provinces and one municipality, and independent third-party monitoring". It operates a periodic monitoring and evaluation system of annual monitoring, five-year evaluations, and special evaluations in key areas. The Demonstration Zone Executive Committee is responsible for organising and coordinating the annual monitoring and evaluation work, and works with the "three tiers and eight parties" across the two provinces and one municipality to implement the relevant tasks and requirements. Through a cooperation agreement, it has also established a long-term partnership with the Territorial Spatial Planning Research Center of the Ministry of Natural Resources, thereby helping to ensure the authority and objectivity of the annual monitoring and evaluation results. After review by the Demonstration Zone Council, the annual monitoring and evaluation report is issued and submitted to the State Council and the people's governments of the two provinces and one municipality, thereby safeguarding the authority of the MRV results.

Since 2023, the Demonstration Zone has carried out annual monitoring exercises for three consecutive years and issued annual monitoring reports. In the most recent 2025 annual monitoring exercise, with the report published in February 2026, the Demonstration Zone further refined its MRV mechanism in two respects. **(1) The range of participating actors was broadened.** In addition to the original model of "Executive Committee-led coordination, full participation by the three tiers and eight parties across the two provinces and one municipality, and independent third-party monitoring", professional teams from Shanghai, Jiangsu and Zhejiang were brought in, further strengthening cross-regional coordination and multi-actor participation. **(2) The role of the annual monitoring and evaluation results in supporting dynamic updating was further strengthened.** During the 2023 and 2024 annual monitoring exercises, the issues identified were fed back to the relevant parties through expert discussions and interdepartmental consultations. In the 2025 annual monitoring exercise, the Demonstration Zone Executive Committee issued the annual monitoring report as an official document to the implementing bodies across the three tiers and eight parties in the two provinces and one municipality, and required that each issue and recommendation be addressed individually with corresponding corrective measures. It also required localities to incorporate the evaluation feedback into their annual key tasks and major planning work.

With regard to the content of the evaluation, the annual monitoring and evaluation of the Demonstration Zone territorial spatial master plan assesses the content of the master plan across several dimensions, including high-quality development, integrated coordination, territorial resilience, ecological and green development, and baseline control. The indicator system follows a "generic indicators + zone-specific indicators" approach. The generic indicators mainly consist of baseline control indicators such as ecological protection red line area, farmland retention, permanent basic cropland protection target, total construction land area and urban development boundary area. The zone-specific indicators are designed to capture the Demonstration Zone's high-quality integrated development. The indicators are drawn from three sources: the indicators set out in the Demonstration Zone territorial spatial master plan, the relevant indicators in the guidelines issued by the Ministry of Natural Resources, and the relevant indicators in the *Indicator System for Integrated High-Quality Development of the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone (Trial)*. In total, the Demonstration Zone has 40 indicators, while the pilot start-up area has 24 indicators. In addition to the overall assessment of implementation rates, the 2025 annual monitoring exercise also introduced a trend assessment. The implementation-rate assessment results are classified as good, average or poor; the trend assessment results are classified as rising, stable, fluctuating or declining.

Objective Dimension	No.	Indicator	Unit	Type	Trend	Implementation Rate
Baseline Control	1	Ecological Protection Red Line area*#	km^2	Mandatory	Stable	100%
	2	Arable land retention target* current arable land area#	10,000 *mu*	Mandatory	Slight increase	115%
	3	Permanent basic cropland protection task*	10,000 *mu*	Mandatory	Stable	100%
	4	Total area of construction land*#	km^2	Mandatory	Fluctuating	100%
	5	Urban Development Boundary area*	km^2	Mandatory	Stable	100%
	6	Expansion coefficient of the urban development boundary*	-	Mandatory	Stable	100%
	7	Share of construction land within urban development boundaries*	%	Indicative	Slight increase	Within target range
	8	Area of historic and cultural blocks (including character-conservation areas)*	ha	Mandatory	Stable	100%
Ecological Sustainability	9	Share of blue-green space*	%	Indicative	Slight increase	Target achieved
	10	Water surface ratio of rivers and lakes	%	Indicative	Slight fluctuation	Approaching near-term target
	11	Control width for clear-water green corridors	m	Indicative	Stable	—
	12	Forest coverage rate*	%	Indicative	Slight decrease	Near-term target achieved
	13	Coverage rate of protection for important habitats*	%	Indicative	Stable	Near-term target achieved
	14	Compliance rate of water quality in designated water functional zones*	%	Indicative	Slight fluctuation	Near-term target achieved
	15	Length of backbone greenways*	km	Indicative	—	—
	16	Per capita park and green space area	m^2/person	Indicative	Slight decrease	Near-term target achieved
	17	Standard compliance rate of park and green spaces along major river corridors*	%	Indicative	Steady increase	Near-term target achieved
	18	15-minute walking distance coverage of forests	%	—	Significant increase	—
	19	5-minute walking distance coverage of park and green spaces and plazas#	%	—	Slight increase	—
	20	Proportion of days with good or excellent air quality#☆	%	—	Slight fluctuation	—
	21	Proportion of surface water sections meeting Grade III standards or above	%	—	Significant increase	—
	22	Water consumption per RMB 10,000 of GRP	m^3/RMB 10,000	Mandatory	Significant decrease	Near-term target achieved
	23	Energy consumption per RMB 10,000 of GDP	tonnes SCE/RMB 10,000	—	Significant decrease	—
High-Quality Development	24	GRP per unit of construction land*	RMB 100M/km^2	Indicative	Steady increase	Notable progress, but gap remains
	25	Share of manufacturing and R&D land in urban-rural construction land	%	Indicative	Slight decrease	Notable progress, but gap remains
	26	Permanent resident population*#	10,000 persons	Indicative	Slight increase	Approaching near-term target
	27	Per capita GDP#☆	RMB 10,000	Indicative	Rapid increase	—
	28	Gross expenditure on R&D (GERD) as a share of GDP☆	%	—	Slight increase	—
	29	Value-added per unit of industrial land#	RMB 100M/km^2	—	Slight decrease	—
	30	Number of national high-tech enterprises	Number	—	Significant increase	—
Integration	31	Internal urban road network density*#	km/km^2	Indicative	Slight increase	Approaching near-term target
	32	Urban jobs-housing land use ratio#	1:X	—	Slight decrease	—
	33	Ratio of per capita disposable income between urban and rural residents#	1:X	—	Slight decrease	—
	34	Area of integrated urban-rural community service facilities per 100 households*	m^2	Indicative	—	—
	35	Public administration and public services land per capita	m^2	—	Slight fluctuation	—
	36	Baseline control height for new buildings*	m	Indicative	Stable	—
Territorial Resilience	37	Annual stormwater runoff control rate in urban areas*	%	Indicative	—	—
	38	Number of hospital beds per 1,000 residents	Beds	—	Significant increase	—
	39	Per capita emergency shelter area#	m^2/person	—	Slight increase	—
	40	5-minute accessibility rate for fire rescue services#	%	—	Significant increase	—

Notes:
1. Indicator Sources: *: Derived from the indicator system of the Master Plan of the Demonstration Zone; #: Derived from the indicator system of the Diagnostic Assessment Guidelines for Territorial Spatial Planning (2025 Revision); ☆ : Derived from the Indicator System for Integrated High-Quality Development of the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone (Trial); Underlined indicators are mandatory; all others are expected.

2. The three indicators—"Area of comprehensive community service facilities per 100 households", "Total annual rainfall runoff control rate in urban areas", and "Total length of primary greenways"—are derived from the Master Plan of the Demonstration Zone. However, due to the current lack of official statistical standards, they are temporarily excluded from evaluation. The indicators "Control width of clearwater green corridors" and "Compliance rate of benchmark height controls for new buildings" serve as planning guidance metrics. They are reviewed as forward-looking assessments integrated into the planning management process, and their implementation rate is recorded at 100%.

Figure 14: 2025 Annual Monitoring Indicator Table for the Master Plan of the Demonstration Zone
Source: "Territorial Spatial Master Plan of the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone (2021–2035)", "Diagnostic Assessment Guidelines for Territorial Spatial Planning (2025 Revision)", "Indicator System for Integrated High-Quality Development of the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone (Trial)"

Objective Dimension	No.	Indicator	Unit	Type	Trend	Implementation Rate
Baseline Control	1	Ecological Protection Red Line area*	km²	Mandatory	25.68	Stable
	2	Arable land protection target*	10,000 *mu*	Mandatory	21.85	Slight fluctuation
	3	Permanent basic cropland protection task*	10,000 *mu*	Mandatory	18.45	Stable
	4	Total area of construction land*	km²	Mandatory	164.7	Slight increase
	5	Urban Development Boundary area*	km²	Mandatory	131.9	Stable
	6	Share of construction land within urban development boundaries*	%	Indicative	Around 70%	Significant increase
	7	Area of historic and cultural blocks (including character-conservation areas)*	ha	Mandatory	450	Stable
Ecological Sustainability	8	Share of blue-green space*	%	Indicative	≥75	Slight fluctuation
	9	Water surface ratio of rivers and lakes*	%	Indicative	≥27.5	Slight increase
	10	Control width for clear-water green corridors	m	Indicative	Urban sections: 30 m management zone and 60 m protection zone; Rural sections: 80 m management zone and 200 m protection zone; Countryside sections: 300 m management zone, 1,000 m protection zone, and 2,000 m core monitoring zone	—
	11	Forest coverage rate*	%	Indicative	≥12	Slight increase
	12	Coverage rate of protection for important habitats*	%	Indicative	100	Stable
	13	Compliance rate of water quality in designated water functional zones*	%	Indicative	100	Slight fluctuation
	14	Length of backbone greenways*	km	Indicative	≥200	Stable
	15	Per capita park and green space area*	m²/person	Indicative	≥15	Slight decrease
	16	Standard compliance rate of park and green spaces along major river corridors*	%	Indicative	≥15	Significant increase
Integration	17	Permanent resident population*	10,000 persons	Indicative	78	Significant increase
	18	Share of manufacturing and R&D land within urban and rural construction land*	%	Indicative	≥22	Slight fluctuation
	19	Area of integrated urban-rural community service facilities per 100 households*	m²	Indicative	≥75	—
High-Quality Development	20	Internal urban road network density*	km/km²	Indicative	≥8	Significant increase
	21	Baseline control height for new buildings*	m	Indicative	Urban areas: ≤ 50; Town centres: ≤ 30; Villages: ≤ 12	—
	22	Urban sewage treatment rate*	%	Indicative	100	—
	23	Rural domestic wastewater treatment rate*	%	Indicative	100	—
Territorial Resilience	24	Annual stormwater runoff control rate in urban areas*	%	Indicative	≥75 (more than 80% of the built-up urban area is required to meet the target)	—

Figure 15: 2025 Health Check Indicators for the Pilot Start-Up Area Master Plan of the Demonstration Zone
Source: "Territorial Spatial Master Plan of the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone (2021–2035)", "Diagnostic Assessment Guidelines for Territorial Spatial Planning (2025 Revision)", "Indicator System for Integrated High-Quality Development of the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone (Trial)"

(3) Climate-Change-Related Content in the Master Plan and Its MRV Implementation

The indicator system of the Demonstration Zone master plan and its annual monitoring and evaluation framework broadly reflect the strategic intent to respond to climate change and systematically translate that intent into the statutory spatial control framework. The indicators are centred on "structural carbon reduction" and "ecological resilience", and are both stringent and legally binding; they offer an early example of the integration of spatial planning and climate action in China. Regarding climate mitigation and adaptation, the current indicator system has three notable features.

