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Planning for Environmental Risk Reduction in China: Policy Recommendations

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Preface

This report contains policy recommendations from the Sino-Norwegian cooperation project “Planning for cost-effective environmental risk reduction”, which began in 2013 and ends in 2016.

The present document is the CONFERENCE VERSION.

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Main recommendations

I. Environmental risk assessment is a powerful tool for environmental management as well as environmental risk prevention and control, and should be comprehensively carried out

China has done a lot in the field of environmental risk assessment, but some problems remain

Since “environmental risk prevention” was included among the main tasks in China’s national 12th Five-year Plan for environmental protection, China has done a lot in the field of environmental risk assessment, including the formulation of the Guidelines on Environmental Risk Assessment in Enterprises (Tentative) which links environmental risk assessment in an enterprise to the corporate environmental emergency plan, and the requirement in the Administrative Measures for Contingency Plan for Environmental Emergencies for corporate and regional environmental risk assessment. In the wake of the step-by-step progress of corporate environmental risk assessment and the reflection on the typical accidents in recent years such as the “Blast in Dalian on Jul. 7”, and “Blast in Tianjin on Aug.12”, research and administrative personnel have had an increasingly thorough awareness about environmental risks.

However, the system is not perfect and some problems remain. This project recommends to conduct regular environmental risk assessments at county levels using the Seven-step Framework. The framework includes development of management strategies and is accompanied by a detailed training program.

Environmental risk assessment provides diagnosis, optimized decision making, guidance and knowledge

As a foundation of environmental risk management, environmental risk assessment has four functions: first, it provides *diagnosis*, that is, the assessment provides systematic analysis and identification of the type, distribution and degree of environmental risk; second, it provides *optimized decision making*, that is, the assessment offers advice on environmental risk prevention and control for decision makers to implement priority managements; third, it gives *guidance*, that is, the horizontal and vertical comparison of assessment results may guide the reduction of environmental risk level in high-risk areas; fourth, it provides *knowledge*, that is, the assessment may lead to improved awareness of environmental risks, environmental risk problems can be identified and the capability of environmental risk management can be improved through the assessment.

The Seven-step Framework for environmental risk assessment forms the basis for environmental management at prefecture and province levels

At the core of the Seven-step Framework lies a numerical assessment system for acute and accumulated environmental risk at the county level. The assessment system forms the basis for a comprehensive, cost-effective environmental management strategy at the prefecture and province levels. The project has thoroughly tested the framework in

two pilot prefectures and two pilot provinces. Based on successful test results the framework has been modified and revised.

The Seven-step Framework is accompanied by a detailed training program in strategic environmental assessment and cost benefit analysis, which are two key methods for developing cost-effective environmental risk management strategies within the Seven-step Framework.

The Seven-step Framework should be applied in all provinces in China. Training should be extended and intensified

It is recommended to apply the Seven-step Framework in all provinces in China in order to obtain a county-level map of acute and accumulated environmental risk that covers the whole country, and obtain cost-effective strategies for environmental risk at the prefecture and province levels that similarly covers the country. To support the Seven-step Framework training in Strategic Environmental Assessment and Cost-Benefit Analysis should be extended and intensified to provincial and prefecture level EPBs in China.

II. The legal system should be improved, the management system should be based on risk assessment, governance should be improved, and data should be collected, applied and disseminated

Based on international experiences in best practice environmental risk management, as well as the pilot prefecture and province tests and application of the Seven-step Framework, this project has identified a number of additional recommendations.

i. The legal system should be improved

In recent years the legal system to support environmental risk management has been strengthened, most recently with the revised Environmental Protection Laws. However, important legal gaps remain. China should:

- Enact special laws and regulations concerning the prevention, control, response and handling of environmental accidents. These should be similar to the EU's Seveso Directives.
- Enact special laws and regulations concerning environmental management of chemicals. These should be similar to the EU REACH directive.
- Enact laws on compensation for environmental damage, soil environmental protection and ecological protection.
- Strengthen the implementation, supervision and enforcement of existing laws.

ii. The environmental management system should be based on risk assessment

So far an environmental risk-based decision-making system has not been established in China and environmental risk assessment has not been comprehensively and substantively incorporated into the strategic planning process. China should:

- Develop a national environmental risk protection strategy and roadmap. The Seven-step Framework provides a way of doing this.

- Incorporate environmental risk assessment and management into the decision-making process of governments at all levels. The Seven-step Framework is a basis for this.
- Speed up the construction of the environmental pollution liability insurance system.
- Establish a green financial system and an environmental risk prevention and control fund.
- Develop a technical guide for environmental risk prevention and control and emergency measures. The Seven-step Framework is a basis for this.
- Strengthen environmental risk prevention based on cost-benefit analysis and strategic environmental assessment. The Seven-step Framework and the Training Program are foundations for doing this.
- Improve the law compliance guarantee system.
- Optimize administrative management, e.g., of standards, environmental impact assessments and the pollution discharge licensing system.
- Promote the environmental information disclosure of enterprises.

iii. Environmental governance and control should be improved

The decentralized ecological monitoring system contributes to the low efficiency of environmental risk prevention and control in China. China should:

- Coordinate environmental risk monitoring in, e.g., environmental protection, forestry, fishery, agriculture, marine industry, as well as other industries. The Seven-step Framework provides a database and indicators for doing this.
- Coordinate supervision and law enforcement
- Coordinate spatial plans.
- Establish a sound priority control and chemical inventory system
- Establish a full life cycle management system for chemicals
- Establish a toxic and harmful substance release inventory system
- Boost environmental assessment by enterprises
- Highlight environmental risk assessment in plans and policies. The Seven-step Framework provides a way of doing this.
- Accelerate regional environmental risk assessment. The Seven-step Framework provides a way of doing this.
- Improve the environmental damage assessment system and promote the damage compensation system

iv. Data collection, application and dissemination should be enhanced

Compared with traditional concepts and methods of environmental management, risk-based environmental management requires more data and data of higher quality. Existing data are unable to support environmental risk assessment and management in a comprehensive manner. China should:

- Build a national integrated network to monitor indicators of environmental risk
- Enhance the monitoring capacity and statistical capacity relevant to environmental risk
- Strengthen information disclosure

- Conduct an overall environmental risk assessment. The Seven-step Framework provides a method for doing this.
- Establish environmental risk pre-warning systems for key fields and key regions. This includes drinking water sources, heavily polluted water, cross-border rivers and trans-boundary river basins, as well as air pollution hot spots.
- Strengthen monitoring of public opinion with the intention of learning what are public concerns.
- Build an environmental emergency response team
- Strengthen environmental emergency response and equipment support
- Improve standards and norms concerning risk prevention facilities and storage of emergency material equipment.

