Case Exercises: Using CBA and SEA to Reduce Environmental Risk in China

案例练习：运用成本效益分析（CBA）和战略环境评价（SEA）法降低中国面临的环境风险

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Preface / 序言

These case studies were developed as part of the Sino-Norwegian project "Planning for Cost-effective Environmental Risk Reduction in China". The Ministry of Environmental Protection, P.R. of China and the Norwegian Ministry of Foreign Affairs via the Norwegian Embassy in Beijing jointly finance the project. The project is carried out over the period 2012-2016 by a Norwegian consortium consisting of Vista Analysis and CICERO (Center for International Climate and Environmental Research in Oslo), in cooperation with the Chinese Academy for Environmental Planning (CAEP) of the Ministry of Environmental Protection (MEP).

本报告中的案例研究是根据中国和挪威合作开展的《构建高效的环境风险防范规划体系》项目的组成部分，。该项目由中华人民共和国环境保护部和挪威外交部（通过挪威驻北京大使馆）共同资助。项目在2012-2016年间开展，由挪威的两家研究机构远景分析（Vista Analysis）和奥斯陆国际气候和环境研究中心（CICERO）组成的联合体与中国环境保护部下属的中国环境规划院（CAEP）合作完成。

As part of the project, the case exercises in this report have been developed for use in workshop trainings with staff from Environmental Protection Bureaus from the project's pilot provinces (Jiangsu, Guizhou) and pilot cities (Tongling in Anhui province and Anshun in Guizhou province), as well as representatives of relevant departments in MEP and CAEP.

本报告中的案例练习练习是项目的组成部分，用于对项目试点省份（江苏省和贵州省）和试点城市（安徽省铜陵市和贵州省安顺市）的环保局工作人员，以及国家环保部和中国环境规划院的相关部门代表进行培训。

An account of the theoretical basis and methodological procedures for SEA and CBA can be found in the Chinese book "Application of SEA and CBA methodologies in environmental planning" (Zhao et al. (2010), China Environmental Science Press), which has been published as part of the first phase of this project. The book is a condensed version of the thorough account of methodological procedures in the English report "Guidebook in using cost benefit analysis and strategic environmental assessment for environmental planning in China" (Econ Report 2011-023). All project material is available at the website http://www.vista-analyse.no/en/projects/planning-for-cost-effective-environmental-risk-reduction-in-china/

关于战略环境评价和成本效益分析运用的理论基础和方法程序，可参考中国出版的《战略环评和成本效益分析方法在环境规划中的应用》（赵学涛等著，中国环境科学出版社2010年出版），该书在本项目第一阶段出版，是英文报告《运用成本效益分析和战略环评进行中国环境规划指导手册》（经济报告 2011-023）提出的整个方法程序的精简版。如需获得与项目有关的所有材料，请访问网站：http://www.vista-analyse.no/en/projects/planning-for-cost-effective-environmental-risk-reduction-in-china/

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1. Introduction / 前言

This report contains two cases with exercises on how to use Cost-Benefit Analysis (CBA) and Strategic Environmental Assessment (SEA) to reduce environmental risk in China. Each fictitious case is followed by a list of questions and a section providing the suggested answers to the questions (for some cases, there are several possible answers). The cases have been designed so that it should be possible for a group to read, discuss and answer the questions of one case in writing (e.g. power point presentation) within a time period of 3 hours. In addition, there should be 2-3 hours for presentation and discussion of the answers, depending on the size of the class (the more groups, the more time needed).

本报告包含两个案例练习，旨在说明如何运用成本效益分析（CBA）和战略环境评价（SEA）来降低中国面临的环境风险。这两个案例是虚构的，每一个案例后都附有问题列表以及提供建议的问题答案（某些情况下，有多种可能的答案）的环节。案例的设计模式让小组成员可以进行阅读、讨论，并根据培训人员数量（小组越多则所需要的时间也越多）在 2-3 个小时内书面形式（如幻灯片演示）回答案例所列出的问题。此外，还应该预留问题演示和讨论时间。

The cases are fictitious but designed to match a stylized Chinese context and provide a platform for discussions of typical SEA and CBA issues and executing SEA and CBA analyses. All numbers are fictitious and provided for the sake of the exercise. In some cases, scientific background articles are referred to, as is explained in chapter 2.3. As in real life, not all relevant information is always available.

这两个案例虽然是虚拟的，但是它们却假设是在典型的中国背景下发生的，而且案例提供了讨论典型的 SEA 和 CBA 问题并执行 SEA 和 CBA 分析的平台。所有的数字都是虚构的，仅用于练习目的。某些案例中涉及到了一些科学背景知识，具体在 2.3 章中阐述。但在现实中，并非都能够获取所有的相关信息。

The cases have been developed with government planners at city, provincial and central levels in mind. There are no particular prerequisites, but in general terms the level presupposes at least bachelor level knowledge in environmental science or related subjects such as environmental economics. Basic knowledge of and access to Microsoft Office or equivalent software is beneficial to support analysis and presentation.

案例开发默认的适用对象是市级、省级和国家级的环境规划人员。案例不需要特别的先决条件，但是一般来说需要人员具有环境科学或相关专业（如环境经济学）本科以上的知识水平。掌握并能使用微软 Office 软件或同类软件有助于进行分析和演示。

1.1 How to use the case exercises in a training session
如何在培训课上使用案例练习

When using and developing this material in the workshops, we suggest using modern pedagogical principles to foster learning and integration of skills among participants. While it is possible for the reader to study the cases and answer the questions alone, the learning effects may be better harvested through group-discussions facilitated by an experienced SEA and/or CBA practitioner. *Please note that the task of the facilitator is not to provide the correct*

answers to the questions, but rather to guide the discussions by providing clarifications and asking appropriate questions.

在培训课上使用案例练习材料的时候，我们建议运用教育学原理来促进受训学员学习并掌握相关技能。尽管学员可以独自学习案例并回答问题，然而在富有经验的 SEA 和/或 CBA 培训师指导下进行小组讨论，这样取得的学习效果可能更好。请注意培训师要做的不是提供正确的问题答案，而是提出合适的问题并进行阐释，从而对小组讨论进行指导。

When conducting the training exercise, all participants should have nametags indicating name and position. This will make direct communication between participants easier. Nametags should be in English and Chinese, if there are non-Chinese participants. The participants should be divided in working groups, mixing participants so that participants from different regions and cities are put together and can learn from each other in the process. The recommended size of a group is 5-6 people.

开展培训练习时，所有参与者应有标明其姓名和位置的名牌。这使参与者直接沟通起来更加容易。若存在非中国人参与者，名牌应用中英文两种语言书写。来自不同地区的参与者应混合起来，分成几个小组，以使来自不同地区和城市的参与者一起培训，并在过程中相互学习。各组建议人数为 5 至 6 人。

The exact time it takes to carry out a training session will depend on several circumstances: The number of participants in the training, the number of working groups, the degree to which translation services is needed, the discipline of the participants, and the ability of the facilitator to control time. It is important that the facilitator guides the process to capture high-value work and discussions, and cut short less constructive work and discussions. The responsibility for time keeping lies with the facilitator, and the facilitator should adapt the process as he/she sees fit at each session. Note that some of the questions in the cases are “easy” and should be handled quickly, while others are “difficult”, require more time, and involve options that should be discussed.

一个培训课所需的确切时间依以下情况而定：培训参与者数量、小组数量、对翻译服务的需要程度、参与者纪律性以及培训师对于建设性的工作和讨论的掌控能力。培训师负责计时，视各个培训项目所需对培训过程进行调整。需要注意到是，对于案例中一些问题比较“简单”的问题，应迅速处理；对于其他比较“困难”的问题，需要更多时间并讨论更多选项。

Each case exercise may be the subject of a full day training session, especially if the participant group includes more than 18 people (3 groups) and there is some need for translation services. This would give time for presentation of the case and work in groups before lunch, and presentation of answers and discussion after lunch.

每个案例练习可以安排一天时间练习，尤其是当参与人数超过 18 人（3 组），且需要翻译服务的时候。可以安排上午组案例演示和下午讨论和答案演示。

It is also possible to carry out each exercise in shorter time, for instance 4 hours, if the group is not too big. This requires good preparations and strict time keeping by the facilitator, as well conscious adaptation of the process according to the needs of the group. When using an English-speaking facilitator time for translation must be kept low, for instance by having prepared bilingual material in advance. The number of questions for each case should also be

reduced slightly, with a focus on the core issues, and presentations should be short. Such a session could be carried out with presentation and group work in the first session (for instance 8.30-10.45), and presentation and discussion after a break (for instance 11.00-13.00).

如果参与组人数不是很多的话，各案例也有可能在更短的时间内完成，比如四小时。这需要良好的展示、培训师严格的计时，及根据各组需要特意对培训过程做出的调整。若培训师以英语授课，则翻译的时间须尽量短，例如，可以提前准备双语资料。各案例需要的问题梳理应略微减少，更注重核心问题，且演示的时间应该尽量短一些。课程可以这样安排：第一节课（例如：8.30-10.45）完成演示和组内工作，休息后（例如：11.00-13.00）完成演示和讨论。

Note that the largest learning potential lies in the group discussion session and it is important to set aside time for discussions. Training experience shows that too much time should not be set aside for group work. It is better for the group to have relatively short time and be forced to work effectively, than for the group to have a comfortable amount of time. It is important to "force" the group to make decisions on how to solve the questions, even if relevant issues can be discussed further. In addition, in real life there is often not enough time to explore issues to the extent one would wish to, before recommendations or decisions are made. A general rule of thumb may be that at least the same time should be set aside for discussions and calculations, as is set aside for group work.

要注意的是，小组讨论是很好的学习机会，有必要留出足够的时间进行小组讨论。但培训经验也表明，不应为组内工作留出过多时间，而应该给小组适当的时间，以迫使他们以更高的效率工作，这样远比给小组太多的时间效果好得多。“强迫”小组在如何解决问题上做决策很重要，尽管相关问题还可以进一步讨论。在实际生活中，在给建议或做决定前通常没有足够时间就问题进行足够长时间的探索。一条通用的经验法则可能是，至少要留出与组内工作同样长的时间进行组间讨论和计算。

The following table is an example of how a training session for either SEA or CBA may be conducted, including indicative timing for the different phases and the different responsibilities of the facilitator and the participants.

下表具体给出了 SEA 或 CBA 培训课程是如何具体开展的，包括不同阶段的时间安排以及培训师和学员的不同职责。

Table 1.1: Case exercise manual / 表 1.1：案例练习指南

Phase 阶段	Time 时间	Role of facilitator 培训师职责	Role of participants 学员职责
0. Ahead of training session 课程开设前	-	Disseminate the case study and Methodological foundations earlier in written form to the participants 以书面形式提前向学员散发案例研究和涉及的基础性方法	Read through the case as well as the relevant theoretical and methodological foundations. 浏览案例以及相关的理论和基础性方法
1. Introduction 介绍	15-20 min. / 30-40 min. 15-20分钟或者30-40分钟 Please note that if translation is required, the time required is higher: 30-40 min. 请注意，如果需要翻译，课程时间将会增加为30-40分钟。	Go briefly through the theory as well as the case in question. Then go through the plan and timing of the rest of the training session. Check with the audience whether anything is unclear. 简要介绍理论以及讨论中的案例，然后进行剩余课程部分的设计和时间安排。询问学员有无不明之处。 After the presentation, divide the participants in groups with – ideally – a minimum of 4 and a maximum of 8 participants in each. It is normally beneficial if each group consists of people with a variety of backgrounds and competences in order to create the most fruitful discussions. 演示过后，对学员进行分组，理想情况是，每组不少于4人，不超过8人。最好如果每组都分配有知识面广且能力强的学员，这样讨论的效果会最大化。	Pay attention and take notes. 注意听讲，做好记录。
2. Group discussions 小组讨论	2 hours 2小时	Encourage the participants to apply their own relevant experience and to be conscious and explicit about why they develop their answers in the way they do. 鼓励学员结合自己的相关经验，有意识地谈谈自己为什么坚持自己的答案。 Remember that the training is about participants learning how to apply a working method in a consistent manner according to context and available information incl. experience. 谨记培训的目的是让学员学会如何根据背景和可用的包括经验在内的信息，始终如一地运用操作方法。	Each group sits together, discusses the case, and make their own solutions to the questions and tasks listed following the case. 各小组围坐在一起针对案例进行讨论，并针对案例后列出的问题和任务提出各自的解决方案。 Each group prepares a power point presentation with their answers and solutions. 各小组准备一份幻灯片，演示自己的答案和解决方案。

		Provide coaching during the workshop: When groups are allowed to work independently it is important to check on them and help them along if they have problems or are being side-tracked by discussions that are not relevant. The facilitator should circulate among all groups. 提供课堂培训辅导： 小组独立讨论时，有必要对其进行检查督导，发现他们遇到问题或者进行不相关的讨论要及时提供帮助。培训师应当在各小组之间来回巡视走动。	Although not required, creating an excel model may be necessary to ease the calculations. 尽管没做要求，有必要创建一个Excel模板来简化计算。
3. Break 休息	15 minutes 15分钟		
4. Presentation of answers and discussions 演示和简短讨论	Total: 2-3 hours. Ca. 30 min. per question (shorter if the questions are "easy"). 总时间：2-3小时 每个问题30分钟（若问题"简单"，时间缩短。） For each question: Step 1. The first group have 5 minutes to present the answer to the first question. 针对每个问题，清除土壤第一组有5分钟演示第一个问题的答案。 (The second group have 5 minutes to present the answer to the second question, and so on…) （第二组有5分钟演示第二个问题的答案等…） Step 2. The other groups comment (10 minutes) if they have answered differently and why. 处理设施其他组若有不同答案及原因可发表评论（10分钟） Step 3. The facilitator presents the suggested answer (5 minutes). 植树培训师演示参考答案（5分钟） 4. Discussion (10 minutes). 小组讨论（10分钟）	Ask clarifying questions to the presenting group if needed. 如有必要，向做演示的组提出阐述问题并主导讨论环节。 Keep strict control of time. 严格控制时间。 Present the suggested answer in a short and concise manner. 简明扼要地演示参考答案。 Facilitate the discussion and keep control of the time 促进讨论，控制时间。	Each group presents their answer on a power point presentation to the plenary, being short and concise. 各小组面向全体人员用幻灯片做答案演示，须简明扼要。接着回答其它小组的提问并进行讨论。 Other groups comment if they have a different answer. 其他组若有不同答案可发表评论。 Close attention is paid to the suggested answer by the facilitator. 培训师须密切注意参考答案。 Active participation in group discussion about which answer is best and why. 积极讨论何种答案最佳及其原因。

2. CBA case exercise: Cost-effective environmental risk reduction of a contaminated site

成本效益分析案例练习：如何高效降低污染 地的环境风险

A Cost Benefit Analysis (CBA) is a systematic method for comparing advantages/benefits of an action to disadvantages/costs. In this CBA case exercise, we discuss actions in the form of environmental investments. The advantage/benefit of an environmental investment consists of the environmental improvement that the investment brings. The disadvantage/cost consists of the investment cost and operation & maintenance cost, as well as other disadvantages that the investment may bring.

成本效益分析指对某一措施的优缺点进行系统比较。在本次的案例分析中，陈本效益分析的主体是具体的改善环境的行为。改善环境的行为的优点包括该行为所带来的环境改善。缺点或者是成本则是该行为所附加的运营成本以及其它的负面效应。

In order to compare benefit to cost we will in the CBA estimate, to the extent possible, the monetary value of benefits. This means answering the question of how an environmental improvement affects us as human beings, and estimating the value of the improvement. Fortunately, there is a large body of research to build on when answering this question. In addition to the environmental benefit, there are often simple economic benefits in the form of cost savings and income to include in a CBA.

为了量化优缺点，我们在成本效益分析里主要采用金钱量化的方法。也就是环境改善如何影响人类，并估算这些影响的大小。当前有很多针对量化的研究方法。除了环境改善之外，成本效益分析通常会考虑到附加的经济效益（比如开源节流了多少）。

Further guidance in the use of CBA for environmental purposes is available in the publication (in Chinese) by Zhao Xuetao et al. (2012): ”Application of SEA and CBA methodologies in environmental planning”, China Environmental Science Press.

环境方面的成本效益分析在赵学涛的一篇文章中有所阐述（《战略环评和费用效益分析方法在环境规划中的应用》）。

2.1 The fictitious case of the Madan industry site
马丹工业场地案例

2.1.1 Introduction to Madan, in Pingzhou
引言

The Madan industry site is an abandoned industry site in the city of Pingzhou. The city has a population of 15 million, increasing by 5 percent annually. The main industries at the site used to be metal manufacturing, chemical manufacturing, papermaking and food processing. All

industries are closed down, but the buildings and production equipment remain and the site looks like a "ghost area". The value of industrial output in 2010, the last year of operation, was estimated at RMB 400 million.

马丹工业场地是平州市的一片废弃的工业场地。平州市有1500万人口，每年人口增长5%。马丹工业场地过去的主要产业有金属制造业、化学制造业、造纸业和食品加工业。目前所有产业均已关停，但是厂房和生产设备保留了下来，因而该地区看似一座"鬼城"。该地区2010年（运营的最后一年）的工业产值估计约4亿元人民币。

Samples of soil from the site show that it is polluted with heavy metals and other toxic substances, causing high levels of accumulated environmental risk and making the site impossible to use for other purposes. The site lies in an attractive area at the outskirts of Pingzhou. Recently there have also been discovered leakages of polluted water from the site into the Luho River, as well as other streams and small rivers in the area. According to the Environmental Protection Agency, the total discharges of untreated wastewater from the site are 271,700 m^3/year. In a report from 2012, the Pingzhou Environmental Monitoring Bureau estimated that as much as 45-55% of the discharges of untreated wastewater in Pingzhou came from the Madan industry site. In addition to the leakages from the Madan industry site, there has been an increase in both point source and non-point source pollution risk in Pingzhou: Farmers have attempted to increase yields through widespread fertilizer use (nonpoint source), and manufacturing firms have dumped inorganic compounds into the water as part of their production processes.

