EU – China Environmental Sustainability Program
Flagship Policy Report

Lot 1: Water Quality Management

Foreign Economic Cooperation Office, Ministry of Environmental Protection of China

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Content

EXECUTIVE SUMMARY

The EU – China Environmental Sustainability Programme (ESP) was a 9 million euro EU-funded project, implemented from 2013 to 2016. It was initiated by the Delegation of the European Union to China, the Ministry of Commerce, and the Ministry of Environmental Protection. The project aimed to introduce advanced European technology and experience into pollution prevention and control and to support key areas in China's efforts to improve overall environmental quality. It consisted of nine sub-projects, divided into water management, solid waste management, and heavy metal pollution prevention, as well as one over-arching project for policy support and networking. Over 40 Chinese and European organizations were involved in the implementation of the project.

This report synthesizes experiences and lessons learnt in the three water quality sub-projects and presents recommendations to support the implementation of policies to prevent and control the pollution of water resources. It includes an analysis of the prioritised water environment issues and the key challenges faced. It then turns to specific solutions tested or identified within the ESP projects that could address some of the identified gaps and priority challenges. Focus is placed on the implementation of the present key policy initiative, the “Action Plan for Water Pollution Prevention and Control” which was issued by China’s State Council in 2015.

Overview of sub-projects

Project 1 developed and demonstrated management tools and practices for pollution reduction in Songhuajiang-Liaohe River Basin. It supported water quality improvement in the demonstration areas in order to realize the goal on water pollution control in SLRB designated in the “12th Five-Year Plan” of China. Project 2 piloted solutions and supported measures to reduce pollution discharge to the sea from the Tianjin Binhai New Area and improve the quality of regional water ecological environment. Project 3 advanced selected nature-based solutions for ecological restoration and non-point source pollution control in the Miyun (Beijing) and Jiaquan (Guangdong) watersheds. It shared lessons learned with other mega-cities throughout China. The sub-projects were led by China Research Academy of Environmental Sciences (CRAES), Tianjin Academy of Environmental Sciences, and IUCN Regional Office for Europe, respectively.

Recommendations

The recommendations below are based on findings and lessons learned in the three ESP sub-projects on water quality. They aim to support the implementation of policies to prevent and control the pollution of water resources. These recommendations provide direction for new or additional measures to be taken, or to upscale already successfully implemented demonstration activities.

- *Discharge licence system*

Currently discharge licences are generally set and provided based on standards set for a type of industry. These are often provided without consideration of the total number of polluters in the river basin, the available treatment capacity or the carrying capacity of the water body. Moreover, the system only applies to the major point-source polluters. Based on the experiences of Project 3, it is suggested that the data from the Environmental Impact Assessment (EIA) reports and the approval of the EIA are used to provide a baseline and foundation for decision making, that a license appeal mechanism is used for administrative litigation, and that the remediation of contaminated environment caused by the closing down or bankruptcy of enterprises and fund guarantee for the activities which has significant environmental impact should be taken into consideration before issuing the license. The Swedish system for integrated permitting is one example that could serve as a model and should be further looked into.

- *Rural water pollution and control*

ESP has provided experience of non-point source pollution control in the form of nature-based solutions, which are applicable in rural areas. The solutions suggested include ecological engineering, such as riparian buffer zone and ecological intercepting ditch for farmland pollution control and restoration. To achieve this, rural residents' awareness and know-how need to be strengthened.

- *Water recycling and reuse*

Project 2 surveyed EU experiences, good practices and possible barriers for expanded recycling and reuse of water resources. Based upon this analysis, it is recommended that the major types and scope of available reclaimed and "non-conventional" water resources are assessed in local contexts nationwide and specific plans to maximize their utilization are drafted. This should be supported by more systematic guidance provided to relevant authorities.

- *Ecological health and environmental risk assessments*

It is recommended that basic surveys (base-lining) are carried out for environmental and ecological assessments of water sources that are of importance for drinking water purposes. River health report cards (a method and index system for assessing the ecological health of drinking water sources), and the groundwater source risk assessment guidelines developed by the ESP sub-projects should be promoted for wider use. Aquatic eco-function zoning mapping can be used as a further applied method to support monitoring and protection of water bodies.

- *Financing platforms for ecosystem protection and pollution prevention*

The concept of ecosystem services is fundamental for protection of drinking water distributed to megacities from rural areas. Payment for such services can be arranged via the China Mega-City Water Fund, which was established as part of the ESP and evaluated with a cost-benefit analysis of the ecological protection measures.

- *Exchanges and cooperation with international think tanks*

All ESP sub-projects have cooperated and interacted with and drawn extensively from international organisations, particularly such based in EU countries. This collaboration has been perceived as mutually beneficial for the involved and furthered the knowledge level and relationship-building. It is therefore recommended that the Chinese government and its environmental 'think tanks' should further expand the cooperation with universities, research institutions and other partners from the European Union.

Introduction

The EU – China Environmental Sustainability Programme (ESP) was a 9 million euro EU-funded project, implemented from 2013 to 2016. It was initiated by the Delegation of the European Union to China, the Ministry of Commerce, and the Ministry of Environmental Protection. The project aimed to introduce advanced European technology and experience into pollution prevention and control and to support key areas in China's efforts to improve overall environmental quality. It consisted of nine sub-projects, divided into water management, solid waste management, and heavy metal pollution prevention, as well as one over-arching project for policy support and networking. Over 40 Chinese and European organizations were involved in the implementation of the project.

This report aims to synthesize demonstrations, experiences and lessons learnt in the three water quality sub-projects of Lot 1. It presents recommendations to support the implementation of policies to prevent and control the pollution of water resources, based upon the findings and learning made in the ESP projects. To ensure recommendations are relevant and applicable in practice, it begins with an analysis of the priority water environmental challenges and the key challenges faced within the existing policies to address those problems. It then turns to find specific solutions tested or potential mechanisms identified within the ESP projects that could address some of the identified gaps and priority challenges for water quality protection in China. Focus is placed on the implementation of the present key policy initiative, the Action Plan for Water Pollution Prevention and Control (also known as the 'Water Ten', hereinafter referred to as the 'Action Plan'). It aims to addresses water-quality issues with the highest impact on human and environmental health and water pollution challenges that are the most challenging to resolve, and therefore require the most attention from policy makers to find and test solutions.

The report includes three chapters and one annex. The first provides overviews and a summary of the results achieved in each of the three sub-projects implemented from 2013 to mid-2016. Chapter two outlines the priority environmental challenges for water pollution prevention and control, and the main contents of the Action Plan including the policy targets and the identified implementation gaps. The last chapter provides recommendations for priority actions to support implementation of water environment policies in China in areas where specific solutions from project experiences can be scaled at different levels. Based upon the key challenges and required types of responses identified, the key learnings and relevant, scalable solutions from each of the projects to address specific priority policy and technical issues are provided in Annex 1.

Sub-Project Results

1. Demonstration of Pollution Discharge Management for Water Quality Improvement in the Songhuajiang-Liaohe River Basin

The overall objective of the project was to develop and demonstrate management tools and practices for pollution reduction in Songhuajiang-Liaohe River Basin (SLRB). It supported water quality improvement in the demonstration area to realize the goals for water pollution control in SLRB designated in the "12th Five-Year Plan" of China.

Results

1. Pollution allocation system based on river units. In managing selected river basins, an integrated approach has been put forward in which both hydrology of the region and administrative jurisdiction division will be considered. This will facilitate division of responsibilities as well as management of water basins.
2. Permit system pilots. Emission limits have been set for industrial and husbandry point-source pollution at selected river basin sites. Studies were conducted on a permit management system based on technology and water quality, and a demonstration platform of permit management system in Qinghe River Basin (Tieling City) has been established.
3. Methodology of ecological health assessment for major rivers. The project also completed river health assessment report cards and a technical guideline for aquatic ecological health assessment in demonstration regions. Methods have been proposed for assessment of ecological remediation impacts, based on test results at demonstration sites.
4. Policy documents. Based on research by the project, "Guideline for Enterprises Environmental Emergency Risk Assessment (Trial)" and "Environmental Emergency Risk Ranking Methods for Enterprises" were completed. An inventory of toxic and hazardous substances in the Liao River Basin has also been compiled.
5. Finally, the project supported the preparation of "Guideline on Drafting of Implementation Plans for Groundwater Protection Projects" for drinking water source protection. The Guideline focuses on problem identification, risk assessment, simulated evaluation, and project design. It was prepared for local governments in drafting groundwater protection and remediation plans.

2. Better water ecological environment in Tianjin Binhai New Area with less pollution discharge to the rivers and Bohai Sea

Results

1. Innovative model: The project introduced a novel model for water environment and water resources management in coastal regions in China where freshwater is scarce. The model focuses on the supply of reclaimed water from passing-by polluting rivers and the strengthened self-purification through the "river-wetland-lake/reservoir" cycle within a region. With the model, water management in a coastal city features "multi purposes, netted circulation, and slow discharge" instead of "single purpose, single route, and rapid discharge". It is applicable for coastal regions undergoing rapid industrialization and urbanization.
2. Innovative techniques: Techniques introduced include localized water environment assessment methods, estimation technology for contamination fluxes from rivers to the sea; applicable water treatment technology for passing and polluting rivers; connections among different water systems in coastal regions; strengthened self-purification process through recycling.
3. Innovative policy approaches: A GIS-based water management decision-making system; important planning programs and policy recommendations including the 13th Five-year Plan of the TBNA on Water Pollution Management and Water Environment Protection (proposal) and the Emergency Plan for Water Pollution Accidents in TBNA. These documents have been adopted by the local government and incorporated into priority agendas of the government such as the Beautiful Tianjin – No.1 Project, Implementation Plan for the Action Plan for Prevention and Control of Water Pollution, and Environmental Contingency Plan for August 12 Tianjin Port Explosion. The International Research Center for Ecological Protection and Risk Control was established.

3. Mega-cities and their Watersheds: Nature-based Solutions for Sustainable Drinking Water Sources

Drinking water sources face both accelerating demand from growing urban areas and increasing pressure from non-point source pollution caused by chemical fertilizers and household waste in discharged from rural areas. While most traditional ways to protect drinking water sources focus on point-source treatment, diffuse pollution remains very difficult to control, resulting in declining ecological health of watersheds across the country. The project piloted nature-based solutions for ecological restoration and non-point source pollution control in the Miyun (Beijing) and Jiaquan (Guangdong) watersheds and shared lessons learned with other mega-cities throughout China under the newly established Partnership for Mega-city Watershed Protection (PMWP). Key activities included an analysis of ecosystem functions and services, especially for water supply and purification, strategy development for landscape restoration; and the creation of long-term management and financing mechanisms to protect drinking water sources such as integrated treatment, and paid ecological compensation and services.

