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Environmental economic impact assessment in China: Problems and prospects☆

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Abstract

The use of economic valuation methods to assess environmental impacts of projects and policies has grown considerably in recent years. However, environmental valuation appears to have developed independently of regulations and practice of environmental impact assessment (EIA), despite its potential benefits to the EIA process. Environmental valuation may be useful in judging significance of impacts, determining mitigation level, comparing alternatives and generally enabling a more objective analysis of tradeoffs. In China, laws and regulations require the use of environmental valuation in EIA, but current practice lags far behind. This paper assesses the problems and prospects of introducing environmental valuation into the EIA process in China. We conduct four case studies of environmental economic impact assessment (EEIA), three of which are based on environmental impact statements of construction projects (a power plant, a wastewater treatment plant and a road construction project) and one for a regional pollution problem (wastewater irrigation). The paper demonstrates the potential usefulness of environmental valuation but also discusses several challenges to the introduction and wider use of EEIA, many of which are likely to be

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of relevance far beyond the Chinese context. The paper closes with suggesting some initial core elements of an EEIA guideline.

Keywords: Environmental impact assessment; Environmental valuation; China; Economic analysis

1. Introduction

The use of economic methods to value environmental impacts (“environmental valuation—EV”) of projects and policies has grown considerably in the USA and Europe in recent years. The USA has been at the forefront of this trend, requiring cost benefit analysis (CBA) of major undertakings, fuelling the academic and political debate with several high profile applications, for example the *ex post* CBA of the Clean Air Act (USEPA, 1997, 1999) and the environmental damage assessment of the Exxon Valdez' oil spill in 1989 (Carson et al., 2003). The main aim of EV and CBA is to enable comparison between environmental protection and social and economic development to achieve more efficient use of scarce resources (Arrow et al., 1996). Several EV guidelines have been developed for practical use, for example OECD (1995, 2002), USEPA (2000) and Belli et al. (2001). More recently, EV has also been taken up by developing countries, to date primarily for project-level evaluation though more city-, regional-, sector- or country-level assessments (so-called strategic environmental assessment—SEA) are increasingly being conducted (Aunan et al., 2004; Saraf et al., 2004; Mestl et al., 2005). Several case study collections have been published in recent years, see for example Abelson (1996), Georgiou et al. (1997), McCracken and Abaza (2001) and Pearce et al. (2002).

Despite the growing position of EV and its potential benefits to the environmental impact assessment (EIA) process, the EV approach appears to have developed more or less independently of current regulations, research and practice of EIA (Hundloe et al., 1990; James, 1994). EV could enter into the EIA process at several stages, i.e. from the initial screening of projects to the environmental impact statement (EIS) stage. In the EIS, EV may be useful in judging and comparing significance of impacts (as an alternative to standard EIA weighting/scaling or ranking/rating techniques), determining the appropriate level of mitigation, comparing alternatives and generally providing a more transparent and objective analysis of tradeoffs that is more informative for decision-making.[1] Further, any EV exercise needs to build on a careful assessment of physical impacts, which is the output of well-conducted EIA processes. With these apparent synergies between EIA and EV, it is indeed surprising that the two traditions have not more often merged into what can be termed “environmental economic impact assessment” (EEIA). Some scattered initiatives of EEIA have been furthered for example by the World Bank (World Bank, 1996; Dixon and Pagiola, 1998) and the Asian Development Bank (ADB, 1996, 1999). The environmental assessment and project appraisal literature appears to have cautiously, and somewhat reluctantly, picked up elements from EV and CBA (Kirkpatrick and Lee, 1997). Recent examples of such studies published in two typical field journals are relatively few: Atkinson and Cooke (2005) in relation to health impact assessment, Knaus et al. (2006) valuing ecological impacts, Ranasinghe et al. (1999) and Haider and Rasid (2002) assessing water supply

[1] As stated by James (1994, p. 1): “The economic approach offers a logical means of integrating applied science and public decisionmaking, of reducing conflicts in environmental and natural resource management, and reaching balanced decisions on development and environmental protection. [..] With recent advances in valuation methods, it has now become possible to place economic values on many–but not all–environmental impacts [..].”

options, and Uri et al. (1998), Morimoto and Hope (2004), Lubulwa (1999), Hearne (1996) and Wattage et al. (2000) assessing costs and benefits of various types of projects. None of these studies consider EV directly in relation to EIA.

Even though some countries have regulations requiring some sort of EV in EIA, there is very little actual practice (Crookes and de Wit, 2002). The situation is similar in China. The new EIA law from 2002 requires use of economic analysis to assess impacts (Wang et al., 2003), but there are no technical guidelines on how to conduct such analysis, and because of that and for other reasons current practice lags far behind regulations. This is specifically the case in relation to EEIA, as China has conducted other types of EV exercises, for example at the national level (World Bank, 1997; ECON Analysis, 2000). Given this gap in the literature, the lack of protocol or guidelines, and the infancy of country practice of EEIA internationally (Crookes and de Wit, 2002), this paper sets out to explore the problems and prospects of EV in EIA, with emphasis on China. China's pollution and environmental degradation problems are well known, and in no other country is the use of EEIA potentially more urgently needed. Our limited but useful starting point is the inclusion of EV in the EIS of large construction projects, extending the application to a regional pollution problem. We ask the following research questions (all with reference to China): (1) How can EV methods be applied to EIA, with emphasis on EISs of large construction projects?; (2) What are the challenges and gaps to the introduction of EEIA and how could the gaps be bridged?; and finally (3) What could be initial elements of a guideline for EEIA?

We focus on the first two research questions in this paper, discussing briefly question 3 in our concluding remarks. The core of the empirical research consists of four case studies of EEIA, three of which are based on EISs of investment projects (a power plant, a wastewater treatment plant and a road plan) and one for a regional pollution problem (wastewater irrigation). A full account of the research, and core elements of an EEIA guideline is given in ECON Analysis (2005).

2. The link between environmental valuation and EIA

2.1. The EIA system and environmental valuation in China

The details of the Chinese EIA system and institutional setup has been thoroughly evaluated and criticised in previous studies (Lo et al., 1997; Chen et al., 1999; World Bank, 2001; Mao and Hills, 2002; Wang et al., 2003). It is, however, useful for our purposes here briefly to summarise the Chinese EIA system and process as it relates to construction projects and EV. The Chinese Environmental Protection Law from 1989 complemented by 15 specific laws or statues (for example addressing water, noise, air pollution, etc.) together form the legislative basis for EIA (Wang et al., 2003). The so-called Ordinance of Environmental Management for Construction Projects (OEMCP) from 1998 makes EIA compulsory for all sizes of construction projects and sets out the fundamental EIA requirements. The OEMCP requires that the EIA of any construction project with substantial environmental effects must include environmental economic analysis. To supplement the OEMCP, more specific guidelines have been developed, such as the "Technical Guidelines for Environmental Impact Assessment", that provide information about what should be covered in the EIS, of which EV is one component. Further, a new national EIA law from 2002, summarised article by article in translated form in Wang et al. (2003), states that economic analysis of mitigation measures should be conducted as well as evaluation (not only analysis and prediction) of impacts.

SEPA has the overall responsibility for environmental management and protection in China. Environmental protection bureaus (EPBs) in the provinces and in prefecture governments across the country are responsible for implementation, while licensed research institutes or agencies conduct the actual EIA. The Appraisal Centre for Environment and Engineering is responsible for providing technical reviews of EISs, supporting research, and training for licensed agencies and EPBs (Wang et al., 2003). The EIA process consists of the same steps that are found in many other countries starting with screening, scoping, EIS, review and monitoring (Wang et al., 2003). The initial step screens construction projects into one of three categories, depending on whether impacts are likely to be significant and adverse (category A), of limited number and significance (B) or expected not to be significant (C). SEPA has issued a list of project types for each category and only category A requires a full-blown EIS. To assess whether a proposed project is likely to cause significant environmental impacts, either the emission volumes, types or complexity and potential for abatement, or "sensitivity of area" (based on ecological, cultural or archaeological importance) are used as criteria. Additional parameters such as size and output levels help the screening process.