马丹工业场地提取的土壤样本分析表明，该地的土壤受到重金属和其它有毒物质的污染，引起累积性环境风险升高，场地不能作为建筑用地。该工业场地地处平州市郊区一片风景秀丽的地方。近年来不断发现有污水从马丹工业场地渗入卢霍河，以及本地的其它几条溪流和小河。环保机构的研究表明，马丹工业场地的未处理废水排放总量高达每年271,700 m^3 。平州市环境监测局2012年发布的一份报告估计平州全市未经处理的废水总量的45-55%来自马丹工业场地。除了马丹工业场地的污水泄漏之外，平州市点源污染和面源污染的风险均在增加：农民们通过广泛使用化肥（面源污染）来提高产量；而制造企业则在生产过程中向水中倾倒大量无机化合物。

2.1.2 Significant environmental risk to health and depletion of groundwater
健康风险和地下水耗尽的重大环境风险

Pingzhou is facing serious depletion of groundwater resources and severe risk of polluting the surface water due to insufficient infrastructure available to accommodate the rapidly increasing amounts of industrial effluent. The river courses in the city have turned black and emit an unpleasant smell. Data from 2012 show that 58% of the monitored river sections in Pingzhou failed to meet grade V, whereas 75% failed to meet grade IV. In other words, 75% of the monitored river sections in Pingzhou are in the nonfunctional water classification categories V and VI. Data on average water grade in various parts of Pingzhou are given in Table 2.1.

由于缺乏足够的基础设施来处理迅速增加的工业废水，平州市面临地下水耗尽和地表水污染风险加大的严重问题。市内河道已经变黑，臭气熏天。2012年的监测数据表明平州市58%的被监测河段未能达到五类水质标准；而75%的河段达不到四类水质标准。也就是说，平州市75%的被监测河段属于五类甚至劣五类水质。平州市不同河流平均水质

分类情况见表2.1。

Direct and indirect health costs due to leakages from the Madan site are currently unknown, but there are concerns that they may be high. Pingzhou hospitals report that the number of digestive cancer fatalities have been increasing steadily the last 10-15 years. There have been several public complaints about the deterioration of surface water bodies in Pingzhou in recent years. Some data from the Disease Surveillance Point in Pingzhou are shown in table 2.1.

马丹工业场地导致的废水泄漏带来的直接和间接健康影响目前虽然无法得知，不过健康影响可能很高。平州市各大医院报告指出，过去10-15年来，本市消化道癌症的死亡人数一直在增长。近年来，平州市出现几起由地表水体污染引起的群体性事件。来自平州市疾病监测点的部分监测数据见表2.1。

Whereas the population in the inner city districts of Pingzhou (totally 2.5 million people) has access to tap water that has been comprehensively treated, there are many people in the towns and rural areas of Pingzhou who use water that has undergone only limited treatment or depend on local wells for drinking water. The poorer segments of the rural population mostly rely on surface water from rivers or lakes as their main source of drinking water, but quantitative data are scarce.

尽管平州市市辖区人口（共250万）可以饮用充分净化的自来水，该市尚有为数众多的乡镇和农村人口只能饮用经过简单处理的水，或者只能依靠当地水井作为饮用水源。更为贫困的农村人口则主要依赖河流或湖泊的地表水作为其主要的饮用水来源，不过缺乏这方面的定量数据。

Table 2.1: Population (million), age-adjusted death rates for digestive cancers, surface water quality, and tap water access in Pingzhou (2012)

表 2.1 平州市 2012 年人口消化道癌症死亡率、地表水质量和自来水普及情况

	Population (Men) 人口（男性）（百万）	Population (Women) 人口（女性）（百万）	Digestive cancer rate (per 100.000) Men 消化道癌症死亡率（每10万人）男性	Digestive cancer rate (per 100.000) Women 消化道癌症死亡率（每10万人）女性	Average water grade surface water 地表水平均等级	Share of population using tap water饮用自来水人口比例（%）
Inner city districts 市辖区	1.25	1.25	79	38	4.9	99
Towns 城镇	2.6	2.4	83	41	5.1	89
Townships 乡镇	1.6	1.6	105	45	5.8	63
Rural pop. (villages) 农村人口（村庄）	2.25	2.25	95	49	5.5	8
Total 总计	7.7	7.5	90 (average) 平均	44 (average) 平均	5.3 (average) 平均	61 (average) 平均

By using data on pollution across China's river basins and cancer rates, a study by Ebenstein (2012) found that a deterioration of water quality by a single grade (on a six-grade scale) increases the digestive cancer death rate by 9.7%. The analysis rules out other potential explanations such as smoking rates, dietary patterns, and air pollution. Generally, higher digestive cancer rates were observed in northern areas with lower rainfall. Overall, digestive cancers represent nearly two-thirds of all cancers. According to the study, the largest effect of water quality on digestive cancer rates is observed in areas where households are less likely to have access to tap water (which can be treated), consistent with the author's hypothesis that the rural cancer epidemic is in part due to a lack of safe drinking water. In fact it was estimated that a one-unit increase in water grade is associated with a 13.1 percentage point increase in areas without tap water, but only a 3.3 percentage point increase in areas with tap water.

Table 2.2 Data from Ebenstein (2012) on the health benefit of better surface water quality

Data from Ebenstein (2012) on the health benefit of better surface water quality	
Percent reduction in digestive cancer when surface water quality improves 1 grade, population with access to tap water	3.3%
Percent reduction in digestive cancer when surface water quality improves 1 grade, population without access to tap water	13.1%
Improvement in surface water quality (six grade scale) when discharge goes down 10%	0.022
Value of statistical life	3,000,000 RMB
Value of life years lost, per year	9,375 RMB
Average number of years lost per case of digestive cancer death	20

表 2.2 地表水质提升带来的人体健康效益（数据来自于 Ebenstein (2012)）

地表水质提升带来的人体健康效益	
当地表水质等级提高一级时，饮用自来水人群中消化道癌症的降低百分数	3.3%
当地表水质等级提高一级时，非饮用自来水人群中消化道癌症的降低百分数	13.1%
排放降低1-%所带来的地表水质改善（分六个级别）	0.022
统计生命价值	3,000,000 RMB
减寿价值	9,375 RMB
每例消化系统癌症死亡所减少的寿命	20

按照中国河流流域污染和癌症发生率有关的数据，爱本斯坦 2012 年开展的一项研究表明水质每恶化一级（一共有六级），消化道癌症的死亡率就增加 9.7%。这项分析排除了其它可能的解释，比如吸烟率、饮食类型，以及空气污染。一般来讲，干燥少雨的北方地区消化道癌症的发生率更高。总体来说，消化道癌症占所有癌症类型的将近三分之二。根据此项研究，在居民无法饮用自来水（可被处理净化）的地区，水质对消化道癌症死亡率的影响最明显，这一点与案例的假设是一致的，即农村癌症的蔓延与农村缺乏安全的饮用水有一定关系。事实上有人曾估计，地表水水质每增加一个等级，无自来水供应地区的癌症发生率就增加 13.1%；而在有自来水供应的地区，增加率仅为 3.3%。

According to Ebenstein (2012) each digestive cancer death on average reduces life expectancy by about twenty years. Calculated as the weighted average of remaining life expectancy, he arrives at an estimated cost of roughly USD 1,500 *per year* of life lost per death (9,375 RMB at 6.25 exchange rate). The cost a statistical death, i.e. a loss of 20 years, is 20 times this amount (discounting may be considered) Other researchers relying on other valuation methods arrive at a Value of Statistical Life (i.e. a cost of one death) of USD 480,000 (RMB 3,000,000) for China, based on studies from other countries. Ebenstein (2012) also estimated the relationship between the overall water grade and the total dumping of untreated wastewater within a river

basin, and found that an increase in dumping by 10% would induce a 0.022 unit increase in water grade (statistically significant at the 1% level).

根据爱本斯坦 2012 年的研究，每一个消化道癌症引起死亡的患者平均减少约 20 年的寿命。按照剩余寿命的加权平均数，爱本斯坦得出每年每一个癌症死亡者的预计减寿成本大约为 1500 美元/年。20 年寿命减少所带来的损失则是该数字的 20 倍（未考虑折现）。其他研究人员依据其它一些评估方法和其它国家开展的研究，得出中国的统计寿命值（如每死亡一人的成本）为 48 万美元（300 万人民币）。爱本斯坦 2012 年进行的研究同时也对一个河流流域内，总体水质等级和未处理的废水总排放量之间的关系进行了评估，结论表明，废水排放量每增加 10%，会导致河水水质等级增加 0.022 个单位（增加到 1%就具有统计学意义）。

There is no further information about the threat to groundwater resources in the Pingzhou area.

而对于平州市地下水污染情况与环境风险等信息尚未获取。

2.1.3 Agricultural production may collapse, but land could be available
农业生产可能面临崩溃，不过耕地还有利用价值

The reduction of clean water availability is impeding agricultural production and the quality of crops (mainly around the Luho River). Agricultural production may collapse within a decade if decisive measures are not taken. A report from the Pingzhou Environmental Monitoring Bureau from 2010 indicated that most of the water used for irrigation in the area is grade V or worse. Industry output in the area is also suffering, with annually increasing costs for pumping of ground water. 80 % of the Pingzhou population lives around the Luho River and its tributaries.

清洁水源利用度的下降正不断冲击当地的农业生产以及农作物的质量（主要是卢霍河周边地区）。如果不能尽快采取措施，农业生产十年之内可能面临崩溃。平州市环境监测局2010年发布的一份报告显示，该地区大部分灌溉用水等级为五类甚至更差。随着抽取地下水的成本连年上涨，该地区工业产值也受到波及。平州市有80%的人口生活在卢霍河及其支流周边的区域。

Prospects for sustainable economic development in Pingzhou depend on cleaning up the Madan site, through reducing the release to water from the site and through using the Madan site for alternative purposes, which is to build apartment blocks. Some 10 000 mu would be released for this. The government already owns the site. The normal price of land along the rivers in Pingzhou is RMB 50 000 per mu.

平州市实现经济可持续发展的前景主要依赖马丹工业场地通过减少废水排放，以及通过把该场地打造成其它用途的地域，即将该地改建为公寓楼。需要划拨大约1000亩土地来建设这批公寓楼。目前政府已经拥有该场地，平州市河流沿岸的正常用地价格为5万元每亩。

2.1.4 Proposal to remove and clean the contaminated soil ("Remove soil")
有关清理和净化受污染土壤方面的建议（"清除土壤清除土壤"）

The Pingzhou municipal government has proposed to clean the Madan site by removing the buildings and production facilities, take away the most contaminated soil, clean it through a special process, and put the cleaned soil in a safe landfill. The remaining soil will be covered and sealed as far as possible to avoid further leakage. Total investment costs are estimated to be RMB 600.5 million. See table 2.2 for a summary of cost assumptions. This should reduce the release of polluted water to some 70,000 m^3/year, and the concentration of pollutants in the released water would be reduced by 40 percent compared with the pre-treatment concentration. These actions are called "Remove soil", and would imply that the whole Madan site could be released for other use. The construction is expected to take three years. Based on national guidelines the city of Pingzhou uses a real discount rate of five per cent to evaluate its investments in cost-benefit analysis. Box 2.1 explains the discount rate and the mode of analysis used by Pingzhou city. Box 2.2 explains how Pingzhou city might think about the health benefits of the Remove Soil investment. In addition there are of course other benefits.

平州市政府建议拆除厂房和生产设备，清理马丹厂区，移走污染最严重的土壤并通过特殊过程净化这些土壤，并把净化过的土壤放进安全的填埋场。剩下的土壤将被覆盖并尽可能密封起来，防止进一步渗漏。总投资预计为6.005亿元人民币。费用假设见表2.2。该工程将把污水排放量减少至7万m^3每年，废水中的污染物与处理前相比，浓度将减少40%。这些行动称之为"清除土壤"清除土壤，这也暗示整个马丹场地将能够作为建筑用地进行开发。这一建设工程预计耗时三年。根据国家指导方针，本土里市在采用成本效益分析来对其投资进行评估的时候，可享受真实的5%贴现率。专栏2.1解释了平洲市采用的贴现率和分析模型。专栏2.2解释了平洲市对清除土壤所能带来健康效益的看法。除此之外还有其他效益。

Table 2.3 : Costs of the alternatives for reducing pollution from Madan (RMB million)

表 2.3：减少马丹污染区替代方案的成本（人民币：百万元）

	Remove soil 清除土壤	Plant trees 植树	Treatment facility 处理设施
Investment costs: / 投资成本：			
Removing polluted soil / 移走受污染的土壤	540		
Sealing the site / 密封场地	60.5		
Planting trees / 植树		100	
Building and structures / 建筑和结构			20
Equipment and supplies / 设备和供给			20.85
Total investment costs / 总投资成本	***600.5***	***100***	***40.85***
Operating and Maintenance (O&M) costs/year 运营和维护成本（O&M）/年			
Electricity / 耗电量			0.4
Salaries / 工资			0.3
Chemicals / 化工产品			0.3
Maintenance / 维护			0.5
Other / 其它			0.6
Total O&M costs / 运营和维护总成本	***0***		***2.1***

Box 2.1 The discount rate and net present value in a CBA

Whether benefits are larger than costs is the key question in a CBA. When benefits and costs occur at different points in time the CBA calculates the net present value of costs and benefits. The formula is

Net Present Value = $\sum_{t=0}^{T} \frac{B_t - C_t}{(1+r)^t}$, where B = benefit, C = cost and r = the discount rate.

"t" is an indicator of year, where year 0 is the first year and year T is the last year that the investment is in operation. It is recommended that B and C are calculated in real terms, that is, without inflation. The discount rate should also be in real terms.

A positive Net Present Value means that the discounted sum of benefits is greater than the discounted sum of costs. The key question in the CBA can therefore be posed in the following way: Is the Net Present Value positive?

Many readers will recognize the formula for Net Present Value from financial analysis. In a CBA we are interested in benefits rather than income, and costs may include disadvantages (non-financial costs).

专栏 2.1 成本效益分析中的贴现率和净现值

CBA 中的关键问题便是成本和效益哪个更多。当成本和效益分别发生在不同的时间时，就需要采用贴现率来计算二者的净现值。公式为

净现值 = $\sum_{t=0}^{T} \frac{B_t - C_t}{(1+r)^t}$ ，其中 B 为效益， C 为成本，r 为贴现率

T 表示当前的年份，0 年表示的是第一年，T 年表示环境投资发生的最后一年。建议计算 B 和 C 时不考虑通胀因素。同时贴现率也不考虑通胀

净现值为正表示效益大于成本。所以 CBA 的问题可以换成：净现值是否为正？

许多读者可能会发现这个公式跟金融分析很像。不过在 CBA 中我们更关心效益而非收入，而成本也可能包括一些潜在的弊端（不一定直接体现为金钱成本）。

Box 2.2 Estimating benefits to health of the Remove Soil investment

The Pinghzou Government knows that the wastewater release from the Madan site is 271,700 m^3/year and that this constitutes about 45-55% of total releases. With 50% a mid-point assumption the total release can be estimated to 2 times 271,700 = 543 400 m^3/year.

The investment Remove Soil lowers the discharge from Madan to 70,000 m^3/year and the concentration of pollutants in the discharge is only 60% of the previous concentration. The release thus is equivalent to 0.6 times 70,000 m^3/year at pre-treatment concentration.
Now the city government of Pingzhou is able to calculate the percentage reduction in discharge from Remove soil. With no information about local conditions the city government decides to use the result of Ebenstein (2012) to calculate the resulting improvement in water quality. Further, it decides to use Ebenstein's results to calculate the reduction in mortality from digestive cancer stemming from improved water quality. Finally, in order to value the reduction in mortality the city government decides to try both the value of a life year lost

along with the estimate of 20 years from Ebenstein, and the value of RMB 3,000,000 per statistical life that other researchers have recommended.

There are some additional issues facing the researchers of Pingzhou City as they strive to calculate the health benefit of the Remove soil investment. When can impacts be expected? How to factor in the significant population growth in Pingzhou? Will a greater share, or number, of the population get access to tap water over time? Will the value of a statistical life grow as China in general and Pingzhou residents in particular become more affluent? And, how long will the investment last; as long as the treatment facility (see below), or longer? The researchers must use their good judgement to resolve these issues in order to estimate the health benefit of Remove soil as accurately as possible.

专栏 2.2　　估算清除土壤所带来的效益

平洲政府很了解马丹场地的排污状况：271700 m^3/年，占总排放量的 45~55%。假设取中间数 50%，则总排放量则为 543400m^3 /年。

清除土壤的措施可将马丹的排放降至 7000m^3 /年，同时污染物的浓度仅为先前的 60%。所以最终的排放量为 7000*0.6m^3 /年。

现在平洲政府可以计算出清除土壤后所减少的污染物排放。鉴于当地没有充足的信息，政府决定采用 Ebenstein (2012)的数据来计算水质的改善情况和降低的消化系统癌症比例。最终政府决定采用 Ebenstein (2012)所提出的生命延长 20 年，统计学寿命价值 300 万的估算方法。

平洲市的智囊们在计算清除土壤带来的健康效益时还面这其他问题。影响合适会显现？如何将平洲快速增长的人口考虑进来。未来是否有更多的人能饮用上自来水。中国或平洲居民的统计学寿命是否会增长？环保投入会持续多久？智囊们应尽可能运用它们的聪明才智来判断和解决这些问题。

2.1.5 Proposal to build a treatment facility ("Treatment facility")
有关建设污水处理设施的建议（"处理设施处理设施"）

Since there will still be some leakage of polluted water from the area it could be necessary to build a Treatment Facility to treat the remaining release of polluted water ("Treatment facility"). The treated water (meeting class III clean water standard) will be discharged into the Luho River for use by industry and agriculture. This should reduce the concentration of the pollutants in the released water by some 40 percent compared to Remove soil. The amount of wastewater (70,000 m^3/y) remains the same. Many poor people using the released water would benefit from the Treatment facility, and these people have formed an NGO that highly advocates this step.

由于仍然有污水从本地渗出，有必要建设污水处理设施（TF）来处理剩余的污水排放（处理设施处理设施）。处理过的污水（满足三类清洁水质标准）会被排放到卢霍河中用于工农业生产。经过处理设施的污水处理，排放水中的污染物浓度与清除土壤清除土壤相比减少约40%。污水总量(70,000 ㎥/年)则保持不变。 处理设施处理设施会让很多使用排放水的穷人受益，这些穷人已组建一个非政府组织来大力推动建设污水处理设

施。

A treatment facility is assumed to be operative for 30 years. The total investment cost for Treatment facility is estimated at RMB 40.85 million and the operating and maintenance costs are RMB 2.1 million per annum (see breakdown in Table 2.3). The construction of the project is expected to take three years.

污水处理设施预期的使用寿命长达30年处理设施处理设施的总投资预计为4085万元，运营和维护成本为每年210万元人民币（见下表分列）。该项目建设预计耗时三年。

2.1.6 Proposal to clean the site by planting trees ("Plant trees")
有关植树造林清洁场地的建议（"植树植树"）

Xiao Ling is a young professor at Pingzhou University and already a member of Pingzhou Society of Engineering. She and her team have researched on a new method for biological cleaning of contaminated sites, known as phytoremediation. Concretely she suggests to the city government to plant willows (Salix sp.), which we will refer to as "Plant trees".

