

## KEY POINTS

- The Huangshan project represents a pioneering and comprehensive ecological protection and green development model for small and medium-sized cities in the People's Republic of China.
- Among the project's innovative features is the adoption of two results-based green financing instruments: (i) a financial incentive mechanism for tea farmers applying improved farm management practices (i.e., the Green Incentive Mechanism), and (ii) a financial investment facility for small and medium-sized enterprises promoting green business (i.e., the Green Investment Fund).
- Measures like the sponge city and low-impact development program are applied as an integrated approach to managing urban stormwater pollution, particularly from first flush.
- A smart environmental, health, and safety management system platform will be established to strengthen industrial and urban environmental monitoring and emergency response capacity.

## A Holistic Ecosystem-Based Approach to Ecological Protection and Green Development: The Case of Huangshan in the People's Republic of China

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### ECOLOGICAL CHALLENGES AND RESPONSES IN THE PEOPLE'S REPUBLIC OF CHINA

Agriculture has surpassed industry as the most notable source of surface water pollution in the People's Republic of China (PRC). The increased use of fertilizers and pesticides in agriculture has increased nonpoint source (NPS) pollution through runoffs. Over the past 2 decades, rapid industrialization and urbanization in the PRC have come at a high environmental cost, with water pollution and flooding becoming major challenges. Urbanization has led to a significant increase in impervious areas, preventing rainfall from draining into the ground. The result is increased stormwater runoff, urban flooding, soil erosion, and the consequent increase in the pollution load carried by stormwater to waterbodies, particularly by the first flush.<sup>1</sup>

The government introduced measures like the sponge city and the low-impact development (LID) program and promotes the use of organic fertilizers and biological pesticides.<sup>2</sup> It launched the Yangtze River Economic Belt (YREB) program,<sup>3</sup> which prioritizes ecological protection, green development,<sup>4</sup> and improved investment efficiency across the program's many provinces. In 2016, the Asian Development Bank (ADB) and

<sup>1</sup> First flush is the initial volume of stormwater runoff from rainfall events in urban areas. It typically has more concentrated pollutants than runoff produced during the remainder of a storm.

<sup>2</sup> These measures help increase permeability and water absorption in urban areas. Sponge city design involves constructions to soak up stormwater and capture water for reuse in urban areas.

<sup>3</sup> Government of the PRC. 2015. *Outline of the Yangtze River Economic Belt Development Plan, 2016–2030*. Beijing.

<sup>4</sup> Green development refers to economic activities and/or growth with environmental impacts that may be managed at a targeted level to ensure environmental improvement and sustainability.



**Huangshan's ancient villages.** Huangshan is home to many distinctive Huizhou-style ancient villages. It is a World Heritage Site because of its great historical and cultural heritage, well-preserved architecture, and magnificent scenery (photo by Mingyuan Fan, Asian Development Bank).

the Government of the PRC agreed to a strategic framework, lending \$2.0 billion to the YREB area from 2017 to 2020.<sup>5</sup> Complementing this is the National Strategic Plan for Rural Vitalization (2018–2022), using an integrated approach to address rural–urban gaps, poverty reduction, food security, and sustainable development. The government requested ADB to assist in demonstrating municipal development that ensures environmental sustainability and social inclusiveness.

## HUANGSHAN MUNICIPALITY AND THE XIN'AN RIVER—A DEMONSTRATION CASE

Huangshan Municipality is in the southern part of Anhui Province in the southeastern YREB area, with a population of 1.4 million by 2019. Its traditional villages and the Yellow (Huang) Mountain, which gives the area its name, have made it a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site. The Xin'an River originates in Huangshan and is 360.5 kilometers long, with a basin size of 17,600 square kilometers. It is the main source of drinking water for the municipality and 10 million people living downstream in Zhejiang Province.

The Huangshan Municipal Government (HMG) is implementing ecological protection, green development, and rural vitalization strategies, making significant progress in industrial and point

source pollution control. In 2012, the Xin'an River was selected as the first demonstration case in the PRC to pilot a cross-provincial ecological compensation scheme, addressing the water quality and the broader environmental protection of a river basin. This is an upstream–downstream financial transfer arrangement between the provinces of Anhui and Zhejiang, with compensation provided for reducing pollutants in the river. The fund invested in wastewater treatment facilities and related infrastructure.

However, urbanization, intensified agriculture production, and tourism made the maintenance of good water quality increasingly difficult. NPS pollution from agriculture is the main source of pollutants, mainly because of the poorly regulated and managed drainage systems, inappropriate fertilizer and pesticide application, and farmers' inadequate waste management. The dispersed nature of agricultural activities further worsens the pollution control challenge.