1. Introduction

The Project on “Planning for Cost-Effective Environmental Risk Reduction” is an extension of the phase I project “Improving the Effectiveness of Provincial Level Five Year Environmental Plans”. Based upon the current situation of environmental risk prevention in China and the main problems in the planning management, this project is designed to learn from foreign systems and methods in relevant fields, strengthen the top-down design, build a methodological framework for environmental risk prevention and planning and improve it through pilot application, offer training and learning of models and methods. On this basis, we provide policy recommendations in order to establish an efficient environmental risk prevention and planning system, promote the effective integration of environmental risk prevention, control and management methods into the environmental planning system, and improve the capacity of pilot provinces and municipalities to apply the environmental risk prevention and planning methods.

The project was divided into 9 main activities:

- Activity 1: Inception and baseline
- Activity 2: Study environmental planning methodologies
- Activity 3: Develop methodological framework for environmental risk prevention and environmental planning methodologies in China
- Activity 4: Applying and testing of risk reduction and environmental planning framework
- Activity 5: Revise risk reduction and planning framework
- Activity 6: Training and Study in Environmental Planning and Economic Modeling
- Activity 7: Policy recommendations for a national framework
- Activity 8: Dissemination
- Activity 9: Management.

Figure 1 is a flow chart of the activities. Among the activities the policy recommendation activity is an important task and outcome of this project, mainly aiming to offer good experience and advice and systematically make suggestions on strengthening the national-level environmental risk reduction, thus promoting improved environmental risk reduction in environmental planning in China.

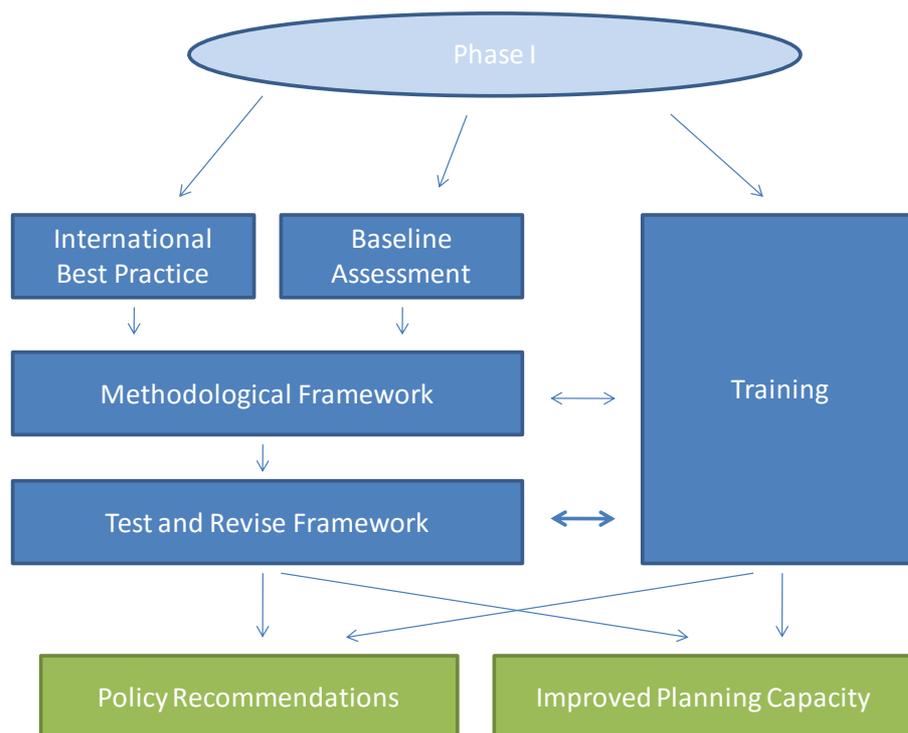


Fig. 1 Flow Chart of Project Activities

Source: Inception Report of the Sino-Norwegian project “Planning for Cost-effective Environmental Risk Reduction in China”.

The policy recommendations in this report are primarily based upon such outcomes as the baseline research report, international experience report, methodological framework and pilot reports from applying the methodological framework. In addition, the discussions between Chinese and Norwegian experts, feedback from the training activity, and results of questionnaires during the project implementation are also important sources for the policy recommendations.

The study of foreign experience shows that a sound legal system is a fundamental guarantee for effectively preventing environmental risks, a well-established environmental risk management system ensures the efficient implementation of various measures, and the basic technological capability plays an important supporting role in preventing environmental risks. Lessons from the pilot application can be found mainly in the environmental risk assessment, data acquisition, risk management measures, and cost benefit analysis.

The policy recommendation in this document mainly includes four major aspects, i.e. improving the system of laws and regulations, improving the management system, strengthening the institution building, and intensifying the supporting capacity building, with concrete corresponding suggestions made on the basis of the current situation and problem analysis.

2. Learning from International Experience

The report *Tackling environmental risks with environmental planning: international experiences* is an important outcome of this project, aiming to learn about laws, regulations and policy measures from EU and US in reducing acute and accumulated environmental risks, and provide experience and lessons for China. Foreign experience shows that a sound legal system is a fundamental guarantee for effectively preventing environmental risks, a well-established environmental risk management system ensures the efficient implementation of various measures, and the basic technological capability plays an important supporting role in preventing environmental risks.