- **First, a clear strategic orientation, with objectives translated into spatial and statutory requirements.** The indicator system translates abstract goals related to the "dual carbon" targets and resilience into measurable and enforceable requirements for territorial development and protection. For example, the broad objective of "reducing carbon emissions" is operationalised through two core indicators: "negative growth in total construction land area" and "a doubling of GRP per unit of construction land". This helps curb high-carbon expansion at source and steers the development model towards higher efficiency and more intensive land use.

- **Second, comprehensive coverage, forming a dual line of defence that gives equal weight to mitigation and adaptation.** On the mitigation side, the system establishes a full-chain pathway of "scale control (source reduction)—efficiency improvement (intensity reduction)—spatial conservation (sink enhancement)". In practice, this is achieved by capping the total amount of construction land to reduce emissions at source, increasing GRP per unit of land to lower emission intensity, and setting ambitious targets for the share of blue-green space and for forest coverage in order to conserve and restore ecological carbon sinks at scale. On the adaptation side, the system focuses on the Demonstration Zone's core vulnerability as a Jiangnan water-town region, particularly water security and heat risk. By setting binding targets for the water surface ratio of rivers and lakes, delineating ecological protection red lines and clear-water green corridors, and increasing vegetation coverage, the system strengthens the region's ecological resilience and its spatial capacity to cope with floods, heatwaves and other extreme climate events.

- **Third, strong regulatory constraints, with all core indicators being binding.** The indicators most directly related to climate change—such as total construction land area, share of blue-green space, water surface ratio of rivers and lakes, and ecological protection red line area—are all defined as binding indicators, thereby providing strong legal backing for climate action through spatial regulation.

Nevertheless, the current indicator design still faces several challenges in supporting more fine-grained and precise climate governance.

- **First, the indicators are highly indirect, and a "last-mile" gap remains in their direct connection to carbon quantification.** The current indicators mainly regulate spatial form and land-use status—such as land scale and spatial proportions—rather than carbon emissions and sink performance as such. For instance, although a blue-green space share of at least 66 per cent can help increase carbon sinks, the plan does not require the direct monitoring and reporting of changes in the actual annual carbon sink capacity of these areas. As a result, assessing the real mitigation effect still depends on separate accounting by the ecological and environmental authorities, and the spatial annual monitoring and evaluation system cannot by itself provide a precise carbon performance statement.

- **Second, direct carbon constraints on the built environment and socio-economic activities remain insufficient.** The indicator system focuses on the spatial baseline, but the carbon constraints it places on the activities that take place within that baseline are relatively weak. For example, sectoral and technical indicators with a more direct impact on carbon emissions—such as building energy standards, renewable energy utilisation rates and the green transformation of the industrial structure—are assigned to special plans and are not directly quantified at the master-plan level.

- **Third, the adaptation indicators are relatively passive and do not yet provide a comprehensive assessment of climate resilience.** Current adaptation indicators, such as the water surface ratio and corridor widths, are designed mainly to strengthen physical protection through spatial reservation and form-based control. They include relatively few indicators that reflect overall territorial resilience, such as socio-economic vulnerability under climate risk, infrastructure redundancy and community emergency-response capacity.

(4) Summary

The master plan of the Demonstration Zone puts forward a whole-lifecycle MRV mechanism built on the unified "One Map" system for natural resource management and territorial spatial planning. By following a sequence of "data integration, dynamic monitoring, periodic evaluation and iterative feedback", it draws on digital tools to turn a cross-jurisdictional blueprint into a closed-loop governance framework.

The main strengths of this mechanism are as follows. First, it pioneers a digital governance model for cross-jurisdictional spatial integration in China. By establishing a unified "One Map" system and a centralised digital management platform that spans Shanghai, Jiangsu, and Zhejiang, it has, for the first time, enabled the unified oversight of cross-provincial territories. This technical arrangement helps overcome the long-standing problems of fragmented platforms and inconsistent data standards, and provides a sound foundation for collaborative cross-boundary governance. Second, it shifts the emphasis from static blueprints to dynamic process governance. Moving beyond the traditional tendency to concentrate on plan-making while paying less attention to implementation, the MRV system redirects regulatory attention away from end-point checks alone and towards continuous oversight of the implementation process by means of whole-lifecycle data tracking and periodic assessments. In this way, the plan becomes a more adaptive governance instrument. Third, it strengthens the binding force of the plan and the accountability for implementation. By incorporating binding indicators into the tracking system and linking them to administrative approvals and project supervision, the mechanism

narrows the scope for discretionary action and supplies the institutional and digital backing needed to ensure that the planning objectives are effectively implemented.

The mechanism also faces several implementation challenges:

- **First, the coordination costs of achieving full data integration are considerable.** Building a truly integrated territorial spatial planning database requires real-time, standardised data sharing across fragmented departments—such as development and reform, transport, housing, and ecology and environment. The administrative coordination, alignment of interests and technical interfacing this demands go well beyond the complexity of digitalisation within a single department, making full integration difficult to achieve in practice.
- **Second, the capacity for automated monitoring of core performance outcomes remains limited.** While the system can track physical spatial changes, such as land-use conversion and construction progress, it is still unable to automatically and directly monitor key performance results. This is particularly evident for climate-related outcomes—for instance, real-time carbon emission intensity, growth in ecological carbon sinks, and thermal comfort at the neighbourhood level.
- **Third, the enforceability of the feedback and plan-adjustment process remains limited.** Although the mechanism requires plans and near-term strategies to be dynamically updated and adjusted on the basis of evaluation results, the operational rules are not yet fully specified. In particular, it remains unclear how adjustments are to be made, who has the authority to initiate them, and what statutory procedures must be followed.
- **Fourth, the oversight of market actors and the associated incentive structures remain underdeveloped.** At present, the system functions mainly as an internal administrative tool for government approvals. For market-driven development projects, a significant practical gap remains: how to integrate dynamic whole-lifecycle data—such as energy use and emissions during construction and operation—into government regulatory platforms in a way that is both technically feasible and affordable, and how to connect these data to positive incentives, such as green finance or carbon-inclusive mechanisms, so as to create a functioning monitoring–incentive loop.

3.2.3 Climate-Change-Response-Related Specialised Plans and Their MRV Content

To implement the objectives of the Demonstration Zone master plan, in 2022 the Demonstration Zone Executive Committee and the governments of the "two districts and one county" jointly issued the *Near-Zero-Carbon Special Plan for Water Town Living Room in the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone*. This is one of the planning documents in the Demonstration Zone most closely linked to climate action. Spatially, Water Town Living Room is centred on the origin point of the Yangtze River Delta and lies at the junction of Shanghai's Qingpu District, Wujiang District in Suzhou, Jiangsu Province, and Jiashan County in Jiaxing, Zhejiang Province. The area covers about 35.86 km² and includes parts of Jinze Town in Qingpu District, Lili Town in Wujiang District, and Xitang and Yaozhuang Towns in Jiashan County. With a dense water network, a strong ecological base, and a distinctive vernacular culture, it has long played an important role in regional development as an ecological buffer and a carrier of Jiangnan water-town heritage.

The core vision of the special plan is to make Water Town Living Room a showcase of the achievements of integrated development in the Yangtze River Delta, demonstrating coexistence between urban development and water systems, shared vitality, and regional sharing. Its central objective is near-zero-carbon development. The plan sets phased targets: by 2025, the carbon reduction rate relative to the baseline scenario is to reach around 60 per cent, per-capita energy-related carbon emissions are to remain at zero growth, and carbon emissions per RMB 10,000 of GDP are to be held at approximately 0.08 tonnes; by 2030, the carbon reduction rate is to exceed 70 per cent, total energy-related carbon emissions are to remain at zero growth, and carbon emissions per RMB 10,000 of GDP are to be around 0.05 tonnes; and by 2035, the carbon reduction rate is to exceed 80 per cent, total carbon emissions are to be kept within 100,000 tonnes of CO_2 equivalent despite continued growth in population and industrial activity, and carbon emissions per RMB 10,000 of GDP are to fall to roughly 0.03 tonnes. On this basis, Water Town Living Room is expected to be essentially complete as a world-class water-town living room, following a carbon-neutrality-oriented development pathway.

To achieve these objectives, the plan focuses on five priority areas: high-quality, low-carbon and energy-efficient buildings; green and people-centred smart transport; a circular and resilient ecological environment; efficient and shared integrated energy systems; and eco-friendly innovation and entrepreneurship. It sets out 18 monitoring and evaluation indicators for these areas (Table 5).

Table 5: Planning Indicators in Key Areas and Phased Development Goals of the Water Town Living Room

Priority Area	Implementation Pathway	Indicator Name	Indicator Type	Phased Targets		
				Short-Term (2025)	Mid-Term (2030)	Long-Term (2035)
High-Quality Low-Carbon and Energy-Efficient Buildings	Three-Star Green Building standard	Proportion of new buildings meeting Three-Star China Green Building standard (%)	Binding	50	50	50
	Near-zero-energy buildings	Proportion of new buildings meeting Near-Zero-Energy standard (%)	Indicative	25	30	35
	Industrialized prefabrication/ modular construction	Proportion of new buildings using industrialized prefabrication/ modular construction (%)	Binding	70	80	90
	Renovation of Existing Buildings	Retrofit and green renovation of existing buildings (%)	Indicative	5	15	25
	Building-integrated/ on-site renewable energy	Percentage of rooftop area with photovoltaic (PV) installations (% of total roof area)	Binding	40	45	50
Green, People-Centered, and Smart Transportation	Green mobility	Share of green travel modes (%)	Binding	85/90[1]	85/90[1]	90/100[1]
	People-centered transport/ pedestrian-first measures	Average walking transfer distance for water–land interchanges (m)	Binding	≤50	≤50	≤50
	Smart transportation/ Intelligent Transport Systems (ITS)	Proportion of new/ renovated bus stops with smart upgrades (%)	Indicative	80	90	100
Circular, Resilient Ecological Environment	Strengthening low-carbon resilience of water systems	Per-capita total water consumption	Indicative	≤300	≤250	≤180
	Advancing zero-waste urban–rural development	Municipal solid waste resource-recovery rate (%)	Binding	80	85	90
	Enhancing carbon-sequestration potential of ecological spaces	Percentage increase in ecological carbon-sequestration capacity (%)	Indicative	4	8	12
Highly Efficient, Shared, and Integrated Energy System	High-efficiency energy systems	Share of renewable energy in total energy consumption (%)	Binding	50	65	80
	Smart energy systems	Coverage of the energy management/ microgrid platform (%)	Binding	50	80	100
	Shared energy systems	Share of green electricity in total electricity consumption (%)	Indicative	50	60	65
		Energy-sector CO_2 emissions reduction rate (%)	Binding	60	70	80
Ecologically Friendly and Innovative Industries	Green development	Carbon intensity of service-sector value-added ($kgCO_2e$/RMB 10,000)	Indicative	≤95	≤40	≤20
	Structural upgrade	Share of value-added from knowledge-intensive services in GDP (%)	Indicative	40	45	50
	Innovation-driven development	R&D expenditure as share of regional GDP (%)	Indicative	4.5	5.0	5.0

Note: [1]The former data refer to the phased development targets of the three functional zones (Jinze, Huhu and Dashun), while the latter data refer to the phased development targets of the "One Site, One Core, Three Parks" (namely the Water Square Courtyard, the Core Area of the Water Town Living Room, and the three themed exhibition parks of Jiangnan Polder, Mulberry-fish Pond and Water Town Wetland).