Results

1. **Developed and applied new methods to assess drinking water sources.** The new methods were applied to assess the ecological health of drinking water sources for 26 main drinking water sources and detailed case studies were published.
2. **Produced new guidelines for non-point source pollution control in rural areas.** These guidelines draw upon pilot project results to give clear instruction on how to facilitate more effective interventions to reduce and control pollution entering water from rural areas across China. Measures included river buffer zones, artificial wetlands, soil testing, ecological agriculture and improved fertilizer management.
3. **Enhanced local capacities in more sustainable agriculture practices.** More than 500 farmers learned ways to engage in improved practices to promote "Beautiful Village, Healthy Water". This ranged from collection of sustainable firewood, safe use of pesticide and fertilizer, and water source protection.
4. **Piloted a new mechanism to promote community-based pollution prevention and control and sustainable village development.** The project launched the China Mega-City Water Fund, which provides payment for ecological services to directly support rural communities to take actions to reduce agricultural pollution. A key innovation made was the initial cost-benefit analysis of optimal ecological protection measures and design of an effective process for stakeholder engagement between financers, communities and knowledge partners to support project implementation.

Current water quality

(1) Surface water

Since the 9th Five-year Plan Period (1996-2000), China has begun to put a focus on the comprehensive improvement of key drainage basins. During the 11th Five-year Plan and 12th Five-year Plan periods (2006-2015), great efforts were made to pollution control and emission reduction and water environment protection was deepened in all aspects from guiding ideology to practices. As a result, remarkable achievements have been realized but major challenges still remain. In the state-controlled sections of seven key river basins (i.e. Yangtze River, Yellow River, Pearl River, Songhuajiang River, Huai River, Hai River, and Liao River) and rivers in Zhejiang, Fujian, northwest China, and southwest China, Grade I-III water accounted for 71.2% while inferior Grade V water accounted for 9.0% in 2014. Generally, the water quality in the abovementioned seven key basins and three regions improved dramatically from 2001 to 2014.

(2) Groundwater

In 2014, the data from 4,896 monitoring centres at prefecture level and above suggested that the percentages of monitoring points with excellent, very good, good, poor, and extremely poor water quality reached 10.8%, 25.9, 1.8%, 45.4% and 16.1, respectively. Main indicators exceeding standards were total hardness, total dissolved solid, Fe, Mn, three kinds of nitrogen (nitrite nitrogen, nitrate nitrogen, ammonia nitrogen), fluoride, and sulphate, etc. At some monitoring centres, the content of heavy metals, such as As, Pb, hexavalent chromium, Cd, exceeded the standards.

(3) Drinking water

In 2014, 329 centralized drinking water sources at prefecture level and above recorded their water use details. Totally 33.255 billion tons of water was abstracted to serve 326 million people in the year. Of them, 31.989 billion tons of water was up to standard, with an attainment rate of 96.2%. The indicators exceeding standards of surface water sources were mainly TP, Mn, and Fe, while those of groundwater sources were Fe, Mn, and ammonia nitrogen.

(4) Coastal waters

In 2014, monitored seawater quality broke down as follows: 28.6% was Level I (+4.0% compared to 2013); 38.2% was Level II (-3.6%); 7% was Level III (-1.0%); 7,6% was Level IV (-0.6%); and 18,6% was worse than Level IV (same as 2013). The main pollution indicators were inorganic nitrogen and reactive phosphate, whose point-based standard-exceeding rates were 31.2% and 14.6% respectively. Of nine important gulfs and bays, the water quality at Yellow River Estuary was excellent; the water quality at

Beibu Gulf was good; the water quality at Jiaozhou Bay was fair; the water quality at Bohai Bay and Liaodong Bay was poor; and the water quality at Hangzhou Bay, Yangtze River Estuary, and Pearl River Estuary was extremely poor.

Key water environment challenges

(1) Pollution emissions exceed environmental carrying capacity

China's industrial, agricultural and domestic pollution discharge load is enormous. In 2014, China's total COD emission reached 22.946 million tons and total ammonia nitrogen emission 2.385 million tons, which were much higher than environmental carrying capacity according to preliminary calculations. Of state controlled surface water sections in China, nearly one tenth (9.2%) lost their function as a water body (below Level V) and 27.8% of key lakes (reservoirs) suffer from eutrophication. The water in many rivers, canals & ditches that flow through towns and cities is black and odorous. Drinking water pollution accidents occur frequently. Water quality is poor or extremely poor in 61.5% groundwater monitoring points. Of the nine key important gulfs or bays in China, seven had a poor or extremely poor water quality.

(2) Scarcity and distribution of water

In China, the per capita water resource availability is low and the distribution water is very uneven. Water use efficiency is low and a great amount of water resources is wasted. The effective utilization coefficient of irrigated water use is 0.52, much lower than the world's most advanced level of 0.7-0.8. Water resources are over exploited in several places, such as the Hai River, Huai River, and Yellow River where the water utilization rate reaches 104.1%, 95.4%, 58.2% respectively. Ecological flow is in many places reduced dramatically and the self-cleaning capacity of the water environment has dropped sharply. Groundwater overdraft is another major problem, affecting roughly 230,000 square kilometres nation-wide and causing serious environmental problems as land subsidence and seawater intrusion.

(3) Seriously damaged water ecology

Historical degradation of natural ecosystems, such as wetlands, coastal zones, rivers and lakes have reduced the conservation capacity of water resources. In Hai River basin, wetland areas have decreased by 83%. In the middle and lower reaches of Yangtze River, the number of river-connected lakes decreased from more than 100 to only two (Dongting Lake and Boyang Lake, which shrink continuously). Coastal wetland areas have also decreased sharply. Offshore biodiversity has gone down and fish stocks declined seriously. The retention rate of natural coastlines in offshore areas was less than 40%.

(4) Hidden risks and illegal discharges in water environment

Nearly 80% of chemical and petro-chemical projects in China are located in sensitive regions, e.g. river bank or populous areas. Illegal pollution discharge and transportation still appear in some drinking water conservation areas, threatening drinking water safety. Environmental hazards occur frequently. Of serious and sensitive environmental emergencies handled by the Ministry of Environmental Protection in 2014, more than 60% involved water pollution. Meanwhile, the number of mass incidents caused by water environment hazards has risen significantly.

Action Plan for Water

The *Action Plan for Water Pollution Prevention and Control* was promulgated and implemented by the Chinese Government in April 2015. As a programmatic document for water environment protection in China, the Action Plan takes into account mid-term and long-term tasks. It has set specific objectives for 2020. Meanwhile, it includes water environment and ecology objectives for 2030 as well as the middle of this century.

Focusing on water environment quality improvement, the Action Plan provides tasks and measures in terms of water resources, environment and ecology, involving such elements as drinking water, surface water, groundwater, and offshore areas. It covers the management of pollution sources from industries, agriculture, urban areas, and transport. Responsibilities are assigned to the government, enterprises, and the public. The Plan promotes systematic approaches to China's water pollution prevention and control management.

With 35 sections in 10 articles, the Action Plan may be divided into four parts in addition to General Requirements, Objectives, and Specific Indexes:

(1) Part I, containing the first three articles, introduces systematic water control. It brings forward such tasks as emission control, acceleration of transformation, and conservation of resources. In respect to coordinated development of environment and economy, it requires improving industrial quality by optimizing industrial structure, adjusting industrial layout, and promoting cyclic development so as to reduce pollutants from upstream. In respect to water environment system protection, it requires saving water and increasing flows by controlling total water consumption, increasing water use efficiency, and strengthening ecologic water use. In respect to pollution control, it requires controlling sources and reducing emissions by preventing and controlling industrial, urban, agricultural, rural, ship, and port pollutions.

(2) Part II, containing articles 4 to 6, introduces how to increase the prevention and control capacity by three key measures, i.e. scientific & technological support, using markets as drivers, and strict law enforcement. It requires increasing the scientific and technological supporting capacity for water pollution prevention and control by

popularizing and demonstrating applicable technologies, making more efforts in scientific and technological brainstorming, strengthening transformation and application of technological achievements, and developing the industry for environmental protection. It also emphasizes bringing the role of market regulating mechanisms and increasing the market economy driving force for water pollution prevention and control by improving resource & environment price mechanisms, tax & credit policies, compensation mechanisms, and seeking more investment and financing channels. In addition, it requires carrying out stricter law enforcement to disincentive various illegal environment-related acts and guarantee the capacity to execute water pollution prevention and control by improving legal and standard systems, environment monitoring capacity, and supervisory and law enforcement mechanisms.

(3) Part III, containing articles 7 & 8, determines a main direction of efforts. It requires tightening environment management by enhancing construction of environment quality objective management, total pollutant emission control, discharge permit, environmental risk warning and assessment systems and guaranteeing water eco-environment safety by focusing on “good water” protection and treatment of seriously polluted water bodies. It puts stress on guaranteeing drinking water safety, giving consideration to large rivers, streams, land and ocean, protecting ocean environment, water and wetland eco-systems, and improving people’s quality of life.

(4) Part IV, containing the last two articles, defines three actors and their responsibilities and obligations. It provides for clear responsibilities of the government, enterprises and public institutions. It requires accountability, pushing on supervision by dissemination, guaranteeing implementation by supervision, carrying out assessment strictly, and promoting water saving and treatment based on joint efforts of the whole people.

Key implementation challenges areas

In this section, we provide an overview of the six major types of challenges that require the most attention from the Ministry of Environmental Protection, due to the scale of the challenge, scope of its impact, and overall level of difficulty to resolve (and thus requiring higher investment of time and resources). These are grouped in areas where difficult challenges are faced and solutions are required: treating “bad water” (Black and Odorous Water with a quality below level V); conserving “good water” (protecting and maintaining drinking water sources); and groundwater. Three additional difficult challenges for policy formulation and implementation are the regulation of industrial pollution; the control of non-point source pollution; and environmental risk analysis. In Annex 1, relevant ESP project findings and good practices that can be applied to each of these challenges are provided in detail.

(1) “Bad Water” treatment

“Bad water” covers black and odorous water bodies in surface water state-controlled sections (usually, large rivers) and built-up areas in cities which are below Level V. The greatest challenge for implementing “bad water” treatment policies lies in treatment of black and odorous water bodies.

According to the National Plan on New Urbanization (2014-2020), urbanization rate will reach 60% approximately in 2020. Population will be centralized in cities continuously. It is estimated preliminarily that, in 2020, about 840 million people will live in cities. Therefore, creating a clean and inhabitable urban water environment is a key for building a well-off society in all aspects.

In recent years, Shanghai (Suzhou River), Shandong (Xiaoqing River basin), Jiangsu (Qinhuai River), and Guangdong (river treatment) carried out comprehensive urban water body environment treatment one after another. Numerous problems resulted from this process, giving an overview of key challenges for improving “bad water” at the required scale. These include:

Failure of systematic responses. In these places, comprehensive treatment were understood as a package of various engineering measures or projects. Treatment measures were not linked closely with improvement of water environment quality. Integrated treatment solutions were not considered.

Insufficient ‘real’ investment in treatment capacity. Attention was paid only to river bank protection, dam construction, and artificial landscapes. Some projects were “vanity projects”, which had nothing to do with actual water quality improvement.

Excessive focus on physical interventions and non-ecological measures. For example, river capping, dam gate construction, use of three-sided concrete slabs etc., were taken in many projects which led to damages in ecosystems during treatment.

Neglect of operation and maintenance. Authorities historically have focused on project construction without performing detailed planning for how to run the facilities once they are built. No department was in charge of the projects upon completion and there was no matching management regulation.

Treatment is costly and requires very large financial investments to bring to scale. According to surveys in Jiangsu, Zhejiang, and Pearl River Delta, each urban black & odorous river was 2-4 km long on average and the treatment cost reached RMB 20-45 million per kilometre (including pollution source treatment, pollutant intercepting, sewage treatment plant construction, dredging, and water diversion, etc.).