## THE HUANGSHAN PROJECT

The HMG requested ADB for help in designing and implementing a project to improve the efficiency and effectiveness of the existing government-driven eco-compensation scheme, and support the pollution management of both urban and rural point sources and agriculture nonpoint sources. ADB approved a loan in

<sup>5</sup> ADB's support for the PRC focuses on addressing the institutional challenges of implementing national policy priorities in areas where it can add most value, such as developing pilot projects and policy innovations, strengthening institutions, promoting reforms and capacity building, expanding private sector operations, promoting advanced technologies, and sharing best practices.

## A Holistic Ecosystem-Based Approach to Ecological Protection and Green Development

December 2019 within the YREB framework for a demonstration project, the Anhui Huangshan Xin'an River Ecological Protection and Green Development Project (the Huangshan project).<sup>6</sup> ADB sought additional technical assistance (TA) support from various grant-funding sources. Substantial specialized technical support was provided by the Cities Development Initiative for Asia, a project preparation facility of a multi-donor trust fund managed by ADB.<sup>7</sup>

Modern concepts, approaches, and technologies were introduced, making the city a pioneer in many fields. In addition, a collaborative platform was established for the ongoing mobilization of further TA projects to address NPS pollution, complementing assistance provided under the loans from ADB and German development bank, KfW. The Nature Conservancy, an international nongovernment organization, is the initial participant, helping establish the Water Funds.

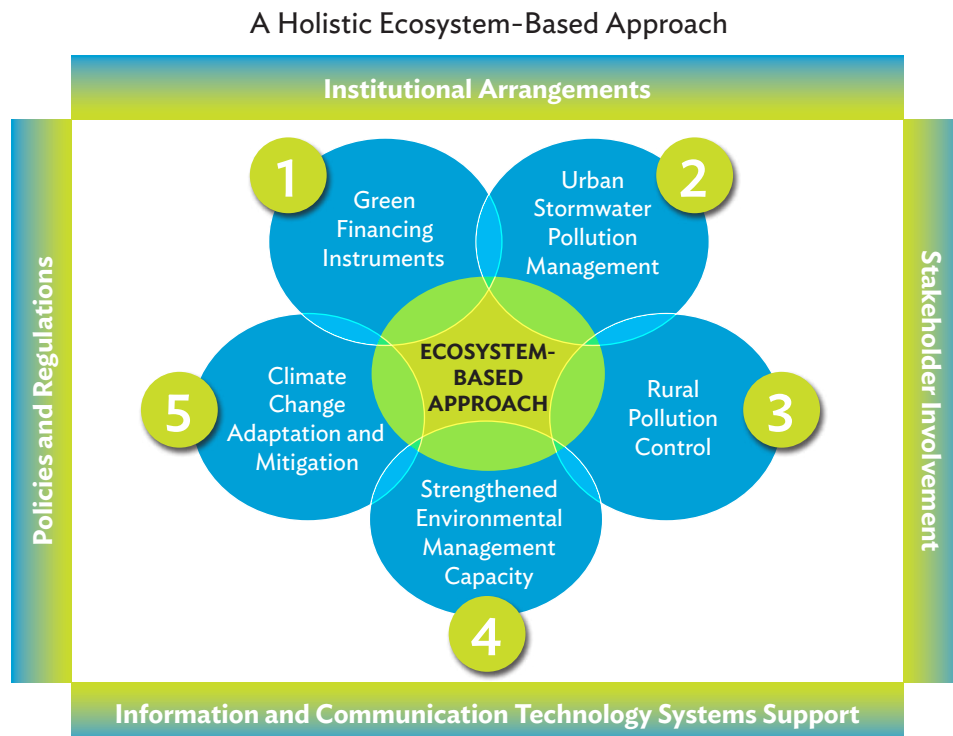
The Huangshan project has been implemented since early 2020 and has

- introduced new operational and financing mechanisms, building on the existing eco-compensation system, for a more comprehensive model of green development;

- demonstrated water pollution reduction in the Xin'an River basin by improving urban and rural wastewater management (reduction of point source pollution);
- prevented soil erosion through drainage ditches and river embankments;
- reduced agriculture-related NPS pollution; and
- strengthened institutional capacities and public awareness of environmental issues.

The project was designed with the following five components: (i) green financing instruments, (ii) urban stormwater pollution management, (iii) rural pollution control, (iv) strengthened environmental management capacity, and (v) climate change adaptation and mitigation.

These components are implemented with an integrative, holistic, ecosystem-based approach, generating synergies through numerous linkages (as illustrated in the figure below). While this brief presents the overall features of the Huangshan project, a focused discussion of the innovative design and contributions of each project component is published as separate reports under the *ADB Briefs* series.