肖玲是平州大学的一位青年教授，同时也是平州工程学会的一名会员。她和她的团队在研究一种利用生物技术来清洁污染地区的新方法，即植物修复。她具体建议市政府种植柳树（柳属），这里我们称之为"植树"。

A characteristic of willow, which makes it a very suitable tree for use in phytoremediation, is that it can be frequently harvested by coppicing (i.e. no additional planting after first year is needed), yielding as much as 0.67-1.0 dry tons per mu per year. A number of studies have shown that, for instance, Cd uptake by willow from moderately contaminated soil may be sufficient to clean the soil within a few years. Given the heavy pollution of Madan the research team at Pingzhou University has estimated that 20 years would be needed to obtain an acceptable level in the area, and the improvement will come gradually compared with that of Remove soil. There is still some uncertainty about the effects of the phytoremediation method. Since the method is new the effects 20 years later have not yet been observed in practice. However, the research team of Pingzhou University is confident that the effects will materialize.

柳树具有一种特点，即可用矮林平茬的方法经常收割（即第一年栽种后不需额外栽种），适合用来进行植物修复的树种，每亩柳树每年可产生多达0.67-1.0干吨。例如，很多研究表明，柳树从中度污染的土壤中吸收的金属镉要在数年内才能完全清除。鉴于马丹地区污染严重，平州大学的研究团队估计需要20年才能让该地恢复到基本可接受的状态，同时这一改善与清除土壤的改善比起来会非常缓慢，三年投资期结束后，清除土壤清除土壤的改善非常明显。植物修复方法的效果仍然存在某些不确定性。因为方法较新，其20年之后的实际效果并不确定。不过平洲大学的研究人员对其信心满满。

The biomass harvested annually has an economic value and its use could contribute to new small-scale industries being developed in the Madan area. Possible end-product uses of Salix biomass include fuel for direct burning as wood chips, raw material for the production of paper, chipboard and charcoal, a source of viscose for the textile industry, basket weaving and the production of briquettes, ethanol and ruminant livestock feed supplement. Use as wood fuel in for instance district heating plants could allow heavy metal recovery through the scrubbing of smoke gases and proper handling of ashes. Researchers at Pingzhou University

estimate that, when the trees have grown for about ten years the *net annual economic output* from the use of biomass from the site is RMB 15 million. The *total investment cost* needed to prepare the field for tree plantation and planting trees is estimated at RMB 100 million.

植物修复每年收获的生物量具有经济价值，而且使用植物修复可以促进马丹地区开发新的小规模产业。柳属植物生物量可能的终端产品用途，包括用于造纸业原材料的木条、用于纺织业和篮子编织的粘胶纤维来源的木屑压合板和木炭，以及生产煤球、酒精和反刍家畜饲料添加剂。柳树还可用作木燃料，比如集中供热厂使用的木燃料，这样可以通过洗涤烟雾气体和妥善处理烟灰，促进重金属回收。据平州大学的研究人员估计，这些树木生长约 10 年后，使用马丹地区的生物量产生的*年纯经济收益*可达 1500 万元人民币。该地进行种植准备并种树所需的*总投资成本*估计为 1 亿元人民币。

We will assume that there are four basic project alternatives:
我们假设有四个基本的替代项目：

1. Status quo
   现状
2. Invest in Remove soil
   投资清除土壤清除土壤
3. Invest in Plant trees
   投资植树植树
4. Invest in *either* Remove soil *or* Plant trees *and* Treatment facility
   投资清除土壤清除土壤*或*植树植树 *和*处理设施处理设施

2.2 Questions/tasks
问题/任务

Task 1: Discuss and make a list of what kind of costs and benefits one would have to include in a CBA for Remove soil, Plant trees and Treatment facility, including costs and benefits which may not be mentioned above. Be aware of benefits that could not be quantified in physical and/or monetary terms. Also, be aware of double-counting of benefits along the effect chain from environmental discharges to ecological and human damage.

任务1：讨论并列出清除土壤植树处理设施清除土壤、植树和处理设施清除土壤、植树、处理设施的时候，成本效益必须包含分析哪些类型的成本和效益，可包括上面未曾提到的成本和效益。请注意不能以实体和/或货币量化的效益。 同时应注意在排放到生态/人体损害的作用链中，需避免重复计算。

Task 2: Using Excel, lay out the time structure of costs and benefits of each action alternative. Using information from the text, estimate for each action alternative in quantitative terms the annual cost and benefit items of the categories you have listed under task one.

任务2：用Excel软件列出每一个替代行动成本和效益的时间序列。利用上下文的信息，量化各类变量，在任务1列出的年度成本和效益类别里，记录下每一个替代行动的数字。

Table 2.4: Matrix for assessing costs and benefits / 表2.3：成本和效益评估矩阵

Remove soil 清除土壤		Plant trees 植树		Treatment facility 处理设施	
Costs 成本	Benefits 效益	Costs 成本	Benefits 效益	Costs 成本	Benefits 效益

Task 3: Calculate the net present value of each cost and benefit item, and for each action alternative. Use the time horizons indicated in the text.

任务3：计算每个任务的成本与效益的净现值，请使用文章中提到的时间序列。

Task 4: Discuss and list main reasons why it may be controversial to value health related environmental risk in a CBA. How can we perform the analysis if the value of health related risk can not be calculated?

任务4：讨论并列出在CBA中重视与健康有关的环境风险会引起争议主要原因。如果与健康有关的环境风险无法计算，如何执行分析？

Task 5: Choose the three most important parameters for a sensitivity analysis and explain why you consider these three the most important.

任务5：选取三个最重要的参数进行敏感度分析，并解释你为什么认为这三个参数是最重要的。

A sensitivity analysis highlights the critical factors affecting the project's viability. This allows the decision-makers to pay attention to these factors during the implementation stage. Choose the three most relevant parameters from the following list, or add others if you think there are more important factors that are not already on the list:

敏感度分析可以凸显影响项目可行性的关键因素。这有助于让决策者在项目实施阶段关注这些关键因素。从下面的列表中选取三个最相关的参数，或者如果你认为有列表中未列出的其它更重要的因素，将其列出：

a) Discount rate 贴现率
b) Salaries 工资
c) Electricity costs 电费成本
d) Investment costs 投资成本
e) Cost per year of life lost 每年的减寿成本
f) Value of statistical life (VSL) 统计寿命值（VSL）
g) Price of land 土地价格
h) Operation & Maintenance costs 运营和维护总成本
i) Time horizon of the analysis 分析选取的时间范围

Task 6: Present what you consider to be the most favorable action to be taken and why. The possible actions are:
任务6：指出你认为的可采取的最有利行动，以及为什么。可能的答案是：

1) No project/status quo,

无项目/维持现状

2) Invest in Remove soil
投资清除土壤清除土壤
3) Invest in Plant trees
投资植树植树
4) Invest in *either* Remove soil or Plant trees *and* Treatment facility.
投资清除土壤植树处理设施清除土壤、植树和处理设施

Task 7: Discuss how the actions could be financed. It should also be considered how the abatement actions should be implemented. Could it for instance be beneficial to sell the site up front to a land developer, and let him/her be responsible for the implementation and thus take some of the risk?

任务 7：讨论这些行动如何获得资助。同时应该考虑应该如何实施减少污染行动。比如，如果将场地预先卖给土地开发商，让他们负责实施并分担一些风险的话，是否有利？

2.3 Scientific background/facts related to the case
科学背景/与案例有关的事实

The risk of discharges to water: Pingzhou residents fear for the consequences of discharges into the river. In fact, when fertilizer and other chemicals drain into waterways, they may stimulate the river's algal growth beyond its natural speed (a process known as eutrophication), which simulates the formation of carcinogenic compounds and chemicals. Through eutrophication, the water becomes populated by cyanobacteria (blue-green algae), leading to the formation of microcystins, which have been linked directly to liver cancer. Additionally, water pollution introduces nitrate into bodies of water, which, when digested, can undergo endogenous reduction to nitrite on contact with bacteria in the gastrointestinal tract, forming highly carcinogenic N-nitroso compounds. Further, chlorine in water used to treat bacteria also poses a risk because it reacts with organic particles in river water to form halogenated hydrocarbons such as trihalomethane, a carcinogen.

*排放废水的危险：*平州居民对于向河里肆意排放废水引起的后果感到十分担忧。实际上，当肥料和其它化学物质排入河道的时候，这些物质可能会刺激河中的藻类非常规地大量繁殖（这个过程叫做水体富营养化），这会刺激致癌化合物和化学物质的产生。富营养化后，水体被蓝藻细菌（蓝绿藻）占据，导致微囊藻素大量形成，而微囊藻素历来与肝癌有直接关联。除此之外，水污染会把硝酸盐引入水体，人体饮用受到污染的水并消化后，会引起胃肠道内与细菌接触的亚硝酸盐的内生性减少，从而形成高度致癌的亚硝基化合物。还有，水中用来处理细菌的氟也会引起风险，因为氟会与河里的有机微粒发生反应，形成卤代烃类化合物，如致癌物三卤甲烷等。

Ebenstein (2012) is a real article. Given that the estimate by Ebenstein (2012) for China corresponds to a relative risk ratio of 1.24 for polluted versus non-polluted water (a relative risk ratio of 1.097 per water grade was found and assuming polluted water is roughly 2.5 grades worse than drinkable water), the estimate is plausible relative to previous estimates. E.g. Gulis et al. (2002) estimate overall cancer incidence to increase by a factor of 1.14 and stomach cancer by 1.24 in high- versus low-nitrate areas of Slovakia. Beaumont et al. (2008) estimated a 1.82 relative risk ratio for stomach cancer in areas where the drinking water was

contaminated by hexavalent chromium. Note that while the study of Ebenstein focused on digestive cancers, the study indicated that non-digestive cancers, such as lung cancer, are also positively correlated with water pollution and may be causally linked to water pollution as well.

爱本斯坦 2012 年的报告是真实的。鉴于爱本斯坦报告中对中国的估计与污染水和非污染水之间 1.24 的相对风险比（每个水质等级相对风险比为 1.097，假设污染水比可饮用水差约 2.5 个等级）是一致的，因而这个估计与之前的估计相比更为可信。E.g. 古利斯等人 2002 年曾估计，斯洛伐克高硝酸盐地区比低硝酸盐地区总体癌症发生率高 1.14 倍，其中胃癌发生率高 1.24 倍。博蒙特等人 2008 年曾估计，饮用水受六价铬污染地区患胃癌的相对风险比为 1.82。请注意，尽管爱本斯坦的研究重点是消化道癌症，他的研究同时也表明肺癌等非消化道癌症也与水污染呈正相关，也有可能与水污染之间存在因果联系。

The text says that “other researchers” arrive at a Value of a Statistical Life of 3,000,000 RMB. This refers to an article by Aunan and Wang (2014).

阿楠和王 2014 年发表的一篇文章指出，统计寿命值为 300 万元人民币。

The text claims that water pollution is more serious in areas with little rainfall. This is for three reasons: First, areas with more rainfall have pollution diluted by the relatively clean water from the atmosphere. Second, areas with more rainfall have faster river currents. If water flows slowly, pollutants are not transported away quickly, and the added time of exposure leads to greater algae growth and, consequently, worse water quality. Third, areas with insufficient rainfall may attempt to compensate by overuse of fertilizer. This leads to excessive runoff and degrades the surface water quality further.

该文指出，降雨量不足的地区水污染更为严重。有三方面的原因：首先，降雨量充沛的地区空气中含有相对清洁的水分，可以稀释污染；第二，降雨量充沛的地区河水流速更快。如果河水流动很慢，污染物就不能及时转移出去，随着污染物滞留的时间变长，导致水藻滋生更快，水质因此变得更差。第三，降雨量不足的地区可能会尝试过度使用化学肥料来促进植物生长，以此弥补降雨不足，而这会导致过度径流，使地表水质进一步恶化。

Phytoremediation: Current practice for remediating heavy metal-contaminated soils relies heavily on ‘dig-and-dump’ or encapsulation, neither of which address the issue of decontamination of the soil. Immobilisation or extraction by physicochemical techniques can be expensive and is often appropriate only for small areas where rapid, complete decontamination is required. Some methods, such as soil washing, have an adverse effect on biological activity, soil structure and fertility, and some require significant engineering costs. Consequently, the low-technology, in situ approach of phytoremediation is attractive as it offers site restoration, partial decontamination, maintenance of the biological activity and physical structure of soils, and is potentially cheap, visually unobtrusive, and there is the possibility of biorecovery of metals. Phytoremediation is defined as the use of plants to remove pollutants from the environment or to render them harmless. The development of phytoremediation is driven primarily by the high cost of many other soil remediation methods, as well as a desire to use a ‘green’, sustainable process (Pulford and Watson 2003).

*植物修复：*目前，修复重金属污染过的土壤的措施严重依赖“挖坑填埋”或封装，而这两个方法都没有解决土壤净化的问题。通过物理化学技术进行固定或萃取成本高

昂，而且通常只适合需要快速完全净化的小片土地。而土壤冲刷等方法会对生物活性、土壤结构和肥力等产生不利影响，而且有些方法需要投入很大的工程成本。因而，技术含量不高的原地植物修复技术前景很诱人，此技术支持原地修复、部分净化，同时还能维持生物活性和土壤的物理结构，而且成本可能极为低廉，视觉效果也不错，另外，金属也有可能进行生物恢复。植物修复的定义是，使用植物来清除环境中的污染物，或者使这些污染物无害。很多其它土壤修复技术成本高昂，同时采用“绿色”的可持续工艺越来越深入人心，植物修复技术因而发展很快。

Five main subgroups of phytoremediation have been identified:
植物修复技术有五个主要的技术：

1. Phytoextraction: plants remove metals from the soil and concentrate them in the harvestable parts of plants
   植物萃取：植物从土壤中吸收土壤，然后将这些金属集中在自身可收获的部分。
2. Phytodegradation: plants and associated microbes degrade organic pollutants
   植物降解：植物和有关微生物对吸收的有机污染物进行降解。
3. Rhizofiltration: plant roots absorb metals from waste streams.
   根际过滤：植物根部吸收垃圾场里的金属。
4. Phytostabilisation: plants reduce the mobility and bioavailability of pollutants in the environment either by immobilization or by prevention of migration
   植物固定：植物通过固定环境中的污染物或阻止其移动，来降低这些污染物的移动性和生物可用度。
5. Phytovolatilisation: volatilization of pollutants into the atmosphere via plants
   植物挥发：污染物通过植物进行挥发，然后进入大气。

See references (chapter 4) for a full list of the scientific references used.
请参考第四章，获取本文用到的所有科学参考。

2.4 Suggested answers
参考答案

Overall comment / 总体评价

The case study provided is a constructed story, designed as a model on which the reader may learn and practice the procedure of conducting a CBA. It mimics a typical real situation faced by the project planner, but with limitations in the amount of information provided. Not all the information to be found here is relevant, and some relevant information may be lacking. Whenever the reader requires addition information not to be found in the text, assumptions should be made. Defining data needs is an important part of conducting a CBA.

以上的案列研究其实是一个虚构的故事，它是一个设计模型，学员可根据这个模型学习并实践 CBA 的操作程序。该模型模拟了项目规划者面临的真实情景，但是所提供的信息量有诸多限制。并非所有可找到的信息都是相关的，而某些相关信息可能是缺失的。学员需要文中未提供的额外信息时，应该做出假设。对数据需要下定义是实施 CBA 非常重要的一部分。

A CBA is always based on a set of assumptions and priorities. When conducting a CBA, it is therefore extremely important to clarify which assumptions and priorities have been made. If the assumptions and priorities are not clarified, the CBA will be useless as it will not be possible for readers to consider the presuppositions behind it and consider if other or additional factors need to be taken into account.

CBA 总是建立在一组假设和优先项的基础之上。因此，实施 CBA 的过程中，阐明究竟做出了哪些假设和优先项极其重要。如果这些假设和优先项没有被阐明，那么 CBA 的实施可能是毫无用处的，因为学员不可能考虑 CBA 背后的前提预设，也不会考虑是否需要把其它或额外的因素考虑进来。

2.4.1 Discuss and make a list of costs and benefits to include in CBA
讨论并列出 CBA 应该包含的成本和效益。

Discuss and make a list of what kind of costs and benefits one would have to include in a CBA for building Remove soil, Plant trees and Treatment facility, including costs and benefits which may not be mentioned above.

讨论并列出建设清除土壤植树处理设施清除土壤、植树和处理设施的时候，成本效益必须包含分析哪些类型的成本和效益，可包括上面未曾提到的成本和效益。

We have listed some main categories of costs and benefits for the alternatives. New land available is the value of the Madan site that will be available for other purposes, for instance apartments.

我们列出了替代方案的一些重要成本和效益类型。新的可用土地是指可用作其它用途的马丹场地的价值，比如公寓楼等。

Table 2.5: List of benefits

Benefits	Remove soil	Plant trees	Treatment facility (additional to Remove soil or Plant trees)
Health	x	x	x
Agriculture and industry	x	x	x
Smell and sight	x	x	x
Other benefits groundwater	x	x	x
Sale land	x	(x)	
Sale biomass		x	

表 2.5:效益列表

效益	清除土壤	植树	处理设施清除土壤植树处理设施（在清除土壤和植树的基础上）
健康	x	x	x
农业和农业	x	x	x
气味和颜色	x	x	x
地下水效益	x	x	x
土地出售	x	(x)	
生物质出售		x	

Table 2.6: List of costs

Costs	Remove soil	Plant trees	Treatment facility (additional to Remove soil or Plant trees)
Investment cost	x	x	x
Operation and maintenance (O&M) cost			x

表 2.6:成本列表

成本	清除土壤	植树	处理设施（在清除土壤和植树的基础上）处理设施清除土壤植树
投资成本	x	x	x
运行和维护成本			x

Deciding what effects should be included or not is both an art and a science. The project planner needs to consider relevance, monetary amount (will the inclusion of an additional effect alter the results substantially) and data availability. The list that we have provided is a selection of effect categories and not exhaustive. As an example, an additional benefit could be increased agricultural and industrial output as a consequence of cleaner water supply. The benefit in terms of smell and sight could also be significant.

决定应该包含或不包含哪些效果既是一门艺术，也是一门科学。项目规划者需要考虑相关性、货币量（加入额外的效果会极大地改变结果），以及数据可用性。我们所提供的列表只是精选的效果分类，有待补充。例如，提供更清洁的水之后，带来的额外效益可能有工农业产值的增加。此外，带来的嗅觉和视觉改善可能也十分显著。

2.4.2 Lay out the time structure of costs and benefits
估算成本和效益模型

Using Excel, lay out the time structure of costs and benefits of each action alternative. Using information from the text, estimate for each action alternative in quantitative terms the annual *cost and benefit items of the categories you have listed under task one.*

利用excel对每个项目的费用效益分析进行建模。利用文章中提供的信息，估算任务一中各类别下的每年费用效益。

Typically, projects with mainly commercial objectives will have benefits in terms of financial returns but with possible environmental costs that are hard to estimate. Conversely, as we can see in this exercise, projects with the aim of improving environmental conditions will be associated with precise cost figures, but the environmental and health benefits are more difficult to estimate.