The policy target: Built-up areas in cities at prefecture level and above should complete examination of water bodies and publish the name of black and odorous water bodies. Persons responsible for these water parties must be identified and comply before the end of 2015. These areas should achieve no large-area floaters on rivers, no garbage on river banks, and no illegal sewage discharge by the end of 2017. The percent of black and odorous water bodies should be no more than 10% by 2020 and by 2030, completely eliminated. Built-up areas in municipalities directly under the central government, provincial capitals, and municipalities with independent planning status eliminate black and odorous water bodies before the end of 2017. For this purpose, the Ministry of Housing and Urban-Rural Development and Ministry of Environmental Protection and other ministries published Guidelines for Treatment of Black and Odorous Water Bodies in Cities, which provide for specific requirements for identification and grading of black and odorous water bodies in cities, ways of drafting treatment plans, selection of treatment technologies and outcome assessment, policies and mechanism guarantees.

(2) "Good Water" conservation

"Good water" mainly covers drinking water sources and rivers and lakes (reservoirs) with a water quality at or higher than Level III. Main challenges for implementing "good water" conservation policies lie in conservation and restoration of space at the banks of rivers and lakes as well as the volume of eco-flows.

In the last 30 years, wetlands and wetland nature reserves in China decreased 8,152.47 square kilometres, some 9% of national wetlands, including 50% of coastal beach and wetlands. Certain minimum ecological flows, so-called eco-flows, must be maintained in order to keep the stability of the structure and function of river ecosystems. Due to intensified human activities in China, frequently occurring extreme climate events and lack of ecological regulation, many rivers have inadequate eco-flows. Meanwhile, total emissions of main pollutants exceed environment capacity, further worsening water environment problems. Surface water resource development rate in Hai River, Huai River, Songhua River, Liao River, and Yellow River Basins reached 98%, 73.8%, 42.1%, 50.6% and 54.7% respectively. This is much higher than the globally accepted limit for water resource development of 40% to maintain a healthy water ecosystem.

The policy target: Existing excellent (at or higher than Grade IIII) water bodies' water quality should be maintained by means of strict city planning and management, for example by promoting active protection of urban aquatic ecosystems by controlling development and pollution occurring along river and lake banks in the city. This also includes selected ecological protected zones where development is prohibited. A number of further specific targets are also enacted, for example covering the conservation of water, wetland ecosystem protection and required volumes of ecological water flow for urban rivers and lakes. By 2020, the aim is that the overall proportion of excellent water quality of seven basins will reach 70% or more. By 2030, it should reach 75% or more. The overall proportion of centralized drinking water source quality in cities reaching or exceeding Grade III should be around 95% by 2030.

(3) Groundwater conservation

Groundwater is an important source of water supply in China but the prevention and control of pollution to groundwater is very difficult. Since there is no established groundwater monitoring network, the basis for monitoring of pollution sources is weak and there is a wide gap to meet groundwater management demands.

Due to pipe breakage and damage or incomplete systems for the diversion of rainwater and wastewater, wastewater often percolates down to aquifers. Leaching from refuge landfills also seriously pollutes groundwater. Some industrial activities threaten groundwater safety, such as the improper storage and disposal of their solid waste. Soil pollution is also a severe and complex problem. Large volumes of chemical fertilizers and pesticides permeate soils to pollute groundwater. Surface water pollution also degrades groundwater quality. Groundwater overdraft is rampant in some coastal regions, resulting in seawater intrusion. Illegal discharge of untreated wastewater from enterprises often reaches aquifers through seepage pits or injection wells. As the hydrogeological conditions of groundwater are very complicated, treatment and restoration are difficult, costly, and time-consuming. Thus environmental and ecological damage is difficult to treat or reverse once it occurs.

The policy target: The Action Plan requires that "by 2020, the proportion of extremely poor groundwater will be controlled to around 15%; to make regular investigations and assessments of environmental conditions in areas such as centralized groundwater drinking water source replenishment area; enterprises engaged in petrochemical production, storage and sales and areas such as industrial parks, mining areas, and refuse landfills should undergo necessary anti-seepage treatment; to publish a list of groundwater pollution sites with great environmental risks and seriously affecting public health within areas such as Beijing-Tianjin-Hebei Region and carry out pilot repair projects". In addition, China has published such documents as National Plan for Prevention and Control of Groundwater Pollutions (2011-2020) and Scheme for Prevention and Control of Groundwater Pollutions in the North China Plain to raise requirements for prevention and control of groundwater pollution.

(4) Prevention and control of industrial pollution

Industrial enterprises are the cornerstone for national economic development. They are also one of the main sources of pollution. Currently, nearly 100,000 water discharging enterprises are registered, and serious pollution is created from them. Some key industries of concern include: paper-making, coking, nitrogenous fertilizer, nonferrous metal, textile printing and dyeing, agricultural and non-staple food processing, API manufacturing, leather making, pesticide, and electroplating industries. Their wastewater contains complex pollutants and has a very adverse effect on environmental and human health.

A key challenge faced is to improve current systems to define enterprises' responsibilities and hold them accountable. The implementation of a pollution discharge license system and improved monitoring of actual discharges made is needed. Since the 1980s, China has implemented "three simultaneous management" systems: treatment standards reached within a time limit, environmental impact assessment, pollution discharge reporting and total pollutant amount control systems.

These have brought about some progress but problems still exist. The failure to define enterprises' responsibilities is the most important reason for the inability to control serious industrial pollution. The punishment for enterprises which discharge pollutants illegally has been insufficient and there has been a lack of effective mechanisms for public participation in environmental protection and social supervision. Secondly, because the state failed to promulgate regulations on the administration of pollution discharge license system, actual issuance of license is not linked up with other environmental management systems effectively. Thirdly, the total pollutant control system is still imperfect. The control of total COD and ammonia nitrogen emissions cannot adapt to new situations and satisfy the requirements in the objective of improving water environment quality in all aspects. Fourthly, the corporate credit evaluation system is still imperfect. Enterprises have historically not had insufficient incentive or pressure to assume environmental protection obligations and social responsibilities consciously.

The policy target: The Action Plan requires the implementation of pollution discharge permits. Each fixed source's total amount control index should be determined by assessing enterprises' allowed discharge limits. By issuing a pollution discharge permit, concerned enterprises' discharge should be managed in a stricter way to realize up-to-standard water quality. Small-sized factories in ten major industries, with insufficient environmental protection facilities and serious pollution impacts will have to be phased out gradually. The Ministry of Environmental Protection is drafting plans and documents on this issues, such as a Scheme for Implementing the Pollutant Discharge License System.

(5) Prevention and control of non-point source pollution

In China, there are about 600,000 administrative villages, with about 630 million rural residents. In addition to the challenges to control and prevent pollution, there are also great needs to adjust the agricultural industry's structure and layout in order to reduce crop area and total water demand and shift towards more drought-tolerant and high-value crops. Geographically, the drought-prone region in Northwest China faces major challenges with both water scarcity and control of agricultural pollution. Inefficient fertilizer and pesticide use in the Central and Eastern regions pose serious non-point chemical fertilizer and pesticide pollution problems. There is considerable room to reduce the use of chemical fertilizer and pesticide and maintain productive agriculture in line with what is achieved in developed countries.

Prevention and control of non-point source pollution is difficult because it requires many small scale interventions and capacity building in hundreds of thousands of villages and millions of people. But it is also an area with some of the strongest sets of solutions, allowing opportunities for breakthrough and innovation.

The policy target: By 2020, 130,000 additional administrative villages should complete integrated solutions for environmental improvement. Within this, there are three key areas of priority that must be addressed to improve control of agricultural non-point pollution. They are:

Shift to low-toxicity and less-persistent pesticides. China has formulated and published

List of Main Low-toxicity and Less-persistent Pesticides Used for the Agricultural Industry, which include 91 pesticides, in line with pesticide toxicity and residue limit standards. A pilot project offered allowances to low-toxicity and less-persistent pesticide users in 11 counties in 10 provinces, covering a demonstration area of 36,000 mu. This experience should be thoroughly reviewed for consideration for wider scaling, or additional piloting.

Carry out soil testing and formulated fertilization, and purify drainages from farmland and surface runoffs. This is one of main ways to reduce non-point pollution in the planting industry and the target to be reached by 2020 requires soil testing and formulated fertilization technology coverage rate should exceed 90%. Fertilizer utilization rate must also increase to reach the minimum target of exceed 40%, whereas the current rate is 30% nationwide. Since 2005, Central Government has invested RMB 5.7 billion cumulatively in soil testing & formulated fertilization, which has covered almost all agriculture-dominated counties and applied to two-thirds of farmland, some 1.2 billion mu.

Reduce household pollution in rural areas. More than 9 billion tons of domestic wastewater and 280 million tons of household garbage are produced annually in rural areas. Most of this is discharged without treatment. Residents live together with livestock in some villages. In recent years, policies to incentivize treatment have been implemented as part of efforts to advance integrated actions to improve rural environment. This mainly focuses on rural domestic wastewater and garbage treatment and drinking water source conservation. This has resulted in 46,000 villages have gained supports in environmental improvement, benefiting more than 87 million rural residents. There is still a significant gap to reach all villages and rural residents.

(6) Environmental risk management and emergency response

China sees a prime period for the outbreaks of environmental pollution. Various major environmental pollution incidents have occurred frequently, as an important factor undermining the health of human kind and ecological environment. They have posed a grave threat to the environmental security, harmonious development of the Chinese society and economy. During the recent 20 years, a total of over 30,000 environmental pollution emergencies happened in China. As a result of layout-related hidden environmental risks and structural environmental risks, environmental emergencies will remain frequent in sometimes to come. The key challenges for the prevention of environmental risks include the assessment and management technologies for environmental risk sources, implementation of strategies for classified environmental risk management.

The policy target: The Action Plan has urged related departments to strictly prevent and control environmental risks, regularly assess the environmental and health risks of industrial enterprises and communities along rivers, lakes, and reservoirs, implement prevention measures, and properly handle water environmental pollution emergencies.

People's governments at local levels shall formulate and improve the contingency plans for water incidents, implement the responsibility of subjects, identify procedures of alarming, forecast, and response, emergency treatment, and guarantee measures, publicize alarming information in a lawful and timely manner.

During the implementation of EU ESP project, the Ministry of Environmental Protection (MEP) issued such files as Contingency Management Measures for Environmental Emergencies and Guide to Risk Assessment of Enterprises' Environmental Emergencies. Under these files, enterprises and organizations are ordered to conduct risk assessment of environmental emergencies, check up and manage hidden environmental safety risks, improve the risk management measures of environmental emergencies. All these measures were proven fruitful, but there are still some prevailing problems. First, efforts shall be made to further identify the functions of various departments and develop a risk management and emergency coordination mechanism, as the functions of environmental source management involves responsibilities of production supervision, environmental supervision, and transportation administration. Second, the technical details of environmental pollution source assessment and hidden risk check-up shall be further perfected and effects of these technologies shall be verified, although the technologies have been developed. Third, the management policies for the environmental risks of enterprises shall be mapped out immediately, identify the common requirements of environmental risk source management and their concrete implementation requirements, and the policy recommendations shall also be put forward according to the environmental characteristics. Fourth, the responsibilities of subjects of environmental risk management shall be further implemented in the policy formulation process as many enterprises still do not voluntarily implement the obligations of environmental protection and shoulder social responsibilities.