There is no explicit reference in the Chinese EIA system to the need to evaluate significance of impacts in the EIS. In practice, as pointed out by Wang et al. (2003), the dominant approach is to compare pollution levels with "legislative requirements, established environmental standards or pollution abatement requirements". If these do not exist, expert opinion is used. If some sort of economic analysis is carried out as part of the EIS, it normally just estimates abatement costs and how much tax and profits are generated (Wang et al., 2003). It is interesting to note that the EIA law from 2002 also requires EIA, and hence some sort of EV, of regional and sector plans, but not of the Chinese 5-year plans or policies (Xiuzhen et al., 2002; Cun-kuan et al., 2004). We will return to SEA when discussing the usefulness of EV.

2.2. Common steps of EIA and environmental valuation

In merging EV and EIA, as mentioned, the literature provides little guidance. The most comprehensive guidance document we are aware of is the workbook by ADB (1996), and the more case-oriented follow up of ADB (1999). The familiar methodological steps of EIA involve identifying a project's *stressors*, and how these pass through *environmental media* to change physical characteristics of *receptors*, manifesting themselves as *impacts* judged as favourable or negative, as outlined in Fig. 1. Impacts, especially of air and water pollution, are often assessed using dose–response (DR) functions from the environmental science or epidemiology literature.

EV starts from the quantification of physical impacts stage, assigns unit values (often known as "prices") in monetary terms and sums across impact categories to arrive at an estimate of total environmental costs or benefits (two last shaded stages of Fig. 1). The prices of the impacts are in standard economic theory most commonly defined as the amount people on average are willing to pay (WTP), i.e. the value of other goods and services they are willing to forego, to avoid the realisation of a negative environmental impact or combination of impacts. WTP can reflect values both related to people's recreational (or other) use of environmental amenities (such as air we breath, clean water for swimming and fishing, etc.) and non-use or existence (for example biodiversity in an area we will never visit).

The EV process then involves choosing the most suitable methodologies to approximate the "true" WTP for different impacts given time, budget and data constraints. In principle, all impacts can be valued, but in practice priorities have to be made depending on the purpose. As in other disciplines, accuracy comes at a cost, but what is "accurate enough" very much depends on what the results are to be used for. In many cases, a conservative EV estimate, or range of estimates,

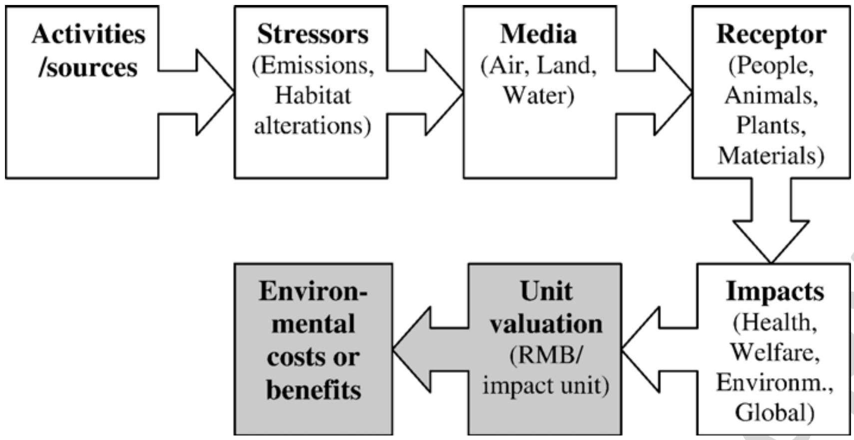

Fig. 1. The steps of identifying and predicting environmental impacts in physical (white) and economic terms (shaded) (figure adapted from ADB (1996)).

based on the data available may be very useful in comparison for example with economic costs or benefits of projects or mitigation measures. If project environmental impacts have a high negative value compared to the economic benefits of the project, it should be revised or stopped. If the figure or range is closer to the economic benefit estimate, a more comprehensive impact analysis may be called for.

The toolbox of valuation methodologies is large and growing. Methodologies are usually placed in two broad categories according to the nature of the data used for estimation. The first category, *stated preferences*, ask people directly, for example in a so-called contingent valuation (CV) survey their WTP for hypothetical environmental changes (including for example changes in mortality risks deriving value of statistical life—VOSL). The methods in the second category, *revealed preferences*, rely on data from observations of people acting in real-world settings, deriving indirectly how people value different aspects of the environment. Often used approaches in this category include travel cost (for example for natural amenities) and hedonic price methods (for example for urban environmental qualities, or VOSL derived from differences in salaries for safe and risky jobs), defensive behaviour (for example costs of buying bottled water) and damage cost methods (for example costs of pollution-related diseases, cost of illness—COI). In practice, to save time and costs of conducting primary valuation work, value estimates from other sites (domestically or internationally) are sometimes transferred in adjusted form to the study setting, known as *benefit or value transfer* (Navrud and Ready, 2006).

A comprehensive discussion of EV methodologies is beyond the scope of this paper and is well covered elsewhere. Important references include Freeman (2003) on the theory of EV, Champ et al. (2003) on methodologies, Hanley and Spash (1993) and Boardman et al. (2006) on CBA, and Brent (1998) on CBA in developing countries. This literature also discusses the critique levelled by ecologists, philosophers and other disciplines against EV. In relation to EIA, EV faces some specific challenges, as pointed out by for example Crookes and de Wit (2002), some of which we will turn to later. With the range of impacts typically identified in an EIA, it is clear that not all impacts can or should be valued. A screening process should be applied, based on different criteria such as potential importance, level of uncertainty, availability of data, resources and time available, purpose of the valuation, etc. However, it does not mean that impacts that are not valued will be left out of the analysis, as they should be described qualitatively or given weights (e.g. as suggested by ADB, 1996). It is important to note that EV relies on careful identification and measurement of physical impacts in the EIS, which we shall see in many cases is lacking from current Chinese EIA practice.

3. Study design and methods

To answer the three research questions, the paper uses a combination of interdisciplinary research reviews, case studies, personal interviews and EIA practitioner workshops. The groundwork for the research lies in a comprehensive review of environmental science and epidemiology in the areas of air pollution, water pollution and land degradation in China. This review turned out a large amount of dose response (DR) functions (mostly in Chinese) related to air pollution, some related to water pollution, and very few related to land pollution and degradation.[2] A challenge assessing this material is to find DR functions suitable for transfer to the site under investigation. Furthermore, a review of EV methodologies in use internationally and in China was conducted to assess state-of-the-art.

The core of the empirical work lies in the four case studies of EEIA conducted, three of which was based on EIS. For a full test of EEIA, it would probably have been better to plan and carry out the EIS in tandem with the EV work. This was not possible due to budget and time constraints, and for EIA procedural reasons. Out of the three EIS, a coal-fired power plant extension in the Shanxi Province and a wastewater treatment plant in the Henan Province were finished. An EIS of a road project in Chongqing was in process as the valuation work started. On the other hand, using two already finished EIS as the basis for EV gave a realistic impression of what is normally their quality and the challenges related to adding EV. A large number of EIS were reviewed in the process. The three chosen cover the different media of air, land and water, corresponding to the categories in the technical guidelines, represent a good geographical spread, and are of a better than average quality. While conducting the case studies, the Chinese team was in contact with the practitioners who had conducted the EIAs to supplement information. In cases where impact information was limited or lacking, additional data were collected using rapid on-site surveys and/or drawn from official sources to the extent possible. The case studies followed the general spirit of the protocol recommended in ADB (1996). Further, low-cost EV methods were chosen to more realistically represent what would be possible to achieve within an EIA process in a developing country (Knowler, 2005). In addition to the three EIS-based cases, the research team wanted to use EV in a situation that would normally escape EIA, but where it would potentially be very useful. An EEIA was therefore conducted for a regional pollution problem of some magnitude in China, namely the use of wastewater for irrigation.