一般而言，以商业目的为主的项目都具有财务回报方面的清晰收益，但是它们可能的环境成本很难估算。恰恰相反，正如我们从这个练习练习中看到的那样，以改善环境状况为目的的项目通常都具有准确、清晰的成本数字，不过它们的环境和健康效益却很难估计。

Table 2.7: Time structure of costs and benefits – Remove soil

Item	Year 1	Year 2	Year 3	Year 4 to 33	Assumption
Investment cost (600.5)	600.5/3	600.5/3	600.5/3		
Sale of land	500 mill.				Sold in year 1
Health benefit				Valued	30 years life time
Other benefits				Described	30 years life time

表 2.7: 成本和效益的时间序列 – 清除土壤清除土壤

项目	第1年	第2年	第3年	第4年到第3年	合计
投资成本 (600.5)	600.5/3	600.5/3	600.5/3		
土地出售	500 mill.				第1年出售
健康效益				定量	30年寿命期
其他效益				定性	30年寿命期

Table 2.8: Time structure of costs and benefits – Plant trees

Item	Year 1	Year 1 to 20	Year 21 to 30	Assumption
Investment cost (100)	100			3 years
Biomass sale		0 (1-9), 15 (10-20)	15	Average from year 10
Health benefit		Valued. Linearly increasing	Full value	Linearly. 30 years life time
Other benefits		Described. Linearly increasing	Full effect	Linearly. 30 years life time

表 2.8: 成本和效益的时间序列 –植树植树

项目	第1年	第1到第20年	第21到第30年	合计
投资成本 (100)	100			3年
生物质出售		0/15	15	15年平均值
健康效益		定量 线性增长	全部值	线性 30年寿命期
其他效益		定性 线性增长	全部效果	线性 30年寿命期

Table 2.9: Time structure of costs and benefits – Treatment facility

Item	Year 1-3	Year 4 to 33	Assumption
Investment cost (40.85)	40.85/3		
O&M cost		2.1	
Health benefit		Valued	
Other benefits		Described	Includes sale of land in year 34 or later

表 2.9：成本和效益的时间序列—处理设施处理设施

项目	第1到第3年	第4到第33年	合计
投资成本 (40.85)	40.85/3		
运行和维护成本		2.1	
健康效益		定量	
其他效益		定性	包括第34年或以后的土地出售

2.4.3 Estimate in quantitative terms the costs and benefits

量化费用效益

Calculate the net present value of each cost and benefit item, and for each action alternative. Use the time horizons indicated in the text.

计算每个任务的成本与效益的净现值，请使用文章中提到的时间序列。

Valuation of health benefits and Net present value

健康效益和净现值估算

Remove soil: / 清除土壤清除土壤：

- Original wastewater from site: 271.7 thousand tons / 初始废水：27.17 万吨
- After Remove soil: 70/ 清除土壤之后：70
- Reduction: 201.7 / 减少：201.7
- Pollution content in remaining discharge: 70 x 0.6 / 剩余排放的污染含量：70 x 0.6
- Wastewater from site is half of all wastewater/ 废水量为废水总量的一半
- Impact on water quality from lower quantity of discharge: 0.022 x 10 x 201.7/(271.7x2) / 降低废水排放量对水质的影响

- Impact on water quality from less pollution in discharge: 0.022 x 10 x 70 x 0.4/(271.7x2) / 降低污染物浓度对水质的影响
- **Improvement in water grade: 0.08166+0.0133=0.09300 /** 水质等级改善：0.08166+0.0133=0.09300

- Improvement in cancer mortality rate, non-tap: 0.093 x 13.1% = 1.22% / 癌症死亡率降低，非自来水: 0.093 x 13.1%
- Improvement in cancer mortality rate, tap: 0.31% / 癌症死亡率降低，自来水: 0.31%
- Baseline mortality rate and baseline population from table 2.1 表 2.1 / 中的基线死亡率和基线人口数
- Use disaggregate numbers / 用分解数值

- Population grows 5 per cent annually / 人口每年增长 5%
- Assumption: Trend increase in access to tap water neutralises the increase in population; and no impact after year 33 / 假设：自来水使用趋势的增加抵消了人口的增长；且 33 年后也没有影响
- **70 avoided cancer fatalities per year / 每年避免了 70 起癌症死亡事故**

- Value of Statistical Life: 3 Million RMB / 统计寿命值：300 万元
- Annual benefit **210 million** RMB / 年收益 2.1 亿元
- 20 life years lost / 减寿 20 年
- Value of one year: Approx 9,375 RMB (at 6.25 exchange rate) / 一年的价值：约 9375 元（基于 6.25 的汇率）
- Discounted value of 20 years: 122,700 RMB / 20 年的折现值：122700 元
- Annual benefit **8.6 million** RMB / 年收益 860 万元
- Big difference between the estimates. This is normal. / 估值间存在差距。属正常。

- NPV of investment cost: 545 million / 投资成本净现值：5.45 亿
- NPV of sale of land (sold year one): 500 million / 土地销售净现值（一年销售）：5 亿
- Health benefit based on life years lost: 114 million / 基于减寿法的健康收益：1.14 亿
- Health benefit based on value statistical life: 2,800 million 基于统计寿命值的健康收益：28 亿
- **NPV total: 70 – 2,750 million RMB / 总净现值：7000 万至 27.5 亿元**
- Plus other health benefits incl other cancers / 加上包括其他癌症的其他健康收益
- Plus agriculture and industry / 加上农业和工业
- Plus smell and sight / 加上嗅觉和味觉
- Plus groundwater… / 加上地下水…

Treatment facility: /处理设施处理设施：

- Same as Remove soil, except improvement in water quality is 0.4 x 70,000 = 28,000 tons / 同清除土壤清除土壤一样，除了水质改善为 0.4 x 70,000 = 28,000 吨
- Improvement in water quality: 0.022x10x0.4*0.6*70/(0.6*70+271.7) = **0.012 grades / 水质改善：**0.022x10x0.4*0.6*70/(0.6*70+271.7) = **0.012 等级**
- Improvement in cancers/ 癌症情况改善
    - 0.15% without tap / 非自来水 0.15%
    - 0.04% with tap / 自来水 0.04%
- **9 lives saved / 挽救了 9 条生命**
- Annual health benefit VSL: 26.4 million / 年健康收益统计寿命值：2640 万
- Annual health benefit life years lost: 1.1 million / 年健康收益减寿：110 万
- NPV in total: **(-50) – 285 million RMB / 总净现值：(-5000 万) – 2.85 亿元**
- + other benefits / 加其他收益

Plant trees: / 植树植树：

- Same as Remove soil, but improvement in water quality is gradual (assume linear, 20 years) / 同清除土壤清除土壤一样，但是水质改善是逐渐的（假设线性，20 年）
- Investment cost: 100 (assume year 1) / 投资成本：100（假设 1 年）
- NPV health benefit life years lost: 72.6 million / 净现值健康收益减寿：7260 万
- NPV health benefit value statistical life: 1,776 million / 净现值健康收益统计生命值：17.76 亿
- NPV income from biomass: 124 million / 生物量净现值收入：1.24 亿

- NPV total: **97 – 1,800 million RMB / 总净现值：9700 万 – 1,8 亿**
- Plus other benefits / 加其他收益
- Sale of land year 31+ not included in estimate / 土地销售超过 31 年未被纳入估算中

2.4.4 Why it may be controversial to value health related risk
为什么重视与健康有关的风险会引起争议

Discuss and list main reasons why it may be controversial to value health related environmental risk in a CBA. How can we perform the analysis if the value of health related risk can not be calculated?

讨论并列出在 CBA 中重视与健康有关的环境风险会引起争议主要原因。如果与健康有关的环境风险无法计算，如何执行分析？

Why it may be controversial to value health related environmental risk
为什么与健康有关的环境风险会引起争议

The main controversy surrounds mortality risk.
主要的争议围绕着死亡风险

Principal objection: A life is fundamentally different from ordinary commodities and cannot by principle be measured in money.
原则：生命从根本上不同于普通商品，因此原则上无法用金钱衡量

Pragmatic problem: 1) A true value of statistical life is difficult to estimate. Data issues etc. 2) it is unclear whether to value a risk to a life or a risk to life years lost, and the two tend to give different answers.
实际上面临的问题：1）统计生命的真正价值很难估算，数据问题等。2）不清楚是要重视对生命造成的风险还是对减寿造成的风险，而这两种情况会产生不同的答案。

The problem of measuring risk and scope of diseases etc. Critique: The methodologies to measure the cost of illness (such as cancer) do not capture the true cost of sickness, illness, disease.
关于健康风险的评估和疾病的范围也存在问题和争议。基于疾病（癌症等）成本评估的方法并不能完全涵盖真正意义上的患病成本。

How to perform the analysis if there is no value of health related risk?
如果没有健康风险数据，如何进行分析？

Both Remove soil and Plant trees save approximately 70 lives per year, but the benefit arrives later in Plant trees.
清除土壤和植树每年分别挽救将近70条生命，但是植树的收益来得相对迟一些。

Plant trees has positive NVP without the value of health benefit; health benefits are obtained for free… This positive NVP (without health) is 24 million RMB. In Remove soil the health benefits will cost something. The negative NVP (without health) is -45 million RMB. But health benefits arrive later and are more uncertain in Plant trees.

植树净现值为正，无健康收益价值；健康收益免费获得… 正的净现值（无健康收益）为2400万元。在清除土壤中，健康收益需要一定成本。负的净现值（无健康收益）为-4500万元。但是在植树中，健康收益来得迟一些，更不确定。

So the question becomes how important it is to obtain early health gains. How important = how valuable… It seems difficult to avoid the question of importance/value of health risk, either explicitly or implicitly.

因此，问题是取得近早取得健康收益有多重要。重要性=价值多少… 看似很难避免健康风险重要性/价值多少的问题。

Treatment facility involves a further 40 % improvement in water quality. In a situation where the benefit of such an improvement is not known the analyst should still lay out the beneficial effects in a transparent way. Above we found that Treatment facility saves approximately 9 further lives per year. The cost is estimated to be 65 million RMB – considerably more than in Remove soil. The benefit falls disproportionately on the poor.

处理设施包括额外的40%的水质改善。在这样的改善收益未知的情况下，分析人员仍应当明显易懂地列出收益。在上文中，我们发现处理设施每年还挽救将近9条生命。成本估计为6500万元—远高于清除土壤中的成本。与富人相比，穷人收益低的不成比例。

It is possible to calculate the break-even value of statistical life.
可以计算出统计生命值的盈亏平衡点。

If the benefit in terms of lives saved cannot be calculated the 40% further improvement may be translated into what it means for water quality in terms of class. This could be compared to the standard in other cities and provinces. Are there examples of defensive expenditures at the household level or industry level that can be saved if the measure is implemented? This should be surveyed. Further, the number of people who would benefit should be described, and also which groups of people in terms of wealth and status. The text says that population grows 5 per cent annually. Does this mean that the group to benefit also will increase 5 per cent annually?

由于需要将水质进一步提升40%，因而处理设施更难操作。即使面临水质改善的效益不明确的情况，分析者仍然应当完全透明地列出效益。具体来讲，水质提升40%可能有助于降低水质等级。这一点可以与其它省市的标准做比较。如果采取相关措施，可以节省居民或产业层面的防御性支出，有没有这样的例子？可以展开相关调查。另外，应当对可能受益人群的数量，以及按照财富和地位，受益人群属于哪些群体进行描述。文中指出该市人口每年增长5%。这会意味着受益人群每年也能增长5%吗？

2.4.5 Three most important parameters for sensitivity analysis
开展敏感度分析的三个最重要参数

Choose the three most important parameters for a sensitivity analysis in this case and explain why you consider these three the most important.

选取案例中三个最重要的参数进行敏感度分析，并解释你为什么认为这三个参数是最重要的。

Of the factors listed, a sensitivity analysis should be conducted on the factors that are most uncertain and are expected to change the outcome substantially if altered. For this reason, the following factors are the most significant ones:
在所有列出的因素中，敏感度分析应当围绕最不确定，同时一旦改变预计可以显著改善成果的那些因素开展。出于这个原因，下面的因素是最重要的：

- Discount rate / 贴现率
- Health costs / 健康成本
- Time horizon of analysis /分析选取的时间范围

In this case health costs by far seem to be the single most important factor to analyze and discuss.
在本案例中，健康成本目前看起来是需要分析和讨论的最重要单一因素。

2.4.6 Present the most favorable action and why
指出最有利的行动，并说明原因

Present what you consider the most favorable action to be taken and why.
指出你认为的可采取的最有利行动，以及原因。

The NPV of a particular project is a measure of the net benefit (if positive) or net cost (if negative) of realizing the project, when all the relevant quantifiable benefit and cost effects of have been accounted for in monetary terms. If the value of life years lost approach (Ebenstein) is chosen we see from Table 1 that the net NPVs are smaller than if the VSL approach is applied. This is a common result, the VSL approach normally yield higher benefits than other approaches. Since the VSL estimate is based on studies from other countries, it should be considered whether this estimate (RMB 3 million) represents a reasonable VSL value for China, for instance through considering how much is spent on risk reduction to save a life in other sectors in China. In the value of life years lost approach most of the benefits are from the sales of land.

特定项目的净现值是指所有相关的可量化收益和成本效果都已按照货币形式统计完毕后，项目完成时得到的净收益（如果是正值）或净成本（如果是负值）。如果选择了爱本斯坦提供的减寿值方法，我们可从表1中看到得到的净现值比采用VSL（统计寿命值）方法时得到的要小。结果普遍是这样，采用VSL方法通常会比其它方法产生更高的收益。由于VSL评估基于其它国家的研究，应该考虑这个估值（300万元人民币）是否是中国合理的VSL值，比如考虑一下，在中国，需要投入多少风险教育资金才能拯救其它部门的一条生命。按照减寿值方法，大部分的收益来自土地销售。

The net NPV of Treatment facility is positive if the value of saved lives is not too low. Since many poor people would benefit from Treatment facility, it could from a social point of view be desirable to carry out the investment even if the NPV might be negative. There are also other benefits to health and well-being

处理设施的净现值在被挽救生命价值不太低的情况下为正。由于处理设施让很多穷人从中受益，从社会的角度讲，即使净现值为负值，也有必要开展投资。从健康和幸福角度来讲，也有很多效益。

The Plant trees alternative offers an alternative to Remove soil. Both save about 70 lives from cancer, but the health benefit arrives later in Plant trees. If saved lives are valued highly Remove soil gives the most benefits. If saved lives are valued lowly other benefits dominate (sale of biomass) and Plant trees gives the most benefits. Plant trees could also be considered more eco-friendly. However, Plant trees is a new and largely unproven approach. In our judgment, Remove soil may be the best choice.

植树的方案提供了清除土壤的替代方案。两者都从癌症中挽救约70条生命，但是植树的健康效益来得相对迟一些。如果被挽救生命的价值被评估地较高，那么清除土壤将产生最大的效益。如果被挽救生命的价值被评估地较低，那么其他效益将占主要地位（生物量销售），植树将产生最大的效益。植树还可以被认为更加生态友好。然而，植树就影响来讲，是一种未被证明的新方法。根据我们的判断，清除土壤可能是最佳选择。

It is important to emphasize that a cost-benefit analysis as a practical matter is far from being a determinate technique. There are challenges with determining the discount rate as we have seen. Equally difficult problems persist in determining the proper figure to use for the value of human life or the intrinsic value of nature. The willingness-to-pay approach is problematic, as it is highly dependent on the ability to pay. It puts a lower value on health and environment in poor areas as the population possesses less than the population in wealthier areas. Additionally, because of the severe limits on current scientific knowledge, we often can do little more than make educated guesses about the effects of a chemical on human health or environmental degradation.

应当十分强调，成本效益分析作为实际用到的一种方法，目前还远远不是一种决定性的技术。正如我们所看到的，决定贴现率的时候会遇到很多问题。决定用于人类寿命或自然的内在价值的合适数字时，会遇到同样困难的问题。支付意愿的方法也有问题，因为这种方法严重依赖支付能力。该方法不太重视贫困地区的健康和环境，因为贫困地区的人口比富裕地区的人口占有的资源少。此外，限于现有的科学知识，对于化学物质对人类健康或环境恶化的影响，我们往往只能够做出有根据的推测。

Environmental regulation involves difficult tradeoffs, and economic analysis, including cost-benefit analysis, can help clarify those trade-offs. However, a cost benefit analysis should not be the sole basis for decision making. It does not provide precise answers to policy questions. Rather, it is a procedure that can provide a crude but highly useful picture of the relative merits of alternative policies. It therefore can be used to identify those investments that are either very good or very bad. A CBA also organizes data that bear on policy decisions and does so in a way that educates us about the important elements of a problem and allows us to test the sensitivity of the decisions to changes in those elements.

环境规制需要进行艰难权衡，包括成本效益分析在内的经济分析有助于阐明这些权衡后的取舍。然而，成本效益分析不应当成为决策的唯一依据。成本效益分析并没有提供政策性问题的确切答案。确切来讲，成本效益分析是一套程序，它好比一幅粗糙但非常有用的图片，勾勒出了替代政策的优缺点。因而成本效益分析可用于辨别非常好或非常糟糕的投资。CBA还可以组织对政策决定有影响的数据，这种组织可以让我们了解构成问题的重要元素，同时还可以让我们测试关于那些元素变化决定的敏感度。

2.4.7 How to finance actions
怎样为行动提供资金支持

Discuss how the actions could be financed.
讨论这些行动如何获得资助。

If the responsible companies for the pollution at the site could be identified, they should pay in accordance with the Polluter Pays Principle. If the responsible company cannot be identified or is unable to pay, the government would have to pay for the cleaning

如果可以确定某些企业应当对该地的污染负责，依照污染者负担原则，这些企业应当提供支付。如果不能确定为污染负责的企业，或者这些企业无力支付时，政府必须为清洁行动提供支付。

In this case sale of land could contribute considerably to the financing. Sale of land could yield some RMB 500 million, which could cover most of the investment costs for Remove soil. Plant trees would not yield any upfront income from sale of land, but would eventually yield annual income from the sales of biomass, and after 30 years the land could eventually be sold for other purposes. However, the annual income from Plant trees is lower than from land sales in Remove soil. This could be an important argument for Remove soil in case of financial constraints.