Policy Recommendations

The following overarching recommendations are based on findings and learning made in the three ESP sub-projects on water quality and aim to support the implementation of policies to prevent and control the pollution of water resources. These recommendations provide direction for new or additional measures to be taken, or upscaling of successfully implemented demonstration activities.

Further improvement of the Discharge license system

Historically, pollution discharge permitting has been done through the setting of standards per industry on overall discharge per size of operation. This has not considered the number of factories or concentration of pollution loads for the entire river basin or sub-basin. Project 1 concluded that improvements are needed in the following areas:

a. Physical monitoring, assessment and modelling of total maximum pollution load per catchment;
b. Assessment of actual pollution discharge per industrial unit;
c. Review or removal of permits to industries to ensure total pollution discharge at the basin level is maintained; and
d. Enforcement of discharge permits to ensure they are upheld, with enforced sanctions on violators.

Project 1 provided technical support to the each of the areas of the above. Project 2 analysed the issuance of discharge license in the TBNA region and experiences from Sweden and the UK. Based on lessons learned in these projects, as linked to the Action Plan, the following general recommendations are made:

1. Make national laws and regulations on discharge licenses to manage fixed point sources by a comprehensive permit, with the support of integrated legislation, monitoring and supervision systems.
2. Strengthen scientific and technological support in the process of implementing pollution permission systems. Draw lessons from international experiences, and implement emission limits based on the “best available technology (BAT)” or “best available control technology (BACT)” as the basic and minimum requirements for each pollution source.
3. Ensure scientific and fair discharge licensing system through sufficient information disclosure and public participation, better monitoring, the introduction of third party supervision, and strict law enforcement.
4. Issue independent discharge licenses to each enterprise, and improve the design and content of licenses to enable clear guidelines for implementation and supervision by responsible authorities.
5. Directly link environmental assessments with the discharge system, and ensure

the correct data is used in environmental assessments to create an accurate baseline.
6. Incorporate the costs of environmental recovery of an industry closing down (in case of bankruptcy or end of operations for other reasons) and the costs of environmental management into the fees charged for activities with significant environmental impacts in the discharge license system.
7. Establish a license appeal mechanism based on administrative litigation and review.

Non-point water pollution prevention and control

Project 3 advanced non-point source pollution control based on nature-based solution (NBS), which are applicable in rural areas. It also developed innovative platforms for financing and implementing them. Based upon these experiences it recommends to:

1. Emphasize nature-based solutions (NBS) for agricultural pollution control and farmland restoration.
2. Enhance the rural residents' awareness of water environment protection, and strengthen publicity and education on actions that can be taken at household and farm levels.
3. Explore effective, sustainable operation models for water environment protection funds. The China Mega-City Water Fund, developed with the project, can be expanded and used as a model for this.

Water recycling and reuse

Project 2 surveyed EU experiences, good practices and possible barriers for expanded recycling and reuse of water resources. Based upon this analysis, the following suggestions are provided:

1. Firstly, revise the Water Law to include the reclaimed water as one kind of water resources. Revise the Article 2 of the Water Law as: The "water resources" referred to in this Law includes surface water, groundwater, and reclaimed water. Add one article in the Water Law as: Identify major types and scope of available "non-conventional" water resources that can be obtained from reclaimed-, sea-, brackish-, rain-, and mine-water and stipulate the principles of prioritized use in the Water Law. Insert "planning program for use of reclaimed water should be made for development, water utilization, and water protection activities" into the Article 14 of the Water Law. By doing this, the gap in water resources planning is filled and at the same time, the legal status of the reclaimed water planning is ensured.
2. Release and implement the formal "Water Resource Argumentation Regulation" as soon as possible. Article 4 of the Regulation mandates comprehensive consideration of surface water, ground water, and other water resources. This

encourages the use of reclaimed water. Mandatory performance of economic benefit analysis is recommended in choosing from various water sources, including retained flood water, desalinated water and reclaimed water to reveal the advantages of reclaimed water in the perspective of sustainability, reliability and relative lower transportation cost.

3. Increase finance for construction of reclaimed water projects and auxiliary projects utilizing best fit technologies to lay and manage pipelines. Encourage the participation of enterprises. Enterprises in the region to save water, process improvements, repetition rate of water, using new sources of priority, reducing the amount of fresh water from the source. Encourage enterprises to invest in infrastructure construction such as the laying of pipe network. Facilitate the application of the public-private-partnership (PPP) models in the construction of reclaimed water treatment systems.
4. Improve standards of quality, supervisory measures and legal liabilities for the utilization of reclaimed water. Improve and simplify the standards of the reclaimed water in accordance with practical needs and allow room for flexibilities in local standards. Higher standards of water quality are needed for water used for cultivation, food processing, human body contact purposes. Demonstration promotion of standard monitoring technique for reclaimed water(Microbiology online monitoring).
5. Develop technical management documents for reclaimed water systems detailing proper processes for recycling and use of water of different qualities and in different localities. Provide more systematic guidance and training materials for local governments to reduce the investment, operation and management costs of reclaimed water systems.
6. Support the formulation of short- to medium-term plans of reclaimed water development and related supportive documents. Based on long-term strategic goals and local demands, develop the short- to medium-term plans to assist financial investment in reclaimed water systems.
7. Strengthen policy support for the utilization and promotion of reclaimed water to encourage its application, including favorable planning strategies, grants, taxes, etc. For example, the government can grant subsidies and tax breaks for newly-established reclaimed water factory so as to ensure the price of reclaimed water acceptable for the public.
8. Strengthen the information disclosure and improve the awareness of public on the reclaimed water. Improve the public’s knowledge of reclaimed water and enhance their awareness of risks to avoid error pipe connection or direct drinking of unprocessed reclaimed water. Encourage the public to use and supervise the use of reclaimed water.

Ecological health and environmental risk assessment

Project 1 developed concrete applied methods including river health assessment report cards that were tested at a demonstration site within the Songhuajiang-Liaohe River Basin (SLRB). It further demonstrated the need to support monitoring and protection of water bodies aquatic eco-function zone mapping. Project 2 assessed the ecological risks that may result from heavy metal (such as Cd) pollution in water, researched the ecological risk assessment and its roles in environmental decision-making, and built an international research centre for ecological environment protection and risk control in Tianjin to strengthen the international cooperation. Project 3 developed the ecological assessment approach system for water sources, as well as the ecological score card as a supplement to the ecological survey in high functional areas. Each offer different means to increase public engagement and awareness of the conditions of their local watersheds, as well as to better conserve and evaluate actions to support protection.

Based on lessons learned from these projects, it is recommended to

1. Carry out basic surveys and baseline ecological quality assessments for surface and ground water sources for drinking water.
2. Promote the use of ESP project outcomes to form a standardized technical guides. These include river health report cards, indexing systems for assessing the ecological health of drinking water sources, and groundwater risk assessment guidelines.
3. At the central level, clarify the position of ecological risk assessment in environmental protection, improve related laws and regulations and issue ecological risk assessment technical guidelines; Conduct necessary data analysis of ecological risk assessment, and integrate the existing research outcome to complete the database; Strengthen communication between government departments responsible for the assessment and use of its results for environmental management. At the local level, strengthen the pollution control. Based on the assessment result of Project 2, stricter wastewater discharge standards in Tianjin and TBNA (e.g. the heavy metals) is recommended; Take full use of the International Research Centre for Ecological Environment Protection and Risk Control in Tianjin based on Project 2 to strengthen international cooperation and experience exchange on risk control.
4. Consider use of Watershed Scorecards as a complement to existing monitoring practices to increase the scope and frequency of data monitoring on the ecological health of basins.
5. Explore and establish an eco-function zoning system to manage aquatic ecological environment in seven major watersheds and three large areas with major problems in each zone identified.
6. Scientifically compute the environmental carrying capacity within each sub-unit of the river basin management zones (which there are currently 1784) as defined by the Ministry of Environmental Protection. For each unit, accurately assess

current and projected pollution sources, sewage treatment capacity and resulting water quality. This could improve the control over the total volume of pollutant emission, planning and investment in adequate water treatment. It could also provide a solid basis for EIA approval or rejection, and the issuing of sound pollution discharge permits. This would further enable potential trade of pollution discharge permits and compensation schemes based on accurate assessment of the impacts on local water environmental health.

International research cooperation and exchange

All ESP projects have cooperated and interacted with and drawn extensively from international organizations, particularly those based in EU countries. While this was part of the very foundation and aim of the ESP, it is noticeable that collaboration has been perceived as mutually beneficial for the parties involved and advanced overall knowledge on environmental protection. It is therefore recommended that:

In the field of water environment protection, the Chinese government and its environmental “think tanks” should further expand cooperation with universities and research institutions, etc., from the European Union, give full play to their experience to help make scientific decisions in regional development, ecological environmental protection, and pollution control.

ANNEX I: Project Experiences

1. Ecological health and environmental risk assessment

1： Ecological Zoning

Division of areas by ecological functions of the water environment

Project 1 applied a framework to determine the water ecological function zones of Liao River Basin. The basin was divided into 4 level 1 ecological zones, 14 level 2 zones, 50 level 3 zones and 150 Level 4 zones.

Diagnosis of Water Environment Problems

Project 1 evaluated the surface water environment quality of the demonstration area of SLRB. This was done through field investigation and data analysis in accordance with The Evaluation Method of Surface Water Environment Quality (Trial) and The Technical Specification for Health Evaluation of River Ecosystem.

The main pollution in Ashihe River Basin comes from surface sources. However, in the river estuary, the drainage load of point sources like industrial enterprises and sewage treatment plants is relatively more serious. This shows that the permit system for pollutant discharge should be strictly implemented for the point sources in the industrial residential areas while the BMP for non-point sources is carried out for the water environment management in demonstration basins.