2.1 A sound legal system is a fundamental guarantee for effectively preventing environmental risks

Foreign laws and regulations contained in the international experience report include the EU Industrial Emissions Directive (IED), EU Water Framework Directive (WFD), EU REACH, The EU Seveso Directives, EU Habitats Directive, US Superfund Act and OSPAR Convention. These directives and conventions are designed to provide at the international or national level a legal basis for any policy and behavior preventing and tackling acute and accumulated environmental risks.

For trans-boundary environmental risks of water, the experience from *the EU's Water Framework Directive* with respect to setting water environment quality and risk prevention goals and the implementation, supervision and evaluation of measures in all countries by using the river basin management planning could be useful for China to learn from.

For the prevention and control of environmental risks of chemicals, the *EU REACH* is deemed groundbreaking in a global context, placing the responsibility for the safe management of the risks of chemicals on the industry, and encouraging enterprises to apply risk reduction measures from an early stage of the life cycle of the substance concerned. The REACH also sets out common rules to handle environmental risks from the production, use and disposal of chemicals and of products containing hazardous substances.

For the prevention of risks from accidents in industry plants, an important lesson from the *EU Seveso Directives* is that the overall guideline on land use and emergency preparedness is important for preventing environmental risks. There should be environmental risk assessment, focus should be placed on the safety management system for whole establishments instead of technical units within an establishment, emphasis should be placed on the domino effect (one incident leading to another), and penalties imposed in the event of noncompliance.

The *EU Habitats Directive* could be useful for China to learn from as it imposes an ecological red line for preserving biodiversity on the basis of regional risk assessment and management in order to reduce ecological risks related to a decline in biodiversity and loss of species.

2.2 A well-established environmental risk management system ensures the efficient implementation of various measures

An environmental risk management system is a key for ensuring that relevant laws are adequately implemented and practically solving environmental risk problems. The US Superfund management system, EU and US climate-friendly air quality management system, the APELL system promoted by UNEP for use in developing countries, management experience from the EU chemical industry parks, and management experience from the Rhine River Basin give useful experience for different problems such as contaminated sites, air quality, pollution accidents, and river basin water quality management.

The US Superfund management system involves experience in the site assessment system and techniques, priorities, and assessment of financing modes for any clean-up action, especially the management strategy for large contaminated sites and complicated groundwater pollution control, which is useful for China to learn from. Useful experience from the EU and US with respect to a climate-friendly air quality management system mainly lies in the source control, market means, co-control, and encouraging enterprises to develop long-term plans. The APELL method aims to enhance the risk awareness in an industrialized community, making the enterprises, local governments and residents prepared for coordination, so as to reduce risks and mitigate damage. The experience from the EU chemical industrial parks shows that top priority should be given to the identification of managerial rules and responsibilities for safety and emergencies, and comprehensive (all round) risk management should be promoted to ensure that emergency preparation is fully implemented inside parks, and ensure a safe distance from the residential area.

Management experience from the Rhine River Basin that is useful for the management of river-basin-wide water environmental risks includes: performing risk investigation and assessment, identifying environmental risks at the sub-regional/provincial level and river basin level, including discharges and water use, identifying the key areas including the water sources; setting the environmental goals for waters based on the types and functions of waters; assessing the effect of current laws and measures, and determining the gap between the current measures and environmental goals. Moreover, useful experiences include identifying the measures to be implemented at the river basin level and sub-river basin levels in order to handle accumulated and acute risks, developing cost-effective measures and plans through analysis and exchanging ideas with main stakeholders, reaching a consensus, and establishing a collaboration mechanism; while keeping the process open and transparent, with all data available to the public.

2.3 The basic technological capability plays an important supporting role in preventing environmental risks

It took a long time to enact and implement the systems and tools such as the Industrial Emissions Directive, the Water Framework Directive, Integrated River Basin Management in the transnational Rhine River Basin, US superfund site risk management, and the Seveso Directives. The basic technological capability was highlighted and played an important role in risk identification, assessment and handling in different fields.

The Industrial Emissions Directive emphasizes the screening of available technologies, providing basic methods for regulating environmental risks from industrial sources on the basis of the Best Available Technology (BAT), focusing on the capability of emission permit management to guarantee “best practice (best method)”. The setting of management goals, cost benefit analysis as well as monitoring and warning methods involved in the Water Framework Directive and Rhine River Basin management are useful for China to learn from. The US Superfund site risk assessment techniques and the National Priorities List (NPL) system for contaminated sites, the methods for assessing environmental risks in enterprises presented in the Seveso Directives, as well as the methods for developing or preparing plans for responding to emergencies at local levels are highly useful for improving the environmental risk assessment and developing emergency plans in Chinese enterprises.

3. Lessons from the pilot application and test

The pilot application and test of the risk reduction framework is an important content of this project, and of great significance for building and improving the methodological framework at the national level. Four pilots, Jiangsu, Guizhou, Tongling and Anshun, were involved starting from the initial building of the framework. Experiences and lessons from pilot application, problem discussion, and advice feedback, experience in environmental risk assessment, data acquisition, risk management measures, and cost benefit analysis are useful for establishing efficient environmental risk prevention system in China.

3.1 Environmental risk assessment is a powerful tool for environmental management as well as environmental risk prevention and control

Since “environmental risk prevention” was included in the main tasks in China’s national 12th Five-year Plan for environmental protection, China has done a lot in the field of environmental risk assessment, including the formulation of the Guidelines on Environmental Risk Assessment of Enterprises (Tentative) which links environmental risk assessment of an enterprise to its environmental emergency plan, and the requirement in the Administrative Measures for Contingency Plan for Environmental Emergencies for corporate and regional environmental risk assessment. In the wake of the step-by-step progress of corporate environmental risk assessment and the reflection on the typical accidents in recent years such as the “Blast in Dalian on Jul. 7”, and “Blast in Tianjin on Aug.12”, research and administrative personnel have had an increasingly thorough awareness about environmental risks. In the pilot areas, it is also widely believed that the environmental risk assessment is an important tool for identifying environmental risk problems and effectively performing environmental risk prevention and control.