Source: Near-Zero-Carbon Special Plan for Water Town Living Room in the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone

At the scale of Water Town Living Room, the special plan further establishes a three-tier indicator control system covering the Water Town Living Room unit, dual-carbon sub-units and individual plots (Table 6), so as to ensure the effective cascading and monitoring of development indicators. At the dual-carbon sub-unit level, the plan includes an overall near-zero-carbon objective for the sub-units and near-zero-carbon indicators for the priority areas. The overall target for the dual-carbon sub-units uses an intensity-based approach to control the carbon reduction rate as a whole. The near-zero-carbon indicators for the priority areas are selected according to the development and construction requirements of each sub-unit and, on the basis of the implementation pathways, give rise to 31 near-zero-carbon planning indicators across four priority areas. Indicators for the industrial sector are controlled and implemented systematically at the Water Town Living Room unit level and are not specified at the sub-unit level. At the plot level, the plan makes full use of established dual-carbon technologies and measures. Following the near-term implementation pathways for three priority areas, it establishes 20 plot-level near-zero-carbon planning indicators. Indicators for the energy sector are controlled and implemented systematically at the first two levels and are not specified at the plot level.

Through this three-tier system, the near-zero-carbon targets are cascaded down, ensuring effective transmission from the whole area to individual plots. The indicators at the plot level are directly linked to near-term implementation and to acceptance checks and verification within the MRV system.

Table 6: Indicator Cascading Framework for Water Town Living Room

Priority Area	Implementation Pathway	Watertown Living Room Unit Level		Dual-Carbon Sub-Unit Level		Implementation Pathway	Plot Level	
		Indicator Name	Indicator Type	Indicator Name	Indicator Type		Indicator Name	Indicator Type
High-Quality Low-Carbon and Energy-Efficient Buildings	Three-Star Green Building standard	Proportion of new buildings meeting Three-Star China Green Building standard	Binding	Proportion of new buildings meeting Three-Star China Green Building standard	Binding	Green Near-Zero-Energy Buildings	Proportion of new residential buildings achieving energy efficiency improvement	Indicative
							Proportion of new public buildings achieving energy efficiency improvement	Indicative
	Near-zero-energy buildings	Proportion of new buildings meeting Near-Zero-Energy standard	Indicative	Proportion of new buildings meeting Near-Zero-Energy standard	Indicative		Number of BIM implementation stages achieved	Indicative
							Electrification rate of cooking and domestic hot-water systems	Indicative
	Industrialized prefabrication/ modular construction	Proportion of new buildings using industrialized prefabrication/ modular construction	Binding	Proportion of new buildings using industrialized prefabrication/ modular construction	Binding	Industrialized prefabrication/ modular construction	Prefabrication rate for buildings	Binding
							Variety of prefabricated interior components used	Indicative
	Renovation of Existing Buildings	Retrofit and green renovation of existing buildings	Indicative	Retrofit and green renovation of existing buildings	Indicative	Renovation of Existing Buildings	Variety of green/ low-carbon building materials used	Indicative
							Variety of carbon-reducing/ waste-derived building materials used	Indicative
	Building-integrated/ on-site renewable energy	Percentage of rooftop area with photovoltaic (PV) installations	Binding	Percentage of rooftop area with photovoltaic (PV) installations	Binding	Building-integrated/ on-site renewable energy	Rooftop Photovoltaic (PV) Coverage	Binding
							Types of renewable energy sources deployed	Indicative

Priority Area	Implementation Pathway	Watertown Living Room Unit Level		Dual-Carbon Sub-Unit Level		Implementation Pathway	Plot Level	
		Indicator Name	Indicator Type	Indicator Name	Indicator Type		Indicator Name	Indicator Type
Green, People-Centered, and Smart Transportation	Green mobility	Modal share of green transport trips	Binding	Public transit mode share	Indicative	Green mobility	Proportion of parking spaces with ev charging facilities	Binding
				Proportion of green public transport vehicles	Binding			
				Share of new energy vehicles in total new vehicle purchases	Indicative			
	People-centered transport/ pedestrian-first measures	Average walking transfer distance for water–land interchanges	Binding	Coverage rate of regular bus stops within a 500-m radius	Binding	People-centered transport/ pedestrian-first measures	Proportion of local service roads with traffic-calming measures	Indicative
				Proportion of road area allocated to active mobility and green space	Indicative			
				Coverage rate of Blue-Route stops within a 1,000-m radius	Indicative			
	Smart transportation/ Intelligent Transport Systems (ITS)	Proportion of new/ renovated bus stops with smart upgrades	Indicative	Proportion of new/ renovated bus stops with smart upgrades	Indicative	Smart transportation/ Intelligent Transport Systems (ITS)	Proportion of new/ renovated bus stops with smart upgrades	Indicative
				Proportion of parking lots upgraded with smart technology	Indicative		Proportion of parking lots upgraded with smart technology	Indicative
Circular, Resilient Ecological Environment	Strengthening low-carbon resilience of water systems	Per-capita total water consumption	Indicative	Annual runoff control rate	Indicative	Strengthening low-carbon resilience of water systems	Annual runoff control rate	Indicative
				Per capita daily water consumption	Indicative		Installation rate of water-saving fixtures	Binding
				Reclaimed water recycling and reuse rate	Indicative			
				Effective utilization coefficient of farmland irrigation water	Indicative			
				Urban and rural sewage treatment rate	Binding			
	Advancing zero-waste urban–rural development	Municipal solid waste resource-recovery rate	Binding	Municipal solid waste resource-recovery rate	Binding	Advancing zero-waste urban–rural development	Number of new local wet-waste treatment facilities	Binding
							Proportion of waste-sorting collection sites upgraded with smart technology	Indicative
				Comprehensive utilization rate of livestock and poultry manure	Binding			
				Comprehensive utilization of crop straw	Binding			
	Enhancing carbon-sequestration potential of ecological spaces	Percentage increase in ecological carbon-sequestration capacity	Indicative	Green coverage rate	Binding	Enhancing carbon-sequestration potential of ecological spaces	Proportion of trees and shrubs	Indicative
							Green-space 300-m access coverage	Indicative
				Proportion of ecological land	Binding			

Priority Area	Implementation Pathway	Watertown Living Room Unit Level		Dual-Carbon Sub-Unit Level		Implementation Pathway	Plot Level	
		Indicator Name	Indicator Type	Indicator Name	Indicator Type		Indicator Name	Indicator Type
Highly Efficient, Shared, and Integrated Energy System	High-efficiency energy systems	Share of renewable energy in total energy consumption	Binding	Share of photovoltaic (PV) generation in total energy consumption	Binding			
				Share of geothermal energy in total energy consumption	Binding			
				Share of hydrogen in total energy consumption	Indicative			
				Share of centralized energy supply	Indicative			
	Smart energy systems	Coverage of the energy management/ microgrid platform	Binding	Coverage of the energy management/ microgrid platform	Binding			
				Proportion of adjustable load	Indicative			
	Shared energy systems	Share of green electricity in total electricity consumption	Indicative	Share of green electricity in total electricity consumption	Indicative			
		Energy-sector CO_2 emissions reduction rate	Binding	Energy-sector CO_2 emissions reduction rate	Binding			
Ecologically Friendly and Innovative Industries	Green development	Carbon intensity of service-sector value-added	Indicative					
	Structural upgrade	Share of value-added from knowledge-intensive services in GDP	Indicative					
	Innovation-driven development	R&D expenditure as share of regional GDP	Indicative					

Source: Near-Zero-Carbon Special Plan for Water Town Living Room in the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone

Regarding the MRV mechanism, the special plan puts in place a closed-loop MRV system grounded in collaborative governance, centred on dynamic evaluation, and supported by digital tools. First, the special plan establishes a coordinated implementation model. The Demonstration Zone Executive Committee, together with the relevant provincial-level departments of Shanghai, Jiangsu and Zhejiang and the governments of Qingpu, Wujiang and Jiashan, strengthens policy coordination and provides implementation support. At the same time, the plan sets up a mechanism for regular monitoring and evaluation. As with the master plan, it provides for a system of dynamic monitoring, periodic evaluation and timely adjustment, so as to ensure consistency with higher-level plans and to enable the plan to be adjusted dynamically on the basis of evaluation results. In addition, to support dynamic monitoring and evaluation, the special plan proposes the development of a digital enabling platform. Building on the Demonstration Zone's Smart Brain, it calls for a Water Town Living Room Near-Zero-Carbon Monitoring and Integrated Smart Management Platform centred on the five priority areas. The platform is designed to support scientific and efficient management across the full cycle of planning, construction, and operation.

However, given the logic of plan implementation and the complexity of cross-regional governance, the mechanism still faces several key challenges.

- **First, a gap remains between the depth of performance monitoring and direct access to the underlying data.** Core performance indicators set out in the special plan, such as the energy-related CO_2 emission reduction rate and the carbon intensity of value added in the services sector, rely heavily on real-time, dynamic data on building energy use, enterprise production and traffic flows. The proposed Water Town Living Room Near-Zero-Carbon Monitoring and Integrated Smart Management Platform is, however, primarily conceived as an integration and management platform. Its effective operation depends on deep integration and real-time data exchange with the existing systems of power grid companies, transport authorities and major energy-consuming enterprises. This involves substantial barriers related to data privacy, commercial confidentiality, administrative authority, and technical standards. As a result, monitoring of core emission-reduction performance still largely relies on estimation or sampling, rather than on precise, real-time tracking of carbon outcomes.

- **Second, the three-tier indicator cascading system imposes high demands on cross-level MRV coordination.** The plan innovatively introduces a three-tier indicator control system covering the Water Town Living Room unit, dual-carbon sub-units and individual plots, with the aim of ensuring the effective cascading of targets from the unit down to the plot level. However, this also creates coordination challenges for the MRV system. One is the consistency of data granularity and statistical boundaries: indicators at different levels may draw on different data sources and monitoring frequencies. For example, the indicator on the share of green travel modes at the unit level depends on large-scale transport surveys or mobile phone signal data, whereas the indicator on the share of parking spaces equipped with charging facilities at the plot level can be verified directly through project acceptance checks. How to aggregate, verify and use micro-level plot data to support the performance assessment of higher-level units still requires further study. Another challenge is attribution. When the overall emission-reduction target of a dual-carbon sub-unit is not met, the MRV mechanism finds it difficult to determine whether the shortfall stems from widespread underperformance across multiple plots or from the implementation deviation of a single project. This uncertainty may directly affect the use of evaluation results and the targeting of subsequent corrective measures.