Source: Asian Development Bank. People's Republic of China: Anhui Huangshan Xin'an River Ecological Protection and Green Development Project.

<sup>6</sup> The Huangshan project has a total estimated cost of \$211.03 million, with expected completion by mid-2026. It is funded by a \$100.00 million loan from ADB; a \$55.53 million loan from KfW, a German development bank; and \$55.50 million counterpart funding from the HMG. About 320,000 people (80% urban) will directly benefit while others will benefit from the improved environment.

<sup>7</sup> The Cities Development Initiative for Asia prepared reports on (i) first flush stormwater pollution management, (ii) environmental health and safety management, (iii) the application of information and communication technologies, and (iv) climate change adaptation and mitigation recommendations.

## Piloting Green Financing Instruments

A key aspect of the project is the rollout of two green financing instruments:

- (i) the Green Incentive Mechanism (GIM), which is a financial incentive tool to motivate farmers, through cash grants, to adopt sustainable farm management practices; and
- (ii) the Green Investment Fund (GIF), which is a financial investment fund to provide much-needed capital, through equity investments, to small and medium-sized enterprises (SMEs) involved in businesses that promote environmental protection.

These new financing instruments were included in the project for piloting to combat the impact of agriculture NPS pollution in Huangshan and improve the long-term sustainability of the existing cross-provincial eco-compensation scheme. They are results-based as opposed to the traditional input-based and infrastructure-oriented public interventions in the PRC. Both were designed with extensive TA support from ADB.

**Green Incentive Mechanism.** The GIM applies a participatory approach to promote ecological and environmentally friendly tea farming practices.<sup>8</sup> The HMG provides cash grants to farmers who achieve certified pollution control targets, in accordance with a specific plan (no repayment is required from the tea gardens to the HMG). The GIM directly targets the key sources of total nitrogen, total phosphorus, and other pollutants. It complements and reinforces the outcomes supported by the cross-provincial eco-compensation system. Through the GIM, the project aims to (i) target areas where ecological damage is most severe; (ii) focus on outcomes rather than outputs; (iii) determine sufficient incentives to encourage farmers to participate; (iv) ensure solid data availability and strong technical support; (v) encourage active involvement of stakeholders, including farmers and farmer associations, technicians, enterprises, and environmental nongovernment organizations; and (vi) be a model for other pilot sites.

Key elements of the detailed design process include (i) selecting 20,000 *mu* (1,333 hectares) as a pilot area,<sup>9</sup> (ii) a technical support system, (iii) eco-tea farm standards and eligible activities for compensation, (iv) a third-party green farming certification scheme and protocol, and (v) a branding and marketing program for the tea products. Tea garden farmers sign incentive payment agreements with the HMG based on their measurable green farming efforts. A third party engaged by the HMG verifies the tea gardens' annual achievements.<sup>10</sup>

**Green Investment Fund.** The GIF provides equity financing to sustainable private SMEs for investments in ecological agriculture, ecotourism, pollution control, climate change adaptation and mitigation, and green business development. It is expected to provide equity financing of \$5 million to \$10 million for each subproject, entering an equity investment agreement with each investee.<sup>11</sup>

## Urban Stormwater Pollution Management

Replacing combined sewer systems with separate sewer and drainage systems across the PRC reduced the risk of urban wastewater overflowing into rivers. However, this also means stormwater is discharged directly into rivers, increasing the risk of contamination from first flush pollution. An integrated approach to stormwater management is applied as a pilot in two relatively undeveloped green parks located along riverfronts in one of Huangshan's counties. The design seeks to preserve the natural environment and minimize the impact of continued urban development. The project replaces combined sewer systems with separate systems for sewerage and stormwater, where possible, and repairing and upgrading the remaining combined sewers to prevent untreated sewer overflows and stormwater from discharging into rivers. This is complemented by modelling, measures for first flush control, LID measures, and the use of green infrastructure (e.g., bioswales and bioretention).

Pollution in urban first flush stormwater is controlled by structural (e.g., engineering installations) and nonstructural measures (e.g., operations, maintenance, and management methods). The project includes cost-effective and space-efficient stormwater drains and advanced detention pond-wetland system as treatment facilities in the two pilot parks. The pond system design equalizes the stormwater runoff flows and removes suspended solids and soluble pollutants before stormwater is discharged into receiving waters. The design is expected to remove almost 60% of the pollution load from the most frequent annual rainfall event, while requiring less space and investment than traditional detention pond systems. Other features include (i) installing pervious pavements, (ii) constructing stormwater tree trenches to collect runoff from sidewalks, (iii) cleaning inlets at the entrance to stormwater drains, and (iv) removing silt and sediments in some sections of the storm drains.