As a foundation of environmental risk management, environmental risk assessment has four functions: first, it provides *diagnosis*, that is, the assessment provides systematic analysis and identification of the type, distribution and degree of environmental risk; second, it provides *optimized decision making*, that is, the assessment offers advice on environmental risk prevention and control for decision makers to implement priority managements; third, it gives *guidance*, that is, the horizontal and vertical comparison of assessment results may guide the reduction of environmental risk level in high-risk areas; fourth, it provides *knowledge*, that is, the assessment may lead to improved awareness of environmental risks, environmental risk problems can be identified and the capability of environmental risk management can be improved through the assessment.

3.2 Data acquisition is the weakest part of the environmental risk assessment and management

In the 7-step regional environmental risk assessment method proposed by this project the method regarding the assessment of regional acute and accumulated environmental risks involves many kinds of assessment indicators, including the risk source, receptor,

exposure pathway, managerial capability, etc. Though the 7-step method explicitly has explained how and where to obtain the data, and how to handle the missing data, data acquisition was still the most prominent problem and difficulty reported from the pilot areas where regional environmental risk assessment was performed.

Existing data mainly involves the emissions of main pollutants as well as the quality of water and air. These data are clearly insufficient for the implementation of systematic environmental risk assessment and management. For many pollutants no monitoring data and environmental quality standards are available. For example, there's no soil environment quality data available. There are not sufficient data for production, use, storage and marketing of environmental risk substances. At the same time, existing data are relatively scattered, and not integrated effectively. Many data are scattered in different authorities, such as environmental protection, safety supervision, transportation, and health authorities. There's not enough data sharing among different authorities. In addition, in the pilot process it was found that local environmental protection authorities had no systematic and institutional procedures for management of relevant data, and no integrated application of data.

3.3 Not sufficient knowledge about the environmental risk prevention, control and emergency response measures

Building an evidence based system for environmental risk prevention, control and response measures is a basic goal and fundamental part of environmental risk management. How to present environmental risk prevention, control and response measures that meet the local reality by effectively using the assessment results was the focus of discussion in the pilot process. This part was described as very weak in the first draft of the initial pilot report.

At present, though high attention is paid to environmental risk prevention at the national and local levels, environmental risk prevention is not sufficiently understood in many areas. The understanding of environmental risk prevention, control and response measures usually focuses on a specific "hardware" or "software", with no systematic, comprehensive and hierarchical understanding. In the pilot areas, many of the staff did not know how to clearly list the possible environmental risk prevention, control and contingency measures. The measures set out in some reports were either incomplete or overlapping.

3.4 Fundamental research and increased application of cost-benefit analysis (CBA) is urgently needed

The "efficient" side of this project lies in solving environmental risk problems using measures with low cost and high benefit. The application of CBA method is one of the highlighted research topics in the project, and cases were devised to offer training in the pilot areas. Through methodology and case training, the concept, method and application level of CBA improved significantly in the pilot areas. But in the four pilot areas, the cost benefit part of the environmental risk management measures is not yet ideal. In most cases it was easier to estimate the cost or expense than to quantify or

monetize the benefit, which was largely described in qualitative terms. Even some costs were difficult to estimate and unrealistic estimates were not uncommon.

This is a widespread problem in the environmental risk management, and even in the environmental management at national level. Main reasons for this problem may include: first, the CBA method is not completely included in the government's environmental protection decision making system. In practice, the government tends to focus on the costs or on the direct investment. Most cost-benefit analyses are limited to the assessment of reduced pollutant emission or concentration, with no quantitative analysis of environmental (risk reduction) benefits; second, most cost-benefit analyses focus on analyzing or evaluating the cost and benefit of a single environmental measure such as environmental engineering or an abatement project, instead of analyzing the comprehensive cost and benefits of an environmental policy; there are no sufficient data and typical cases available for CBA. As a whole, it is hard to quantify the rationality, effectiveness and economics of the measures.

4. Main policy recommendations

4.1 Improve the laws and regulations system

4.1.1 Strengthen the legislation

As the revised Environmental Protection Law has come into effect, a legal system on environmental protection has been established in China. This includes the Environmental Protection Law, the Emergency Response Law, the Law on Prevention and Control of Atmospheric Pollution, the Law on Prevention and Control of Water Pollution, the Law on Prevention and Control of Environmental Pollution by Solid Waste, and the Law on Prevention and Control of Marine Pollution. Many of these laws have included the principle of environmental risk prevention. At present, however, there are no special legal provisions concerning the prevention, control, tackling and handling of environmental risks of major accidents, compensation for environmental damage, and prevention and control of soil pollution. Thus, there's not enough and powerful legal basis for local authorities and enterprises to do such kind of risk prevention and reduction work.

(1) Enact special laws and regulations concerning the prevention, control, response and handling of environmental risks of major accidents. These should be similar to the EU's Seveso directives, specifying and detailing the enterprises' environmental safety entity responsibility, streamlining the administrative supervision functions of safety, environmental protection, transportation, public security and other authorities and institutions involving work safety and environmental risks, establishing consistent and independent systems for safety supervision and environmental risk prevention, control, and response, and providing a powerful legal guarantee for forming consistent, rigorous and efficient systems of safety supervision and environmental risk prevention, control and response.

(2) Enact special laws and regulations concerning environmental management of chemicals. We should learn from the EU REACH, and base regulation on the source prevention and control before the occurrence of damage of chemical substances to the health and environment. We should regulate chemicals in their full life cycle from the R&D, production, import, marketing, export, use, disuse to final disposal, enact a series of supporting regulations on chemical substance registration, hazard identification, environmental risk assessment, release and transfer control, phase-out limitation, key environmental risk source management, and lifetime pollution accountability system.