To better understand the institutional and practical challenges involved in introducing EEIA in China and to supplement the experiences from the case studies, a number of interviews were carried out with EIA practitioners, SEPA EIA specialists, policymakers, EPB staff and with EIA experts in Hong Kong (which is considered to have an advanced EIA system) in the period from November 2002 to May 2005.[3] Several workshops with EIA practitioners from EPBs and SEPA were organised in Beijing to discuss and interpret the case studies and to analyse the challenges for EEIA in China. The first-hand experience of the EIA practitioners was useful to the research process, since the actual practice, as is often the case, deviates from the intentions and requirements that can be read out of written sources such as EIA laws and regulations.

[2] Literature review documents in Chinese of collected DR functions is available on request from the Chinese co-authors. Partly translated versions are available in ECON Analysis (2005).

[3] A list of people interviewed and representation at the workshops are available on request from the authors.

4. Environmental economic impact assessment case studies

The four case studies are summarised below, generally following the format: *background and project description, impact assessment, EV and conclusions*.

4.1. Coal-fired power plant in Datong, Shanxi Province

4.1.1. Background and project description

Datong No. 2 coal-fired power plant located in the southern suburb of Datong City, Shanxi Province, is one of the most important power plants in northern China. From 2002 to 2007, China is planning to upgrade in a second phase the 200 MW plant with two sets of 600 MW air-cooling facilities. The second phase has potentially significant and adverse impacts and is therefore made subject to a full EIA, on which we base our EEIA. The case demonstrates that, even if the EIS predicts relatively low local changes in concentrations, impacts may still be important in economic terms. Further, it illustrates the significance of the project boundary and that more mitigation than planned may be warranted.

4.1.2. Impact assessment

The expansion of the plant is located on existing land of the power facilities therefore limiting land use impacts. Furthermore, the dust from ash and coalfields are relatively low, so the most important environmental impacts are emissions to air. Since the plant is located south of the city and the wind generally comes from the north, most of the emissions do not affect the city itself. However, the southern suburbs are also densely populated, and contain some agricultural districts. The scope of the EIA was expanded somewhat from the required 20 * 20 km with the power plant at the centre to 456 km^2 to include the cultural heritage site of the Yungang grotto and an ash field. The EIS forecasted the air quality at 10 monitoring locations and predicted the most important stressors to be nitrogen dioxide (NO_2), sulphur dioxide (SO_2), particulate matter (PM_{10}), total suspended particulates (TSP) and fluoride (F), in descending order. The SO_2 emissions account for 1.5–6.5%, NO_2 for 8–30% and PM_{10} 0.02–0.08% of the total concentration at the three key southern monitoring spots. The overall conclusion of the EIS was that, since the plant adopted desulphurization equipment, low-nitrogen combustion equipment, an effective electrostatic dust remover and a high 240 m stack, the increase in concentrations at southern monitoring spots would be relatively small and air quality would be kept better than class 2 in the impact area.[4] The EIS did not cover other potentially important stressors, such as ozone (O_3) and heavy metals.

4.1.3. Value of health impacts within EIA- and extended boundaries

We first value the impacts within the original EIA boundary using the damage cost method.[5] Then, to contrast this result, we extend the project boundary to take account of the regional

[4] There are five air quality levels in the Chinese air quality regulations (5 being the worst).

[5] Defensive expenditures that people may incur to avoid the effects of pollution can be assumed to be less important than the actual damage costs in our case studies, so we mostly use the damage cost approach. Defensive expenditures are also much harder to calculate since data very rarely are available and must be collected separately. For stressors to induce a behavioural response, defensive measures must be physically available to the individual and she must have the means (practical, knowledge-wise, financial) to take action at the right time. This cannot be generally assumed to be the case in our poor case study areas. Research also shows that defensive behaviours are more common during temporary, but extended contamination incidents (often with public notification), which are not typical for our case studies (see Dickie, 2003).

Table 1
Health costs for the Datong Power Plant within the EIA boundary

Health cost	SO_2 (1)	SO_2 (2)	PM_{10}
RMB/year	20,700,000	2,700,000	570,000
RMB/ton emissions	1450	187	428

SO_2 (1) is based on DR function from Xu et al. (1995), and SO_2 (2) from Aunan and Li (1999).

dispersion of pollutants. Judging from the level of emissions predicted in the EIS, available DR research, what is possible to quantify and what is likely to be the most important, we focus on SO_2 and PM_{10} and their impact on human health. The most important diseases related to SO_2 and PM_{10} are respiratory system disease and cardiovascular disease. Two other potentially important diseases, respiratory system cancer and chronic bronchitis cannot be calculated with current data. Deposition of acid oxides such as SO_2 and NO_2 leading to acidification of water ecological systems and land are left out of the analysis as they are outside the EIA boundary and not predicted in the EIS. Trial calculations show that air pollution impacts on agricultural production are likely to be small, so these are not given further mention.

Since the EIS does not contain information on DR functions and economic data on disease treatment costs, this information had to be collected separately from statistical yearbooks of Shanxi and other sources. To estimate the costs of mortality, we transfer a VOSL estimate based on Miller (2000), adjusted for the GDP per capita in the Shanxi Province, equalling USD 63,000 or around RMB 450,000.[6] Morbidity costs are calculated based on treatment costs (outpatient service, hospitalization) and loss of workdays. Average treatment costs are estimated at RMB 87 per outpatient visit; for hospital admission, the estimates are RMB 5840 per case of respiratory systems disease and RMB 4102 for cardiovascular disease (Shanxi Provincial Health Department, 1996). Workday loss for the ill person and family members accompanying the person to hospital is approximated with GDP/capita for the province. Since we find that two suitable DR functions for SO_2 vary quite a lot, we use both for sensitivity analysis. Total health costs within the EIA boundary are given in Table 1.

Total health costs from emissions of SO_2 and PM_{10} within the EIA boundary vary between RMB 3.3 and 21.3 million annually. Even if we assume a mean value of approximately RMB 12 million per year, then this represents substantial costs of mortality and morbidity for a project in which the EIS asserts as having a limited impact due to low concentration of pollutant emissions. We also calculate the health costs per ton emissions in the table, of RMB 187–1450/ton SO_2 and RMB 428 for PM_{10}. Even if the overall value is uncertain, the range is likely to be a conservative estimate of the overall health costs.[7]

The health costs above are the local impacts within the immediate project boundary of 456 km^2 in the case where some pollution control measured have been installed. To illustrate the potential limitation of the project boundary, we use an example of health costs if also regional impacts were included. Zhang and Duan (1999) calculate the annual average health costs[8] of a coal-fired power

[6] The following formula is used for calculation of mortality costs L (where P is population, Δc change in concentration of PM_{10} or SO_2, M mortality rate): $L = \sum \text{VOSL} * P * \Delta c * M * \text{DR}$.

[7] The EU research project ExternE, externalities of energy, for example, calculates the marginal external costs of a ton SO_2 and $PM_{2.5}$ emitted in an European city of several million inhabitants (like Datong) at Euro 90,000 and Euro 495,000 per ton, respectively (NETCEN, 2004). Adjusted by the GDP per capita in 2004 of USD 29,291 in EU and USD 789 in Shanxi, the EU estimates applied in Shanxi would yield about RMB 24,200 for a ton SO_2 and RMB 133,300 for a ton of $PM_{2.5}$. The EU estimates cover a wider range of impacts and also estimate the cost of the more harmful, smaller particles $PM_{2.5}$, so the figures are for illustration purposes only.

[8] That study includes a broader range of stressors, PM_{10}, SO_x, NO_x, ozone, lead, mercury, radiation and other toxic chemicals (based on transfer of international DR functions), and looks at impacts for land/waste, air and water.

plant in the Guangdong Province, by geographical area. The study shows that the air pollution impacts within 30 km of the plant, which is a bit further than the 20 km used in our case, are only about 1% of the total health costs. The remaining costs are distributed as follows: 8% for the 30–80 km range, 36% for the rest of the province (>80 km) and 55% for out-of-province impacts. Using the 1% estimate for illustration, assuming similar geographical cost distribution, would for the Datong case yield uncounted air pollution health costs outside the project boundary of between RMB 327 million and RMB 2.1 billion annually. The highest damage per unit of emissions found in Zhang and Duan (1999) was RMB 6889/ton of PM_{10}, more than 10 times higher than our estimate for the narrow boundary above.