- **Third, the linkage between market incentives and binding control within the MRV mechanism needs to be strengthened.** The plan includes both indicative and binding indicators, but the design of its MRV system does not yet provide a clear institutional arrangement for using monitoring and evaluation results to incentivise or constrain different types of development actors in a differentiated manner. For indicative indicators, such as the share of near-zero-energy buildings, the current MRV system focuses mainly on tracking progress; it does not, however, automatically and institutionally link strong performance to market-based incentive tools—such as floor-area-ratio bonuses, green credit or carbon-inclusive credits schemes. This weakens the incentives for market actors to take proactive action. For binding indicators, such as the share of three-star green buildings, the MRV mechanism concentrates on verification at the approval and completion-acceptance stages. Yet no low-cost, long-term monitoring approach has been established to verify whether projects continue to meet the requirements during operation—for instance, whether actual building energy use remains within the target levels. This creates a risk of buildings that are designed to be energy-efficient but underperform in operation.

- **Fourth, the practical complexity of aligning cross-administrative data standards and integrating platforms remains considerable.** Water Town Living Room spans Qingpu in Shanghai, Wujiang in Jiangsu Province and Jiashan in Zhejiang Province. Although the plan proposes to build a unified platform on the basis of the Demonstration Zone's Smart Brain, the three localities do not yet have fully aligned standards, rules and management procedures for building energy measurement, carbon accounting and government data sharing. Achieving a truly unified platform requires a high degree of consistency in data definitions, interface specifications and update mechanisms across the provincial, municipal and district/county levels. The associated coordination costs and implementation difficulties are therefore considerable.

- In sum, the MRV mechanism of the near-zero-carbon special plan for Water Town Living Room is advanced in its top-level design, but its effectiveness will depend on whether it can overcome four practical bottlenecks: data silos, target cascading, incentive linkages and administrative coordination. Future improvements should focus on three areas: establishing binding cross-departmental data-sharing agreements and standards; developing MRV technical guidelines and accounting tools suited to multi-level governance; and exploring concrete pathways for linking MRV results to policy instruments such as carbon markets and green finance.

3.3 Other Pilot Cities/ Regions: MRV Mechanisms in Territorial Spatial Planning and Their Response to Climate Change

3.3.1 Jiaxing

Jiaxing is a core part of the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone—Jiashan County, which falls under Jiaxing's jurisdiction, is one of the "two districts and one county"—and a pilot city of the Urban-Act programme. Accordingly, Jiaxing's annual monitoring and evaluation of territorial spatial planning are clearly oriented towards regional coordination and low-carbon transition. In March 2024, the project "Integrated Actions for Low-Carbon and Resilient Territorial Spatial Planning under the Context of Climate Change" extended its pilot coverage to the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone, including Jiaxing. Against this backdrop, Jiaxing has strengthened the climate-change-response dimension of its territorial spatial planning system. In addition to reinforcing climate change considerations in the municipal territorial spatial master plan, Jiaxing has prepared the *Special Plan for Low-Carbon and Resilient Cities under Jiaxing's Territorial Spatial Planning System* and has conducted *Research on Detailed Plans for Pilot Areas in Low-Carbon and Resilient Jiaxing* at the detailed plan level.

In terms of institutional arrangements, Jiaxing's annual monitoring and evaluation of territorial spatial planning is jointly organised by the Jiaxing Municipal People's Government, led by the Municipal Bureau of Natural Resources and Planning, and involves the municipal departments responsible for development and reform, housing and urban-rural development, ecology and environment, transport, and water resources, each within its respective mandate. As an integral part of the Demonstration Zone, Jiashan County also benefits from overall coordination and technical guidance provided by the Demonstration Zone Executive Committee. Regarding evaluation content, Jiaxing carries out a comprehensive assessment in line with the *Urban Diagnostic Assessment Guidelines for Territorial Spatial Planning*, focusing on six areas: strategic positioning, baseline control, scale and structure, spatial layout, support systems, and implementation safeguards. It has also put in place a monitoring indicator system composed of basic indicators, mandatory indicators and recommended indicators. On climate change response, Jiaxing explicitly sets green and low-carbon development targets in its territorial spatial master plan, and the annual monitoring exercises focus on indicators such as the reduction rate of carbon emission intensity, energy consumption per unit of GDP, the share of renewable energy use, and the share of blue-green space. Each year, Jiaxing produces an annual monitoring report. After review by the Municipal Planning Committee, the report is submitted to the Municipal People's Government for approval and then uploaded to the provincial natural resources authority via the territorial spatial planning implementation monitoring network. The annual monitoring and evaluation results for Jiashan County are also incorporated into the cross-provincial annual monitoring and evaluation reporting system of the Demonstration Zone.

3.3.2 Xi'an

Xi'an is one of the pilot cities of the Urban-Act programme in western China and is also one of the 12 pilot cities designated for "real-time monitoring and evaluation" in the *Notice on the Implementation of the Urban Diagnostic Assessment Guidelines for Territorial Spatial Planning*, issued by the General Office of the Ministry of Natural Resources in August 2021 (Natural Resources Office [2021] No. 55). Its territorial spatial planning monitoring and evaluation system serves as an important reference and model for other cities in north-western China. As a sub-provincial city and a key central city in western China, Xi'an has a relatively complex territorial spatial planning system and administrative structure.

In terms of institutional arrangements, Xi'an's territorial spatial planning monitoring and evaluation is led by the Xi'an Municipal People's Government and carried out by the Municipal Bureau of Natural Resources and Planning. The municipal government exercises a strong coordinating role and has put in place an efficient inter-departmental monitoring and evaluation mechanism. Xi'an has issued an *Implementation Plan for Urban Monitoring and Evaluation*, setting out three main objectives: to develop a localised indicator system, to build an information platform, and to establish a long-term mechanism for corrective action. This has enabled end-to-end linkage from indicator assessment and data integration through to implementation, creating a routine closed-loop mechanism for identifying weaknesses and driving improvement. Technical support is provided by the Municipal Planning Formulation Research Center and the Information Center under the Municipal Bureau of Natural Resources and Planning. The municipal departments responsible for development and reform, ecology and environment, housing and urban-rural development, transport, water resources and urban management contribute data collection and submission in line with their assigned indicator responsibilities. District governments, including those of Xincheng, Beilin, Lianhu and Yanta, are responsible for tracking implementation and providing feedback on issues within their respective jurisdictions. Regarding

evaluation content, Xi'an conducts annual monitoring and evaluation in accordance with the unified requirements of the Ministry of Natural Resources and the local context, focusing on urban safety and resilience, the appropriateness of the spatial layout, the coverage of public service facilities and the effectiveness of ecological and environmental protection. In terms of climate change, Xi'an is located on the Guanzhong Plain and faces the dual pressures of air pollution control and water scarcity. In its territorial spatial master plan, Xi'an has integrated climate change response into its urban development strategy, and the implementation of planning measures is being tracked in priority areas such as the low-carbon transformation of the industrial structure, the uptake of clean energy, the mitigation of the urban heat island effect, and the strengthening of flood prevention and drainage capacities. As regards evaluation outputs, Xi'an's annual monitoring and evaluation report is reviewed by the Municipal Territorial Spatial Planning Committee, approved by the Municipal People's Government, and submitted to the provincial natural resources department. At the same time, Xi'an's evaluation results provide a reference for spatial governance in the coordinated development of the Guanzhong Plain urban agglomeration.

3.3.3 Xiamen

As a coastal special economic zone and an Urban-Act pilot city, Xiamen has been among the front-runners in China in territorial spatial planning monitoring and evaluation. In 2021, following the Ministry of Natural Resources' concerted push for urban monitoring and evaluation, Xiamen, as one of the first 108 pilot cities nationwide and one of the 12 pilot cities for real-time monitoring and evaluation, actively explored implementation pathways and working methods, and developed what has come to be known as the "Xiamen experience", which has provided a useful reference for other cities.

In terms of institutional arrangements, Xiamen has established a well-developed organisational structure for monitoring and evaluation. In designing its system, the city treats the urban area as an organic living system and upholds the concept of "whole-city health", thereby creating a comprehensive, easy-to-use and intelligent real-time monitoring and evaluation system. In February 2023, the General Office of the Xiamen Municipal People's Government officially issued the *Work Plan for Urban Monitoring and Evaluation of Territorial Spatial Planning in Xiamen*, and established a leading group for urban monitoring and evaluation of territorial spatial planning, headed by municipal leaders. The Municipal Bureau of Natural Resources and Planning serves as the lead agency, with the municipal departments of development and reform, housing and urban-rural development, ecology and environment, transport, municipal landscaping and water resources, among others, as member units, while district governments assist with implementation. At the same time, Xiamen established an expert committee system for urban monitoring and evaluation of territorial spatial planning to provide technical support and professional advice.

In terms of evaluation content, Xiamen has developed a territorial spatial planning monitoring and evaluation indicator system comprising 122 indicators, forming a multi-dimensional framework with local characteristics. The evaluation covers six areas: strategic positioning, baseline control, scale and structure, spatial layout, support systems and implementation safeguards. Regarding climate change, as a coastal city Xiamen places particular emphasis on climate adaptation issues such as response to sea-level rise, mitigation of the urban heat island effect, prevention and control of rainstorm-induced waterlogging, and protection of blue-green space. The annual monitoring exercises include indicators such as green building coverage and the density of waterlogging points in the built-up urban area. In terms of working mechanisms, Xiamen has innovatively launched a pilot real-time monitoring and evaluation programme, using digital tools to shift monitoring and evaluation from an annual exercise to routine, dynamic monitoring. In terms of outputs, Xiamen has established a "1+1+6" output system, namely one annual general report on urban monitoring and evaluation, one thematic report, and six annexes, including the indicator conclusion table, the list of completed key tasks, analytical maps, the social satisfaction survey report, the basic database and the database construction note. After review by the leading group, the report is submitted to the Municipal People's Government for approval and then made publicly available for oversight. Xiamen also places strong emphasis on broad-based citizen satisfaction surveys, gathering residents' views on urban spatial quality through both online and offline channels, and thereby integrating public participation deeply into the monitoring and evaluation process.

3.4 Summary

A review of practices in Shanghai, the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone, and representative pilot cities including Jiaxing, Xi'an and Xiamen indicates that, despite being at different stages of development, all of these jurisdictions have put in place and are operating MRV mechanisms centred on territorial spatial planning monitoring and evaluation. These mechanisms have become an important instrument for overseeing plan implementation under China's ongoing territorial spatial planning reform.

Several common features can be observed across the pilot areas. First, the institutional framework for MRV has largely been put in place. Most pilot areas have adopted the statutory cycle of "annual monitoring and five-year evaluation", together with regular reporting arrangements, making MRV an institutionalised governance tool. Second, the digital foundation for MRV is gradually being strengthened. Building on the "One Map" implementation supervision information system for natural resource management and territorial spatial planning, pilot areas have established digital platforms that integrate planning outputs with dynamic monitoring data and enable spatially referenced management and analysis. Third, mechanisms for data sharing and inter-departmental coordination have been broadly established. In all cases, natural resources authorities play the lead role, while other departments contribute through collaborative data-sharing and coordination arrangements. Finally, climate change considerations have increasingly been incorporated into monitoring and evaluation systems. Although climate-related monitoring in most cities still relies primarily on indirect indicators related to spatial form and land use, the inclusion of climate-related indicators within territorial spatial planning MRV frameworks represents an important step towards integrating climate action into spatial governance.