这种情况下，土地销售可提供大部分资金支持。土地销售可获得约 5 亿元人民币，可分担清除土壤所需的大部分投资成本。植树不会产生任何提前支付的土地销售收入，不过每年可带来生物量销售收入，满 20 年后土地可卖掉作其它用途。然而，植树带来的年收入要低于清除土壤的土地销售收入。如果发生财政紧缩，较高的土地销售收入可能成为清除土壤的重要论据。

A special challenge would be to ensure financing of operating costs over time for Treatment facility.
一个特殊的问题在于如何确保为处理设施不断产生的运营成本提供资金支持。

3. SEA case exercise: Reducing environmental risks in the Snow Dragon River basin

战略环境评价案例练习：降低雪龙河流域的环境风险

3.1 The case of the Snow Dragon River basin
雪龙河流域案例

A Strategic Environmental Assessment, SEA, is a tool to identify and assess significant positive and negative effects from policies, plans and programmes. SEA can be viewed as an extension of the Environmental Impact Assessment, EIA, moving from individual projects to policies, plans and programmes.

战略环境影响评价（SEA）是识别和评估政策、规划、项目中重要利弊的工具。战略环评可以看做是环境影响评价的延伸：从孤立的项目延伸到政策，规划，和项目上

SEA is a means to safeguard environmental assets, and to promote sustainable development. A SEA can improve decision making by:

- Providing environmental-based evidence to support informed decisions.
- Improving the identification of new opportunities.
- Preventing costly mistakes.
- Providing a "big/strategic picture" giving directions for Environmental Impact Assessment studies of specific projects or policies at a local level.
- Facilitating trans-boundary co-operation.
- Building public engagement in decision making for improved governance.

战略环评旨在保护环境资源，促进可持续发展。战略环评可以通过以下方面改善决策制定：

- 为决策提供环境方面的支撑；
- 加强新机会的发现几率；
- 避免代价高昂的错误；
- 为单个项目或政策环评提供更高远的视野;
- 促进多变合作；
- 促进政府管理，加强公众参与。

In this exercise, a SEA-approach is applied at a country level in order to strategically map environmental risk and design a cost-effective pollution reduction program. The exercise also draws on the principles of Integrated River Basin management (IRBM). It may be beneficial to have a 45 minutes lecture on principles of SEA and IRBM, before starting the training exercise.[1]

[1] Such a presentation, called ”IRBM in the Rhine river: EU’s approach to regional cooperation in protecting water sources and reducting risks to health and ecology” (bilingual, English-Chinese) is available at the project website ”Reducing environmental risk in China”: http://vista-analyse.no/no/fokusomraader/klima-milj-og-energi/planning-for-cost-effective-environmental-risk-reduction-in-china/ The presentation focuses on experiences in the Rhine River Basin in Germany, based

在该案例练习中，战略环评方法被用来识别环境风险源，并设计一套具有成本效益的污染治理方案。练习同样定义了全过程流域管理的主要原则。在开始练习之前，最好能抽出45分钟的时间学习一下战略环评和全过程流域管理的主要原则。

Further guidance in the use of SEA for environmental purposes is available in the publication (in Chinese) by Zhao Xuetao et al. (2012): "Application of SEA and CBA methodologies in environmental planning", China Environmental Science Press.

战略环评的指导方法在赵学涛的一篇文章中有所阐述（《战略环评和费用效益分析方法在环境规划中的应用》）。

3.1.1 Introduction to the Snow Dragon River in the country of Sendong
森东国雪龙河介绍

The Snow Dragon River runs through the country of Sendong, from the mountains in the West to the lowlands in the East, where it empties out into the ocean (ref. figure 3.1 with map[2]). The Sendong culture and civilization has since time immemorial been linked to the river and the country of Sendong today corresponds roughly with the Snow Dragon River basin. Sendong consists of 9 provinces, each of them numbered and marked with a separate colour in the map (figure 3.1).

雪龙河是森东国的一条河流，它发源于该国西部的高山，流向东部的低洼平原，最后注入大海（参见图 3.1 地图）。雪龙河从远古时代以来就是森东国的母亲河，是孕育森东国文化和文明的摇篮。今天的森东国大致就按照雪龙河流域展开。森东国下辖 9 个省份，每个省份在下图中都作了编号，并用单独的颜色标记（参见图 3.1）。

Economically, Sendong is in the middle of an industrialization process. In the cities we often find strong industrial bases related to for instance mining and metals, chemicals, and production of cement. In the more advanced cities on the coast, high-tech and services industries are strong. The Snow Dragon River is a very important transport corridor, carrying resource and manufactured goods from inner provinces to downstream provinces and to the coastal cities for consumption and export.

从经济上看，森东国处于工业化中期。森东国有很多实力雄厚的工业基地城市，比如采矿和金属、化学，以及水泥制造发达的城市。该国沿海有很多发达城市，高科技和

on a report of international experiences with tackling environmental risk (see Aunan et al. 2014 (pp. 270-305), which describes the Rhine River Basin example in more detail).
相关演示报告见：http://vista-analyse.no/no/fokusomraader/klima-milj-og-energi/planning-for-cost-effective-environmental-risk-reduction-in-china/。报告主要分析了德国莱茵河流域处理环境风险的相关国际经验，其中对莱茵河的案例有具体的分析。

[2] You may note that a map of the Rhine River Basin has served as the basis for the map of Snow Dragon River Basin (ref. figure 3.1) in this exercise. Except for the physical outline, the data for the Snow Dragon Riber Basin is different from those of the Rhine River Basin.
你也许会发现莱茵河流域底图是案例中雪龙河流域的底图（图 3.1）。除了边界外，雪龙河流域的数据与莱茵河流域的并不相同。

服务业实力很强。雪龙河是一条重要的运输走廊，把资源和工业制成品从内陆省份运到下游省份和沿海城市进行消费和出口。

Due to the wisdom of the administrators of old, each province corresponds with a sub-river basin in the Snow Dragon river basin. In different historic periods, different provinces have functioned as more or less independent countries and there are significant cultural differences between provinces and to some extent different administrative practises and traditions. A main focus of each province is to reach national targets of economic growth, and provinces often compete to fulfil such goals without taking into full consideration the effects of activities on other provinces.

由于老一辈领导人的智慧，森东国的每一个省都符合雪龙河流域的子流域特征。在不同历史时期，不同的省份曾经是不同的独立国家，因而各省之间存在显著的文化差异，甚至管理方法和传统也不尽相同。每个省的核心任务都是完成国家设定的经济增长目标，为了完成目标，各省之间通常会你追我赶展开竞争，并没有充分考虑到这些竞争活动对其它省份带来的影响。

Over the last three decades, Sendong has experienced high levels of economic growth, which has led to higher living standards and a large middle class but also intense pollution problems. The famous Snow Dragon River has largely turned into a sewer due to pollution from point sources as well as agriculture, and several endemic nature types and species have gone extinct or are on the verge of extinction. In many places, humans are experiencing severe health problems due to pollution, and in major cities it is becoming increasingly difficult to secure drinking water supply. A large chemical spill from a plant in the industrial heartland (Ganshu, province no. 4) last year, had severely detrimental effects in the whole downstream river basin and led to the extinction of the already vulnerable Sendong crocodile – famous as a symbol of courage in traditional Sendong poetry.

过去三十年以来，森东国经历了高速经济增长，人民生活水平大幅提高，中产阶级不断壮大，同时污染问题也十分突出。由于严重的点源污染和农业污染，该国著名的雪龙河基本上已经变成了一条污水沟；一些地方特有的自然类型和物种要么已经绝迹，要么濒临灭绝。在很多地方，污染使人们面临严重的健康问题；在大城市，保障饮用水供应显得越来越困难。去年，工业中心（第四个省份）的一家工厂发生了化学品泄漏，对整个雪龙河下游流域造成了严重破坏性影响，导致本已经十分脆弱的森东鳄鱼（作为传统森东诗歌中勇气的象征而出名）的灭绝。

The chemical spill and a drought exacerbating the already critical lack of water in the capital province (Sandong, province no. 9), prompted the central Government to declare the need for creation of the first overall Snow Dragon River basin management plan. The plan shall include a RMB 100 billion program of action over 10 years to reduce environmental risk at regional and local levels (equal to 1% of GDP).[3] Provinces are of-course free to provide additional

[3] Please note that this number is realistic. As a comparison, the Rhine Action Programme for cleaning up the Rhine River in Europe spent Euro 13 billion in the period 1989-1995 (ICPR 2003), the largest cost being improvement of wastewater treatment plants. Using an exchange rate of Euro 1 = CNY 8, this would equal RMB 104 billion over a 6 year period.
请注意，该数字并非不切实际。在 1989-1995 年，欧洲实施《莱茵河行动计划》清理莱茵河共花费 130 亿欧元，最高的花费主要在废水处理设施的改进上。按 1:8 的汇率计，6 年共花费人民币 1040 亿元。

funding for local measures and technological upgrading in the industry is expected to contribute to reduce pollution.

化学品泄漏，加之又发生了一场旱灾，使缺水本来就很严重的首都所在省（第九个省份）的用水面临更加严峻的形势，中央政府不得不宣布，需要立即启动第一个雪龙河流域总体管理规划，以及历时 10 年、耗资 1000 亿人民币的行动项目来降低地区和当地面临的环境风险（相当于 1%的 GDP）。当然，各省不需为本地采取的措施提供额外的资金支持，且产业技术革新预计也会有利于降低污染。

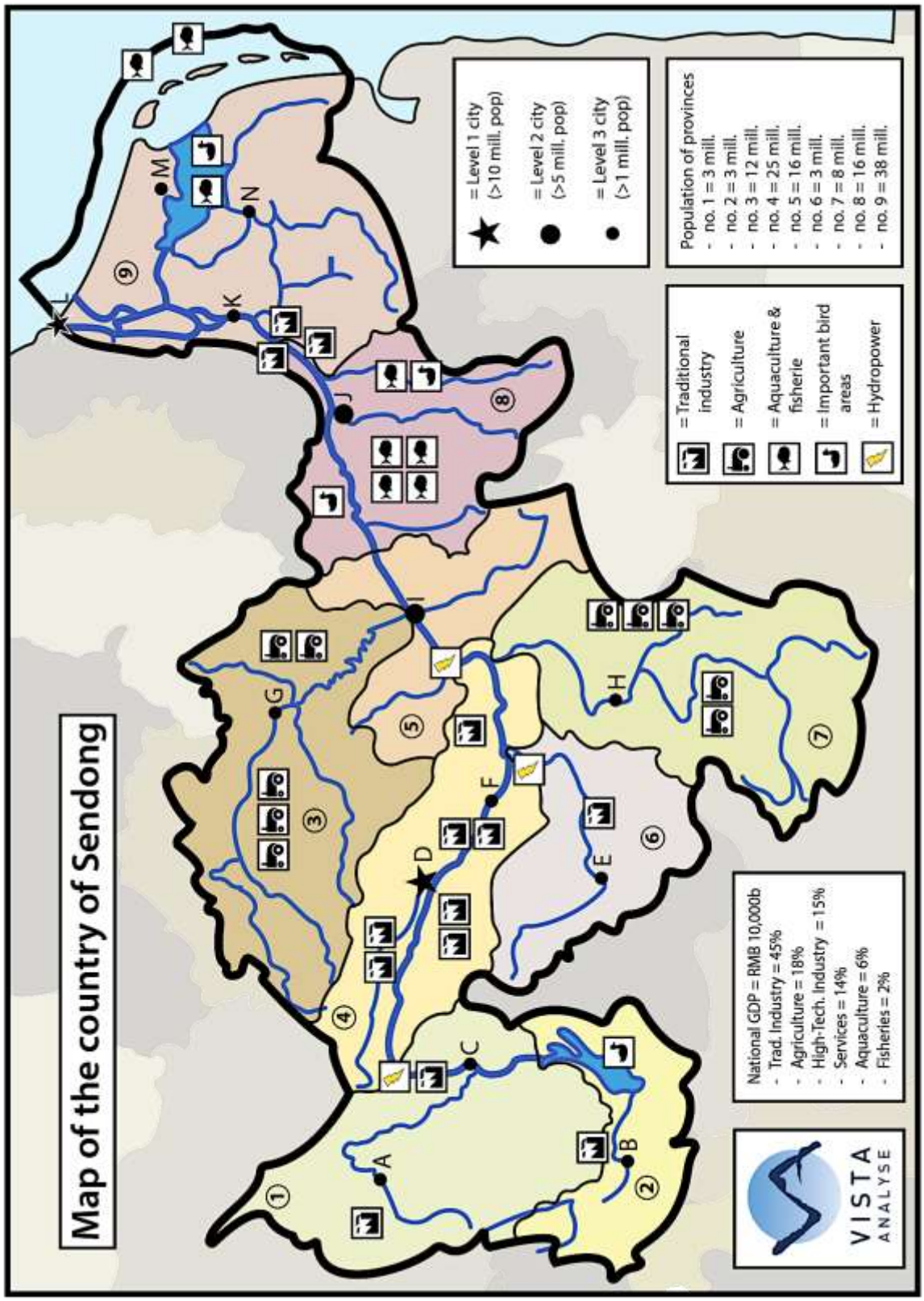
3.1: Overview of the nine provinces in Sendong

No.	Name	Characteristics
1	Qingai (青埃省)	Mountains rich with minerals. Rainforests with abundant wildlife. Population 3 million. Two major cities of +1 million that are old centers of mineral industry.
2	Sizhuan (四专省)	Mountains rich with minerals. Rainforests with abundant wildlife. Green Crystal Lake, Sendong's largest lake, famous for endemic aquatic ecology and breeding ground for the rare Red Crown crane. Traditionally known as one of the best regions in Sendong for recreation and angling. Population 3 million. One major city of +1 million, an old center of mineral industry.
3	Leimenggu (类盟古省)	One of the two main agricultural regions in Sendong. Traditionally known for many small villages, abundant crop fields and rich wildlife. Today dominated by industrial agriculture in the form of large monocultural plantations. Population 12 million, one major city with a population of +1 million.
4	Ganshu (干树省）	The industrial heartland of the country. Densely populated. Population 25 million, two major cities: one of +10 million and one of +1 million. Hydropower plants where the river comes down from Qingai (1) and Helan (6).
5	Sanxi (三西省）	Major marine transportation hub. Eastern part characterized by wetlands, small lakes, channels and a region for aquaculture. Rich aquatic biodiversity. Population 16 million, one major city with a population of +5 million. Hydropower plants where the river comes down from Ganshu (4).
6	Helan (河蓝省)	Mountains rich with minerals. Rainforests with abundant wildlife. Traditionally known as one of the best regions in Sendong for recreation and angling. Population 3 million. One major city of +1 million, an old center of mineral industry.
7	Anfei (安飞省）	One of the two main agricultural regions in Sendong. Traditionally known for many small villages, abundant crop fields and rich wildlife. Today dominated by industrial agriculture in the form of large monocultural plantations. Population 8 million, one major city with a population of +1 million.
8	Fobei (佛北省)	Characterized by wetlands, small lakes, channels and Sendong's main region for aquaculture. Rich aquatic biodiversity. High tech industry in the east. Population 16 million, one major city of +5 million.
9	Sandong (三省	Sendong's main region for high-tech industry and services. Traditionally dominated by agriculture and fisheries in the large and shallow Blue Lagoon and along the coast. Rich biodiversity. The best soil for agriculture in Sendong. Densely populated. Population 38 million, four major cities: Sendong's capital with a population of +10 million, and three cities of +1 million.

表 3.1：各省份概览

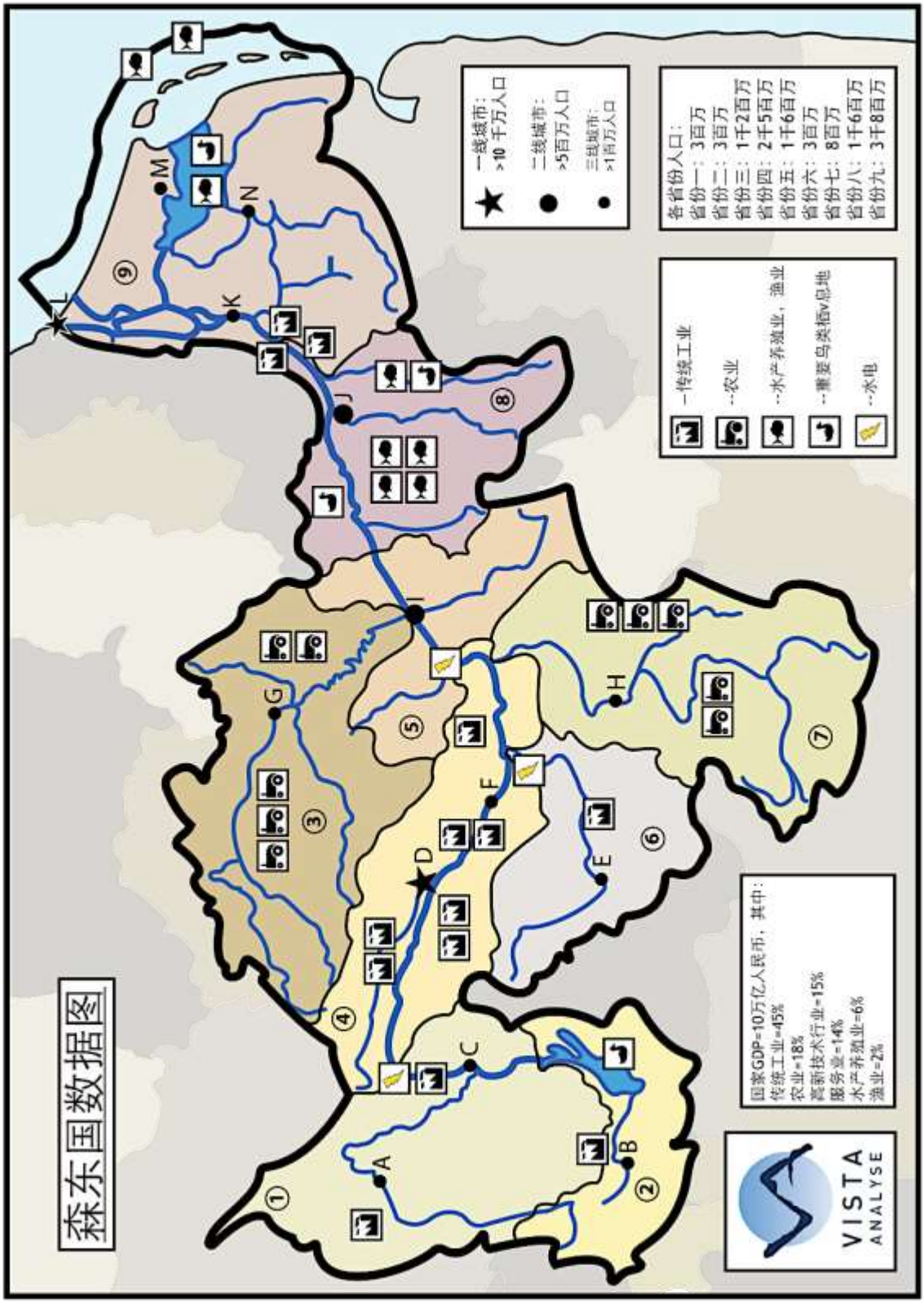
编号	省份名称	特点
1	青埃省	富矿山区分布广泛。具有茂密热带雨林与丰富的野生动物。人口约 300 万，两座主要城市均为采选业导向型城市，聚聚着约 100 万人口
2	四专省	富矿山区分布广泛。热带雨林和丰富的野生动物。绿水晶湖是森东国最大的湖泊，以著名水生生态和红冠鹤栖息地闻名。一直是森东国娱乐和钓鱼圣地之一。该省人口约 300 万，一座主要城市，该城市以采选业为支柱产业，聚居着约 100 万人口
3	类盟古省	森东国两个主要农业地区之一。一直闻名于众多小村落，丰富的农田和丰富的野生动物。现如今主要支柱产业为工业化农业、大型种植园。 人口 1200 万，并且有一个主要城市（人口约 100 万）。
4	干树省	森东国工业中心，人口稠密，约有 2500 万人口，2 个主要城市（一个人口约 1000 万，一个约 100 万）。分布有数个水电站，电力水源来自省份 1 和 6。
5	三西省	该省为主要的海上交通枢纽。该省东部以湿地、小湖泊，直流和水产养殖区域为主，水生生物多样性丰富。该省人口 1600 万，有一个主要城市（500 万人口）。电力水源来自省份 4（干树省）。
6	河蓝省	富矿山区分布广泛。热带雨林和丰富的野生动物。一直是森东国娱乐和钓鱼圣地之一。该省人口约 300 万，有一座主要城市，该城市长久以来一直是矿产行业中心，聚居着约 100 万人口
7	安飞省	森东国两个主要农业地区之一。一直闻名于众多小村落，丰富的农田和丰富的野生动物。现如今主要支柱产业为工业化农业、大型种植园。 该省人口 800 万，有一个主要城市，人口约为 100 万。
8	佛北省	该省以湿地、小湖泊，直流和水产养殖区域为主，水生生物多样性丰富。东部分布有高新科技区。该省人口 1600 万，有一个主要城市，人口约为 500 万。
9	三东省	森东国主要的高新科技产业服务区域。之前一直以蓝泄湖和海岸线周边的农业和渔业为主。生物多样性丰富。森东国最适宜种植农作物的土壤。人口稠密，约 3800 万人，有四个主要城市，一个是首都（人口约 1000 万），另外三个人口均在 100 万以上

Figure 3.1: Sendong country: Map with sub-river basins and data / 图 **3.1**：森东国数据图



Created by Vista Analyse. Design by Marcus Reinvang-Melo.