(3) Enact a law for environmental damage compensation. Integrate ecological environment damage into the assessment and compensation of ecological destruction and environmental pollution; define the limit, entity and mode of compensation for ecological environment damage, and the like. We should improve the environmental prosecution system, and prescribe the litigation subject causing the personal or property damage, causality recognition, limit of compensation, responsibility sharing, and management of compensation in the tort liability law, civil procedure law, administrative procedure law, and relevant judicial interpretation. There should be

more channels for settling disputes of environmental damage compensation in order to safeguard the lawful rights and interests of the affected persons in good time.

(4) Introduce a law on soil environment protection. China should promulgate provisions on environmental administration of contaminated soil, develop regulations on environmental protection of arable soil, and control of environmental risks of soil on new construction land. When revising such laws and regulations as the law on prevention and control of water pollution; law on prevention and control of atmospheric pollution; and law on prevention and control of solid waste, provisions on soil environment protection should be added in order to consider the soil environment protection and the prevention and control of atmospheric and water pollution as a whole. Local laws and regulations on soil environment protection should be enacted, promulgated and implemented.

(5) Enact a law on ecological protection. China should include the ecological system management, natural resource development, and ecological compensation into laws, specify the objects, principle of ecological protection, as well as the subjects and objects of law enforcement in China. China should research and enact regulations on ecological red line protection, and boost the process of ecological red line legislation so as to solidify the position of ecological red line protection with laws and regulations.

4.1.2 Intensify law enforcement

Supervise law enforcement is an important part of environmental protection. Slack law enforcement and refraining from punishing the law-breakers have always been a difficulty for implementing the laws and regulations related to environmental protection, practically improving the environmental quality, and effectively preventing and controlling the environmental risks. The newly revised “toothy” Environmental Protection Law provides a powerful basis and tool for environmental law enforcement. For example, it includes language such as “seal up”, “detain”, and “penalty on a daily basis”. However, if one wants to fundamentally reverse the situation of slack law enforcement, it is necessary to intensify the implementation and supervision of existing laws, intensify joint law enforcement, and establish a long-term environmental protection supervision system.

(1) Strengthen the implementation and supervision of existing laws. We should strengthen the enforcement of existing laws and regulations, boost capacity building of environmental supervision law enforcement, improve the law enforcement officers’ service capability and comprehensive quality, strengthen the information disclosure, publicity and education, and enhance the public’s enthusiasm and effectiveness of participation in the supervision of law enforcement.

(2) Strengthen the unified and coordinated law enforcement. Build a proper regional environmental supervision network, coordinate the environmental law enforcement efforts between provinces and related municipalities, provide a consistent scale for environmental protection supervision law enforcement, establish a consistent system for handling administrative cases of environmental protection, standardize the environmental law enforcement procedures and instruments, strengthen the linked law enforcement by multiple authorities, establish a linkage mechanism for law

enforcement by multiple authorities, and create an efficient composite force of law enforcement by moving forward the gateway of environmental law enforcement.

(3) Establishing a sustainable environmental protection supervision system. Strictly carry out the Plans for Supervision of Environmental Protection (Tentative), detail and fix the key objects, key things, scheduling, organizational form and implementation measures of supervision, and use the supervision of environmental protection as a long-acting system tool for strictly fulfilling the responsibility of environmental protection subjects, improving the leaders' target responsibility check-up system, and investigating the leadership and regulatory responsibilities.

4.2 Improve the environmental governance system

4.2.1 Establish an environmental risk-based decision making system

So far, an environmental risk-based decision-making system has not yet been established in China and the environmental risk assessment has not been comprehensively and substantively incorporated into the planning process of significant strategies. In addition, the environmental management mechanism is segmented, making it hard to cope with a variety of environmental risks. Although the term "environmental risk prevention" was mentioned in the 12th 5-year economic and social development plan and in some development strategies, it is still in a relatively weak position compared with economic development. Actually, the major strategies and plans only contain a principal requirement to prevent environmental risk. There is still a lack of specific tools such as environmental risk assessment to use when determining how to implement such strategies and plans.

(1) Develop a national environmental risk protection strategy and roadmap. Relevant departments should conduct short-term, middle- and long-term environmental risk assessment and work out an effective environmental risk control roadmap during the modernization process of the State, especially the process of constructing an all-round well-off society, of new-style urbanization, of implementing the "one belt and one road" strategy, of achieving the integrated development of Beijing, Tianjin and Hebei, and of constructing Yangtze River economic zone, etc.

(2) Incorporate the environmental risk assessment and management into the decision-making process of governments at all levels. The environmental risks should be taken into account by authorities in making and implementing policies and departmental, regional and urban plans that might affect the human health or environmental quality or the integrity of the ecosystem. Relevant departments shall earnestly implement the Measures for Holding Party Leaders Accountable for Ecological/ Environmental Damages (trial), and establish sound supporting systems for implementing detailed rules prepared by party committees and governments at all levels and relevant functional departments of the State Council.

4.2.1.1 4.2.2 Unify the national environmental supervision systems and mechanisms

The decentralized ecological environmental monitoring system is contributing to the low efficiency of environmental risk prevention and control in China. The monitoring

and supervision departments in environmental protection, forestry, fishery, agriculture, marine and other industries, have function overlaps. Some fields are subject to management of multiple departments and some are subject to none. In addition, plans of different departments concerning spatial control and ecological/environmental protection are not well coordinated and integrated. It is urgent to unify the supervision and control by coordinating functions.

(1) Coordinate governmental functions. Authorities should coordinate functions of environmental protection in forestry, fishery, agriculture, marine and other industries in terms of pollution prevention and environmental protection. Efforts should be made to establish relevant environmental risk assessment systems, technical systems and national environmental risk pre-warning systems involving all elements and departments at all levels.

(2) Unify supervision system. Violators causing environmental pollution or ecological destruction should be subject to a unified supervision system, which integrates land and marine, air, water and soil protection in a coordinated way between different departments and regions. The environmental safety should also be included into the government performance evaluation mechanism.