Because of fundamental differences in governance scale, administrative structures, and core policy mandates, urban and regional MRV frameworks exhibit distinct design logics and operational priorities. From an institutional perspective, urban MRV systems—such as those in Shanghai, Jiaxing, Xi'an and Xiamen—are embedded within a unified municipal hierarchy. They benefit from streamlined chains of command and highly efficient decision-making, which facilitate the rapid mobilisation of resources and the top-down enforcement of planning targets at the municipal level. In contrast, regional MRV systems, exemplified by the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone, span multiple provincial boundaries and incur markedly higher coordination costs. Compared with city-based systems, they require the creation of dedicated multilateral consensus-building platforms—such as the Demonstration Zone's "Council–Executive Committee–Development Company" structure—to devise institutional solutions that bridge jurisdictional divides and enable horizontal collaboration. This operational divergence is equally evident in data integration. For urban MRV systems, the main challenge lies within the municipality itself: harmonising data sharing and standardising metrics across departments within a single administrative apparatus. At its core, this means resolving friction within one system. Regional MRV systems, however, must additionally overcome deeply complex inter-governmental bottlenecks, including conflicting data protocols, platform interoperability issues and divided legal jurisdictions across different provinces and cities. The technical and institutional difficulty of data integration therefore increases substantially. Monitoring priorities also differ. Urban MRV systems focus primarily on micro-scale spatial optimisation and on improving the quality of development within the city, giving priority to detailed indicators such as public service accessibility, infrastructure density, urban regeneration and location-specific land-use efficiency. Regional MRV systems, by contrast, place greater emphasis on macro-scale spatial synergy and cross-boundary connectivity, concentrating on metrics such as joint ecological conservation, coordinated environmental governance and the regulatory control of regional infrastructure corridors. The pathways for cascading targets and indicators differ accordingly. Urban MRV systems generally follow a direct, vertical chain from the municipal level to districts and then to specific spatial units. Regional MRV systems, however, must manage the cascading and transmission of targets across a complex, multi-level administrative matrix—region, province/municipality, district/county, spatial unit. This extended chain demands rigorous cross-level calibration and considerably greater precision in implementation.

Despite these divergent operational modes, both urban and regional approaches face a set of deep-seated, shared challenges in developing their MRV mechanisms to support proactive climate action. **1. A deficit in the direct monitoring of climate performance outcomes.** Existing monitoring frameworks are highly effective at capturing changes in spatial form, such as land-use shifts and development density. They lack, however, the built-in capacity to measure absolute climate mitigation and adaptation outcomes—such as real-time greenhouse gas inventories, net ecosystem carbon sequestration, or quantified reductions in thermal risk. The resulting reliance on indirect spatial proxies makes it difficult to capture, and to communicate clearly, the empirical impacts of climate change. **2. Persistent cross-sectoral data silos.** While the digital "One Map" spatial infrastructure provides an essential foundation, structural misalignments between departmental datasets have yet to be fully resolved. Energy consumption data held by development and reform authorities, building operations data managed by housing and urban-rural development departments, and environmental permitting records maintained by ecological authorities frequently differ from the natural resources "One Map" in update frequency, statistical boundaries and spatial granularity. This fragmentation continues to obstruct holistic, real-time analytics based on fully integrated datasets. **3. Weak institutional force in the policy feedback loop.** Although spatial diagnostics have become routine, the governance mechanisms that determine how monitoring and evaluation outcomes are translated into corrective action lack statutory force.

In the absence of binding procedural rules specifying how evaluation deficits are to automatically trigger statutory plan revisions, dynamic budget reallocations or executive accountability within performance assessments, the link between monitoring and evaluation outcomes and tangible remediation remains fragile. **4. Inadequate lifecycle regulatory coverage of market actors.** Current MRV architectures are designed primarily to serve government administrative approvals and pre-construction compliance checks. They lack the long-term, low-cost automated tracking tools needed to verify the actual operational energy consumption and carbon footprints of private developers or industrial enterprises. This enforcement gap severely limits the system's ability to establish a closed "monitor–disclose–incentivise" market loop, thereby constraining the mobilisation of private-sector participation in climate action.

4 Current Bottlenecks and Challenges in the Implementation of the MRV Mechanism

A review of the municipal territorial spatial planning system, MRV implementation pathways, and pilot cities and regions (Shanghai, the Yangtze River Delta Demonstration Zone, Jiaxing, Xi'an and Xiamen) shows that the current MRV mechanism for territorial spatial planning still faces bottlenecks in both the data and institutional dimensions, which constrain its ability to effectively support urban climate action.

4.1 Data Dimension

Regarding the data dimension, the MRV mechanism for territorial spatial planning is relatively well supplied with spatial-form data. The main bottleneck is the inadequate support for climate action performance data. At the same time, the integration of multi-source, heterogeneous data and their linkage across different administrative levels remains subject to unavoidable technical discontinuities. Four main challenges can be identified.

First, support for climate action performance data is still insufficient, and indirect indicators cannot accurately reflect substantive outcomes. The current monitoring and evaluation indicator system relies mainly on spatial indicators with a low-carbon orientation, such as spatial scale controls and proxies for resource-use efficiency. The core indicators that directly quantify climate action performance have not yet been incorporated into routine monitoring. The key difficulty is that the cross-departmental data system still lacks standardised spatial linkage interfaces. In particular, effective rules for linking and matching the ecological and environmental department's greenhouse gas inventory and key-enterprise carbon accounting data with the natural resources department's "One Map" system have not yet been fully established. At the same time, operational models for linking the development and reform department's energy balance tables and the housing and urban-rural development department's building energy consumption monitoring data to planning control units are still under development. Against this backdrop, planning monitoring exercises can only infer carbon sink gains from indirect signals of spatial change, which, to some extent, hampers the fine-grained spatial implementation of the "dual carbon" goals.

Second, differences in precision and update frequency across levels of data may distort vertical aggregation. At the national level, macro spatial data obtained through satellite remote sensing—such as land-use change surveys—are mainly at the pixel level (for example, 10 m × 10 m), have annual or quarterly update cycles, and focus on the static identification of land-cover types. By contrast, city-level climate-related operational data, such as building sub-meter energy consumption, real-time traffic flows and carbon emissions from industrial park production processes, rely on IoT sensors, smart meters and enterprise self-reporting systems. These data are updated hourly or daily and require spatial precision down to the scale of individual buildings or parcels. The two types differ in statistical scope, temporal reference points and aggregation methods. During upward reporting, local high-frequency, fine-grained data may be forced to match the requirements of higher-level platforms through coarse-graining and dimensional reduction, resulting in the loss of key local information—such as clusters of high-energy-consumption buildings in old urban districts or peak-emission surges along commuter corridors. As a result, the data cannot directly support decisions such as micro-scale climate-risk identification.

Third, the substantial differences in cross-departmental data standards are difficult to overcome, and integration costs remain high. The data systems of the development and reform, housing and urban-rural development, ecology and environment, transport, and statistics departments are independent of one another and lack unified standards for indicator definitions, classification codes, measurement units and update rules. Integrating multi-source data into the "One Map" system requires complex processes of cleaning, alignment, and spatial transformation—for example, interpolating enterprise point-source emissions data into areal pollution-load layers. This may not only delay data availability but also introduce systematic errors through the transformation algorithms, such as evenly allocating transport-related carbon emissions to parcels along the road network while ignoring the tidal characteristics of commuting flows. This affects real-time climate-risk simulation and scenario analysis based on integrated datasets.

Fourth, the oversight of market actors and micro-level entities remains challenging, and monitoring during the operational phase is insufficient. The current MRV mechanism mainly serves government administrative approval and macro-level oversight, while monitoring coverage of micro-level market actors remains at an exploratory stage. Technically, IoT sensing networks cannot yet achieve full coverage of major energy-consuming units, and sensor calibration and data

transmission protocols often lack unified standards. Institutionally, enterprise energy-use and carbon-emissions data involve commercial confidentiality, and there is a lack of legally binding requirements and secure transmission mechanisms. Economically, there is a shortage of low-cost automated data collection tools and of mechanisms that can generate value from the data. As a result, the full-lifecycle "construction–operation" data chain cannot be closed. Green building star ratings or emission-reduction targets for industrial parks promised at the planning approval stage lack a continuous assessment mechanism during operation, which may create management loopholes where buildings are designed to be energy-efficient but underperform in practice.

4.2 Institutional Dimension

At the institutional level, the main challenges lie in weak coordination mechanisms, unresolved jurisdictional friction over authority, and an evaluation-feedback loop that lacks statutory force. These constraints manifest themselves in five areas.

1. Reliance on ad hoc coordination for cross-sectoral data sharing: No routine, highly efficient collaborative mechanism has yet been put in place. While the "One Map" platform provides a sound technical foundation, mandatory data-sharing obligations and update frequencies remain largely uncodified in municipal regulations or local statutes. Cross-departmental data integration therefore relies heavily on temporary joint committees or ad hoc administrative mandates. This informal approach is highly vulnerable to staff turnover and struggles to sustain the high-frequency, precise data streams required for dynamic climate monitoring.

2. Asymmetry of authority in cross-jurisdictional governance: Misaligned rights and responsibilities weaken the efficiency of regional governance. In the Yangtze River Delta Demonstration Zone, for example, the established "Council–Executive Committee–Development Company" structure faces inherent limitations. As a cross-provincial coordinating body, the Executive Committee lacks statutory permitting and appraisal authority over its constituent jurisdictions (the "two districts and one county"). Cross-border data sharing therefore demands repeated ad hoc negotiations to overcome territorial jurisdiction barriers, delaying the flow of data and preventing joint evaluation findings from being translated into binding corrective mandates for local governments.

3. Administrative delays in multi-level coordination: The multi-level hierarchy undermines the system's capacity to respond rapidly to climate-related events. Within the four-level (national–provincial–municipal–county) MRV network, local natural resources authorities must operate within a complex matrix of horizontal reporting structures (to peer departments such as environment and reform) and vertical ones (to higher-level platforms). The bottomup transmission of local climate monitoring data—which requires multiple rounds of approval and format conversions at the county, municipal, provincial, and ministerial levels—can take several months. Conversely, by the time topdown macrolevel remote sensing verifications reach localities, the optimal window for corrective intervention has often already closed, thereby weakening emergency response capabilities for acute climate risks.

4. Insufficient binding force in the evaluation–feedback loop: The closed-loop mechanism that links evaluation results to executive decision-making remains incomplete. Although procedural guidelines exist for translating spatial diagnostic outcomes into dynamic plan updating (e.g., localised refinement of Ecological Protection Red Lines), near-term construction adjustments and resource quota allocations, the system lacks clear regulatory triggers. Without defined quantitative thresholds, mandatory deadlines for corrective action and strict oversight protocols, the enforcement of monitoring and evaluation (M&E) outcomes remains fragmented.

5. Decoupling of MRV mechanisms from market-based incentives: Current frameworks do not link spatial monitoring outcomes with market-driven policy instruments, resulting in weak private-sector participation. Indicative climate indicators—such as the share of near-zeroenergy buildings or the selfsufficiency rate for renewable energy—are not institutionally integrated with incentive tools such as floor area ratio (FAR) bonuses, green finance interest subsidies or carbon credit mechanisms. Furthermore, while binding indicators (e.g., green building star ratings) are strictly enforced during the administrative approval and completion acceptance phases, they lack sustained tracking and rewardandpenalty mechanisms over the operational life cycle. This separation of monitoring from incentives discourages market actors from proactively disclosing operational data or investing in lowcarbon technologies, and thereby weakens the marketdriving potential of spatial MRV.