4.1.4. Conclusions

The total health costs of the Datong power plant extension is estimated at between RMB 3.3 and 21.3 million annually, including mortality and morbidity impacts from PM_{10} and SO_2 within the local EIA boundary only. Adding regional health impacts the costs would increase substantially. The health costs are relatively high, given the conclusion from the EIS that effects on concentrations would be limited and within relevant standards. The estimated health costs are calculated for the situation after planned instalment of some pollution control measures (see Table 2 below).

Electrostatic dust removers are known to remove as much as 99.5% of the particles, and both desulphurisation equipment and high stacks (such as this) also lower the health costs (see for example Mestl et al., 2005). However, in our case, the pollution control measures have relatively modest impacts on local concentrations. Given the substantial annualised pollution control costs, only a full regional assessment of the health benefits would likely justify the investment from a cost–benefit perspective. Considering the potential magnitude of the regional costs we indicate above, it is likely that more mitigation would also be cost-effective, though this can only be determined through a more detailed CBA of mitigation options.

4.2. Wastewater treatment plant in Huai River Basin, Henan Province

4.2.1. Background and project description

Wangxinzhuang Wastewater Treatment Plant (WWTP) is located in the southeastern part of Zhengzhou City, the capital of Henan Province. The WWTP mainly treats the municipal and industrial wastewater discharged into the sewer system of an area of 105 km^2 and a population of about 1 million, making it one of the most important plants in the Huai River Basin. The WWTP uses an activated sludge process removing biological oxygen demand (BOD), chemical oxygen demand (COD) and suspended solids (SS) content, discharging the treated water into Jialu River, a branch of Huai River. Jialu River then drains into Shaying River downstream in Zhoukou City. The plant started operation in December 2000, and the EIA for the project was finished in 1996. The WWTP has positive environmental impacts, but as we shall see, the value of these impacts is

Table 2
Investment in pollution control measures for the second phase

Equipment	Investment (thousand RMB)
240 m high stack	18,640
Electrostatic dust remover	66,890
Desulphurization instalment	337,640
Total	423,170

likely to be relatively small as the water quality in the local area is so bad that the WWTP in isolation is not enough to change the situation significantly. However, considered as part of a wider plan to improve water quality in the area, the WWTP still has value. The EIS does not consider impacts further downstream and in Shaying River, which makes it difficult for the EEIA to assess these without additional costly primary data collection. The case demonstrates the use of simple techniques coupled with information in the EIS and secondary sources of statistics and data, to estimate environmental benefits of the WWTP.

4.2.2. Impact assessment

As the upper stream was blocked, Jialu River actually receives no clean water and has a water quality inferior to level 5, the most polluted according to Chinese standards and not suitable for any uses (SEPA, 2002). The EIS has a fairly limited scope considering impacts only 41.5 km from the plant downstream of Jialu River, within the Zhengzhou City zone. The report predicts likely reductions in COD, BOD and SS at one of the central monitoring points. Expected changes in ambient atmosphere, groundwater, soils and agricultural products are only superficially described. Even after treating about 60% of COD, BOD and SS in 2003 the water quality of the Zhengzhou part of Jialu River is still worse than level 5. Due to the bad water quality, nobody uses the water in the river. This raises a problem for impact assessment and EV. In one sense, it is true that the WWTP has very low real physical impacts on for example health, and hence the *marginal* economic value is also low. It is likely required that the water quality would have to improve at least to level 3, before people again would use the water. However, the *average* contribution of the plant for a hypothetical clean up, for example as part of a plan or programme, to level 3 generates positive impacts. We will consider this case from the latter point of view and estimate the value of the plant's contribution.[9]

The EIS does not go beyond predicting concentration levels to a full assessment of positive impacts. Quantifying these means finding the relationship between each stressor and changes in receptors. Since this step has not been conducted in the EIS, we shall use suitable DR functions from the literature to make the bridge to the EV part of the EEIA. First, we screen out the impacts that are likely to be the most important and that are possible to quantify. These are likely to be health impacts, and agricultural production through use of polluted water for irrigation. It is also likely that aesthetical impacts (odour and looks) may be of importance especially for the stretch running through the city, but this impact is difficult to quantify, without using CV. Other impacts, such as on fisheries downstream, are likely to be small. We select the four stressors, COD, BOD and SS, which are the main pollutants treated by the plant, for further analysis. The EIS provides insufficient analysis of the impacts even within the project boundary, and we have to supplement with available statistics, project documents, current monitoring data and simplifying assumptions to arrive at an estimate of changes in receptors and the contribution by the WWTP.

4.2.3. Value of health benefits

Turning first to the health impacts, the next step is to review suitable DR relationships from the Chinese literature linking the stressors with changes in health endpoints. This review turns out six

[9] In environmental economics, this is a case of a flat environmental damage curve beyond a certain level of pollution, i.e. changes in pollution from this level does not change environmental damage from an already high level. Since the abatement costs typically increase monotonically at an increasing rate, multiple abatement optima are possible, including corner solutions. It is a fairly uncommon situation in the western world, where the environmental quality situation typically is located on the positive section of the marginal damage curve. The slope of this curve very much depends on type of receptor, pollution or environmental impact and time perspective under consideration.

Table 3
Dose response relationships for areas in China comparing areas of clean (level 3) and dirty water (level 5 or worse) for irrigation

Health endpoints	Waste water irrigated area
Standardized mortality	Higher by 2‰
Cancer mortality	Higher by 0.6‰
Cancer morbidity	Higher by 0.9‰
Hepatomegaly[a] morbidity	Higher by 70‰
Morbidity of stomach and intestines disease	Higher by 40‰
Birth defects in children	Higher by 10‰

Source: Song (2004).
[a] Hepatomegaly is the enlargement of the liver beyond its normal size.

DR relationships that are suitable to be transferred to the study site most of which only compare health endpoints in regions using clean (standard 3) and dirty water (standard 5 or worse) for irrigation (see Table 3).

Cancer, hepatomegaly, tummy and intestines disease, and birth defects in children generally have a higher prevalence by 0.6‰ to 70‰ in the dirty area. The DR functions as reported in the literature are relatively crude and it is not possible to adjust for population, health and other characteristics that may differ between the site of the study and Zhengzhou. Since we only have DR functions comparing two water quality levels, we need to calculate what would be the contribution of this plant to a (hypothetical) water quality improvement in the area to level 3. One way of making a pragmatic estimate of this share is the following. According to the EIS, the WWTP serves 820,000 people, while the total population in the Zhengzhou area is 2,000,000 in 2000. From this and the fact that 83% of the sewage to Jialu River comes from this area, we use the simplifying assumption that the WWTP makes a 33% contribution to a two level water quality improvement in the river (and hence of the health benefits of water quality improvement).[10] What would be the impacts of a water quality improvement from levels 3 to 5? The population in the area does not currently use the water from River Jialu as it is known to be severely polluted (Huili, 1999). However, parts of the groundwater and other sources are also polluted (Yong, 2004), and we estimate conservatively that 15% (about 100,000) of the population in the area drink seriously polluted water. These people would turn to River Jialu if the water quality there had been improved to level 3, avoiding water-quality-related diseases from current consumption. Economic data have not been provided by the EIS, so we collect this information from official statistics. Using the cost of illness approach, we can finally value the health costs saved, as attributed to the WWTP, using available estimates of costs of treating the three main diseases of cancer, hepatomegaly and intestinal disease (see Table 4).[11]

Using the so-called modified human capital approach,[12] popular in China, the total COI that would be saved in Zhengzhou from an improvement in water quality from five to three, is RMB

[10] I.e. 820,000/2,000,000=41% multiplied with 81% equals 33% contribution.
[11] $S=[P\sum T_i(L_i-L_{oi})+\sum Y_i(L_i-L_{oi})+P\sum(L_i-L_{oi})H_i]M$ (Lihua, 1991): S=loss caused by environmental impact on human health; P=human capital or net production value per capita; M=population in the polluted area; T_i=working hours loss per capita of the patient suffering from the disease i; H_i=working hours loss per capita of the personnel accompanying the patient suffering from the disease i; Y_i=medical treatment and nursing expenditure per capita of the patient suffering from the disease i; L_i=morbidity of the disease i in the polluted area; L_{oi}=morbidity of the disease i in the clean area.
[12] The human capital approach uses an estimate of the production value per capita per year to estimate work time lost through mortality and morbidity.