(3) Promote multiple-plan coordination. Relevant departments should comprehensively assess the environmental risks, environmental risk control costs and benefits of integrated plans, identify the priority areas and dominant risks in environmental risk management and specify the red line of ecological conservation in such plans.

4.2.3 Improve environmental risk management means

At present, the environmental risk management in China is mainly conducted by following orders. The adoption of economic means in environmental management is still at an early and exploratory stage. First, there is a lack of legal basis for mandatory implementation. For example, to stress the pollution liability, the new Environmental Protection Law only encourages entities to buy the environmental pollution liability insurance; Second, the value of environmental resources has not been widely accepted by the existing economic system, and the environmental economic means are not well integrated into the existing corporate environmental liability system, which has hindered the adoption of financial means in environmental risk management.

(1) Speed up the construction of the environmental pollution liability insurance system. Authorities should clearly define the position of the environmental disruption liability insurance in laws and regulations, and force high risk industries to buy the insurance, and prepare a technical guide in classifying the enterprise environmental risks, determining the premium rate, assessing losses and setting the compensation standard, so as to provide technical support to the perfection and comprehensive implementation of the environmental risk liability insurance system.

(2) Establish a green financial system. Efforts should be made to speed up the construction of a green financial system in accordance with the Overall Ecological Civilization System Reform Plan, and based on the green credit interest subsidy

mechanism, green project guarantee mechanism and green securities, to guide enterprises to actively cope with environmental risks.

(3) Establish an environmental risk prevention and control fund. The central government should promote the establishment of an environmental risk prevention and control fund, including the environmental emergency response fund and the contaminated site remediation fund, and select key industries and regions to conduct pilot projects. A special fund management system should also be established and gradually improved.

4.2.4 Improve the corporate environmental liability system

Industrial enterprises in China generally have a low awareness of environmental liability. Their deliberate violation of laws is one of the main causes of environmental risks. Some enterprises purely pursue economic benefits; some are engaged in the production or processing of dangerous chemicals, with aged equipment, poor management and insufficient input in environmental protection. The environmental risk prevention and emergency management systems and facilities are either incomplete or formalistic, with huge environmental security loopholes. Moreover, there are no sufficient measures to guide and urge enterprises to fulfill their environmental liabilities either through markets or the information disclosure mechanism. In terms of environmental management, how to improve the law compliance of enterprises remains a long-term challenge.

(1) Improve the law compliance guarantee system. Relevant departments should sort out rights and obligations of enterprises, governments and the public in the whole process of environmental risk identification, assessment, pre-warning and emergency response, to provide a legal basis for all work to be carried out in environmental risk prevention and control. Laws and regulations governing the environmental criminal liability prosecution and civil compensation should be perfected to severely punish violators and fully embody the deterrent effect of law and to enhance the environmental risk prevention awareness and motivation of enterprises.

(2) Optimize administrative management. The concept of risk prevention should be effectively integrated into the existing environmental management system to improve such systems as environmental standards, environmental impact assessment and pollution discharge licensing system that aim to protect human health and the environment. Authorities should introduce a classified and hierarchical management system to enterprises, strengthen the supervision over high-risk enterprises and encourage capable enterprises to adopt higher level risk prevention standards and explore a certification system applicable to enterprises' environmental management system. A series of incentive and punishment policies concerning investment, credit, tax, land, market access and government procurement, among others, may be adopted by making full use of the policy and economic leverage, to encourage leading enterprises to actively establish an environmental risk liability system and to promote the construction of the third-party service market.

(3) Promote the environmental information disclosure of enterprises. Efforts should be made to earnestly implement the Measures for Environmental Information

Disclosure of Enterprises and Institutions that require enterprises to timely and accurately disclose relevant environmental information, encourage and guide the public to play their supervision role by reasonably and effectively participating in the environmental risk management and control of enterprises; develop and implement regulations that require enterprises to include the environmental risk information disclosure into their financial report required by China Securities Regulatory Commission. Through introducing the mandatory environmental risk information disclosure system, authorities can make the environmental risk management an important factor influencing the financing of listed enterprises, so as to turn the environmental risk management of such enterprises into their intrinsic, conscious and proactive behavior.

4.3 Strengthen the construction of systems and mechanisms

4.3.1 Improve the multi-level environmental risk assessment system

At present, subject to the economic and social development and natural resources, the environmental risks in China boast significant regional features. For example, areas around Bohai Sea and along Yangtze River have a high density of chemical enterprises, and thus are at high risk of chemical accidents. Hunan and Guangxi, among others, have long seen massive mining, processing and smelting of non-ferrous metals, and thus are at high risk of environmental pollution by heavy metals. A lot of work has been done in the area of environmental risk assessment, including the preparation of the Guide to Environmental Risk Assessment of Enterprises (draft) that links the environmental risk assessment with enterprises' environmental emergency plan. In the Measures for Coping with Environmental Emergencies, the environmental risk assessment by enterprises at the regional level are explicitly required.

However, the environment risk assessment by enterprises has not yet been fully carried out; not all high-risk enterprises are fully covered; the environmental risk assessment methods encountered some obstacles in actual application; relevant plans and policies lag behind the construction projects and the environmental risk assessment; the environmental risk assessment is not included in assessments already conducted, resulting in insufficient consideration given to environmental risks in the process of making big decisions; the current regulations concerning regional environmental risk assessment just play a disciplinary role; without mandatory regulations, the local governments are not fully activated and lack technical guidelines to conduct such assessment.

(1) Boost the environmental assessment by enterprises. Authorities should apply the classification and graded management mechanism to all the risk enterprises and improve the risk assessment methods. The environmental risk prevention and emergency response capabilities should be effectively incorporated into the environmental risk assessment system of enterprises to comprehensively and objectively reflect the level of environmental risks under the condition of effective prevention and control. Enterprises should be guided and encouraged to achieve higher goals while completing the environmental protection task in compliance with laws and regulations.