5 Brief Summary of International Experience and Comparison with Chinese Practice

5.1 International Experience

5.1.1 The London Plan

The London Plan is the spatial development strategy for the UK capital, prepared and overseen by the Mayor of London. Its MRV mechanism is built around the Annual Monitoring Report (AMR), which rests on a clear legal basis and a welldeveloped indicator system.

With regard to the legal basis, Section 346 of the *Greater London Authority Act 1999* imposes a statutory duty on the Mayor to monitor the implementation of the spatial development strategy, to collect data in support of plan preparation, review, revision, replacement and implementation, and to publish an annual monitoring report for the public. This provision gives the MRV mechanism a solid legal foundation.

Regarding institutional arrangements, the MRV mechanism for the London Plan is based on a clear division of responsibilities among several actors. The Mayor of London is ultimately responsible for plan implementation and provides overall leadership for the MRV process, as well as approving and publishing the monitoring report. The planning team within the Greater London Authority (GLA) is responsible for drafting the AMR, including data collection, indicator analysis and report writing. The London Datastore serves as an open data platform, giving the public access to all monitoring data and related research reports. The London boroughs are responsible for providing planning implementation data from their respective jurisdictions and for supporting the preparation of the AMR.

Regarding the indicator system, the 2021 London Plan sets out 12 indicator areas under the six dimensions of "good growth". These cover new housing supply, affordable housing supply, office space supply, affordable workspace, industrial land, protection of the Green Belt and Metropolitan Open Land, carbon emissions from new development, travel mode shares, active travel, air quality, heritage impacts and cultural infrastructure provision. Among these, the indicator on carbon emissions from new development and that on Green Belt protection are the core indicators most directly linked to climate change. The AMR also tracks a broader set of environmental indicators through supplementary data, including those on energy, flood risk and heat risk.

The London Plan MRV mechanism has three distinctive features. First, it has strong legal force: the preparation and publication of the AMR are statutory duties of the Mayor, not discretionary administrative actions. Second, it is transparent and open: all monitoring data are made publicly available through the London Datastore and can be accessed and used by the public and researchers. Third, it is highly quantified: indicators are linked to clear target values and timeframes, enabling precise progress tracking and comparison across boroughs.

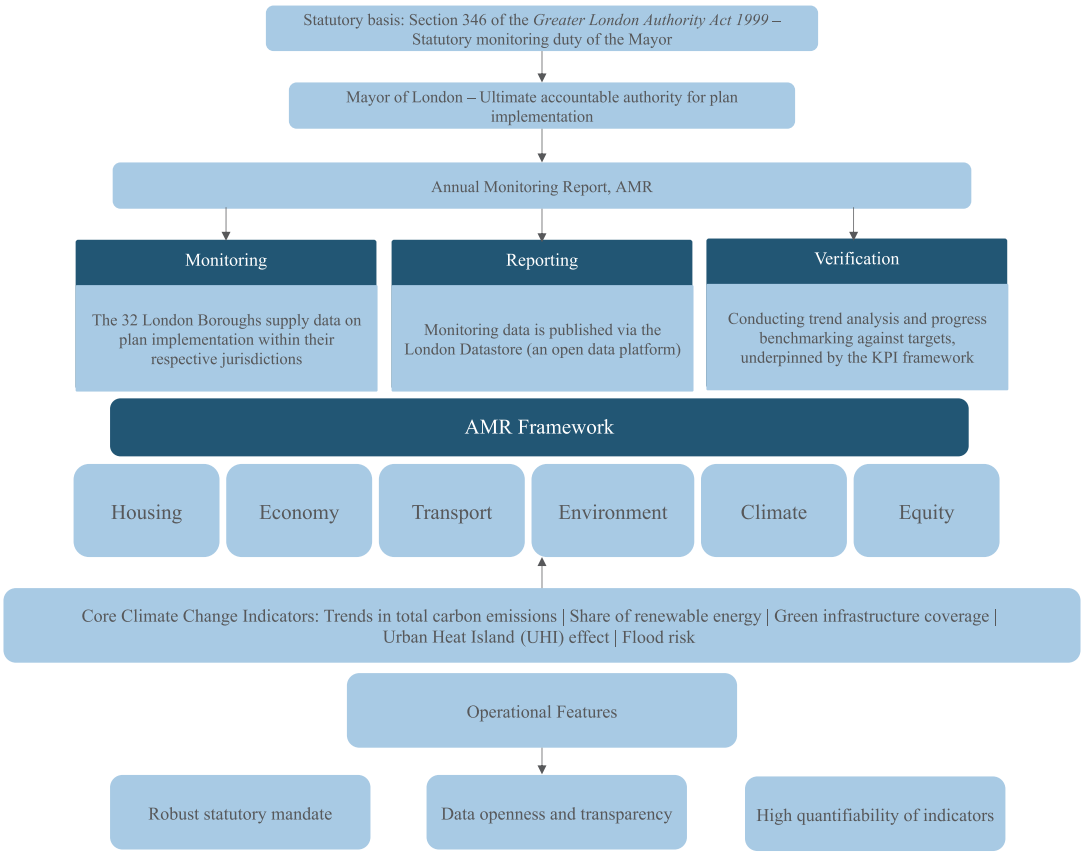


Figure 16: MRV Mechanism Framework of the London Plan
Source: Compiled from Greater London Authority, London Plan Annual Monitoring Report 19 (2021/22)

5.1.2 OneNYC 2050

OneNYC 2050 is New York City's long-term development strategy. It is led by the Mayor's Office and addresses eight major dimensions of urban development, with climate change and sustainability at its core. Its MRV mechanism is characterised by data-driven management and public transparency.

With regard to institutional arrangements, the preparation and implementation of OneNYC 2050 rely on an inter-departmental coordination mechanism based in the Mayor's Office. The Mayor's Office of Climate Policy and Programs holds lead responsibility for OneNYC 2050, while the Mayor's Office of Operations plays a key role in performance management and the collection of indicator data, consolidating inputs from relevant municipal agencies. Functional departments provide data on implementation progress and performance in areas such as housing, transport, environment, health, education and infrastructure, according to their respective mandates. A OneNYC Advisory Board, composed of members drawn from the city's five boroughs and from community, public policy, civil society, and public sector backgrounds, contributed to the preparation of the plan.

Regarding monitoring indicators, OneNYC 2050 puts in place an annual tracking mechanism centred on key performance indicators. These indicators are used to assess progress against eight strategic objectives, and historical data are published through platforms such as NYC Open Data. Core indicators include local election turnout, total employment, reductions in poverty and near-poverty, severe rent burden among low-income tenants, racial income gaps, premature mortality, air quality, on-time high school graduation, the share of greenhouse gas emissions reduced, eliminated or offset, and the share of sustainable trips. The core climate-related indicators focus on progress in greenhouse gas reduction or offsetting, clean electricity, and sustainable mobility. Building energy use, tree canopy cover and flood risk are tracked as supplementary indicators supporting New York's climate governance and resilience policies.

As for operational features, the OneNYC 2050 monitoring system is distinguished by three characteristics. First, it emphasises annual reporting and public accountability: key performance indicators are published on an annual basis, rather than being updated in real time. Second, it builds on New York City's long-established performance management and open data infrastructure, linking OneNYC

indicators with the Mayor's Management Report, departmental data, and open data platforms. Third, it aligns local strategy with the United Nations Sustainable Development Goals (SDGs). New York City was the first city in the world to submit a Voluntary Local Review (VLR) to the United Nations, and OneNYC 2050 incorporates the SDGs into both the plan's wording and its annual review framework. The VLR is best understood as a systematic mapping and selective annual reporting of how OneNYC relates to the SDGs, rather than as a full, one-to-one correspondence with all SDG indicators. Taken together, OneNYC's monitoring, reporting and evaluation mechanism reflects the city's integrated approach to bringing together open data, cross-departmental performance management, climate action and social equity within a long-term strategic governance framework.

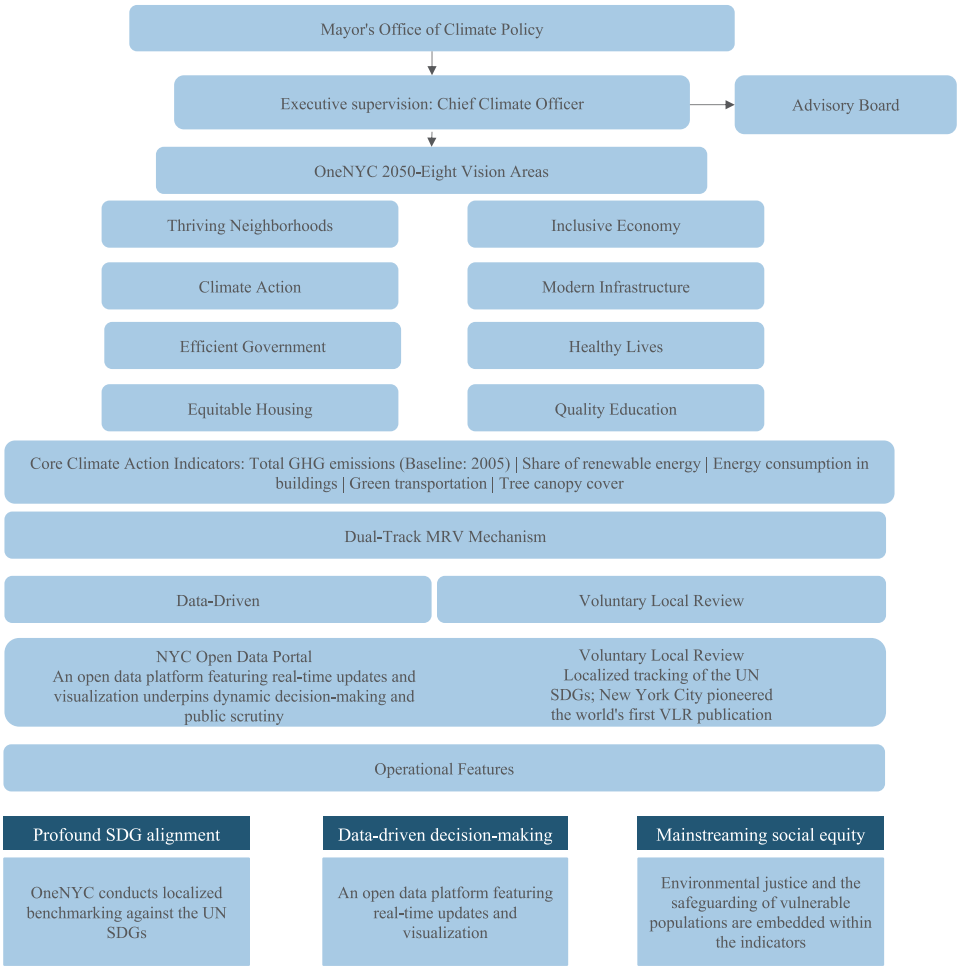


Figure 17: MRV Mechanism Framework of OneNYC 2050, New York
Source: Compiled from City of New York, OneNYC 2050: A Livable Climate (2019) and the VLR (2019)

5.1.3 Future Tokyo: A Strategic Plan

Future Tokyo: Tokyo's Long-Term Strategy is the long-term development strategy of the Tokyo Metropolitan Government (TMG). It sets out a vision for Tokyo in the 2040s, with 2030 as the key medium-term milestone. First released in 2021, the strategy has since been updated annually through a process known as "Version Up", which continuously incorporates new policy priorities and implementation progress into the strategic framework.