图 3.1：森东国数据图


森东国数据图
一线城市：
>10 千万人口
二线城市：
>5百万人口
三线城市：
>1百万人口
各省份人口：
省份一：3百万
省份二：3百万
省份三：1千2百万
省份四：2千5百万
省份五：1千6百万
省份六：3百万
省份七：8百万
省份八：1千6百万
省份九：3千8百万
--传统工业
--农业
--水产养殖业，渔业
--重要鸟类栖息地
--水电
国家GDP=10万亿人民币，其中：
传统工业=45%
农业=18%
高新技术行业=15%
服务业=14%
水产养殖业=6%
渔业=2%
VISTA
ANALYSE

3.1.2 Profile of provinces (= sub-river basins) in Sendong
森东国各省（子流域）简介

The provinces Qingai (no. 1), Sizhuan (no. 2) and Helan (no. 6) are home to the famous mountain rainforests with abundant wildlife and species diversity. (Sizhuan (no. 2) is home to Green Crystal Lake, the largest natural lake in Sendong, famous for its endemic aquatic ecology and the breeding of thousands of rare Red Crown cranes in the late spring. The mountains in these provinces are rich with minerals and the level 3 cities A, B, C and E are old centres of mineral industry. In Qingai (1), Sizhuan (2) and Helan (6) it has been estimated that around 15% of the population live in villages where water and soil pollution of heavy metals from abandoned mines have negative health impacts. It is unclear what it will cost to clean up such sites, which are estimated to about 2 000. Local Environmental Protection Bureaus are working on assessing the costs and have made a preliminary estimation of a cost of RMB 5 billion for cleaning up all the 2 000 sites. Local pollution also has severely negative impacts on wildlife and biodiversity. Green Crystal Lake has high pollution levels and many endemic species, as well as the Red Crown crane, are severely threatened. The structure of the mining industry is still dominated by many small mines with not up-to-date technology and some discharge heavy metals directly into the river without treatment. Air quality and quality of drinking water is at risk in the major cities.

第一、第二和第六个省拥有著名的山地雨林，野生动物资源和物种多样性十分丰富。森东国最大的天然湖泊—绿晶湖位于第二个省境内，这个著名的湖泊拥有颇具特色的水生生态，每到晚春时节，成千上万只红顶鹤在这里栖息繁殖，蔚为壮观。这三个省的山脉富含矿物质，三线城市 A、B、C 和 E 都是曾经的矿业中心。在第一、第二和第六个省，据估计，大约有 15%的人口生活在农村，废弃的矿山遗留下来的重金属造成当地水源和土壤污染，对当地人的健康带来严重影响。目前尚不清楚清理这些污染地区需要耗费多少投入，据估计，约有 2000 个污染地区，当地环保部门正努力对成本进行评估，当前预计清理完 2000 个场地需要 50 亿元。当地的污染对野生动物和生物多样性也造成了严重影响；绿晶湖污染严重，很多特有的物种和红顶鹤的生存受到严重威胁。为数众多的小型矿山仍然在使用过时的技术，这是目前采矿业的主流。有些小矿甚至不经过任何处理措施，直接排放重金属。大城市的空气和饮用水质量也面临风险。

At the borders between Qingai (1), Helan (6) and Ganshu (4), the landscape gradually drops from a plateau of 1500 meters above sea level (MASL), to about 700 MASL. Here we find the country's largest hydropower plants, which have broken the ecological connectivity for migrating fish species and eel to the mountainous areas. This has especially affected Sizhuan (2) province) and Helan (6) province negatively, as well as several endemic species that are on the verge of extinction. Sizhuan (2) and Helan (6) are traditionally known as the best regions in Sendong for recreation and fishing, and the once famous migrating fish festivals in the many small cities are today barely celebrated. A study showed that more than 50% of the population in Ganshu (4), Sanxi (5), Fobei (8) and Sandong (9) would like to visit these famous festivals annually, if they could be re-established. It has been estimated that an average household would spend about RMB 1,250 locally on such a visit. It has also been estimated that a program of measures to halt decline of local fish stocks in Qingai (1), Sizhaun (2), Helan (6) and Fobei (8) provinces (by stocking and setting out smolt and similar supportive measures, as well as removing barriers at sub-basin level) would cost RMB 2.5b.

在第一和第六个省交界地区和第四个省，地形从海拔 1500 米的高原逐渐降低到海拔约 700 米的平原。该国最大的水电站群就在这里，这些水电站阻断了生态连接度，使鱼类和鳗鱼不能够迁徙到山区。这尤其对第二和第六个省，以及几种濒临灭绝的珍稀物种产生了不利影响。第二和第六个省传统上是森东国最佳旅游休闲和垂钓胜地，曾经十分有名的、很多小城市都举办过的鱼类迁徙节今天几乎销声匿迹。一份研究报告表明，第四、五、八和第九个省超过 50%的居民表示，如果这些有名的节日恢复举办的话，自己愿意每年去参加这些节日活动。据估算，参加这样的节日庆祝时，平均每位居民将在本地花费大约 1250 元。而据估算，阻止第一、二、六和第八个省的本地鱼群存量（通过储备和放养小鲑鱼，采取类似的支持性措施，以及清除子流域障碍）下降的一揽子措施方案将耗资 25 亿元。

Ganshu (4) is the industrial heartland of the country and densely populated. Large coal deposits have provided the basis for energy intensive industry such as production of cement and steel, and the last decade chemicals industry has become a major industry. The major cities in Ganshu (4) are known for the highest general levels of air pollutants and soil pollutants, and the disease burden from pollution has been estimated to 15% above the national average. Downstream of the provincial capital (city D), the main artery of the Snow Dragon River is a sewer, with water unfit even for agricultural purposes. The drinking water sources of the cities along the river in Ganshu (4) are already showing signs of pollution, from local pollution but also from the small amounts of highly toxic pollution carried by the river from especially Qingai (1) and Sizhuan (2). It has been estimated that on average, at least 70% of the industrial pollution at the mouth of the Snow Dragon River comes from Ganshu (4). The last decades, on average one major pollutant spill has been reported in the province every five years and two significant spills have been reported every year. It has been estimated that a minority of spills, maybe as little as 25%, are reported.

第四个省是该国的工业中心，人口稠密。该市拥有丰富的煤炭矿藏，为发展水泥和钢铁制造等资源密集型产业奠定了良好的基础；过去 10 年来，化学工业也发展为支柱产业之一。第四个省的主要城市空气污染物和土壤污染物的程度最高；污染导致的疾病负担估计比全国平均水平高 15%。雪龙河主河道流经省会城市（D 城市）的下游河段是一条污水沟，这里的水甚至都不适合用于农业生产。第四个省的沿河城市的饮用水来源已经显示出污染的迹象，这些污染不仅有来自本地的污染，还来自尤其是第一和第二个省的河段带来的少量剧毒污染。据估计，雪龙河河口处平均至少有 70%的工业污染来自第四个省。过去 10 年来，该省平均每五年发生一次重大污染物泄漏事故；据报道平均每年发生两起严重污染物泄漏事故，而据估计只有部分约 25%的泄漏事故得到了报道。

Leimenggu (3) province and Anfei (7) province are the main agricultural regions in Sendong. Traditionally, these provinces were known for their many small villages, abundant crop fields and rich wildlife. Over the last decades, industrialization of agriculture has led to large expanses of intensively run mono-cultural plantations, at the expense of biodiversity and with fertilizer use leading to massive pollution of nutrients in rivers. It has been estimated that at least 70% of the agricultural pollution at the mouth of the Snow Dragon River comes from Leimenggu (3) and Anfei (7).

第三和第七个省是森东国主要的农业区。传统上这些省份拥有众多村庄和千里沃野，野生动物资源也十分丰富。过去 10 年以来，随着农业产业化的实施，这些地区形成了大片从事单一种植的集约型种植园，生物多样性不复存在；此外，大量使用化肥导致河水大规模富营养化。据估计，雪龙河河口处平均至少有 70%的农业污染来自第三和第七个省。

At the border of Ganshu (4) and Sanxi (5) province, the landscape gradually drops from 700 MASL til 300 MASL and we here find a series of hydrological power plants down to the provincial capital (city I), which has broken ecological connectivity between the middle and lower sections of the river. Here we also find a major maritime transportation hub, where goods coming in with smaller boats from upstream are loaded unto bigger boats taking them to the coast. The intense maritime activity has at several times proved to involve environmental risk, leading to significant spills and pollution of sometimes highly toxic substances. It has been estimated that about six significant spills take place every year, and most spills are reported as they involve a loss of product for the buyer and a claim for compensation. It has been estimated that accidents and spills are behind at least 5% of the total pollution load at the mouth of the river.

在第四和第五个省的交界处，地形从海拔 700 米逐渐降低到 300 米，在省会城市（城市 I）分布着一系列水电站，阻断了河流中下游河段之间的生态连接。这里同时也分布有交通枢纽，货物源源不断地用小船从上游运过来，然后换乘大船运往沿海地区。密集的海洋活动有好几次被证实可引发环境风险，导致时不时发生剧毒物质的严重泄漏和污染事故。据估计，每年大约发生 6 次严重泄漏事故。而大部分泄漏事故被报道是因为泄漏事故给买家造成了产品损失，他们因此提出索赔。据估算，这些泄漏事故造成的污染至少占到雪龙河口污染总量的 5%。

The landscape downstream from the provincial capital of Sanxi (5), city I, and down to the provincial capital of Fobei (8), city J, is characterized by wetlands, small lakes and a maze of channels, and this is the main region for aquaculture in the country. However, channelization of the main river has significantly reduced natural water dynamics, at the expense of rich local biodiversity (including endemic species) and water quality. Water pollution has also contributed to cause the abandonment of aquaculture from the best areas along the main river, and limited aquaculture activities to the southern tributaries. In the region between city J and city K (in Sandong (9) province), high-tech industries are based. A study showed that restoration of natural river dynamics and wetlands could potentially reduce total pollution at the mouth of the Snow Dragon River with 5% and increase aquaculture output with 300%. Another study showed that immediate measures to mitigate pollution influence on areas of special importance for maintaining biodiversity is necessary to halt the rate of loss of biodiversity, and estimated the necessary minimum investment for the whole river basin to RMB 2.5b in a first phase.

第五个省省会（城市 I）下游一直延伸到第八个省省会（城市 J）的地形复杂多样，有湿地、小湖泊和错综复杂的沟渠，这片区域是森东国从事水产养殖的主要地区。然而，自从实行干流渠道化后，河水的天然流动能力显著降低，本地丰富的生物多样性（包括珍稀物种）受到影响，水质下降。严重的水污染还导致沿河最好的河段被迫放弃水产养殖业，因而目前只能在南部支流进行养殖活动。城市 J 和城市 K（位于第九个省）之间的区域，是高科技产业集中的地方。一项研究表明，如果河流的天然流动能力和湿地得到恢复，雪龙河河口的总污染量可能降低 5%；同时水产养殖业产值有可能增长 300%。另外一项研究表明，某些地区对于维持生物多样性特别重要，有必要立即采取措施减轻污染对这些区域的影响，以防止生物多样性继续衰减。据估算，整个流域第一阶段完成修复所必须的最少投资为 25 亿元。

Historically, agriculture and fisheries in the large and shallow Blue Lagoon as well as along the coast, has dominated economic activity in Sandong (9), the capital province. Today, the economy is dominated by high tech industry and services. Over the last decades, agricultural

activities have come under pressure from urban sprawl and are hampered by water shortages due to pollution and falling groundwater levels. A government study showed that preserving the rich agricultural soil in the region is essential for the long-term food security of the nation. During the last 10 years, fisheries in the Blue Lagoon have virtually stopped due to high pollution levels and severely declining fish and shrimp stocks. Also coastal fishing is much reduced compared to historic levels, for the same reasons. The economic output of the shrimp and coastal fishing sector is now only 20% of what is was a decade ago. Sinking ground water levels in the main cities due to over-extraction, are contributing to a water crisis in the region.

从历史上看，广阔而浅的蓝泻湖和沿海岸地区开展的农业和渔业活动主导了首都所在省（第九个省）的经济活动。如今，该省的经济支柱为高科技产业和服务业。最近 10 年来，伴随着城市化进程加快，该省的农业生产面临巨大压力；同时，污染和地下水水质下降引起的水资源短缺也对农业生产造成影响。政府开展的一项研究表明，维持该地区丰富的农业土壤对于国家长期的粮食安全是十分必要的。过去 10 年以来，污染不断加剧，鱼虾存量严重萎缩，蓝泻湖区的渔业活动近乎陷入停顿。同时，由于同样的原因，与历史产量相比，沿海捕捞产量也大大减少。虾和沿海渔业部门目前的经济产值仅为 10 年前的 20%。由于过分开采地下水，主要城市的地下水水位不断下降，本地区面临严重的水危机。

3.1.3 Additional background data and estimations
其它可用的背景资料和评估

An expert commission at the Capital University has set an estimated sustainable pollution load at the mouth of the Snow Dragon River (the outlet to the ocean at the capital and at the Blue Lagoon) to 100 standard units per year and estimated the current pollution load to 300. The growth in pollution pressure generally follows the growth in GDP.

经首都大学专家委员会估算，将雪龙河河口（入海口位于首都的蓝泻湖处）可承受的污染量设定为每年 100 标准单位，据估计，该地目前的污染量高达 300 标准单位。随着 GDP 不断增长，面临的污染压力也随之加大。

The sources of the total pollution load has currently been estimated to Agricultural pollution = 40%, Industrial pollution = 35%, Urban wastewater = 15% and other sources = 10%.

目前的总污染量来源估计值为：农业污染占 40%；工业污染占 35%；城市废水占 15%；其它来源占 10%。

The cost of regional and local pollution to water, has been estimated to an average RMB 1 000 per person per year in health cost. The cost of a basic structure of 8 monitoring and emergency response centres in the river basin has been estimated to RMB 18b for a period of 10 years.

地区和本地水污染付出的健康成本估计为平均每人每年损失 1000 元。组建一支由流域内的 8 个监测和应急反应中心组成的基本组织估计每年耗资 18 亿元。

A Global Bank survey of newly industrialized countries in Asia, showed that on average some investments in reducing pollution are more effective than others: On average, an investment of RMB 1 billion in reducing pollution from agriculture leads to a pollution reduction of 3.3

standard units per year. On average, an investment of RMB 1 billion in reducing pollution from traditional industry leads to a reduction of 2 standard units. On average,an investment of RMB1 billion in urban wastewater treatment lead to a reduction of 1.5 standard units. The study suggested that for "other" measures, one may on average assume that an investment of RMB 1 billion leads to pollution reduction of 0.8 standard units per year.

环球银行发布的一份亚洲新兴工业化国家调查表明，某些减排措施投资要比其它的更为有效。平均每投资 10 亿元来减轻农业污染将促使污染每年降低 3.3 个标准单位；平均每投资 10 亿元来减轻传统工业污染将促使污染每年降低 2 个标准单位；每投资 10 亿元用于城市污水处理将促使污染每年降低 1.5 个标准单位。研究表明，对于"其它措施"而言，年投入平均 10 亿元可以每年减少 0.8 标准单位的污染物排放。

Preliminary estimations made by Environmental Protection Bureaus in Sizhuan (2) province indicate that costs to clean up pollution of heavy metals from abandoned mines averages about RMB 2.5 million, but this may vary significantly from case to case.

第 2 个省的环保部门做出的初步估计表明，清理废弃矿区造成的重金属污染所需成本平均约为 250 万元，但是根据不同的案例，成本可能会发生显著变化。

Last year, the annual GDP was RMB 10 000 billion and GDP is estimated to grow by 10% annually over the next decade, with an equal growth between sectors.

去年森东国的 GDP 为 10 万亿元，预计未来 10 年 GDP 将维持每年 10%的增速，各产业部门保持同等增长。

Please note that relevant data is also included in the map of Sendong (ref. figure 3.1.).