Figure 1. Spatial Distribution of Pollution Point Sources in Ashihe River Basin

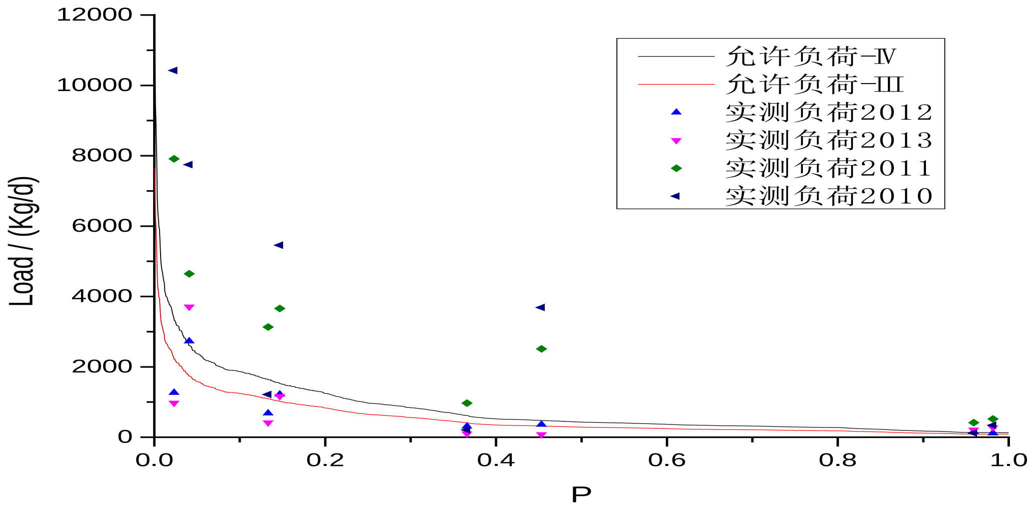


Figure 2. NH4-N Load Duration Curve of Control Sections in Acheng

2: Environmental capacity measurement and distribution

Measurement of carrying capacity of water ecosystems

Project 1 simulated the runoff, confluence, non-point source pollution load and transport process in the basin based on hydrologic models (SWAT, HSPF model) in Qinghe and Ashihe River Basins. It then built a receiving water model in the basin of the demonstration area (EFDC model) and evaluated the response relationship between pollution loads and water quality of river in the basin. This was used to calculate the carrying capacity of water bodies in all basin control units. For example, the model of Ashihe River Basin was based on HSPF model. It divided the basin into 30 sub-catchments and 198 HRU as per the DEM, land utilization and administrative division in the basin. It built the model of Ashihe River Basin and simulated the runoff generation and confluence and the non-point source pollution load generation and transport process in the basin.

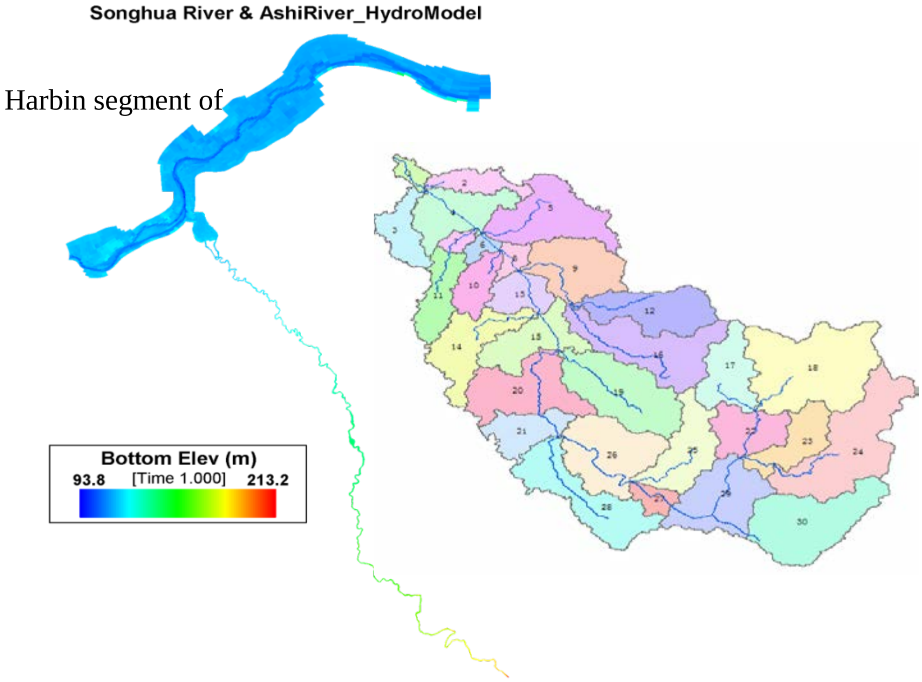


Figure 3. Sub-catchment Area Division of Hydrologic Model in Ashihe River Basin and Measurement Areas of Receiving Water

Based on the division structure of control units of Qinghe River Basin, a one-dimensional steady water quality model was used to calculate the water quality response coefficient of Qinghe River Basin. This applied a linear programming model to preliminarily calculate the water environmental capacity of Qinghe River Basin, COD 515.8t/a, NH4-N 35.6t/a.

Pollution load distribution based on control units

Project 1 carried out optimal distribution for the pollution loads of all the control units in the basin. This was based upon the selected distribution principle on the basis of the calculation for the carrying capacity of the demonstration basin. For example, it carried out exploratory and preliminary distribution for pollution loads of 18 control units in Qinghe River Basin by considering capacity utilization efficiency, population, GDP, influence of pollution discharge situation and current capacity situation respectively.

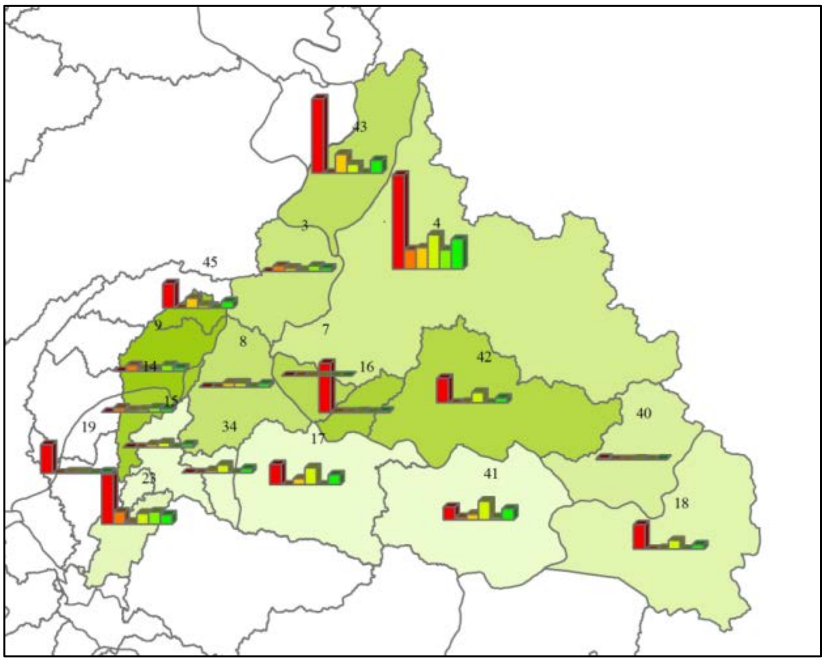


Figure 4. Distribution of Pollution Loads of Control Units in Qinghe River Basin

3：River health evaluation report card

Evaluation of the ecological functions of a water system provides a better understanding of a river systems health than the measurement of its water quality alone. EU approaches to water health evaluation can inspire and inform implementation of the Action Plan and water environment conservation measures. Project 1 evaluated Liao River health in selected protection areas. As shown in the health evaluation report card of 2013, the project gave a priority to recovering the ecology at the sites with poor ecosystem health.

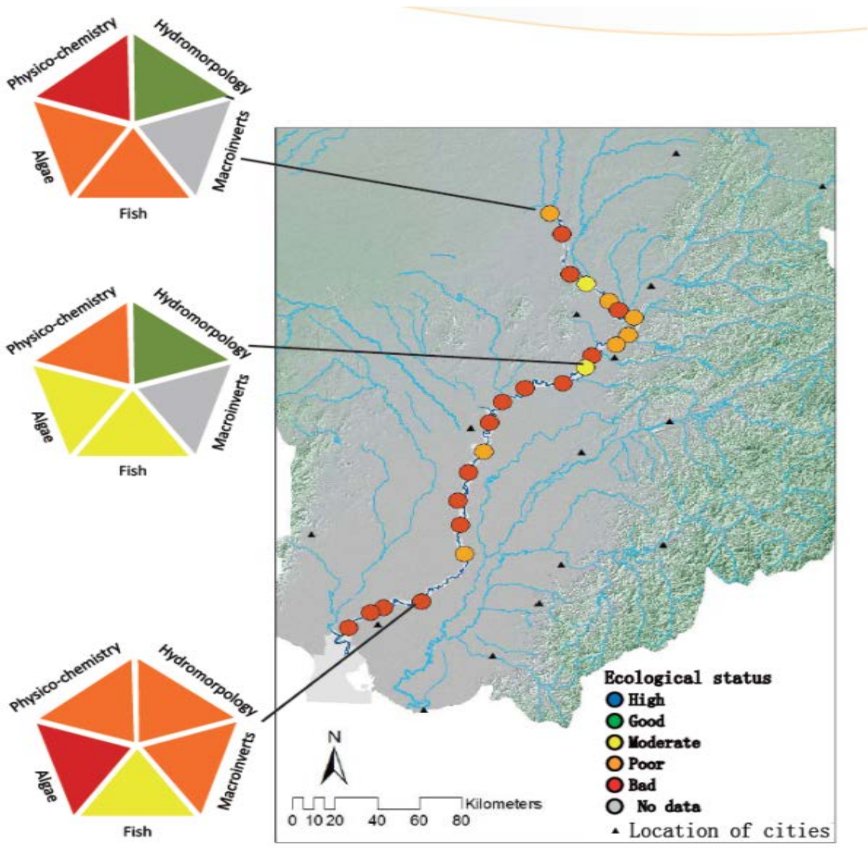


Figure 5. Health Evaluation Report Card of Liao River Protection Area in 2013

Based on the result of river health evaluation, four types of wetlands, i.e. tributary estuary, river course, pond and estuary mudflat were chosen for the wetland recovery plan of Liao River protection area. The chosen areas for this are shown in the map below.

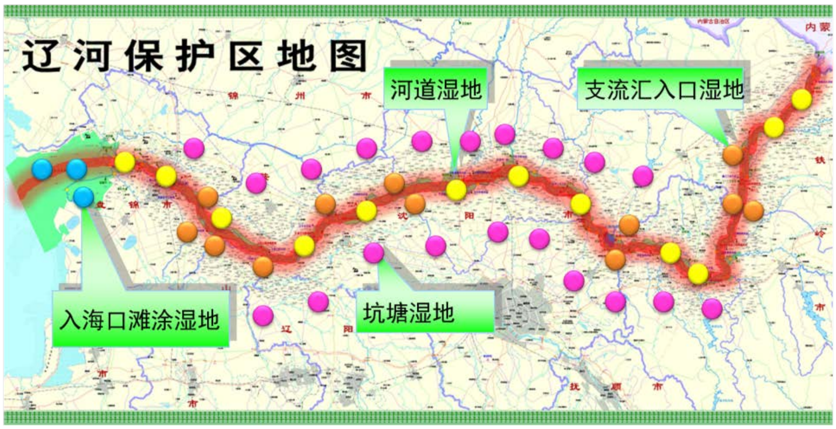


Figure 6. Map of Wetlands in Liao River Protection Area

(辽河保护区地图 Map of Liao River Protection Area 河道湿地 river course wetland; 支流汇入口湿地 tributary estuary wetland; 坑塘湿地 pond wetland; 入海口滩涂湿地 estuary mudflat wetland)

4: Identification of water environment risks

Main activities

Project 1 completed a survey of aquatic environmental risk source in Liao River Basin, and studied both management experience and approaches to identify water environment risks. It investigated various international laws, rules, and technical systems in this area, such as the Seveso Directive of EU, Inventory Methodology of Germany, and the Regulation of Chemical Incident Prevention/Risk Management Plan (RMP) of the US. It analyzed the indicators for the evaluation and classification of risk assessment, as well as the basis and legal evidence used for classification.