Compared with the London and New York plans, the MRV mechanism underpinning Future Tokyo is characterised by a strong emphasis on continuous adaptation and iterative updating. Rather than maintaining a fixed planning document throughout a predefined planning cycle, the strategy incorporates policy progress, implementation outcomes and emerging urban issues into its annual updates. This allows Tokyo to keep long-term objectives stable while responding to evolving challenges such as demographic change, industrial transformation, digital governance, disaster risk and climate change. From an MRV perspective, the annual Version Up process

is more than a conventional plan revision exercise: it functions as an adaptive management mechanism that integrates monitoring results, policy feedback and strategic adjustment. By linking annual policy updates to monitoring and evaluation outcomes, the strategy maintains a high degree of flexibility and responsiveness.

With regard to institutional arrangements, MRV activities under Future Tokyo are coordinated by the Office of the Governor for Policy Planning of the TMG. Individual departments are responsible for advancing implementation in their respective policy fields and for reporting progress regularly. The TMG also makes progress on implementation publicly accessible through its online Policy Dashboard.

As for monitoring arrangements, Tokyo's MRV system is distinguished by a distinctive iterative updating mechanism. Unlike traditional approaches based on fixed review cycles, Future Tokyo incorporates the latest implementation progress and policy adjustments into its annual Version Up releases. This continuous updating model enables the MRV system to respond more flexibly to changes in the external environment and to emerging policy challenges. At the same time, the TMG tracks progress on the local implementation of the Sustainable Development Goals (SDGs) through its Tokyo Sustainability Action framework, thereby linking urban climate action to the wider global sustainable development agenda.

The Future Tokyo MRV mechanism has several distinctive features. First, it embodies a highly flexible adaptive management approach. Annual Version Up releases enable the strategy to incorporate emerging priorities in a timely manner—for instance, postpandemic recovery measures in 2022 and measures to address the declining birth rate in 2023. Second, it places a strong emphasis on digital transparency: the Policy Dashboard is available on both webbased and mobile platforms, allowing the public convenient access to information on implementation progress. Third, it places particular emphasis on linking the longterm vision to short and mediumterm action. Guided by its 2040s vision, the annual strategic updates are used to track progress towards the 2030 mediumterm targets and to inform subsequent policy adjustments.

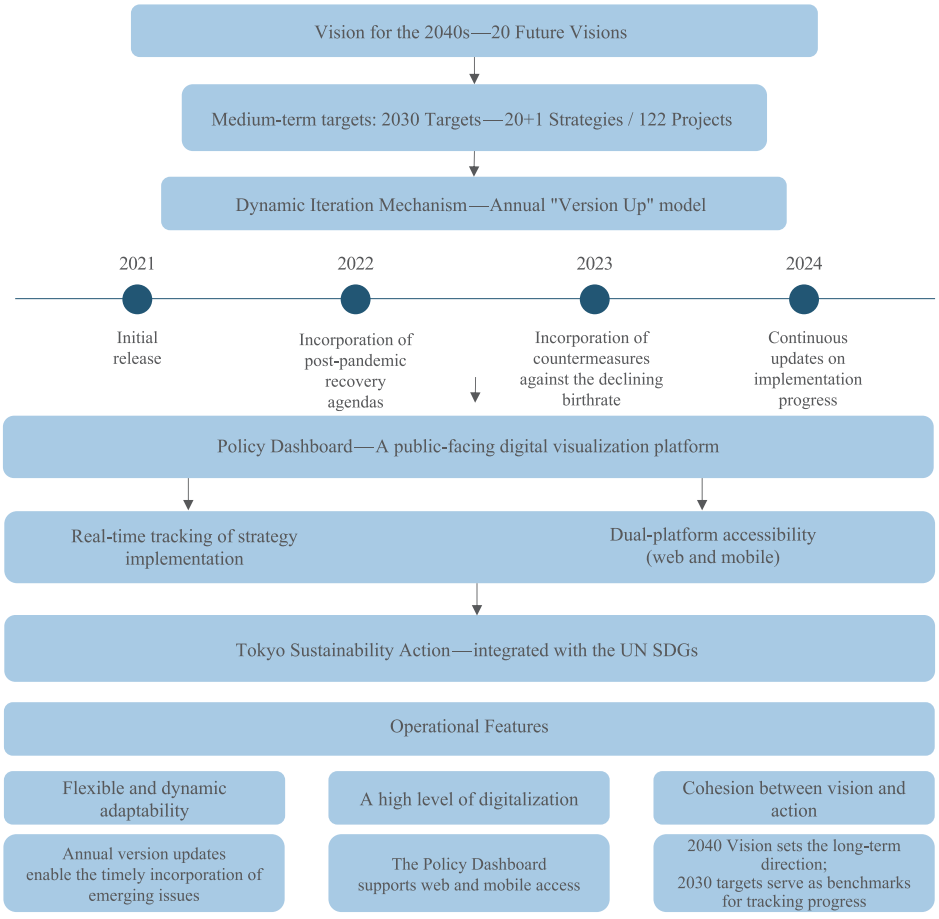


Figure 18: MRV Mechanism of Future Tokyo: Tokyo's Long-Term Strategy
Source: Adapted from Tokyo Metropolitan Government, Future Tokyo: Tokyo's Long-Term Strategy (Version Up 2024)

5.2 Comparative Analysis of International Experience and Chinese Practice

A comparative review of the MRV mechanisms in London, New York, and Tokyo, set alongside China's territorial spatial planning MRV framework, reveals both shared features and instructive differences.

First, the institutional foundations differ. International MRV mechanisms are generally supported by relatively clear legal or policy mandates. In London, the Annual Monitoring Report system makes the review of spatial development strategy implementation a continuing statutory obligation. In New York, planning targets, departmental responsibilities and public reporting are linked through long-term strategic and climate policy frameworks. In Tokyo, the annual "Version Up" process connects policy implementation with ongoing strategic adjustment. By comparison, China's territorial spatial planning MRV mechanism is built mainly on technical regulations, sectoral standards and implementation supervision requirements issued by the natural resources authorities. The "annual monitoring and five-year evaluation" cycle has already become routine institutional practice, but the framework as a whole still rests more on administrative procedures and technical standards than on legislation. In the future, higherlevel legal instruments could further clarify the legal status of MRV, the responsible entities, the procedural requirements and the use of results.

Second, international cities place greater emphasis on the transparency and public accessibility of monitoring data. London, New York, and Tokyo have all developed relatively mature open-data platforms or public information portals that make data on plan implementation, climate action, public services, transport, and environmental quality accessible to the public. This openness supports not only internal government management but also public oversight, independent research, and policy feedback. China's "One Map" system for territorial spatial planning already provides a strong foundation for unified base maps, standardisation, spatial control and administrative supervision. While the system performs an important integrating function for plan approval, implementation oversight and data submission, local governments are also exploring modules that offer public access to data and applications. Looking ahead, and subject to data security, national security and personal privacy requirements, selected planning monitoring results, climate action indicators and urban performance data could be made available to the public on a more regular basis.

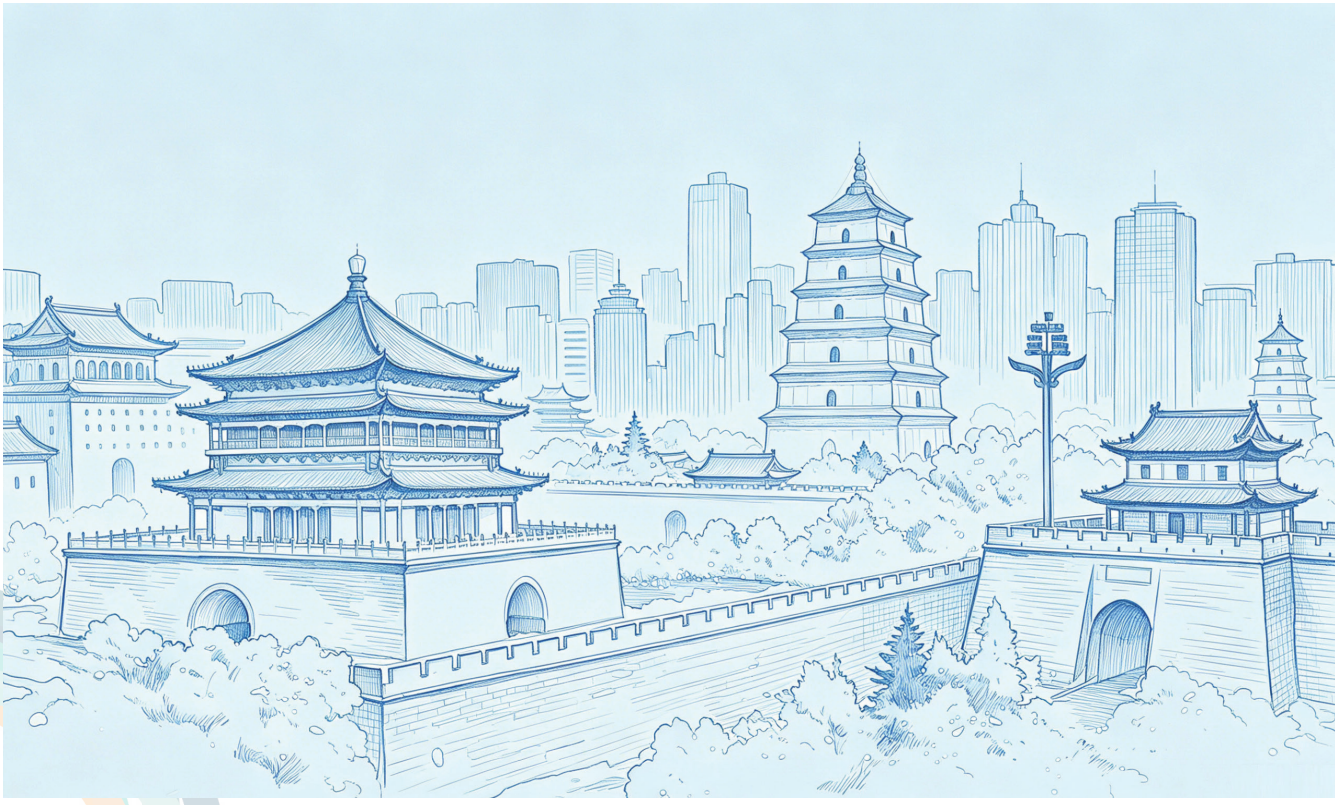
Third, the indicator systems differ in emphasis. International experience tends to attach greater weight to direct climate performance indicators, whereas China's current system places more stress on spatial governance and baseline control. In London, New York and Tokyo, indicators such as total carbon emissions, energy mix, green transport, building energy efficiency, climate resilience and social equity are often directly incorporated into strategic implementation reviews. China's territorial spatial planning monitoring system, by contrast, gives greater prominence to spatial governance and baseline control indicators, such as land-use change, Ecological Protection Red Lines, permanent basic cropland, urban development boundaries, construction land efficiency, public service coverage, and urban safety and resilience. Its strength lies in enabling the systematic monitoring of the spatial pattern of development and protection on the basis of a unified spatial base map. From the perspective of MRV for urban climate action, however, future improvements could make climate mitigation, climate adaptation and urban resilience indicators more direct, more quantifiable, and more verifiable.