(2) Highlight environmental risk assessment in plans and policies. The environmental risk assessment and management should be included in policy-making of governments at all levels, and the Seven-step Framework proposed by this project could be used for environmental risk assessment and reduction decision-making at prefecture and province level based on county level data. During the process of making various plans and policies (concerning energy, industry, traffic and regional development), the State and relevant departments must consider the environmental risk assessment as an important factor, especially when the implementation of such plans or policies might affect vulnerable groups, to further safeguard human health and ecological safety and to promote the application of the cost-benefit analysis (CBA) and strategic environment assessment (SEA) methods.

(3) Accelerate the regional environmental risk assessment. Efforts should be made to boost the preparation of the regional environmental risk assessment norms. Authorities should set the environmental risk assessment as a prerequisite for compiling the regional environmental plans and emergency plans by combining the restrictive rules with guiding policies. Based on the Seven-step approach and other research outcomes, the technical guide to regional environmental risk assessment should be introduced as soon as possible. Regions with distinctive risk characteristics and geographical features should be selected to conduct pilot projects.

4.3.2 Improve the effectiveness of environmental risk prevention and emergency measures

Environmental risk prevention has just been advocated by the central government for a couple of years. Many local authorities are not fully aware of the concept, lacking a systematic, comprehensive and deep understanding of environmental risk prevention and control and emergency response measures. This was particularly true for the pilot provinces and cities, in which people generally did not know how to clearly list the potential environmental risk prevention and emergency response measures.

It is hard to quantify the rationality and effectiveness of environmental protection measures. There are fewer quantitative data about environmental benefits and fewer application cases. The cost-benefit analysis method has not been fully included in the governments' environmental protection investment and policy making framework. There are no guidelines for how to conduct such analyses, and the current research methods do not take into account issues like fairness and inequalities in risk exposures. In addition, the cost-benefit analyses of environmental policies are few. People mainly focus on the cost-benefit analyses or assessment of individual environmental projects, instead of environmental policies, which are far more extensive and complex, and thus are more worthy of cost-benefit analyses.

(1) Develop a guideline or technical guide for environmental risk prevention and control and emergency measures. Relevant departments should strengthen the study of effectiveness of environmental risk prevention and control and response measures, and systematically sort out relevant measures specified in laws and regulations, and figure out their purpose, function and effectiveness, as well as establish a system of classified and hierarchical measures. While issuing a guideline or technical guide to regulate the environmental risk prevention and control measures and emergency

responses of local governments and enterprises, the central government should guide them on how to take effective measures.

(2) Strengthen cost-benefit analysis of environmental risk prevention and control.

Relevant departments should strengthen the cost-benefit analyses, improve the understanding of and attach greater importance to such analyses. While improve the acknowledgement of the economic, social, biological and environmental benefits of environmental risk prevention and control, relevant departments should focus on environmental management, raise the awareness of relevant costs among environmental management and planning personnel, improve the economy and efficiency of government investments and invest limited resources in priority areas. A guideline should be developed for cost-benefit accounting in environmental risk management, including cost-benefit accounting in individual projects and the cost-benefit accounting in integrated projects, so as to develop and implement the environmental risk control measures in a more effective manner. Pilot projects should be conducted to explore relevant techniques and systems.

4.3.3 Speed up the establishment of the environmental damage assessment, compensation and accountability mechanisms

Although China has seen the rapid progress of the environmental damage assessment over the past few years and the central government has confirmed its position in laws and regulations and pointed out the direction, the construction of the whole system has just started. The technical system is incomplete; the number, capacity and quality of assessment agencies are inadequate, and relevant supporting systems need to be further improved. The environmental damage compensation system is lagging behind, without clear compensation contents, form and procedures. In addition, the accountability mechanisms of governments and enterprises are defective.

(1) Improve the environmental damage assessment system. Relevant departments should earnestly implement the Environmental Protection Law and improve the environmental damage assessment system, as well as perfect the environmental damage assessment technical system. Efforts should also be made to establish a supporting environmental damage forensic assessment system to promote the standardized assessments and specify the capital source; establish a special fund for this purpose, and include the environmental damage assessment costs during law enforcement and in criminal cases into the government budget.

(2) Promote the environmental damage compensation system. New means, such as financial, monetary and taxation means should be exploited to facilitate the diversification of modes of assuming the environmental damage compensation liability. Pilot projects shall be conducted locally to initially form a compensation system oriented towards pollution remediation and ecological restoration.

(3) Improve the accountability mechanism. The legal, economic, technical and administrative means may be combined to further specify and effectively cause enterprises to fulfill their liability in environmental safety and regulate their environmental safety behaviors. The planning, project approval, regulatory responsibilities, among others, involved in the environmental risk management should

be expressly specified, and functions of all departments involved in environmental risk prevention and control, including the environmental protection, security, transportation, public safety and environmental impact assessment, pollution prevention, environmental monitoring, environmental supervision and environmental emergency departments, should be straightened out. Relevant departments should regulate the contents of environmental damages to human body, properties or ecological value and relevant procedures, establish and improve the ecological environmental damage lifelong accountability system, and strictly implement the ecological environment damage compensation system.

4.3.4 Improve the chemical-induced environmental risk management and control system

Large amounts of chemicals are produced, transported, stored and used in China. Different participants have different technological levels. Some enterprises have rather backward technology, and many chemical transportation routes are located in residential areas or environmentally sensitive areas such as upstream of water intake. Other problems are: the chemical supervision system is defective; the supporting standards or norms are incomplete; a full life cycle management system is not yet established; and the chemical priority control and inventory management lags behind.

(1) Establish a sound priority control and chemical inventory system. Based on the environmental and health risk assessment of toxic and harmful chemical substances, relevant departments should generate a list of chemicals that should be restricted and eliminated, and strictly follow the list of substances that are restricted in production, distribution and consumption as well as the regulatory requirements.