The project put forward approaches to identify and classify environmental risk sources, developed the classified assessment indicator system based on the quantity of environmental risk substances, processes, and risk control technologies, and environmental protection objectives. This was done according to the “source-transmission path-recipient”. It also built the classified matrix characterization approach for environmental risk sources, thereby preparing the inventory of environmental risk substances.

It further conducted a demonstration of these approaches to identify and classify environmental risk sources in Liao River Basin for 1,008 enterprises. It found 149 posing significant risks, accounting for 12.5% of the total, and 240 at common risks, accounting for 20.2% of the total.

Main outcomes and impacts

The project introduced Measures to Prevent and Control Environmental Risks in Liao River Basin. Proposed measures included the optimization of industrial layout, source control, deep processing for discharged water of sewage treatment plants, monitoring in high water period, clean up and disposal for hazardous substances in sledges. Additional technical support for the environmental risk management for Liao River Basin was provided.

Three technical trainings and exchanges were held in China and Europe. In January 2016, they held a training workshop for the technologies of environmental risk management in Liao River Basin. The responsible personnel and reporters of the province, city, region, and area joined a discussion about the status of environmental risk management, including such content as the approaches to identify risks, the outcomes of identification of enterprises of environmental risk in Liao River Basin, status of hazardous and toxic pollutants and the control strategies. About 30 people joined the training, including environmental management personnel, corporate representatives, and students.

2. Control of industrial pollution

1: Improving the discharge licensing system

The discharge license system is the most basic and important approach for the supervision and management of pollution sources. Project 1 integrated all the requirements of existing environmental management systems, reflecting a complete-process, using a long-term and refined management concept with roles going beyond those of all the other systems.

The focal point of the license system for pollutant discharge is to detail and implement the requirements stipulated in the laws, regulations, policies, standards, target of total volume control and normative management documents for environmental protection. All the requirements should be clarified in a discharge license system in a specific, concrete, and centralized manner, so as to restrict the discharge behaviours and control pollution made by industries. The issuance and management of discharge license is subject to guidance by an environmental protection authority and the system is implemented after an application is made and approved. In the meantime, the policies and technologies to monitor the implementation of discharge license system must be improved. Based on the management experience and current weaknesses in implementation, project 1 developed a recommended issuance and management process for discharge licenses. This was then tested at a demonstration site in Tieling. The process is provided below in brief.

1. Confirm the application object and scope of the discharge license
The list of units applying the discharge license at city and district (county) levels in Tieling was confirmed by the EPB and released on the official website of the Tieling Environmental Protection Bureau, http://www.tlepb.gov.cn. These are done in accordance with required information on environmental quality improvement requirements, environmental management demand, dischargers' environmental impacts, and discharge of characterized pollutant.

The management department shall make sure that the enterprises in the river basin will apply to get the discharge license within the stipulated period; and punishments will be made to those are overdue in applying for the license, or not following it.

The environmental protection bureaus at city, district (county) levels in Tieling are responsible for the issuance, supervision and management of discharge license within own administrative areas.
2. Verify the application materials
Enterprises shall file online an application for a discharge license and sign a commitment letter verifying the industrial category they belong to. The application materials include three forms: certificate, material of pollutant disposal and discharge supervision. Project 1 built the Tieling municipal discharge license management system (http://221.203.162.6:6020) as the platform for enterprises to file an application.

3. Application and issuance of discharge license

3.1Application and material review

The enterprises shall complete the application via the discharge license management system of Tieling City in line with their industry category, pollutant discharge conditions and prepare relevant materials according to requirements. An environmental protection bureau at city, district (county) level in Tieling receives the application materials submitted by the enterprise. The application is completed upon passing the review of Tieling Environmental Protection Bureau; the materials failing to pass the review shall be modified and resubmitted till acceptance.

3.2 Issuance of license

(1)Tieling Environmental Protection Bureau shall, according to the application materials submitted by the units, check the limit values of discharging, including checking discharge volume and setting a limit value. The discharging limit values include the technology-based value and water quality-based value. The values shall be confirmed as per the technology for discharge license set out in Practice 1 of 3.3.1.

(2)Tieling Environmental Protection Bureau should call on relevant units to hold a seminar to check results and discuss rational setting of values.

(3)Prepare and make public the discharge license to be issued according to the verified values. A license will be issued when there’s no dissent. The environmental protection bureau will, in consideration of feedback and explanation of dischargers, then decide whether to issue a license in case of dissent.

With the support by Tieling Municipal Environmental Protection Bureau and the establishment of the license platform, Project 1 has:

- Responded the tasks and requirements of the laws and regulations and policies such as the Action Plan.
- Defined the pollution sources in the demonstration sites, playing an active role for the construction of local water environmental monitoring database.
- Promoted the monitoring of pollutant discharge conducted by local pollution enterprises and the check of pollutant discharge conducted by local environmental monitoring departments. To receive the discharge license, the enterprises should report the discharge capacity timely and accurately and the environmental protection department should conduct annual inspection and spot check.

3. Water recycling, reuse and non-conventional water

1: Storage, retention, and treatment of rainwater and floods

Reclaimed Water Source Production

TBNA is characterized by low precipitation, heavy surface water pollution, high groundwater mineralization, and general scarcity of available water resources. All the water used by TBNA is taken from external sources, resulting in a serious shortage of water for residents, industrial production, and ecological use. Project 2 adopted high algae and high turbidity surface water (rainwater and floodwater) for optimal treatment technologies to produce reclaimed water resources. It helped alleviate in small part water resources shortage and degradation of water quality.

Learning from the experience of the advanced water resource management in the EU, Project 2 has developed a new integrated water management model for coastal city according to the specific problems faced by TBNA. In most coastal cities of China, the traditional water environment management model characterized as "single purpose, single route and rapid discharge" has been extensively adopted. Different from the traditional mode, the new mode developed under the Project 2 is centered with "multiple purposes, netted circulation and slow discharge mode”. Two key technological measures for improving the regional water environment have been applied in the new mode. One measure is to increase unconventional water supply through producing reclaimed water from micro-polluted in-transit water and developing multipurpose utilization. The other is to increase hydraulic circulation among rivers, reservoirs, and wetlands, making full use of natural water supplement, in-transit water efficient treatment, storage, ecological purification and even flood control through innovative approaches. While ensuing flood safety, in-transit water would be effectively stored and purified through reclaimed water technologies, and fills up the gap of urban water demands. And the pollution load into the sea can also be reduced drastically.

- The core of the model is based on flood control, the use of upstream water, storm water, wastewater treatment plant effluent, recycling water and other water. This mode has the following features: Combines EU water management experience and involves overall consideration on water quality, water quantity and water ecology.
- Evaluates and makes different plans for different water sources (particularly unconventional water source) to appropriately allocate them for household use, production use and ecological use.
- Makes full use of existing water resources, including the rivers, wetlands, and reservoirs by connecting them, dredging, reducing pollution, enriching water quantity to achieve ecological restoration and finally to enhance environmental quality. Provide more comprehensive technological support for planning and decision making through technical models and tools such as GIS and MIKE11.

- Reinforces ecological risk evaluation and elevates water quality standards.
- Flood prevention and environmental risk control.
- Facilitates improvements in relevant laws, standards and systems (e.g. Pollutants Discharge Permit System).
- Establishes effective coordination mechanism among related departments.

This mode takes into full consideration of the features of the local water resources by properly dispatching, allocating and utilizing water resources to ensure ecological water supply and water rehabilitation. With the concept of integrated planning, this mode combines engineering solutions, IT, and environmental protection technologies together to ensure water quality improvement, water quantity allocation and water ecological rehabilitation and alleviate the rain and flood disasters. It is suggested that this mode be duplicate in flood areas, water shortage areas and coastal areas.

Furthermore, for the reclaimed water, the project 2 has carried out the following activities:

Long-distance Transport and Water Supply Guarantee of Reclaimed Water

Compared with drinking water, reclaimed water usually has higher degree of mineralization, higher conductivity and concentration of chloride and lower PH, which increase the possibility of corrosion of pipeline inner wall. Therefore, the reclaimed water system is more prone to be corroded than the drinking water system. Project 2 put forward the guarantee measures for comprehensive control from several main aspects (transport medium, transport system, including design, construction and operation management maintenance). The control technology of long-distance transport and water supply guarantee of reclaimed water was applied in all the management activities of source, transport and use, ensuring the water quality and safety.

Multi-objective recycling model of reclaimed water for different water quality demands

Reclaimed water is applied for five primary uses: supplementary water (surface water, groundwater); industry; agriculture, forestry, animal husbandry and fishery; urban non-drinking water; and landscaping. The recycling models for sewage regeneration include centralized and distributed ones. With both strengths and weaknesses, they are indispensable and irreplaceable for reclaimed water recycling and are mutually supplementary. Project 2 carried out technical and economic analysis for the total costs for the recycling of reclaimed water in TBNA. The technical and economic calculation was made by a using capital expenditure model for reclaimed water, operating cost models for a centralized sewage regeneration recycling plant, distributed sewage regeneration recycling projects, and a distribution system of reclaimed water and critical distance. This informed a recommendation for TBNA to adopt a centralized reclaiming model for its urban area and distributed model in suburban areas.

2: Coordinated improvement of water resource, environment and ecosystem under flood control constraint

Situated at the downstream of Hai River, TBNA features many trenches and streams, as well as abundant wetland resources. Due to the low water quality and quantity, they are exposed to water pollution and ecological degradation. With the development of economy and society, the rivers and wetlands generated increasingly high ecological demands. In consideration of such factors as ecological water demand, unconventional water resources, and flood prevention safety, Project 2 put forward the plan of coordinated improvement of water resource, environment, and ecosystem for TBNA under flood prevention constraint.

In order to identify the maximum water storage of rivers/wetlands under the target of flood prevention, Project 2 introduced the storm intensity formula to simulate the calculation for the maximum water quantity that could be stored in rivers, under various storm intensities and durations, so as to maximize recycling and improvement of aquatic ecological quality. The technical roadmap is as follows.

Outcomes and influences

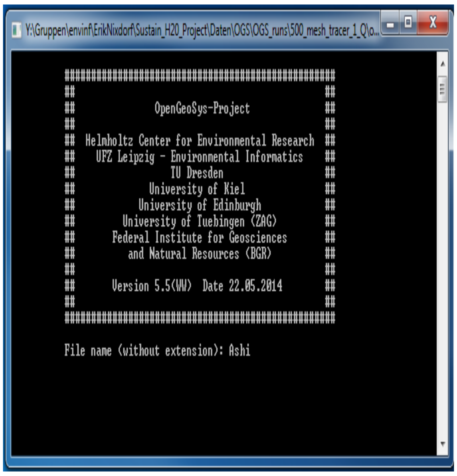
The available water sources are mainly rain water, reclaimed water and passing-by water. A priority is given to rainwater for ecological water supply in view of the uncontrollability, but water supplement turns to reclaimed water and passing-by water in case of a deficiency. Artificial water supplement of unconventional water resource happens between March and November, as a result of evaporation, frozen period, and seasonality of rainfall. Thus Project 2 put forward the water regulation plan of multi sources.