Fourth, institutional coordination is organised differently. International cities usually emphasise highlevel coordination and crossdepartmental cooperation, whereas China's approach relies more on strong topdown transmission and administrative mobilisation. In London, New York, and Tokyo, MRV mechanisms are typically led by city governments, strategic planning departments or climaterelated bodies, and depend on crossdepartmental data collection and public reporting to support implementation. China's territorial spatial planning MRV mechanism is led by the natural resources authorities and built on the "Five Levels, Three Types" territorial spatial planning system, the "One Map" implementation supervision information system, and the urban monitoring and evaluation system. This has created a strong vertical chain of transmission and data submission across the national, provincial, municipal, and county levels. Its strength lies in largescale, crosslevel spatial monitoring and planning control. At the same time, because climate action involves the natural resources, ecology and environment, development and reform, housing and urbanrural development, transport, water resources and statistics departments, among others, crossdepartmental data sharing, the harmonisation of indicator definitions and the coordination of responsibilities remain major challenges.

Fifth, the use of evaluation results differs in emphasis. International experience places strong emphasis on the continuity between monitoring, disclosure, feedback, and policy adjustment, while China stresses the role of evaluation results in feeding back into dynamic plan updating

and climate policy adjustment. In London, New York, and Tokyo, MRV mechanisms do not stop at producing technical reports; monitoring results are also used to inform later policy revision, budget allocation, project delivery and public communication. China has already established the routine "annual monitoring and five-year evaluation" mechanism and is using the territorial spatial planning implementation monitoring network and the "One Map" system to advance the monitoring of plan implementation. In practice, China has already put in place a policy framework through which monitoring and evaluation results can trigger plan revision, the adjustment of special actions, fiscal resource allocation and departmental accountability. However, the finer procedural design still needs to be strengthened. Future reforms could further consolidate a closedloop system of "monitoring—evaluation—feedback—updating—remonitoring", so that territorial spatial planning MRV serves not only the oversight of plan implementation, but also the continuous improvement of urban climate action.

Overall, the key lesson to be drawn from international experience is not the straightforward replication of a particular city's annual reporting or updating format. It is, rather, to help MRV evolve from a technical monitoring tool into a broader governance instrument. China's territorial spatial planning MRV system already possesses significant strengths in unified base maps, unified platforms, vertical transmission, and spatial control. The next step is to improve the directness of climate indicators, the transparency of data access, the effectiveness of crosssectoral coordination, and the institutional rigour with which evaluation results are fed back into dynamic plan updating and climate policy adjustment.



6 Recommendations for Strengthening Territorial Spatial Planning MRV

In response to the data- and institution-related challenges identified above, this chapter puts forward a set of systematic recommendations organised around three themes: strengthening the MRV mechanism itself, improving data-sharing arrangements, and developing an indicator framework for evaluating climate action.

6.1 Recommendations for Improving the Municipal Territorial Spatial Planning MRV Mechanism

To address institutional weaknesses—in particular, the need for stronger feedback from evaluation results and more efficient cross-departmental coordination—the MRV mechanism should be strengthened in the following ways.

First, a more firmly institutionalised mechanism for using evaluation results should be put in place. The outcomes of monitoring and evaluation exercises need to be linked more tightly to plan updating, near-term construction programming and the annual allocation of land-use indicators. Whenever problems are identified through evaluation, clear rules should be established specifying deadlines for corrective action, the entities responsible and the arrangements for follow-up oversight, so that the closed loop of "monitoring—evaluation—feedback—corrective action" is made operational in practice.

Second, cross-departmental MRV coordination should be improved. At the municipal level, a standing MRV coordination mechanism should be set up, led by the senior municipal government official with portfolio responsibility and bringing together the departments of natural resources, development and reform, ecology and environment, housing and urban-rural development, transport, and statistics. This mechanism would serve to coordinate cross-departmental issues concerning data sharing, indicator monitoring and evaluation.

Third, whole-lifecycle oversight of market actors should be strengthened. Opportunities should be explored to link real-time building energy-use data and enterprise carbon-emission data to the "One Map" system through standardised interfaces. At the same time, MRV results should be linked to market-based incentive instruments—such as floor-area-ratio bonuses, green credit and carbon-inclusive schemes—so as to create a positive "monitoring–incentive" cycle.

Fourth, institutional arrangements for cross-jurisdictional MRV coordination should be explored. Drawing on the experience of the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone, cross-regional planning management should further strengthen the substantive authority of joint assessment bodies in cross-boundary planning contexts. Mandatory requirements and technical standards for cross-regional data sharing should be clarified, and mechanisms for resolving disputes and coordinating responses should be established.

6.2 Recommendations for Improving Climate-Related Data Sharing

To address difficulties in data access, weak standardisation and gaps in cross-level linkage, the following improvements to the data-sharing mechanism are recommended.

First, place departmental data sharing on a stronger regulatory footing. The municipal government should issue administrative regulations on data sharing that clearly define the obligations, scope, frequency, and quality standards for each department's submission of data to the "One Map" system. Data-sharing performance should also be integrated into the annual performance appraisal of departments.

Second, standardise the integration of climate action data. Technical standards should be developed to link territorial spatial planning data with carbon emissions data, and a unified methodology for the spatial allocation of carbon accounts should be established. This would enable the standardised linkage of greenhouse gas inventories from ecological and environmental departments, energy consumption statistics from the energy sector, and the "One Map" system for natural resource management and territorial spatial planning.

Third, enhance the multi-level connectivity of climate-related data across the national, provincial, municipal, and county levels. The interface specifications of "One Map" systems at different administrative levels should be harmonised. Automated data submission and verification procedures should be put in place, and the CSPON network should be used to enable the real-time upward aggregation and quality assurance of monitoring data.

Fourth, make data collection more intelligent. Greater use should be made of IoT, artificial intelligence and other technologies in

planning monitoring. Satellite remote sensing, drone inspections and sensor networks should be more widely deployed to enhance the automatic collection and analysis of fine-grained indicators, such as carbon emission intensity and neighbourhood thermal comfort, and to reduce the uncertainty associated with manual intervention.

6.3 Recommendations for Building an Indicator System for Urban Climate Action

To address the indirect nature of current climaterelated indicators and the gaps in existing evaluation standards, the following measures are recommended for developing a municipal indicator system for climate action monitoring and evaluation.

First, create a dual "spatial–performance" framework. Building on existing spatialform indicators, new quantitative indicators that directly capture climate action performance should be introduced, covering total carbon emissions, carbon emission intensity, carbon sink increments and carbon emissions per unit area. This would establish a dual framework that combines spatial control indicators with climate performance indicators.

Second, design sectorspecific indicator sets. Indicators should be developed for three main fields: climate mitigation, climate adaptation and resilience building. For climate mitigation, indicators could include the reduction in carbon emission intensity, the share of renewable energy and the share of green travel modes. For climate adaptation, indicators could cover the share of builtup area meeting sponge city standards, flood prevention and drainage compliance rates, and coastal shelterbelt coverage. For resilience building, indicators could include emergency shelter area per capita, the redundancy of lifeline infrastructure and community emergencyresponse capacity.

Third, establish pathways for feeding municipal indicators into national reporting. The relationship between municipal climate action indicators, the national greenhouse gas inventory, and the national reporting framework for Nationally Determined Contributions (NDCs) should be clearly defined. This would help ensure that municipal monitoring data can effectively inform the preparation of national climate action reports.

Fourth, incorporate social equity and public participation. The indicator system should include indicators that reflect social equity and public engagement, such as assessments of the adaptive capacity of vulnerable groups to climate change and surveys of public satisfaction with urban climate action. This would strengthen the social inclusiveness of the MRV system.

7 Recommendations for Other Countries on Building Planning MRV Mechanisms

Drawing on China's experience in establishing and operating territorial spatial planning MRV mechanisms and in integrating climate change responses into them, the following recommendations are put forward for other countries seeking to build or strengthen planning MRV systems.

First, robust data collection, data governance and a digital backbone are the foundation of any planning MRV mechanism. Data collection, governance and analysis lie at the heart of monitoring and evaluation. To put an effective planning MRV system in place, countries should first strengthen their data collection capacity, using a range of methods—including statistical censuses, remote sensing, IoT sensors and drone surveys—to ensure that different types of data can be collected reliably. Because MRV involves data from multiple sectors and multiple administrative levels, data governance capacity must also be strengthened. Common statistical definitions, update frequencies and conversion rules need to be established to reduce integration errors caused by misaligned standards. At the same time, a digital backbone akin to China's "One Map" system should be developed to serve as a basic platform for data aggregation and for connecting digital workflows across departments and levels of government.

Second, the core of an MRV mechanism is a closed working loop of "plan-making—monitoring—evaluation—feedback—updating". The purpose of MRV is to support the refinement of plans and to contribute to higher-quality urban development. Monitoring and evaluation should therefore be aligned with the content of the plan and should capture the degree of implementation, actual performance, and the plan's capacity to respond to change. The results of monitoring and evaluation should also be used to support plan updating, plan adjustment and the formulation of spatial governance policies, thereby establishing a clear closed loop.

Third, regular and periodic operating mechanisms, a stable organisational structure and a clear division of responsibilities are essential safeguards for the MRV mechanism. Monitoring should be conducted annually, and evaluation cycles should be aligned with the target years of the spatial plan. This helps ensure that monitoring and evaluation become routine tasks of planning management, not adhoc assignments. Furthermore, a standing organisational mechanism should be put in place to carry out these assessments periodically. This mechanism should be led by the municipal government (or regional management authority), coordinated by the department responsible for plan formulation, and should involve planning participants, relevant urban management departments, the public, and thirdparty entities. Responsibilities within the MRV framework should be explicitly defined in line with each actor's role in plan formulation and urban management.

Fourth, a coordination mechanism involving multiple administrative levels, departments and stakeholders is a vital pillar of the MRV system. Multilevel coordination encompasses cooperation in data submission and in operational working mechanisms across different tiers of government. In practical terms, this means standardising data interfaces across platforms at various levels so that automated data submission and verification processes can be put in place, thereby resolving data integration problems between levels. Crossdepartmental coordination requires government regulations that clearly set out the boundaries of rights and responsibilities, as well as data standards, for each department. This would help dismantle institutional barriers to data sharing and operational collaboration among the development and reform, housing and urbanrural development, ecology and environment, transport, and other systems. Multistakeholder coordination entails linking MRV evaluation results with marketbased instruments to incentivise proactive participation by market actors, while also embedding social participation mechanisms, such as public satisfaction surveys, into the framework. In this way, the MRV framework can move from being a purely internal governmental technical tool to a governance mechanism grounded in broader social consensus. In addition, the design logic of urban MRV needs to be distinguished from that of regional MRV. Urban MRV operates within a single administrative entity and focuses on intracity departmental coordination and vertical transmission. Regional MRV, by contrast, involves multiple administrative jurisdictions and therefore requires a joint evaluation body with substantive operational authority, not a platform limited solely to consultative functions.

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Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

GIZ Office China

Tayuan Diplomatic Office Building
1-13-2 14 Liangmahe Nanlu,
Chaoyang District 100600 Beijing, PR China
T +86 10-8527 5180
F +86 10-8532 1405
E giz-china@giz.de
I www.giz.de/china