(2) Establish a full life cycle management system for chemicals. Efforts should be made to accelerate the establishment of the hazardous chemical management system including environmental risk assessment, registration, release and transfer report system and labeling, to establish and improve measures to monitor chemicals and their particular pollutants under key environmental supervision, to enhance the capability of environmental protection departments at all levels in monitoring particular chemical pollutants and to perfect the management system.

(3) Establish a toxic and hazardous substance release inventory system. The inventory should be established based on data reported by enterprises and by using the monitoring, statistical systems of environmental protection, safety supervision, transport and other relevant departments, and should also be disclosed to the public, which can provide a base for deciding the toxic and hazardous substance environmental risk prevention and control measures and emergency responses.

4.4 Enhance data collection, application and dissemination supporting capacity

4.4.1 Improve the environmental risk monitoring, statistics and data application management systems

Through the development over the past decades, China has established relatively sound environmental monitoring, supervision and statistical systems. The quantity, coverage and quality of environmental data have greatly improved, enabling the environmental management to be conducted in a more effective and scientific manner. However, compared with traditional concepts and methods of environmental management, the risk prevention-based environmental management requires more data and data with higher quality. The existing data are unable to support the environmental risk assessment and management in a comprehensive and efficient manner.

The existing data available for environmental risk assessment and management in China cannot meet the requirements either in term of “quantity” or “quality”. The existing data are mainly about the discharge of major pollutants and the quality of water and air. Monitoring data about many pollutants and environmental quality are unavailable, including data about the quality of soil environment, and data about the production, usage, storage and distribution of substances imposing environmental risks. This problem was prominent in pilot provinces and cities in the process of conducting environmental risk assessment. Moreover, the existing data are separated and not well organized. Many data are held by different departments, such as the environmental protection, safety, transport and health departments, and are not sufficiently shared. In addition, the quality of such data is low or difficult to assess. The quality of some environmental monitoring data is questioned or cannot be verified.

(1) Build a national integrated environmental monitoring network. Relevant environmental monitoring stations should be integrated, and data from different departments and different regions, including the environmental protection, safety, transport, health, land and marine departments, should be shared. To achieve this, a unified national environmental risk database (platform) should be established to enhance the data utilization efficiency. The environmental monitoring in key regions and key drainage basins, such as Beijing, Tianjin and Hebei, Yangtze River Delta and Pearl River Delta should be subject to unified planning, management, standard and disclosure. A new environmental monitoring pattern featuring three-dimensional environmental perception, synergic and high-efficient management and integrated internal and external services should be built by making full use of new-generation information technology, such as mega data, cloud computing, Internet of Things and mobile Internet and by resorting to the instrumented, interconnected and intelligent means. The key area environmental quality management agency should be established.

(2) Enhance the environmental risk monitoring and statistical capacity. While expanding the coverage of the general survey, ad hoc survey and on-line monitoring conducted by the central government and relevant departments should speed up the construction of the monitoring and statistical systems for particular pollutants with distinctive features of local environmental risks, establish an environmental risk prevention and control database and include it into the ecological civilization database,

and press ahead with the research of methods and parameters concerning local health and ecological risks.

(3) Strengthen information disclosure. Relevant departments should strengthen the information disclosure and effectively include the environmental risk information into the process of preparation and revision of the environmental information disclosure system in accordance with the requirements of “establishing a sound environmental information disclosure system” in the “basic systems for reform of environmental governance” in the Recommendations for the 13th Five-Year Plan for Economic and Social Development issued by the Central Committee of CPC.

4.4.2 Establish sound environmental risk forecasting and pre-warning systems

The current descriptions of the environment are mainly about the overall emission reduction and environmental quality, which is unable to fully and effectively reflect environmental risks. Environmental risk forecasting and pre-warning systems at the national level and targeting key fields and key regions are unavailable, resulting in the lack of pertinence and initiatives in environmental risk prevention and control. People are very passive in the face of high-frequent environmental emergencies. In addition, the systems for monitoring, guiding and addressing public opinions are defective, easily causing an environmental accident to evolve into a mass incident.

(1) Conduct the national overall environmental risk assessment. Based on environmental risk monitoring and statistical management systems, and the Seven-step Framework suggested here, establish an assessment indicator framework, conduct overall environmental risk assessment to comprehensively and objectively reflect the risk profile and conduct priority management in accordance with the type, distribution and extent of environmental risks.

(2) Establish environmental risk pre-warning systems for key fields and key regions. Efforts should be made to speed up the establishment of the environmental risk forecasting and pre-warning systems targeting drinking water sources, heavily polluted water, trans-boundary rivers and basins, to accurately forecast heavy pollution days, pollution exposure, industrial accidents, transportation accidents and other pollution risks.

(3) Strengthen monitoring of public opinions. Relevant departments should assess and forecast major social risks following from environmental risks, to provide a basis for timely and scientifically coping with risks threatening environmental safety.

4.4.3 Comprehensively enhance the integrated support for coping with environmental emergencies

Although a lot of work has been done since the “11th Five-Year Plan”, under the severe situation where environmental emergencies keep popping up, the emergency rescue supplies are inadequate, and equipment is outdated. It is urgent to improve the integrated support for coping with environmental emergencies.

(1) Build an environmental emergency response team. Efforts should be made to quicken up the construction of environmental emergency management agencies, and fully play the role of six major supervision centers in environmental emergency management, speed up the building of social rescue force and set up an environmental emergency expert team.

(2) Strengthen emergency response material and equipment support. Rapid pollutant sampling, monitoring and analysis equipment should be developed to cope with environmental emergencies. Emergency supplies should be increased through various channels, and the sound emergency supplies monitoring network, pre-warning system and the production, storage, allocation and distribution systems should also be established.

(3) Improve standards and norms concerning the risk prevention facilities and emergency material reserves. Relevant departments should carefully study the existing standards and norms to identify the blank area, and formulate standards, norms and guides concerning the environmental risk prevention facilities and emergency material reserves of governments, enterprises and industrial parks.

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