## Rural Pollution Control

The National Strategic Plan for Rural Vitalization (2018–2022) promotes innovative approaches to support green agricultural and ecological practices. Huangshan implemented this in its rural areas

<sup>8</sup> Current eco-compensation programs in the PRC are at the macro level, in large areas, usually based on top-down approaches related to the financial or taxation systems, and do not touch the level of farmers' households and farming practices. The Huangshan project instead applies international best practice, which points to the importance of a results-based program focusing on active participation of individual farms.

<sup>9</sup> A *mu* is a Chinese unit of measurement (1 *mu* = 1/15 hectares).

<sup>10</sup> Alternatively, a second party being considered consists of tea farmers, tea processing and marketing enterprises, consumers, tea production technical centers, local governments, and other stakeholders.

<sup>11</sup> The HMG selected the Huangshan Trust and Investment Corporation (HTIC), a state-owned enterprise owned by the HMG, as the GIF implementing agency. The HTIC is also the fund administrator for the existing cross-provincial eco-compensation system. Prior to recommending investments to an Investment Decision Committee of the GIF, the HTIC conducts integrity, financial, technical, environmental, and social due diligence on proposed investments.





**Adapted detention pond design.** The adapted detention pond design, with batch type operation, traps highly polluted rainwater in the early stages of rainfall, allowing cleaner rainwater to overflow directly into a waterway in the later stages (photo by Cities Development Initiative for Asia, Asian Development Bank).

by (i) installing water supply networks; (ii) introducing decentralized sewage collection, on-site treatment systems, and environmental management in villages; (iii) changing practices for fertilizer and pesticide application at pilot agriculture and forestry sites; (iv) constructing walkways, parking lots, public toilets, rural production roads, and ecotourism facilities; (v) introducing solar-powered insecticidal lamps; and (vi) improving pine forest conditions through disease monitoring and prevention. Environmental infrastructure will be built in more than 120 villages directly benefiting about 50,000 people, and rural nonpoint pollution control measures will be implemented in about 7,000 farms. Studies were launched to define a rural wastewater discharge standard and effective pig manure management approaches.

### Strengthened Environmental Management Capacity

The project is developing a smart city management information system, making use of information and communication technology (ICT)-based systems to strengthen the municipality's industrial and urban environmental monitoring and emergency response capacity.<sup>12</sup> This includes establishing environmental, health, and safety (EHS) management systems and enhancing the capacity in water resources management and flood forecasting.

The project demonstrates the benefits of networked, real-time monitoring for reducing the risk of water and air pollution and highlights the advantages of data sharing between separate but

integrated ICT-based systems by adopting an integrated approach to currently isolated information systems, developed and managed by different levels of government and departments.

An innovative and comprehensive web-based EHS management system will be developed and installed in two adjacent chemical industry parks located close to a tributary to the Xin'an River.<sup>13</sup> It will be part of Huangshan's Smart City platform to allow efficient data and information sharing among the park administration, enterprises, monitoring departments, regulators, and local government emergency control centers. The system will be integrated with regulatory monitoring and enforcement, and with the EHS procedures of the manufacturers in the parks; it is expected to improve the efficiency and EHS behavior of the enterprises. It includes an emergency response system, addressing emergencies even before they develop.

### Climate Change Adaptation and Mitigation

Huangshan was designated a pilot city for the low-carbon policy by the national government in 2017 to actively address climate change risks and explore low-carbon and green development paths. A multidisciplinary approach and an integrative intervention process for climate change evaluation and communication were applied in the project planning and design. Climate vulnerability assessment identified climate change risks and recommended adaptation and mitigation measures

<sup>12</sup> Smart systems incorporate sensing, actuation, and control functions to analyze situations and make decisions based on available data in a predictive or adaptive manner (thereby performing smart actions).

<sup>13</sup> These industrial parks are major provincial chemical parks. They produce epoxy resins and dyeing materials and are key economic engines of the municipality. They lie only 1–2 kilometers from a tributary to the Xin'an River.

specifically for small and medium-sized cities like Huangshan.<sup>14</sup> Key climate change vulnerabilities were found in urban flood control, stormwater and wastewater collection systems, riverside wetlands and constructed landscapes, agriculture, and ecosystems.