Table 4
Unit treatments costs and time lost to illness

Disease	Treatment (RMB)	Work time lost	Accompanying time[a]
Cancer	5595	12 years	36 days
Hepatomegaly	280	1 year	25 days
Intestinal disease	93	15 days	10 days

Source: Song (2004).
[a] It is common practice in China that at least one relative or friend accompanies the ill person to hospital.

26.9 million of which 33% or RMB 8.8 million can be attributed to the WWTP. This is a very conservative estimate of the health benefits, since we have not been able to account for the costs of other diseases and because the human capital approach, rather than the internationally more common (and typically much higher) VOSL approach, has been used in this case.

4.2.4. Value of agricultural and other benefits

Quality and quantity of crops will improve when cleaner water is used for irrigation in the Zhengzhou area. We use a similar approach as above to estimate this value by applying DR functions for different crops from the literature comparing situations using clean and dirty water for irrigation (see Table 5). The DR functions estimate both the reduction in quantity (production) and quality of crops as compared with the use of polluted water (level 5) for irrigation.

The wastewater irrigation areas are located in the suburbs of Zhengzhou City, and to assess impacts on crops with the DR functions we use the closest monitoring station point in the river near this agricultural district. A share of the (hypothetical) changes in the water quality improvement and impacts on crops is then attributed to the WWTP. The main irrigated crops are wheat, paddy and vegetables. To simplify we assume that water consumption per unit of cropland is fixed, and that irrigated cropland just includes paddy and wheat since no data exists on vegetables. Due to lack of local data, we also assume that the distribution of these two crops in the Zhengzhou area is the same as for the three main wastewater irrigation regions in the Henan Province (of which Zhengzhou is one). When we know the annual water use, crop area and production for the two crops, we can use the DR functions to estimate the increase in quality and quantity of agricultural production. Applying country average prices of paddy and wheat for 2000, of RMB 1.03/kg and RMB 1.10/kg respectively, we can first estimate the value of increased production, ca. RMB 1 million per year and the quality improvement (assuming that prices increase proportionally with quality change from the DR functions), at RMB 180,000/year. Total agricultural benefits attributed to the WWTP are then RMB 1.2 million per year. We also approximated the plant's benefit to underground water resources with the average increased costs (RMB 0.42/ton) of treating polluted water from River Jialu that filtrates through the ground, totalling RMB 3.4 million.

4.2.5. Conclusions

The EIS did not assess changes in concentration beyond the immediate and relatively narrow boundary of the urban stretch of the Jialu River. Just assessing the local area, the EIS concludes that the impacts on water quality in an already severely polluted river will be minimal. This conclusion is true and from a marginal contribution point of view the environmental value would also be close to zero, since the water is still too polluted to be used. Considering the contribution of the plant as part of a plan to improve water quality to level 3, the total value of the agricultural, groundwater and health benefits has been conservatively estimated at RMB 13.4 million per year for the immediate area of Zhengzhou. This is likely to underestimate the true benefits. However,

Table 5
DR functions for crops in areas using clean (level 3) and dirty (level 5) water for irrigation (related to COD concentration)

Endpoint	Impact on production	Impact on quality
Vegetable	Decrease by 25%	Decrease by 4.5%
Paddy	Decrease by 20%	Decrease by 4%
Corn, wheat	Decrease by 10%	Decrease by 2%
Crop as a whole	Decrease by 20%	Decrease by 3.5%

Source: Song (2004).

the benefits within the project boundary only are clearly dwarfed by the estimated operating costs of the plant between RMB 61 and 83 million per year. This suggests that unless the benefits of the plant are considered as part of regional clean up programme (and not only within the local area, which was what the EIS allowed us to estimate), the WWTP investment may not be efficient use of scarce public resources.

4.3. Regional EEIA of wastewater irrigation in Shijiazhuang, Hebei Province

4.3.1. Background and project description

China has a long history of sewage- and wastewater irrigation due to water scarcity and for other reasons. The practice is potentially very harmful to human health and has other negative impacts as the wastewater pollutes and changes the soil quality. Each individual farmer would generally not be required to consider environmental impacts, and assessed individually, impacts would for most cases be minimal. However, taken together the cumulative impacts for a wastewater region would potentially be substantial. To illustrate the significance of such impacts on the regional level, the Shijiazhuang wastewater irrigation district in the Hebei Province district was chosen as a case representing land pollution.

4.3.2. Impact assessment

Shijiazhuang district is mainly located in the Xiao He River and Hutuo River Basin in the Hebei Province. The irrigation practice has been dominant in this area for over 30 years, covering wastewater irrigation of 225,000 Mu,[13] in which 160,500 are located in Luan Cheng County. The most common crops are corn and wheat (on a rotational basis), while only a small amount of rice and vegetables are grown. Due to the drying of the Hu Tuo River in the late 1970s, irrigation mainly uses the water from Xiao He River, which receives wastewater discharges from industrial and domestic sources in the urban areas. The water quality of Xiao He River exceeds grade 5 by about four to seven times (Hebei Environmental Monitoring Station, 2003).[14] Unlike for air and water pollution, the existing EIA system gives little attention to land, which makes it harder to provide the necessary basis for economic analysis. To assess the impacts of wastewater irrigation, four villages in the region were chosen: Xiahuzhaung and Wangjiatun (in Luan Cheng county) and Fancun and Xinhecun (in Zhao County). In Luan Cheng county, ca. 93% of the total cultivated land is irrigated with wastewater, while in Zhao County the average is 55%. The population ranges from 830 to 1577 for each village.

[13] A unit of land area measurement in China, to which there is a traditional and a modern standard of measurement. In modern China, the mu is often reckoned to be exactly 1/15 hectare (Rowlett, 2006).

[14] Although China has issued irrigation water quality standards, there is in practice not sufficient monitoring and enforcement. This is also the case for food and farm produce quality.

Table 6
Corn and wheat production 2003

Village	Cultivated land (Mu)	Population	Irrigated land (Mu)	Wheat output (kg)	Corn output (kg)	% of irrigated land in total	Wheat (kg/mu)	Corn (kg/mu)
Xiahuzhuang	1300	1400	1200	400,000	475,000	92.3%	333.3	395.8
Wangjiatun	1038	1038	980	340,000	393,500	94.4%	346.9	401.5
Fancun	3370	1577	2400	900,000	1,104,000	71.2%	375.0	460.0
Xinhecun	1075	830	467	165,000	280,000	43.4%	353.3	599.6
Hejiazhuang	Clean water						541	570
Average output per mu for the four wastewater counties							352.1	464.2

Source: Zhang (2004).

COD, BOD and chromium (Cr) contents in the wastewater all exceed the standards by around double and more in 2003. The pollution levels have increased significantly from being roughly at and below the standards in 1995 for both Luan Cheng and Zhao counties. Not surprisingly, the quality of soils, for example accumulating arsenic and Cr, shows similar patterns. The monitoring data of the Hebei Agricultural Department show a worrying build-up of heavy metals in agricultural produce, exceeding standards for wheat by for example 62.5% for mercury (Hg), 37.5% for cadmium (Cd) and 75% for Cr. It is highly likely that this trend is mostly caused by the practice of wastewater irrigation.