4. Conservation and protection of groundwater

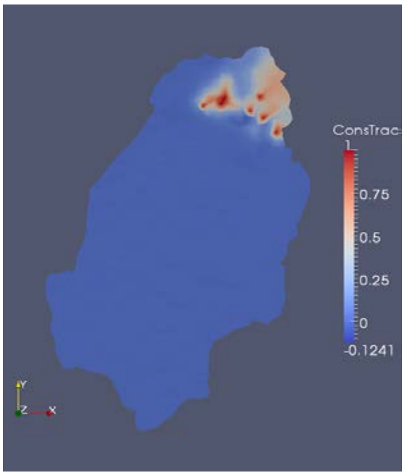
1: Simulation Model for Groundwater Environmental Values

Main activities

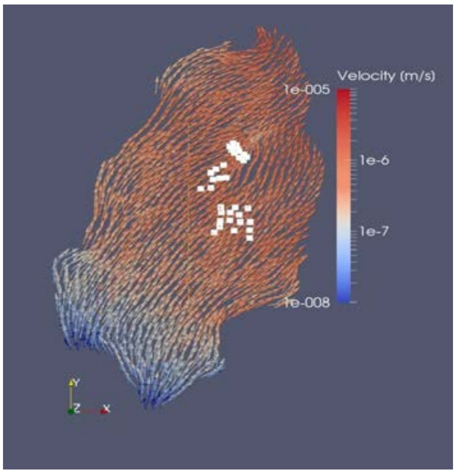
Based on the collected data for the groundwater and geological conditions of Ashi District, Harbin, the hydrological and geological database was completed. The collected data mainly include the survey report of Acheng District, stratum and geological structure; the groundwater characteristics include occurrence characteristics, enrichment principle, cycling characteristics, and dynamic changes. The meteorological data were also collected, covering temperature, evaporation; the topographic conditions include catstep and terrace; groundwater supply types include atmospheric precipitation, surface water infiltration, and water-bearing stratum self-supplement. Based on the above data, the hydrological analysis was conducted for demarcation: the right margin is the Ashi River and the rest is the catchment area; the terrain consist of the terrace on the western and southern parts, and flood plain in the east and north (145-138m), with a total area of 265 km2.



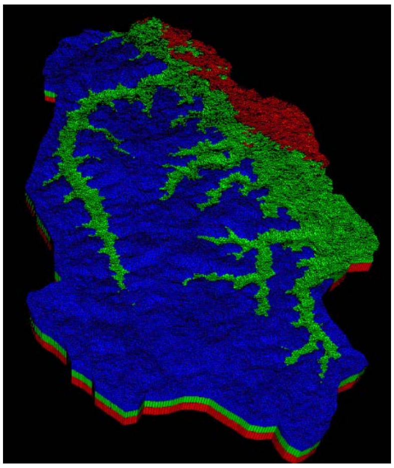
A interface of simulation program



B simulation of groundwater pollution transport



D groundwater flow field



C model of groundwater 3D values

Figure 7. Groundwater simulation program

Main output and influence

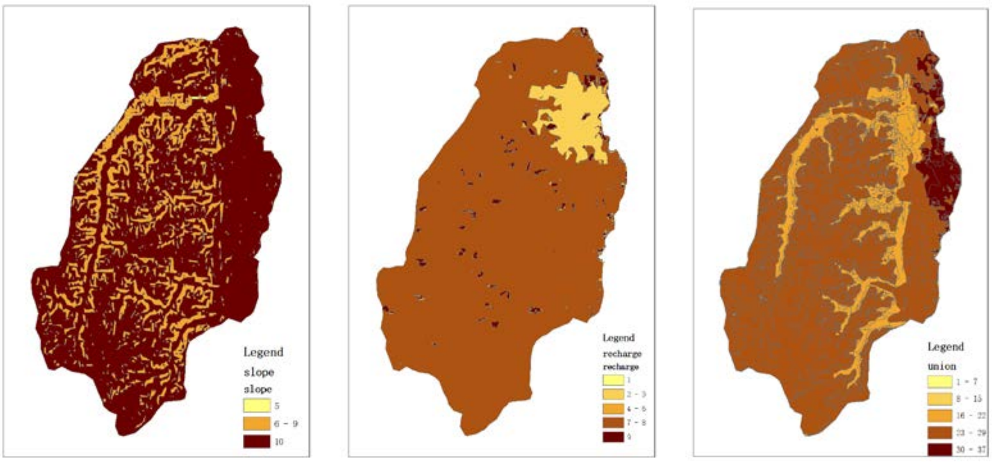
Given the groundwater value simulation team and integration system of the partner UFZ, we take advantage of the technologies of UFZ to conduct 5 events of academic exchange and technical training at home and abroad: trainings in Beijing and Harbin in September and October 2014, September 2015, two visits to Germany. The content of these events include the usage of Open Geological System (OGS) software and relevant output of application. The number of the participants is around 100, including management of environmental authorities, researchers, and students.

Furthermore, we learn from the German groundwater simulation technology to boost the establishment of groundwater simulation team of Chinese Research Academy of

Environmental Sciences (CRAES). In view of the starting stage for groundwater researches in China, the team is using this approach to help build the groundwater quality simulation systems for Harbin and other regions, extending the scope of application.

2: Protection Strategy of Drinking Groundwater Source

The project on drinking water source protection, as one of key tasks of drinking water safety, chose to establish a demonstration base at a groundwater drinking water source. Based on the groundwater value simulation and risk assessment, they analyzed the fragility of ground pollution source and geological conditions for the drinking water source. The project classified the fragility of drinking water sources and came up with 3 kinds of different protection plans, guiding the local protection of drinking water source and relevant pollution sources of groundwater type. The ArcGIS software is employed overlaying function of ArcGIS software to acquire a map of groundwater fragility.



Terrain Slope **Net Recharge** **Levels of Fragility**

Figure 8. Map of Groundwater Fragility of Ashihe River Basin

Main outcomes

The Action Plan suggests that a regular assessment shall be conducted on the drinking groundwater sources and pilots for environmental protection shall be launched. Learning from the outputs and technologies for the prevention of drinking water sources, we assisted the then pollution Department of Pollution Prevention and Control, current Department of Water, to complete the *Preparation Guidelines of Implementation Plan of Groundwater Environmental Protection Project.* Of them, a priority is given to the protection drinking groundwater sources to identify problems, assess risks, simulate, and setting relevant projects.

Three training events were held since the release of Guideline, with over 300 participants. Major participants include water management staff of environmental protection bureaus, technicians and management of local institutes of environmental sciences. Provinces like Ningxia, Anhui, and Shaanxi, according to the Guideline, have finished preparing the implementation plans of groundwater environment protection, which have been approved by the municipal governments.

Inspired by the thinking of EU Water Framework Directive and Groundwater Directive, Project 1 applied the experiences and approaches of groundwater management in SLBR, making sure that feasible for scaling up nationwide.

A Risk Assessment Guideline for Groundwater Sources in SLBR provides technical supports for local environmental authorities as well as training content of groundwater source management and recovery as follows: Groundwater dynamics 3D simulation technology; Simulation of pollutant transport of groundwater water-bearing stratum; and Risk prevention and regulation for drinking groundwater source

Project 1 also provided technical supports for environmental supervision and pollution recovery of drinking groundwater sources. Relevant outputs and thinking have been incorporated into the Preparation Guideline of Implementation Plan of Groundwater Environment Protection and Pollution Recovery Project (draft), which has been released for implementation.

3: Groundwater Risk Assessment

Main activities

Project 1 built models for groundwater flow and pollutant transport of typical areas in the SLRB, adapting learning from advanced EU approaches of groundwater risk assessment. It further worked to develop a groundwater risk assessment indicator system, and a method to form divisions of groundwater fragility of the basin. This contributes to protection of drinking water sources from groundwater. The project team further completed the Preparation Guidelines of Implementation Plan of Groundwater Environmental Protection Project, guiding the preparation work of groundwater environmental protection and pollution recovery plan of local authorities.

During the implementation of Project 1, researchers visited SLRB for many times, confirmed the demonstration areas, collected the hydrological, geological, and meteorological data, so as to identify environmental problems. The researchers studied three types of groundwater risk assessment approaches and relevant management policies of EU countries. They learned the technical systems of groundwater risk and water quality assessment by giving a priority to EU Water Framework Directive. In consideration of the actual conditions of the demonstration areas, they selected a total of 17 indictors such as groundwater fragility and pollution source characteristics to build the risk assessment indicator system, and determine weights and values for indicators to calculate the risk indexes.

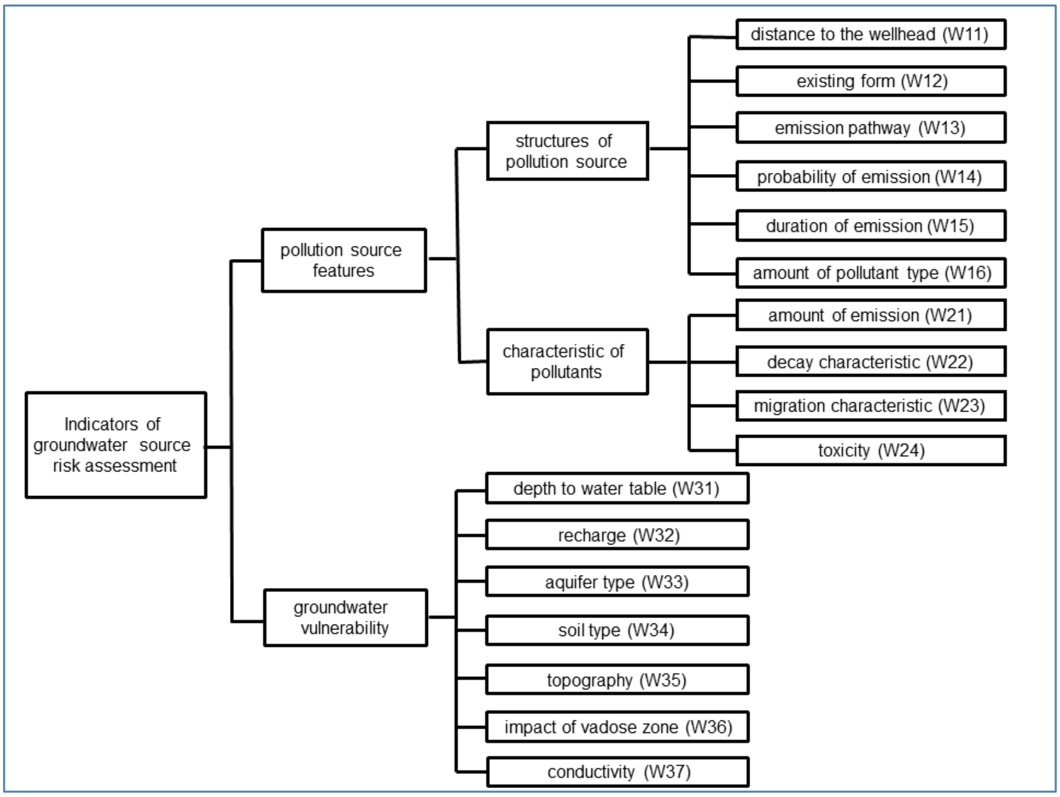


Figure 9. Groundwater Risk Assessment Indicator System

Main Result and Influence

The team completed preparing *Groundwater Source Risk Assessment Guideline for Songhuajiang* and Liao River Basins. Now the risk assessment approaches have been established for the demonstration areas and the risks have been calculated at different levels. A training of technical approach of risk assessment has been conducted in Beijing and Harbin, Heilongjiang Province. A total of 50 people participated in the training, with content such as risk assessment approach, risk classification technology, and typical pollution identification.