请注意相关数据也包含在森东地图中（参考图表 3.1）。

3.2 Questions / tasks
问题/任务

Please note that, like in real life, not all relevant information is always available. The task of the participant is to use the presented information in the manner he/she considers best, in order to make transparent and informed decisions. The participant should supplement the data provided in the case and the calculations based on these data, with his/her own experience of related issues when answering the questions in order to make the exercise as realistic as possible.

请注意如同在现实生活中一样，并非总是获取可以所有相关信息。学员的任务是以他们认为最佳的方式使用提供的信息做出透明且明智的决策。回答问题时，为了使演练尽可能贴近现实生活，学员可以根据他们自己处理相关问题的经验对案例中提供的例子和计算所得的数据进行补充。

Please note that most of the time should be set aside for answering question 3, which has five steps.

请注意应预留绝大部分时间来回答问题 3，其中包括 5 步。

1. When carrying out a SEA it is important first to establish how the situation and future looks like if no action is taken, including quantifications of negative consequences to the extent possible. Such a description constitutes a “reference scenario”, and this reference scenario makes it possible to assess the benefits of mitigation actions that reduce the negative environmental pressure.

当使用 SEA 方法的时候，首先要确定，如果不采取任何措施，当下和未来的情形会怎样，尽量将可能产生的负面影响定量。以此建立一种参考情形，来帮助我们评价所采取的减轻环境压力的措施的效益。

> Please list main facts (quantitative data) describing the current situation and consequences of business-as-usual development. Begin with the most important. Make calculations if necessary. How high is the pollution level? What are the main pollution sources? Which areas are the most affected? How many people are affected? What do we know about the costs and future impacts of the reference scenario?

请按照由主到次的顺序，用定量的数据列出当前的主要情况，以及如果照旧发展下去会产生的后果。 必要的时候可进行计算。（污染程度会怎样？主要的污染源是什么？会主要影响哪些区域？会有对少人受到影响？对于基线情况下的影响和成本，我们是否有一些初步的意见？

> *Estimated time needed: 30 min. / 估计需要时间：30 分钟*

2. When preparing to design an environmental risk reduction program, it is important to identify the most important risk sources, the most important impacts, and cases where the area producing the environmental risk is not the same as the area affected by the environmental risk ("uneven distribution and impact").

   设计一项降低环境风险的方案时，首先要识别主要的风险源、可能带来的主要影响、以及有哪些区域产生的环境风险与受到的环境风险影响不对等（风险分布和影响不均）

   a. Please list what you consider the three most important sources of environmental risk, describing the type of risk and in which province it is located.
      请列出三个你认为最重要的环境风险源，并说明风险类型和风险源位于哪个省。

   b. Please describe what you consider the main impacts of these risk sources, describing the type of impact and in which province it is located.
      请列出这些风险源的主要影响，并说明这些影响的主要类型和受影响的省份。

   c. Please provide examples of uneven distribution and impact of environmental risk, and explain shortly why this issue is important.
      请给出风险分布和影响不均的例子，并简要解释这种问题的重要性。

   Please go through the text closely and summarize in writing the main sources, the main impacts and examples of uneven distribution.
   请仔细阅读背景材料，并以书面形式总结出主要的风险源、主要的影响和分布不均的例子。

   Estimated time needed: 15 min. / 估计需要时间：15 分钟

3. The national government has set aside RMB 100 billion for a 10-year programme to reduce environmental risk in the Snow Dragon River Basin. Present how and where you would spend this money, to reduce urgent risks and get the best overall effect.

   国家政府划拨了 1000 亿元，开展为期 10 年的项目来降低雪龙河流域面临的环境风险。指出你会把这笔资金花在哪里，如何花来降低紧迫的环境风险，并获得最佳的总体效果。

   Estimated time needed: 2 hours. / 估计需要时间：2 小时

   Please follow five steps (a-e) to answer question 3: / 逐步回答问题 3 的过程：

a) Estimate as accurately as you can where the pollution comes from: How much of what kind of pollution comes from each province? Note that the share of the total pollution load (300 units) at the mouth of the river has been given: "agriculture" (40%), "industry" (35%), "urban wastewater" (15%) and "other" (10%). We also know how large a share of agricultural and industrial pollution that comes from certain of the provinces. If nothing specific is mentioned about source, assume that the source of pollution is evenly distributed per capita.

尽可能准确地估计出污染源来自哪里；不同类型的污染，每个省分别排放了多少；注意河口的总污染负荷（300 单位）贡献率已经给出："农业 40%，工业 35%，城市污水 15%，其他 10%"。我们也知道了各个省份农业和工业污染的贡献率。 如果没有提到具体的污染源信息，假设污染按人口平均分布。

Use the following table:
使用如下表格：

Table 3.2: Population and type of pollution per province and total (template)

表 3.1: 各省和总体的人口和污染类型

		Population 人口		Pollution (standard units) 污染（标准单位）					
Province 省份		Million 百万	%	Agriculture 农业	Industry 工业	Urban 城市	Other 其它	Total 总计	Total % 总计%
1	Qingai								
2	Sizhuan								
3	Leimenggu								
4	Ganshu								
5	Sanxi								
6	Helan								
7	Anfei								
8	Fobei								
9	Sandong								
SUM 总计									

b) Identify issues that you think should be addressed immediately. Then list the cost of specific measures that address these issues, if cost estimates are available. Finally, you summarize the costs.
列出你认为应当立即解决的问题和需要采取的措施，为每项措施分配资金，并计算出资金总额。

Use the following table format (add rows if necessary):
可采取以下表格的形式（可根据需要增加表格）

Issues that should be addressed immediately 需要立即解决的问题	Solutions 方法	Cost 资金
SUM 合计		

c) When designing an environmental risk reduction program, you will usually not have sufficient funds available to reduce all risks to the extent that would be ideal. This is also the case here: Reducing all pollution from agriculture, industry, urban wastewater and other sources would cost RMB 144 billion (estimation).

当设计一个降低环境风险的方案时，可或许没有足够的资金将所有的风险降低到理想水平。现在就是这种情况，削减来自农业、工业、城市污水和其他污染源的所有污染物估计需要 1440 亿（144,000,000,000）人民币。

We have about RMB 72 billion left, after addressing the urgent issues (ref. 3b). What is the best way to spend the remaining funds, while addressing the most pressing issues (some areas may be more important than other areas) and reducing as much pollution as possible per RMB?

在解决了亟待解决的问题（也就是 b 题中的问题）之后，我们只剩下 720 亿人民币。怎样分配剩下的资金，既能够解决最急需解决的问题（某些区域可能比其他区域更重要），又能够保证污染物去除效益（单位成本去除的污染物的量）最大化？

i. First list the factors and principles (such as cost-effectiveness) you consider fundamental and that will guide the way you prioritize.
首先列出你分配资金的基本的因素和原则（比如费效比）

ii. Then describe how you would allocate remaining funds to different measures (agriculture, industry, urban or other) in the different provinces, following the factors and principles you consider important.
然后，遵循你认为重要的因素和原则，说明你如何为各省不同的措施分配剩余的资金（农业、工业、城市污水和其他）。

iii. Finally summarize your distribution of funds in the table below.
最后在下表中总结你的资金分配。

Table 3.3: Measure and cost, for how to spend the rest of the budget

Measure 措施	Province(s) 省份	Cost 资金	Comments 备注

Remember that there may be different ways to design a good program, depending on which factors you consider the most important. A good program is a program that addresses the issues you prioritize and the general picture in an effective manner.

请谨记，基于你认为重要的因素组合，可能会设计出截然不同的项目。好的项目应该是按照既定的优先顺序逐个解决问题，并有效地控制总体形式。

d) Effects of the program
方案的效果

i. Estimate how much pollution you were able to reduce, using the following table.
估计你能够削减多少污染物，填表 3.4.

ii. Please describe in writing the main effects of the program (what kind of pollution is reduced the most and where) and other important effects for the environment.
请阐述该方案的主要影响（削减最多的污染物是什么，哪个地区削减最多），有哪些其他的主要环境影响。

使用如下表格描述主要的发现：

Table 3.4: Pollution reduced (in standard units) by implementing program (template)

表 3.4：方案实施降低的污染量（以标准单位计）

Province 省份		Agriculture 农业	Industry 工业	Urban 城市	Other 其它	TOTAL 总计
1	Qingai					
2	Sizhuan					
3	Leimenggu					
4	Ganshu					
5	Sanxi					
6	Helan					
7	Anfei					
8	Fobei					
9	Sandong					
SUM 总计						

e) What are the main successes and which are the main remaining problems?
取得了哪些成效，还剩下哪些主要问题？

Summarize main successes and remaining problems in writing, and use the following table:
使用如下的表格总结主要的成效和剩余的问题：

Table 3.5: Pollution remaining (in standard units) after implementing program (template)

表 3.5：方案实施后剩余的污染量（以标准单位计）

Province 省份		Agriculture 农业	Industry 工业	Urban 城市	Other 其它	TOTAL 总计
1	Qingai					
2	Sizhuan					
3	Leimenggu					
4	Ganshu					
5	Sanxi					
6	Helan					
7	Anfei					
8	Fobei					
9	Sandong					
SUM 总计						

Note to question 3: / 问题 3 注释：

- Pollution increases with economic growth until a decoupling is achieved. In order to make the exercise more simple, we assume that the effect of all actions take place in year 1 of the 10 year program.
环境污染总是与经济增长相伴而生，直到人们找到有效方法来解除二者的共生关系。为了让练习更加简单，我们假设所有行动的效果在 10 年项目期的第一年就显现出来。

- We also consider a reduction of pollution to have the same value per standard unit no matter where in the river basin it takes place. (Normally, upstream reductions will generally have larger positive effects per unit than more downstream reductions.)
我们同时也认定无论污染减轻发生在流域内的哪个地方，这种减轻具有相同的每标准单位值。（正常情况下，上游河段污染得到减轻，一般会比下游污染减轻产生更大的每单位正面效应。）

3.3 Suggested answers

参考答案

3.3.1 Costs and consequences of business-as-usual (the reference scenario)

保持现有发展模式下可能的环境成本和后果

- The total pollution level is already triple the sustainable level (100 standard units), and is set to grow by 10% each year, reaching 778 standard units in 10 years.
  当前总的污染程度已经是可维持程度（100 标准单位）的三倍，而且假设每年都以 10%的速度增长，十年后达到 778 标准单位。

- Health costs = RMB 124b/year (+ 10% increase each year?).
  健康成本=1240 亿元/年（每年增长 10%）。

- At least one major pollutant spill every 5 years in Ganshu (4) province; affect Sanxi (5), Fobei (8) and Sandong (9) provinces (total of 70 million people) as well as parts of Ganshu (4) province itself (total of 25 million people).
  第四个省每五年至少发生一起重大污染物泄漏事故，影响范围包括第五、八和第九个省（7000 万人口），以及第四个省部分地区（约 2500 万人口）。

- At least 8 significant pollutant spills every year from Ganshu (4) and Sanxi (5) provinces; affect Fobei (8) and Sandong (9) provinces (total of 54 million people) as well as parts of Ganshu (4) (total of 25 million) and Sanxi (5) (total of 16 mill.).
  第四和第五个省每年至少发生 8 起严重污染物泄漏事故，影响范围包括第五、八和第九个省（7000 万人口），以及第四个省部分地区（约 2500 万人口）和第五个省（约 1600 万人口）。

- Drinking water sources will likely become contaminated in cities along the river, especially in Ganshu (4) province.
  沿河城市的饮用水来源很有可能受到污染（特别是第四个省）。

- Water shortages will affect agriculture in Sandong (9) province negatively and compromise long-term food security in Sendong.
  水资源短缺将对第九个省的农业生产造成不利影响，并影响森东国长期的粮食安全。

- Further reduction in aquaculture and fisheries in Fobei (8) and Sandong (9) provinces.
  第八和第九个省的水产养殖业和渔业产量减少。

- Ecological river connectivity remains broken and increased pollution pressure makes more endemic species go extinct and threatens the Red Crown Crane etc.
  生态的河流连接度依然处于断裂状态；污染加剧使更多的珍稀物种灭绝，并严重威胁红顶鹤等生物的生存。

3.3.2 Main sources and impacts of pollution / uneven distribution

主要污染源和污染影响/分布不均

a. The three most important sources of environmental risk: 三大环境风险来源：
    1. Agricultural pollution from Leimenggu (3) and Anfei (7) provinces.
       第三和第七个省的农业污染
    2. Industrial pollution from Ganshu (4) province.
       第四个省的工业污染
    3. Toxic industrial pollution from Qingai (1), Sizhuan (2) and Helan (6) provinces.
       第一、二和第六个省的有毒工业污染

    Another candidate for top 3:另外一个答案
    4. Accidental spills from Ganshu (4) and Sanxi (5) provinces.
       第四和第五个省的意外泄漏事故

b. Main impacts of the most important risk sources / 首要环境风险源的主要影响
    1. Sandong (9) province is affected by all upstream pollution, leading to increased health burden and threats todrinking water sources, agriculture, and fisheries,
       第九个省（上游污染导致日益严峻的的健康、饮用水安全、农业和渔业生产安全问题）
    2. Fobei (8) province is affected by all upstream pollution, leading to increased health burden and threats to drinking water sources, aquaculture and biodiversity.
       第八个省受上游污染的影响，其对健康负担、饮用水安全、水产养殖业和生物多样性等造成了更为严重的负担。
    3. Ganshu (4) province is affected by industrial pollution and toxic pollution from Qingai (1), Sizhuan (2) and Helan (6) provinces, leading to increased health burden and severe threats to drinking water sources.
       第四个省受第一省工业和有毒物质的污染，对健康负担和饮用水安全造成了更为严重的负担。
    4. Sanxi (5) province is affected by all upstream pollution, leading to increased health burden and threates to drinking water sources.
       第五个省受上游污染的影响，其对健康负担和饮用水安全造成了更为严重的负担。
    5. Qingai (1), Sizhuan (2) and Helan (6) provinces is affected by heavy metal pollution, leading to increased health burden and threats to drinking water sources and biodiversity.
       第一、二和第六个省受重金属污染，其对饮用水安全和生物多样性造成了更为严重的负担。

c. Examples of uneven distribution and impact / 污染分布不均和影响示例
    1. Downstream provinces are generally hit hardest by pollution produced outside their own province; especially Sanxi (5), Fobei (8) and Sandong (9) provinces that get the accumulated pollution of the upstream provinces. Sandong (9) province is the most affected.

下游省份以外地区造成的污染通常对下游省份造成的危害最严重；特别是遭受上游省份累积污染的第五、八和第九个省（其中第九个省受影响最大）。

2. Ganshu (4) province is affected by pollution of heavy metals from Qingai (1) and Sizhuan (2) province
第四个省受到来自第一和第二个省的重金属污染的影响

It is important to identify cases of uneven distribution and impact of environmental risk, because this affects the ability of involved parties to effectively address the problems. Those who are affected directly by the pollution have a large incentive to act to reduce pollution, as they are experiencing the negative consequences. Those who are not directly affected have less incentive to act to reduce pollution. This makes it complicated in cases where there is uneven distribution and impact. Documenting such instances makes the authorities and businesses in the region where pollution is produced aware of the negative effects of the activity in their province, and increases the political and public pressure for them to act to reduce it. Documenting uneven distribution and impact also makes it clear for those affected where the problem comes from, so that they can engage in cooperation with authorities and businesses at the source to reduce the pollution that affects them. Finally, documenting such instances makes it possible for national authorities to make sure that provincial authorities and businesses work to reduce pollution in a coordinated and effective manner.

识别环境风险的不均分布和影响非常重要，因此这对于相关方有效解决问题而言具有非常重要的影响。那些主要承受污染负面影响的相关方会更有动力去降低污染，而这个因素也使得不均污染分布的情况下，污染问题变得更为复杂。对案例的记录分析有利于企业或政府机构对排污区域的负面作用有一个更为深刻的认识，同时也促使它们在公众和污染双重压力下减少污染物的排放。对“不均分布”案例的记录分析则有利于那些承受污染的相关方搞清楚这些污染到底源于何处，从而促使其与企业和政府机构合作治污染。此外，对此类案例的记录分析也有利于企业和省级机构通过通力合作和有效的方式进行节污减排。

3.3.3 Where and how to spend RMB 100b
1000 亿元花在哪些地区，如何花，以及花在哪些方面

A. Sources of pollution / 污染源

The pollution (standard units) of each province is calculated by using the data given in the case:
各省污染（标准单位）使用案例中的数据来计算：

- The sources of the total pollution load (300 standard units) is: Agricultural pollution = 40%, Industrial pollution = 35%, Urban wastewater = 15% and other sources = 10%.
总污染量（300 标准单位）的来源是农业污染，占 40%，工业污染占 35%，城市污水占 15%，其他污染占 10%。
- At least 70% of the industrial pollution at the mouth of the river comes from Ganshu (4) province.
至少 70%的河口工业污染来自第四个省。
- At least 70% of the agricultural pollution at the mouth of the river comes from Leimenggu (3) and Anfei (7) provinces.
至少 70%的河口农业污染来自第三和第七个省。

- The remaining pollution is to be distributed between provinces per capita
  剩余污染将平均分配给各省。

Table 3.6: Population and type of pollution per province and total

表 3.6: 各省和总体的人口和污染类型

		Population 人口		Pollution (standard units) 污染（标准单位）					
Province 省份		Million 百万	%	Agriculture 农业	Industry 工业	Urban 城市	Other 其它	Total 总计	Total % 总计%
1	Qingai	3	2.4 %	1.04	0.95	1.09	0.73	3.81	1 %
2	Sizhuan	3	2.4 %	1.04	0.95	1.09	0.73	3.81	1 %
3	Leimenggu	12	9.7 %	42.00	3.82	4.35	2.90	53.08	18 %
4	Ganshu	25	20.2 %	8.65	73.50	9.07	6.05	97.27	32 %
5	Sanxi	16	12.9 %	5.54	5.09	5.81	3.87	20.31	7 %
6	Helan	3	2.4 %	1.04	0.95	1.09	0.73	3.81	1 %
7	Anfei	8	6.5 %	42.00	2.55	2.90	1.94	49.38	16 %
8	Fobei	16	12.9 %	5.54	5.09	5.81	3.87	20.31	7 %
9	Sandong	38	30.6 %	13.15	12.09	13.79	9.19	48.23	16 %
	SUM	124	100.0 %	120.00	105.00	45.00	30.00	300.00	100%

* Pollution above 10 standard units highlighted with light grey colour.