4.3.3. Value of reduced crop quality and quantity

The first method we use for valuing the impacts of wastewater irrigation assesses the negative changes in the receptor directly. We demonstrate a slightly different valuation approach than the wastewater treatment plant case, namely a comparison of local conditions in the wastewater-irrigated region with a clean reference area (rather than transferring DR functions from the literature). The city of Hejiazhuang also located in the same region in Zhao County was chosen as the clean area. Based on data collected from the local government, research institutes and a small survey conducted at the household level, a comparison of the corn and wheat production in the four villages and the clean reference village was conducted (see Table 6 below).

As can be seen from the table, the clean area generally has the highest production per unit of land for wheat and corn, with the exception of wheat in Xincheun. The data for crop production is not disaggregated enough to provide the actual production for those areas that have been irrigated using wastewater, only the total for the county. To evaluate the value of productivity reductions, we use the prices of wheat (RMB 1.04/kg) and corn (RMB 0.84/kg) from the local market in 2003. The soil quality changes caused by the wastewater also reduce quality of the crops. No price information on different qualities of products exists, and we conservatively assume here for simplicity that prices are 10% lower on average for lower quality produce. As the data available is for unit output, assuming no crop production cost changes, we can compare the output per mu in the clean area with the average output for the dirty areas, applying the prices above.[15] This calculation yields a total loss of RMB 360/mu, of which the quantity loss is RMB 285, and the quality loss RMB 75/mu. This is a conservative estimate, as the average production

[15] Using the general formula $E = \left(\sum_{i=1}^{k} p_i q_i - \sum_{j=1}^{k} c_j q_j\right)_x - \left(\sum_{i=1}^{k} p_i q_i - \sum_{j=1}^{k} c_j q_j\right)_y$, where p is price of crop i, q is quantity of output i, and c is price or cost of unit input of j. The bracket subscript x and y refer to the clean and "dirty" soil or land, respectively. E, then, is the total market value of the changes in quantity (lower q) or quality (lower p) of agricultural products due to soil pollution.

Table 7
Cost of illness (annual RMB) for the four villages

	Local unit cost of treatment	Incremental morbidity %	Treatment costs
Heart and brain disease	3000	0.5	72,675
Cancers	20,000	0.525	508,725
Digestive system ailments	500	4.49	89,148
Mouth and teeth	20	3.68	4351
Total cost of illness			674,899
Total cost per mu wastewater irrigated land of 5047 mu			134

Source: Zhang (2004).

for all the dirty areas is used, which masks the fact that only between 43% and 94% of the land in these areas is irrigated using wastewater. Assuming instead the average production of 340 kg/mu of wheat and 399 kg/mu of corn for the two counties of Xiahuzhuang and Wangjiatun where more than 90% is dirty, for all four counties, would yield a total loss of RMB 422/mu.

4.3.4. Value of health costs

Using the COI approach, we can value the most important costs related to diseases from wastewater irrigation. According to our investigation, the morbidity rates of heart and brain disease, and cancer are 0.5% and 0.525% higher than in the clean areas, respectively. The morbidity for mouth and teeth diseases were found to be 4.49% higher and digestive system disease about 3.68% higher (Hebei Province, 2000). Based on the local field survey at the hospitals and information from health authorities, the average treatment cost for a case of heart and brain disease for one year is about RMB 3000, cancer is RMB 20,000, digestive system is RMB 500, and mouth and teeth is RMB 20 (Table 7).

It can be seen from the table that the cost of illness for these relatively small and poor communities are a high RMB 674,899/year, which translates to RMB 134 per wastewater irrigated mu. These are just medical expenses. No account has been taken of workday loss or the WTP to avoid the suffering people endure in this case. Furthermore, the value of higher mortality rates in the “dirty” areas has not been estimated, due to lack of data. Hence, the simple calculation of health costs conducted here is a lower bound of cost of illness, and serves as an illustration of the potential significance of cumulative impacts from many, small sources.

4.3.5. Valuation based on compliance behaviour and preventive expenditures

For purpose of illustration, we apply two alternative approaches to valuing the environmental impacts of wastewater irrigation: compliance behaviour and preventive expenditures. The first approach approximates the impacts from wastewater irrigation with the costs of treating the Xiao River water to an acceptable standard (i.e. that would comply with standards). The water quality of Xiao River is worse than grade 5 and therefore needs to be treated to the grade 3 to satisfy the surface water and crop irrigation standards. 300 tons of water for irrigation is used per mu and year, and treatment cost of sewage water is ca. RMB 0.35/ton (Liu, 2000). Hence, the pre-treatment cost of wastewater is RMB 105/mu.[16]

[16] Treatment costs, $L=\Sigma[W\times b_i\times(S_i-S_0)]\times C$, where W=total water quantity used for irrigation, b=share of polluted water, S_i=water pollution indicator, S_0=water level grade 3 (i.e. baseline) and C=unit treatment cost for different pollutants.

Table 8
Summary of the EV of wastewater irrigation impacts

Methods		Loss per mu (RMB/year)
Impacts on final receptor	Regional comparison approach	495
Pre-treatment		105
Preventive approach		63

For purposes of illustration, we also apply the preventive expenditure approach. This approach equals the value of the impacts as the costs incurred to avoid using polluted water for irrigation. According to the field investigation, there are two reasons for using wastewater to irrigate: (1) increase productivity of crops; (2) reduce the agricultural input, especially the use of fertiliser, electricity and water charges. We therefore apply the irrigation using clean water by wells driven by electricity, which costs RMB 15/mu, compared with the irrigation cost of using wastewater of RMB 1/mu (Zhang, 2004).[17] The average frequency of irrigation is three times a year. The opportunity cost of using wastewater is thus RMB 42/mu. If clean water is used, about 30 kg of ureophil fertiliser is needed, with a price of RMB 0.7/kg, equalling RMB 21/mu. If the water use fee is assumed to be roughly equal between wastewater and clean water, the opportunity cost of using wastewater is RMB 63/mu.

4.3.6. Conclusions

From the case study of wastewater irrigation, it is clear that the value of impacts is large, at around RMB 495/Mu annually, which is about 56% of the current output (see Table 8). Even for such a conservative and simple analysis, the results are accurate enough to have strong policy implications, i.e. that mitigation or prevention measures should be carried out as they most likely are cost effective.

4.4. EEIA of the Chongqing Highway Network Plan

4.4.1. Background and project description

The wastewater irrigation case is an example of land *pollution* impacts. The following and simpler case illustrates impacts of land *use* decisions related to the routing of a highway plan network in Chongqing, connecting central and western China. It demonstrates how simple use of economic principles can assist in comparing two alternative road routings from an environmental point of view. The Chongqing Highway Network Plan (CHNP) is at the proposal stage and the application of EV was carried out simultaneously with the EIA. In order to improve the conditions of the highway network and the transportation capacity, a more advanced and wide covering range highway network connecting all the urban areas, districts, cities and counties is proposed to be built within a planned time frame of 2003–2030. The proposed plan combines 18 roads with a road length of 4306 km, in which about 3800 km is new road construction.

4.4.2. Impact assessment

Two highway network routes were proposed in the plan, both of which will mainly be constructed in suburban areas, with relatively few people affected. In addition, the existing plan has in earlier planning stages given consideration to biodiversity and landscape impacts, and avoided ecologically sensitive areas, and major infrastructure (such as water supply systems). If it

[17] Based our investigation, the groundwater pollution situation is not very serious, and there is no evidence showing that drinking water is affected. We therefore assume that the water in the wells is of near clean quality.

is assumed that other environmental impacts, such as noise, accident frequencies and traffic emissions will be roughly the same for both routes, then land use will be the most important factor separating the two routes from an environmental point of view. Therefore, the case study will for sake of simplicity just consider losses due to the land use pattern changes. The road will take up significant amounts of land of various quality, use and value, temporarily and permanently. The land take was estimated overlaying the highway plan map with that of land use patterns. A width of 50 m was assumed to be taken permanently and 25 m temporarily (for a 3-year construction period), based on Chinese road engineering technical standards. The land use types were divided into agricultural land, forested land, grassland and water covered land. The areas of land taken annually by the two proposed routes were recorded in the EIS on a county and district basis, for a total of 32 districts. The task is then to compare the significance of the land impacts of the two routes for all the districts.