5. Non-point source pollution prevention and control

Rural non-point source pollution primarily results from agricultural activities and households. It is diffuse and therefore difficult of collect and control. Due to complex pollution content, it also challenging to remove by normal methods. Project 3 conducted various activities to address non-point pollution sources in the demonstration river basins from agriculture and households.

1: For agricultural activities – nature-based agricultural non-point source pollution control

Buffer Zones

It built buffer zones (200m*5m) in Miyun. A three-level buffer zone was installed to control the impacts of chemical substance used in agricultural activities on river system. The monitoring results suggest that the removal rates of total nitrogen and total phosphorous were 30% and 50% respectively.

Figure 10. Buffer Strips before and after construction in Xiaowopu Village, Miyun

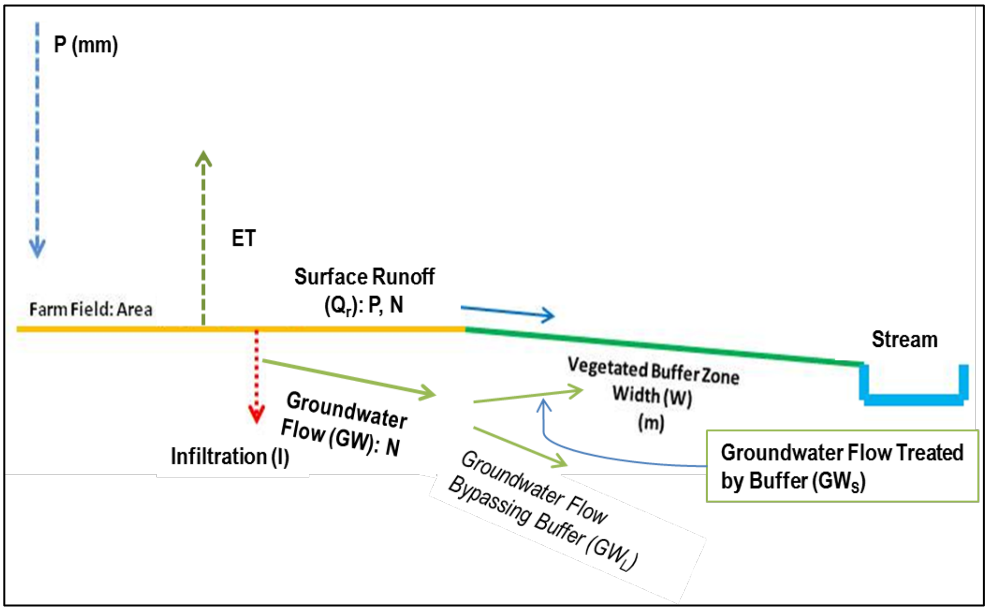


Figure 11. Three-level River Buffer Zone

Artificial Wetland

It built an artificial wetland in Jiaquan River Basin and piloted ecological agriculture, influencing communities of about 1,000 people.

Soil testing and formulated fertilization and ecological agriculture

An in-depth survey and analysis was completed for agricultural fertilization in Miyun. In addition, the optimized fertilization volume and plan was made for the chemical fertilizer additive. A 200-mu soil testing and formulated fertilization was also finished.

The project team conducted a demonstration of ecological agriculture of 200 mu in Guangdong Jiaquan River Basin. The concept and approach of Biodynamic Agriculture of Australia were introduced. The fertilizer-free approach of vegetable and rice crop shift has promoted the rice quality and revenue of communities, boosting the recovery of soil.

It also conducted agricultural pilots such as 3D orchard and ecological oranges in Jiaquan River Basin. All these efforts improved the biodiversity level and reduce the usage of chemical fertilizer, and maintained or improved soil quality. Notably, the project helped communities to develop their own agricultural products and sell them directly to customers. People can use such methods as a rural market place. It also promoted PPPs to link farmers directly with consumers and also connect with other local farmers as customers. This agricultural marketplace can also become a space to develop their own brands. With the development of the market, the project provided incentives for the business transition of the community.

2: For rural life – exploration to a sustainable model for rural environmental protection

Environmental Infrastructure Construction

On the principle of “integrated management for water sources”, the project team built the ecological toilets and a garbage tank for a formal collection of domestic garbage; built buffer strips in rivers close to farmland for degrading, removing, and keeping the agricultural non-point source pollution substance. With the implementation of the project, the appearance of the village has been greatly improved, and the living environment of residents has improved. The project has made an in-depth survey and analysis on the optimized fertilizer use in the Miyun communities.

The project built the permeable mall at the demonstration points, which enable rainwater to supplement the groundwater more effectively, greatly reducing negative impacts of runoff on harden roads as well as the residual content of the confluence.

The project conducted a 200-mu-plus ecological agricultural construction in Guangdong Jiaquan River basin. Advanced biodynamic agriculture was introduced and conducted zero-fertilizer and zero-pesticide crop rotation of vegetables and rice in the river basin, promoting the quality of rice and income of communities, boosting the recovery of soil. In addition, the project conducted 3D fruit garden and ecological organs and other sustainable agricultural demonstration. Biodiversity conservation was promoted and the use of fertilizers and pesticide reduced, lowering the risks of non-point source pollution and conserving land and water resources.

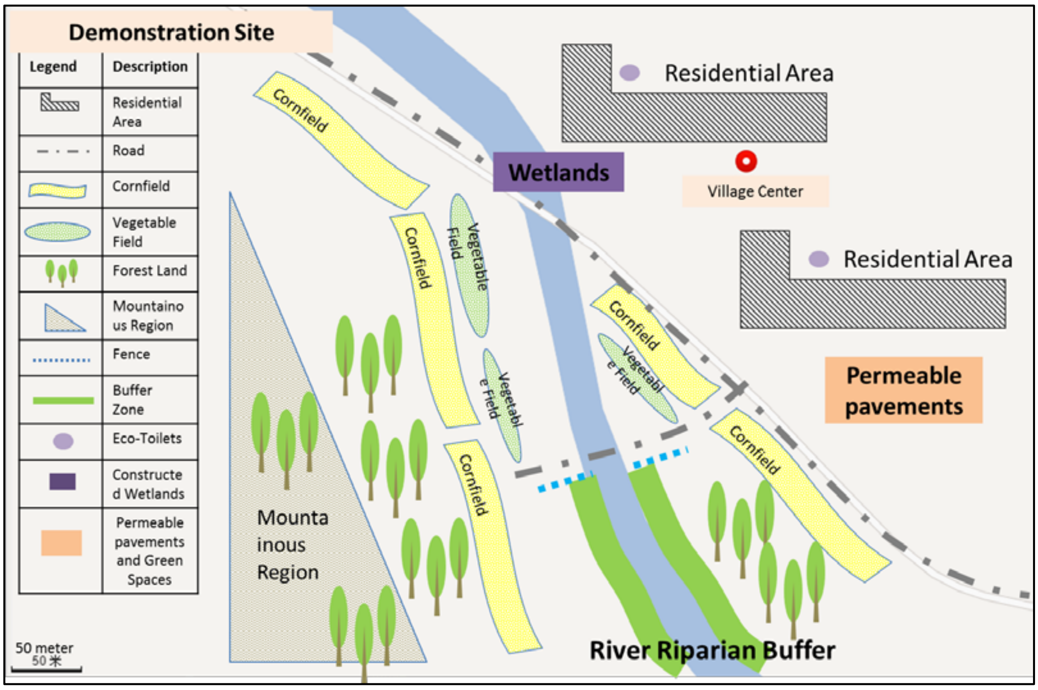


Figure 12. Green Infrastructure in Xiaowopu, Miyun

Dissemination of results and improving environmental awareness

The project conducted basic capacity building activities in an aim of "Beautiful Village, Healthy Water Source". Various training events were held, covering basic knowledge of environmental protection, collection of sustainable firewood, safe use of pesticide and fertilizer, relevant knowledge of water source protection. Preferential training participants in the sub river basins have hit 500 person times, covering 70% of the river basins.

Figure 13. Farmers Dancing on Permeable Brick Square, Participating in Training

In Jiaquan River Basin, the project worked with domestic institutions and senior experts from home and abroad to engage farmers to join capacity building events. Furthermore, in accordance with the baseline survey and participation type conference of land utilization, it held relevant trainings in these villages, with content including environmental protection and substitute planting, ecological rice planting and bee breeding, fire-wood joint planting, and ecological farming. Farmers were also invited to join a field visit and the self-service teams were built. A total of 18 training events were held, with participation by 500 people.

Figure 14. Lecture and Field Training of Farm Class

Develop substitute livelihood, promote social attention, strengthen sustainability

The project promoted sustainable farming models that reduce or avoid the use of pesticides or herbicides in the pilot areas. All the measures are aimed at garnering more sources to ensuring the revenue of farmers, reducing farming activities' pressure on environment and life. The project team helped the communities in Jiaquan River Basin to develop local agricultural product brands and match farmers with consumers at marketplaces, online stores, and PPP. The role of the market provides an incentive for the ecological transition of the communities.

Figure 15. Establishment of Longmen County Changkeng Village Bee Farmers' Professional Cooperative; farmers receiving bee breeding articles

As a village of bee-breeding tradition of about one hundred years, Changkeng Village saw many farmers were breeding bees in the past. And the bee-source plants were planted in the mountains, undermining the ecological environment and causing pollution. The eucalyptuses have been planted to replace former local trees featuring a biodiversity, while the wide use of herbicide and pesticide has gravely impacted the growth of bees. The bee farmers had to trudge long to another city for collecting honey. More and more villagers had to turn to other trades. To support the remaining bee farmers and recover the biodiversity, the project team has helped an old man sell bee, engage the local authority of the village to build a bee breeding team consisting of 19 bee farmers. With the help of the project team, a bee farmers' cooperative was established. We cemented a good partnership with the county bee breeding association to jointly recover bee source, develop bee products, and provide articles and technologies for the bee farmers' cooperative. The project further disseminated the stories of the bee farmers, call on more people to help them, ensuring their long-term benefits and protecting the local ecological environment.

Miyun basin boasts a long tradition of hand-making broidery and farmers can make a variety of products featuring Hebei style when they are away from farming. The project team assisted the farmers to make broidery products like placemat, turn into gifts and develop the market.

Figure 16. Folk handicrafts of substitute livelihood of Xiaowopu Village, Miyun

The promotion of sustainable livelihoods in rural communities is an essential requirement to reduce agricultural pollution. Building a long-term financing mechanism is necessary to ensure communities can be capacitated and compensated to improve farming practices. Based on the experiences of the demonstration sites and the Partnership for Mega-city Watershed Protection (PMWP), the project helped build the China Mega-City Water Fund, which is aimed at integrating resources of the stakeholders and sustainable protection of water sources. Different from the former platforms, the Fund will, under the theoretical framework of water source protection, conduct a quantitative analysis on the cost benefits of the technologies for water source protection, so as to select suitable technologies according to concrete conditions, ensure the high efficiency and transparency of the project.

Figure 17. Launch of China Mega-City Water Fund

As an innovative financing mechanism based on the project, China Mega-City Water Fund, centred on paid ecological services, will support the development of sustainable livelihoods and improved water environment management.