In addition to separating sewers, constructing river embankments, and installing the EHS systems, the project adopts the following **climate change adaptation measures**: (i) applying sponge city measures like upgrading sewage and drainage systems and installing ecological stormwater interceptor traps, tree pits, and porous pavements; (ii) increasing the green cover ratio; (iii) using cool surface materials with high thermal radiative effect; (iv) constructing wetlands with green features for better flood and drought resilience; and (v) monitoring forest health and preventing disease to reduce the risk of forest fires and pest outbreaks.

Other engineering measures were applied like (i) using reinforced structural materials in construction; (ii) selecting species native to the region and resilient to local conditions in landscaping; and (iii) adhering to low-carbon engineering practices following relevant national standards and practices similar to the “4B’s” (build nothing, build less, build clever, and build efficiently) approach.<sup>15</sup>

The following **climate change mitigation measures** were adopted to reduce, avoid, or sequester greenhouse gas emissions: (i) carbon sequestration through enhanced agriculture and forestry practices, including the reduced use of



**Greenfield and vegetation.** The landscape design should consider native species resilient to local conditions and able to endure high temperatures, periodic waterlogging, and drought (photo by Cities Development Initiative for Asia, Asian Development Bank).

chemical fertilizers in tea farming and pest control; (ii) emission reduction through wetland construction (processing carbon); and (iii) emission reduction by implementing anaerobic wastewater treatment systems.



**Xin'an River in Huangshan Municipality.** Its mountainous terrain makes Huangshan vulnerable to flooding. Effective stormwater and sewerage systems, along with reduction of pollution from first flush and agricultural runoff, are important in addressing the water quality issue of the Xin'an River (photo by Mingyuan Fan, Asian Development Bank).

<sup>14</sup> To generate appropriate measures, the ARCCE approach was applied: (i) Assess climate change scenarios, (ii) Review development projects and related data, (iii) Communicate with policy makers and local experts, (iv) Collaborate with engineering consultants, and (v) Engage relevant stakeholders.

<sup>15</sup> R. Twinn, K. Desai, and P. Box. 2019. *Net Zero Carbon Buildings: A Framework Definition*. London: United Kingdom Green Building Council. The 4B's approach emphasizes (i) **build nothing**: where possible, challenge the need to build new infrastructure and explore alternative approaches to achieve the desired outcome; (ii) **build less**: maximize use of existing assets and optimize asset operations to reduce the new construction required; (iii) **build clever**: use low-carbon materials, streamline delivery processes, and minimize resource consumption; and (iv) **build efficiently**: embrace new construction technologies and eliminate waste.



## CONCLUSION

The Huangshan project represents a new, more advanced, and comprehensive ecological protection and green development model, particularly for small and medium-sized cities. It builds on the existing cross-provincial ecological compensation scheme between Anhui and Zhejiang, and takes advantage of existing technology in the HMG to develop new ICT-based systems. A web-based EHS management system platform, for example, demonstrates how industrial park administrations and manufacturing enterprises can improve EHS compliance and emergency response.

Huangshan will continue to take advantage of changing technologies to improve urban services and the intelligence and automation in the municipal administration, including new financing instruments. The sustained and effective use of integrated ICT solutions will also improve the capacity for climate change evaluation and strengthen Huangshan's overall green development.

Maintaining water quality at the upstream of Xin'an River is a long-term endeavor that goes beyond the Huangshan project. It will require continued emphasis on environmentally sustainable farming practices to control NPS pollution and strengthen the finances of local environmental SMEs. During its implementation, the project explores additional measures to enhance program management, including new market-based policy instruments and eco-compensation tools.

Changing farming practices through the participatory GIM pilot may catalyze wider farmer adoption by demonstrating potentials for increased farm incomes and improved

productivity from the organic certification of tea products and production processes. Self-assessment approaches, with strong scientific technical (possibly commercial) extension services may be explored to monitor and refine the compensation system. In the future, the certification is expected to be conducted by a reputable international certification organization to allow green tea products exposure to international markets and customers. Arrangements and systems for branding, marketing, distribution, and product tracing may also be established.

The GIF pilot may change the perception of low financial returns from investments in ecological agriculture, ecotourism, and pollution control. Divested capital under the GIF program will be redeployed as new investments in SMEs, supporting the long-term financial sustainability of the eco-compensation system. A successful GIM may attract funds from new sources. With its license as a private equity fund, the Huangshan Trust and Investment Corporation (the fund manager of the GIF) may mobilize new funds from external investors.

The project takes a comprehensive and holistic approach to resilience by combining physical, ecological, financial, social, and institutional aspects. Project experiences, lessons learned, and best practices—particularly with respect to the governance and institutional development context established in the Huangshan project, as well as the benefits generated from the individual green financing investments—should be shared and broadly disseminated for better replication.

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