4.4.3. Value of land use impacts

In the choice between these two proposed routes, a complicated economic analysis that strives for methodological perfection and absolute accuracy is not necessary. The purpose is to enable comparison between the value of land use, for instance as input to an overall CBA of the two routes. There are, of course, costs and benefits other than the environmental, for example construction costs, local economic benefits and poverty alleviation, etc. Further, it may be sufficient for this particular planning problem if the economic analysis can contribute to a ranking of the two options (i.e. relative accuracy of estimates rather than absolute). We use the *opportunity cost approach* to estimate the cost of land utilisation by the road construction, i.e. the value of the land for its best alternative use, applying the following formula (for each district) to calculate the land use costs:

$$C = \sum_{m=1}^{k} p_m s_m$$

C = total land use losses, k = types of land (m = 1, 2, …, k), p_m = unit value (opportunity cost in RMB) of m types of land use and s_m = area affected (hectare) for m types of land use. The unit value of land is estimated by calculating the average economic output value for different land uses from district statistics. As an example, the opportunity costs, based on the current output values, of cultivated land, forest, grass land and water areas in the district of Yunyang is RMB 7690, RMB 390, RMB 276,760 and RMB 1710 per hectare, respectively.[18] Livestock output values drive the relatively high prices for grassland. Summing the net opportunity costs over all districts for the two routes yield land use costs of RMB 284.9 million for alternative one and RMB 273.4 million for alternative 2 (Table 9).

To estimate the total net present value, the annual loss is discounted over the 30-year period for the permanent land occupied. Estimates depend on the choice of discount rate, but the difference between the two alternatives become smaller the higher the discount rate. Using a discount rate of 5%, the net present value land take costs are RMB 4.43 billion for route 1 and RMB 4.24 billion for route 2. The value of the environmental impacts in this case measured as opportunity costs of land use favour the second network route.

[18] The reason why the output value per hectare of grassland is so much higher than for cultivated land is that the cultivated land is located in marginal, mountainous areas where the output of grain is low. Since these farmers are poor, the marginal lands are still cultivated for subsistence. The high value of grassland is driven by livestock production, but the fact that cultivated land cannot be used for livestock grazing drives a large wedge between the productivity values of the two types of land.

Table 9
Annual value of the economic loss in 2003

Land type	Unit output value RMB 10,000	Land use for route 1 (ha)	Annual loss 10,000 RMB	Land use for route 2 (ha)	Annual loss 10,000 RMB
Forest	0.039	105	4.095	224.9	8.7711
Grass	27.676	984.7	27,252.557	942.6	26,087.398
Cultivated	0.769	1607.9	1236.4751	1607.3	1236.0137
Water	0.171	0	0	41	7.011
Total			28,493.127		27,339.193

Source: Zhang (2004).

4.4.4. Conclusions

This case illustrates, although the end results turned out not to be substantially different between the two alternatives considered, how simple valuation techniques can contribute relevant information about the land use costs to the choice of different routes of a road network. If a full CBA is carried out, the land use costs can be included for the two alternatives on par with other costs and benefits that vary between the routes (for example fuel savings due to shorter mileage, economic opportunities generated, etc.).

5. Results and discussion

5.1. Lessons from the case study EEIAs

5.1.1. EV can add value to the EIA process

Our review of the Chinese and international state-of-the art on EV methodologies and DR research, at least for air and water pollution impacts, is quite encouraging for the prospect of EEIA, and the case studies have demonstrated how one can pragmatically apply available research usefully to specific impact assessment situations. A crucial question one needs to ask, however, is whether EV passes its own cost–benefit test, i.e. whether the benefits to the EIS (and ultimately decision-making) of introducing EV outweighs the extra costs. Or stated differently: Does the use of EV add anything significantly different or new to the EIS and impact assessment? We alleged in the introduction that EV may be useful in judging and comparing significance of impacts, determining the appropriate level of mitigation, comparing alternatives, and generally providing a more transparent and objective analysis that is more informative for decision-making.

The power plant case illustrates that emissions considered by the EIS to be small may indeed still cause quite substantial health impacts in monetary terms. Further, the *EV painstakingly exposes the weaknesses of a typical EIA project boundary*—again calling for a regional focus. The difference between the predicted (within-boundary) impacts and the actual, regional impacts is substantial in monetary terms and may justify more mitigation.

The wastewater treatment plant case illustrates that benefits in the immediate local area are rather limited, since water quality is too bad for the plant to make a big difference. This is also the conclusion of the EIS. *Comparing the economic value of these limited benefits from the EEIA with the relatively high investment costs suggests that the plant may not be the most efficient use of scarce public funds if the main problem is water-related health issues among the rural poor.* However, assessing and valuing the benefits of the plant on a wider geographical scale as part of a programme to clean up the river basin may have given a different conclusion. The EIS does not make such an assessment possible, both due to the limited project boundary and the individual, project-level assessment that is conducted.

The third case of wastewater irrigation is somewhat different, as it is not based on an EIS, but conducted from scratch. *It illustrates how useful simple EV techniques could be within the scope of a regional EIA*. Health and agricultural costs of wastewater irrigation are substantial, calling for measures limiting the practice and/or protecting those exposed. Such measures would most likely be efficient use of public resources. It is a general problem in Chinese EIA, for example as pointed out by Chen et al. (1999), that small industrial and non-industrial pollution sources escape EIA, creating substantial cumulative impacts. Our case suggests that using EV in such situations may be particularly effective. The final case, the road network plan, gives an example of how simple environmental economic analysis of land use options can contribute relevant information to a decision between two alternative road routings. When conducted in parallel with the EIS, extra costs of such an analysis may be reasonable.

5.1.2. But there are deficiencies in current EIA practice and methodology

However, despite the generally positive value added of EEIA to the case studies, our review of several EISs and the cases have laid bare the deficiencies of current EIA practice and methodology as compared with intentions and international best practice. *Chinese EISs often do not identify all key receptors (such as materials and human health) and fail to establish relationships between stressors, media, receptors and impacts*. What is typically done is only to describe for instance the level of emissions and to some extent concentration levels, and to compare these to existing standards. This is clearly not sufficient, neither for EIA nor EEIA, as standards are often too lax and crude to limit impacts to reasonable levels. And in many situations for example for land impacts there are no standards, so impacts must be assessed case by case. As we have seen, the physical impacts must be quantified for EV to be applied. As long as this gulf exists between the point at which current EIA ends and EV begins (refer back to Fig. 1), it will be a difficult task to introduce wider use of EEIA.

The reasons for these EIA deficiencies are many and complex (see for example Wang et al., 2003). Of particular relevance to EEIA is the fact that *current regulation to some extent limits EIAs in covering all relevant stressors and receptors* (for example acid precipitation from SO_2 emissions).

Another reason is *the complexity involved in making the step from emission levels and concentrations to establishing impacts*, as most EIA practitioners do not know how to navigate in the jungle of DR literature or to apply such methodologies. We should also say here that the results reported in the DR literature vary in detail, quality and level of uncertainty. Results are often site specific and not easy to apply. And for the case of land impacts, there is very limited Chinese research that can be used (except for some on soil pollution). Nevertheless, to serve its purpose EIAs need to assess impacts based on the best available knowledge, even if the assessment may be uncertain.

A third and more fundamental reason is how *EIA more often is seen as a bureaucratic hurdle to development than as an important decision-making tool*. This is a problem frequently noted in the EIA literature, though not all studies share this bleak view (Christensen et al., 2005). If it is the case in China, however, no amount of high quality EV work is going to make any difference, since the solution lies elsewhere than in improving the methodologies of EIA.