* 10 个标准单位以上的污染用浅灰色突出显示

B. Issues that should be addressed immediately / 应当立即解决的问题

Table 3.7: Pollution issues that should be addressed immediately with cost estimates

表 3.7: 应当用成本估计立即解决的污染问题

Issues that should be addressed immediately 应当立即解决的问题	Solution 解决方案	Cost 成本
Reduce/eliminate accidents 减少/消除事故	Eight monitoring and emergency centres 八个监测和应急中心	18b (1.8b/year) 180 亿元 (18 亿元/年)
Secure drinking water sources, esp. in Ganshu (4) and Sandong (9) provinces. 保障饮用水源，特别是第四和第九个省的饮用水源。	Reduce overall pollution levels 降低总体污染程度	
	Reduce pollution in Ganshu (4) and Sandong (9) provinces. 降低第四和第九个省的污染	
	Reduce heavy metal discharge from Qingai (1) and Sizhuan (2) provinces. 降低第一、二和第六个省的有毒污染	
Ensure food security by securing water for agriculture in Sandong (9) province. 保障第九个省的农业用水，确保粮食安全	Reduce overall pollution levels 降低总体污染程度	
	Reduce pollution in Sandong (9) province. 降低第九个省的污染	
Reduce health risk in “cancer	Clean up old sins	5b (estimate)

villages" in Qingai (1), Sizhuan (2) and Helan (6) provinces. 降低第一、二和第六个省"癌症村"的健康风险	(2 000 abandoned mines) 清理历史欠账 （2000 个废弃矿区）	50 亿元 （估计）
Ensure ecological red lines 确保生态红线	Reduce overall pollution levels 降低总体污染程度	
	Mitigate pollution in prioritized areas for biodiversity. 减轻优先地区的污染，维持生物多样性	2.5b (estimate) 25 亿元 （估计）
	Measures to uphold local fish stocks and restore river connectivity in Qingai (1), Sizhuan (2), Helan (6) and Fobei (8). 第一、二、六和第八个省将要采取维持本地鱼群数量和恢复河流连接度的措施	2.5b (estimate) 25 亿元 （估计）
SUM 总计		**28b** **28 亿元**

It seems that reducing general pollution levels also will solve many of the urgent issues. We have thus not set aside money for them here, but will address this below in the cost-effectiveness assessment. However, we see that efforts should be prioritised in province 4 and 9, and we will take this into consideration below.

看起来降低总体污染程度也会有助于解决很多迫切问题。因而我们没有为总体污染预留资金，而是在下面的成本效益评估中解决此问题。然而，我们认为第四和第九个省的环保行动应该置于优先位置，我们会在下面考虑这一点。

We have 100b – 28 b = 72b left.
1000 亿元－280 亿元，资金还剩下 720 亿元。

C. How to allocate the rest of the money (72b) / 如何分配剩下的资金（706 亿元）

We need to find a balanced and effective way to reduce pollution, taking into account that some areas are at higher risk than others.
我们需要找到一个平衡且有效的方法降低污染，同时也要考虑到某些地区面临的环境风险比其它地区更高。

i. We consider the following factors and principles to be fundamental and guiding:
我们认为下面的因素是根本性的指导因素：

- The programme should address the most urgent issues while being cost-effective, in order to reduce as much pollution as possible.

- Action to reduce agricultural pollution is generally the most cost-effective and this points to prioritizing such action in Leimenggu (3) and Anfei (7) provinces.
降低农业污染的行动通常是最有效的，这需要给予第三和第七个省的环保行动优先权。

- In addition, Sandong (9) province is a priority for such action due to strategic importance of agriculture, high population and problems with drinking water. We may also assume that reducing local agricultural pollution is important for fisheries and wildlife in the Blue Lagoon and along the coast.

此外，由于农业在战略上极为重要、人口众多以及饮用水问题，第九个省同样也应当置于优先位置。我们也可以假设，降低当地农业污染对于蓝泻湖和沿海地区的渔业和野生动物也具有重要意义。

- Major efforts to reduce industrial pollution are needed in Ganshu (4) province, which will have important local benefits and significant downstream benefits.
  第四个省需要下大力气整治工业污染，这将使当地极大受益；对下游地区也会产生显著好处。
- Urban wastewater needs to be addressed across all provinces.
  所有省都需要解决城市污水问题。

- All provinces should get some funding for reducing pollution from agriculture, industry as well as urban wastewater.
  所有省份都应当获得资金支持，用于减轻农业、工业和城市污水污染。

- Investing in reducing pollution from "other sources" is less effective than reducing pollution from other sources. At least some of the pollution form "other sources" probably comes from accidents, and our investment in emergency centres will likely contribute to some reduction of this pollution. Besides accidents, we have no information that the pollution from "other sources" is particularly problematic or urgent. We therefore choose not to invest in reducing such pollution as part of the programme.
  投入资金到其它污染源治理中可能会较为低效一下。其它污染源中有一些包括突发事件，而对应急中心的资金投入可以在一定程度上减少这种污染。除了突发事件意外，其它污染源的信息并不充足，因而也就无从判断该类别中的污染是否较为紧急或问题较大。基于以上原因，最终的资金投入并没有涉及到其它污染源治理。

ii. Description of how we would allocate remaining funds
ii. 剩余资金投入概述

Qingai (1), Sizhuan (2) and Helan (6) are mountain provinces with low populations, very little agriculture and which already have got +6b allocated for addressing different urgent issues. We suggest allocating an additional RMB 2b for urban wastewater treatment in these provinces, no funds for agricultural pollution, and a share of funds to reduce industrial pollution that is proportional to the population size.

第一、二和第六个省属于山区，人口稀少，农业规模小，这些省已经获得额外的 50 亿元资金用于解决不同的紧迫问题。我们建议额外分配 6 亿元用于城市污水处理，然后将剩余的资金（700 亿元）优先用于剩下的 6 个省（第三、四、五、七、八和第九个省），其中用于工业污染治理的资金与各省的人口数量成正比，且无资金用于农业污染治理。

All provinces and cities need some basic investments. To clean up all urban wastewater in the other 6 provinces (Leimenggu (3), Ganshu (4), Sanxi (5), Anfei (7), Fobei (8), Sanding (9)) will cost 30b. We cannot afford to spend that whole amount, but will set aside 2/3 – 20b – and then the remaining will have to be financed later (and maybe some of it can be funded with local sources?). We now have 50b left.

所有省市都需要获得一些基本投资，处理 6 个省所有的城市污水将花费 300 亿元。我们不能把 300 亿元全部花掉，而是预留 2/3，也就是 200 亿元，剩下的资金留待以后提供（也许有些资金可以从本地筹措）。现在资金剩余 500 亿元。

To clean up all agricultural pollution will cost 36.4b and to clean up all industry pollution will cost 52.5b. We cannot do both. Reducing agricultural pollution is most cost-effective, but the situation in for instance Ganshu (4) province (industrial pollution) is critical and we also have to address that strongly, which also will benefit the downstream provinces.

清除所有的农业污染和所有的工业污染将分别耗费 364 亿元和 525 亿元。我们无法完成两个任务。尽管降低农业污染成本效益最高，但是比如第四个省面临的形势（工业污染）很紧迫，这时我们也不得不大力解决这个问题，这也会使下游各省受益。

We suggest setting aside 15b to reduce industrial pollution in the remaining 6 provinces, allocated according to share of pollution (Ganshu) and population (when we don't know the province's share of industrial pollution). An additional 5b will be earmarked for reduction of industrial pollution in Ganshu (4) province.

我们建议分配 150 亿元的资金用于降低剩下 6 个省的工业污染，资金分配按照人口比例进行(具体的各省工业污染比例并未提供)。将额外划拨 50 亿元用于减轻第四个省的工业污染。

- This gives a total reduction of 41 standards units, caused by industrial pollution
  这将引起工业污染引起的标准单位下降 40 个单位。

- Main beneficiaries: / 主要受益人：
  - Ganshu (4) province; reduction of 31 standard units
    第四个省降低 31 个标准单位。
  - Sandong (9) province; reduction of 4 standard units
    第九个省降低 4 个标准单位。

We suggest setting aside the remaining RMB 30b to reducing agricultural pollution in Leimenggu (3), Ganshu (4), Sanxi (5), Anfei (7), Fobei (8), Sanding (9), allocated according to share of agricultural pollution.

我们建议分配剩余的 300 亿元的资金用于降低第三、四、五、七、八、九省的农业污染，资金分配按照农业污染比例进行。

- This gives a total reduction of 99 standard units, caused by agricultural pollution
  这将引起农业污染引起的标准单位下降 99 个单位。

- Main beneficiaries: / 主要受益人：
  - Leimenggu (3) and Anfei (7) provinces; reduction of 2 x 35 = 70 standard units
    第三和第七个省降低 2 x 35 = 70 个标准单位。
  - Sandong (9) province; reduction of 12 standard units
    第九个省降低 12 个标准单位。
  - Ganshu (4); 8 standard units
    其它省降低 8 个标准单位。

With this program, we have tried to be cost-effective while also addressing main issues in a targeted manner.

我们力求使本行动方案尽可能实现成本效益最大化，同时有针对性地解决主要问题。

iii. Summary of distribution of funds in table / 资金分配一览表

Table 3.8: Measures with costs, for how to spend the rest of the budget (RMB 72b)

Measure	Province	Cost	Comments
Urban wastewater	Qingai (1), Sizhuan (2), Helan (6)	2b	Allocated according to population.
Urban wastewater	Leimenggu (3), Ganshu (4), Sanxi (5), Anfei (7), Fobei (8), Sandong (9)	20b	Allocated according to population.
Industrial pollution	Ganshu (4)	5b	
Industrial pollution	Leimenggu (3), Ganshu (4), Sanxi (5), Anfei (7), Fobei (8), Sandong (9)	15b	Allocated according to share of pollution (Ganshu) and otherwise population.
Agricultural pollution	All provinces	30b	Allocated according to share of pollution (Leimenggu 35%), Anfei 35%), otherwise population.
SUM		**72b**	

表 3.9: 减排措施、成本、720 亿资金分配

减排措施	省份	成本（亿）	备注
城市污水	第 1、2、6 省	20	根据人口分配
城市污水	第 3、4、5、7、9 省份	200	根据人口分配
工业污染	第 4 省	50	
工业污染	第 3、4、5、7、8、9 省份	150	根据污染比例或人口分配
农业污染	全部省份	300	根据污染比例（第 3 和第 7 省各占 35%）或者人口分配
总计		720	

Table 3.10: Distribution of funds per province and type of pollution

Province 省份		Agriculture 农业	Industry 工业	Urban 城市	Other 其它	TOTAL 总计	
1	Qingai	0.00	0.15	0.67	0	0.81	1%
2	Sizhuan	0.00	0.15	0.67	0	0.81	1%
3	Leimenggu	10.50	0.59	2.09	0	13.18	18%
4	Ganshu	2.37	15.50	4.35	0	22.22	31%
5	Sanxi	1.52	0.79	2.78	0	5.09	7%
6	Helan	0.00	0.15	0.67	0	0.81	1%
7	Anfei	10.50	0.40	1.39	0	12.29	17%
8	Fobei	1.52	0.79	2.78	0	5.09	7%
9	Sandong	3.60	1.88	6.61	0	12.09	17%
SUM 总计		**30.00**	**20.40**	**22.00**	**0**	**72.40**	**101%**
%		43%	28%	30%			

表 3.11: Distribution of funds per province and type of pollution

省份	农业	工业	城市	其它	总计	
1	0.00	0.15	0.67	0	0.81	1%
2	0.00	0.15	0.67	0	0.81	1%
3	10.50	0.59	2.09	0	13.18	18%
4	2.37	15.50	4.35	0	22.22	31%
5	1.52	0.79	2.78	0	5.09	7%
6	0.00	0.15	0.67	0	0.81	1%
7	10.50	0.40	1.39	0	12.29	17%
8	1.52	0.79	2.78	0	5.09	7%
9	3.60	1.88	6.61	0	12.09	17%
总计	30.00	20.40	22.00	0	72.40	101%
%	43%	28%	30%			

D. Effects of the program/ 减排效果

i. Estimate how much pollution you were able to reduce, using the table.
利用表格估算实际减排污染量

Table 3.12: Pollution reduced (in standard units) by implementing program

表 3.10：方案实施降低的污染量（以标准单位计）

Province 省份		Agriculture 农业	Industry 工业	Urban 城市	Other 其它	TOTAL 总计	
1	Qingai	0.00	0.30	1.00	?	1.30	1%
2	Sizhuan	0.00	0.30	1.00	?	1.30	1%
3	Leimenggu	34.65	1.19	3.13	?	38.97	23%
4	Ganshu	7.82	31.00	6.52	?	45.34	26%
5	Sanxi	5.00	1.58	4.17	?	10.76	6%
6	Helan	0.00	0.30	1.00	?	1.30	1%
7	Anfei	34.65	0.79	2.09	?	37.53	22%
8	Fobei	5.00	1.58	4.17	?	10.76	6%
9	Sandong	11.88	3.76	9.91	?	25.55	15%
SUM 总计		**99.00**	**40.80**	**32.99**	**?**	**172.79**	**100%**

* Pollution reduction above 5 standard units highlighted with light grey colour.

i. Please describe in writing the main effects of the program (what kind of pollution is reduced the most and where) and other important effects for the environment.
请描述减排措施的主要效果（哪种污染被减少最多，以及在哪里减排），以及其它的环境效益。

The suggested program will give a total reduction of: / 建议实施的方案相当于一共减少了

- 1 standard units from industry in Qingai (1), Sizhuan (2) and Helan (6) provinces.
第一、二和第六个省 1 个标准单位的工业污染

3 standard units from urban wastewater in Qingai (1), Sizhuan (2) and Helan (6) provinces.第一、二和第六个省 3 个标准单位的城市污水污染
- 30 standard units from urban wastewater in the other 6 provinces
  其余六个省 30 个标准单位的城市污水污染
- 31 standard units from industry in Ganshu (4) province
- 第 4 省减少了 31 个标准单位的工业污染 10 standard units from industry in the other 6 provinces
  其余六个省 10 个标准单位的工业污染
- 99 standard units from agriculture in all provinces
  所有省 99 个标准单位的农业污染
- TOTAL = 172 standard units / 总计 172 个标准单位

We know that "other sources" are responsible for an annual pollution load of 30 standard units, and some of this likely comes from accidents. We have invested RMB 18b in monitoring and emergency centres, which likely will contribute to reduce "other pollution" – but we don't know how much.
其它污染源每年产生 30 个标准单位的污染，其中可能有一些来自于应急事故。我们已经投入了 180 亿人民币在应急中心上，但是具体的效果还难以量化。

In addition, the program will: / 除此之外，该方案将
- Reduce accumulated and acute risk to ecology in general and in priority ecological hotspots (such as Green Crystal Lake, the Blue Lagoon).
  降低总体和优先生态热点地区的累积和突发性生态风险（如绿晶湖和蓝泻湖）；
- Reduce accumulated risk to local fish species in Qingai (1), Sizhuan (2) Helan (6) and Fobei (8) provinces.
  降低第一、二、六和第八个省本地鱼群的累积风险；
- Hopefully prevent species extinction (sustainability risk?) until the ecological situation in the river basin can be improved even further.
  有望防止物种灭绝（可持续性风险），直到流域生态形势进一步得到改善。

E. Main successes and remaining problems / 主要成就和剩下的问题

- Main successes/ 主要成就
  - The total pollution load is now only 29 standard units above sustainable level (the sustainable level is 100)
    总体污染量当前仅比可维持水平（该水平为 100 标准单位）高 29 个标准单位；
    (But in reality not quite so good as the effect of economic growth and time of implementation has not been taken into account.)
    （但实际上可能没有这么好，因为没有考虑经济增长的影响和实施时间）
  - Acute environmental risk reduced significantly with emergency centres, which probably also reduces pollution from "other sources" (but how much is unknown)
    建立了应急中心，显著降低了突发性环境风险，也有可能同时降低其它污染源的污染，但是具体数字不得而知；
  - Huge reduction in agricultural pollution (82,5%) and urban wastewater pollution (73%).

农业污染（82.5%）与城市污水（73%）极大降低；

- Critical health situations in in Qingai (1), Sizhuan (2) and Helan (6) handled.
  处理应对了第一、二和第六个省严峻的健康形势；
  Pollution has especially been reduced in provinces that are main sources of pollution and/or are critically affected by pollution; Ganshu (4) – 46 units, Leimenggu (3) – 39 units, Anfei (7) – 38 units, Sandong (9) – 26 units, Sanxi (5) – 11 units, and Anfei (8) – 11 units.主要污染源所在省份的污染浓度被极大降低：第 4 省降低 46 个标准单位，第 3 省降低 39 个标准单位，第 7 省降低 38 个标准单位，第 9 省降低 26 个标准单位，第 5 省降低 11 个标准单位，第 8 省降低 11 个标准单位
- Improvement for fisheries and agriculture in Fobei (8) and Sandong (9) provinces.
  第八和第九个省渔业和农业生产得到改善；
- Fundamental improvement with regards to ecological red lines
  生态红线得到根本改善。

- Main remaining problems/ 剩下的主要问题
  - 60% of industrial pollution remains
    仍然有 60%工业污染有待治理；
  - Industrial pollution in Ganshu (4) province is still bad, and is now clearly the highest single source of pollution in the river basin (43 standard units)
    第四个省的工业污染依然严重，成为目前流域内最大的单一污染源（43 个标准单位）；
  - Especially Ganshu (4) – 53 units and Sanding (9) – 22 units still have high levels of pollution, and also Leimenggu (3) – 14 units, Anfei (7) – 12 units, Sanxi (5) – 10 units and Fobei (8) – 10 units still have significant levels of pollution.
    特别是第 4 省，依然有 53 标准单位的污染物，第 9、3、7 省仍然有 22、14、12 标准单位的污染物。下游的第 5 和第 8 个省污染程度仍然很严重，各有 10 个标准单位的污染物。
  - Agricultural pollution is still a problem in Leimenggu (3) and Anfei (7).
    第 3 和 7 省份的农业污染依然是很多省面临的难题；
  - Urban wastewater treatment only secured for 2/3 of urban wastewater.
    城市污水处理仅处理了污水总量的 2/3。

Table 3.13: Pollution remaining (in standard units) after implementing program
表 3.11: 方案实施以后各省剩余的污染量（以标准单位计）

Province 省份		Agriculture 农业	Industry 工业	Urban 城市	Other 其它	TOTAL 总计
1	Qingai	1	1	0	1 (?)	3
2	Sizhuan	1	1	0	1 (?)	3
3	Leimengguu	7	3	1	3 (?)	14
4	Ganshu	1	43	2	6 (?)	52
5	Sanxi	1	3	2	4 (?)	10
6	Helan	1	1	0	1 (?)	3
7	Anfei	7	2	1	2 (?)	12
8	Fobei	1	3	2	4 (?)	10
9	Sandong	1	8	4	9 (?)	22
SUM 合计		**21**	**65**	**12**	**31(?)**	**129**

* Pollution above 5 standard units highlighted.
5 个标准单位以上的污染用浅灰色突出显示

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