5.1.3. Critique of EV in EIA is important, but may be overstated

Before turning to institutional and capacity challenges for EEIA in the next section, some brief comments are in order on some of the critique of EV in EIA, as for example discussed in Crookes and de Wit (2002). Our experience from the case studies is that EV does not need to be expensive, methodologically difficult, or data collection time consuming and lengthy, as often claimed. As argued before, the cost and effort put into the valuation work should depend on the purpose. A comprehensive (and often expensive) valuation study may be warranted for a large construction project or an SEA, but for smaller undertakings simpler, low-cost techniques, that we have used, may suffice. It is often argued that some techniques are more controversial than others, for example CV (Venkatachalam, 2004). A balanced reading of the current literature, however, points to strengths and weaknesses of both revealed and stated preference techniques and that both have a place in the valuation toolbox (Champ et al., 2003). In China, the acceptability and use of stated preference techniques is growing, and CV could also be a tool to improve public consultations processes in EIA in China, as public participation and consultation is known to be weak there (Wang et al., 2003).

Finally, it is true that some types of impacts may be harder to accept in monetary terms than others, such as the loss of statistical life or natural amenities with high existence or symbolic values. For VOSL, we think that the controversy in mostly based on misunderstandings. VOSL is about WTP to reduce mortality risks, not about value of life *per se*. Statistical lives are assigned implicit values all the time in public decision-making, so it is high time to make them explicit in environmental assessment. In China, the human capital approach has traditionally been used, though VOSL is becoming gradually more accepted.

5.2. Institutional challenges and gaps for EEIA

The interviews with EIA experts and review of the Chinese EIA regulations and practice revealed a number of institutional and capacity challenges for the introduction of EEIA, as discussed in turn below. *The legal and practical role of EV in the current EIA law and regulations in China is not sufficiently clear.* Although EV is required by both, it is not specified for what purpose or how it should be conducted. In addition, how inputs from EEIA to the general planning and approval process (for example in relation to CBA or financial project analysis) could be utilised is not well defined. Furthermore, as discussed above, if all that is required for EISs to be approved in practice is to compare stressors, for example emission and concentration levels, with existing regulatory standards, what would then the purpose of EV? When both the underlying law and implementing regulations are vague on these central points, it is not surprising that EEIA practice has been slow to evolve. *What is needed seems to be a comprehensive guideline or protocol for EIA practitioners setting out why and how*, but also increased awareness among relevant planning authorities of how the potential improved information content of EEIA could be utilised in the planning process. This is a crucial first step to introducing wider use of EV in China. A related point is that regulations should not necessarily require EV for all types of level A projects, as is the case now. EV may be at its most useful for large construction projects and, as suggested by the case study work, for more strategic types of assessments, for example regional development plans. It may be, though not specifically addressed in this paper, that EV could be useful also at other stages of the EIA process, most notably at the screening stage.

In addition to the weaknesses of current EIA practice and regulations noted above, some important institutional challenges for EEIA have been identified. First, even though there is a large interest in EV techniques among EIA practitioners and the environmental management bureaucracy in China, the level of competence in this area is generally low. Staff working in the EPBs and the licensed EIA agencies seems mostly to be engineers or (to a lesser extent) environmental scientists, and have very little, if any, training in economics. Training in economics, or inclusion of environmental economists on EIA teams would be essential, at least for carrying out more comprehensive EV exercises. The necessary level of competence to carry out EEIA would also depend on the level of detail provided in future SEPA guidelines on EEIA. To be able to carry out low-cost EEIAs it is crucial that existing data and statistical sources are used efficiently. It is a well-known problem in China that data are costly and sometimes difficult to access from official government sources at different levels. Sometimes, only personal acquaintance will get you the data or statistics, which should be in the public domain. In an EEIA, as we have seen, many types of data may be necessary, for example local economic data, agricultural statistics and health data. The flow of information and statistics in China is of course part of a wider problem, but may be in the process of freeing up—to the benefit of the wider society and EEIA.

A final point is the lack of funding for EIAs in China, and the conflicts of interest between development-oriented local governments and the environmental protection agencies they fund (Wang et al., 2003). The funding of environmental protection agencies is of course a serious problem of its own, but it will make it even harder to justify inclusion of additional analytical work like EEIA that more effectively exposes negative impacts.

6. Conclusions

This paper has assessed the problems and prospects of introducing environmental valuation (EV) techniques into EIA in China, to satisfy current laws and regulation, but more importantly to improve the information content of Environmental Impact Statements (EIS) and enable comparison with economic development benefits. Four environmental economic impact assessment (EEIA) case studies were conducted using low-cost valuation techniques, three of which were based on EISs of construction projects (a power plant, a wastewater treatment plant and a road network plan) and one of which was conducted for a regional pollution problem of some magnitude in China (wastewater irrigation). The case studies clearly demonstrate the usefulness of EV, but also reveal important methodological, practical and institutional gaps and challenges to the wider use of EEIA in China. Challenges and gaps include among others unclear laws and regulations, lack of guidelines, institutional and capacity constraints within EIA agencies and the environmental protection bureaucracy, limited availability of data and statistics, funding constraints and lack of comprehensive analysis of impacts on receptors in current EISs (i.e. beyond noting for example emission levels compared to standards), and to some extent insufficient scientific knowledge of physical relationships (for example dose–response functions for land impacts).

Furthermore, the economic analysis clearly demonstrates the importance of expanding the project boundary for measuring impacts and to assess projects in combination, suggesting that EV may be even more useful at strategic levels of impact assessment (for example for regional development plans). The gaps and challenges to introducing EV are part of a complex set of weaknesses inherent in the Chinese EIA system and cannot be bridged over night. The perhaps most important first step would be for SEPA, as the executive body of the EIA law, to clarify the role of EV within projects, plans and programs. It would also be necessary to clarify and coordinate the purpose of EEIA as decision-making support tool with that of other economic appraisals, such as national economic evaluation (CBA). Once this role has been clarified, current EIA practice needs to be evaluated and most likely strengthened in certain areas, for EV to be applied. Key among these is improving the assessment of actual impacts in EISs, beyond the minimum of reporting stressor and concentration levels. A detailed set of guidelines for EEIA could then be drawn up by SEPA to cover the nuts and bolts of EEIA for projects, plans and programs and at various stages of the EIA process. SEPA should also facilitate access for EIA practitioners to relevant statistics, data and DR research to ameliorate the current data and information bottlenecks between government departments, statistical bureaus and research institutes in China. It would probably also be essential to couple the introduction of the guideline with a comprehensive training programme for EIA implementing institutions and practitioners in environmental economics. Many of the challenges of integrating EV into EIA identified here are likely not to be specific to China, and a comparative cross-country study would be an interesting topic for further research.

This paper has been of an explorative kind, and has not set forth at this early stage to flesh out the details of a possible EEIA guideline or protocol for China. However, some core elements for large construction projects can be identified. Plans and programs have not been evaluated specifically. EEEI of suitable category A projects should follow the standard EIA process in China. After the screening and scoping stages, EEIA would require an assessment ("impact screening") of which impacts should be subject to further quantitative study for example as judged by size, concreteness and certainty of the impact. The impact prediction stage in an EEIA should, we suggest, be significantly expanded as compared to an ordinary scoping stage. This stage would consider which impacts should be subject of monetary valuation based on potential importance of impacts, available valuation methods, data and research, and EIA/EEIA budget. Experience from our study and international experiences suggest that the following impacts should be among the candidates for monetary valuation: (a) human health, particularly from air pollutants SO_2, soot/dust ($PM_{10}/PM_{2.5}$) and to some extent NO_x; (b) materials, particularly from SO_2; (c) vegetation and crop growth from SO_2; (d) noise; (e) health from water pollution, particularly biological water-borne diseases (acute/short term impacts); (f) water reliant crops, fish and industries from low water quality and pollution-induced water shortage; (g) some land use changes and soil pollution; (h) combinations of impacts valued together using special methods, for example contingent valuation. Economic valuation methodologies could be chosen from the full toolbox, perhaps focusing on methods using observed prices and costs, as stated preference surveys in China are still relatively immature. Finally, EEIA should be designed, conducted and reported with the four main uses of the results in mind: (1) enter into a full CBA, (2) motivate or prioritise mitigation options, (3) comparison of significance of different impacts and (4) make it easier to compare alternatives.

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