Trans-jurisdictional pollution control options within an integrated water resources management framework in water-scarce north-eastern China

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Abstract

The extent and severity of water pollution in China is well known, as is the fact that until the 11th Five Year Plan (FYP) in 2006, much greater importance was placed on economic growth than environmental protection. There were few incentives to reduce pollution owing to an inadequate legal framework, the absence of economic measures for pollution control in favour of a command-and-control approach, and weak enforcement. Passing through four provinces and Tianjin Municipality, Zhangweinan River (Canal) Basin, part of the water-scarce Haihe River system in north-eastern China, provides an example of the types of trans-jurisdictional water pollution disputes that are common throughout China owing to inadequate application of integrated water resources management (IWRM) principles. The Zhangweinan River has a decreasing flow downstream and virtually zero assimilation capacity owing to waste loads that are vastly larger than the assimilation capacity of the river system. The fact that these trans-jurisdictional issues keep arising and, for the most part, are never resolved, reflects the failure of IWRM governance in this basin. We explore legal, institutional, planning, technical and market measures that would greatly reduce trans-jurisdictional disputes and contribute to successful IWRM in China.

Keywords: China; IWRM; Pollution control; Pollution rights; Total load; Water rights; Water scarcity; Zhangweinan River Basin


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1. Introduction

China’s water quantity and quality has been described as a crisis (Wang, 2009). In 2008, 26% of surveyed river sections nationwide in February, 2008 and 21% in January, 2009 (CNEMC 2008, 2009) had water quality that is unfit for any beneficial use (worse than Class 5). Failure in integrated river basin management (IRBM) continues to be a root cause owing to the combination of an inadequate legal framework, weak enforcement and the institutional and legal separation of water quality and water quantity management. Since 2007 there has been a significant change in water pollution management nationwide arising from (i) increasing water scarcity caused by loss of any beneficial use from pollution; (ii) probable continuing decline in water resources in north China owing to climate change and (iii) a number of high-profile pollution incidents in recent years that have had serious environmental, social and political consequences, (iv) a significant shift from ‘grow first’ to environmentally sustainable and socially harmonious growth in the 11th Five Year Plan (FYP) and (v) substantial growth in fiscal income of the country.

Extremely poor water quality is especially widespread in water-scarce north-eastern China owing to low or zero flows for much of the year, with 60% of the Haihe River, which encompasses much of the North China Plain, being worse than Class 5 in 2007 (MEP, 2008). The national target for chemical oxygen demand (COD) reduction in the 11th FYP (2006–2010) is 10%; however this can vary from one region to another. For the Haihe River, including the Zhangweinan sub-basin, the target is 14.2% reduction. However, in February 2010 the Ministry of Environmental Protection (MEP) announced, after a two year national pollution survey, that the actual levels of COD in 2007 were twice as high nationally than previously estimated owing to previously unmeasured sources, including agriculture that was not accounted for in earlier national COD statistics (People’s Daily, 2010). While there has been progress in reducing point source discharges of COD and ammonia, the overall effect on water quality of rivers is reported by many authors to be negligible and the contamination of rivers with heavy metals and other toxic contaminants is widespread yet barely reported. Eutrophication of Chinese lakes by phosphorous and nitrogen is severe, with 66% of 50 surveyed lakes being eutrophic or hyper-eutrophic (Jin, 2002), often leading to intense and potentially toxic algae blooms.

2. Trans-jurisdictional water management in China and overseas

This situation has led to many trans-jurisdictional water resource and water quality conflicts across China. A major problem of integrated water resources management (IWRM) in China is the inability to deal effectively with trans-jurisdictional (especially inter-provincial) water pollution. The Chinese Constitution devolves natural resource management, including water and environment, to provincial jurisdiction. This has proved to be extremely vexatious insofar as provincial governments have little accountability in law or practice to maintain water quality at provincial boundaries. The Five Year Planning process identifies water quality objectives at provincial boundaries; however these are not based on science and are not linked to the target pollution load reductions required of each province in the same plan, so the objectives usually cannot be met. This is a problem in much of the country and particularly so in the Haihe (Zhangweinan) River Basin. Major public health emergencies caused by trans-jurisdictional pollution have prompted intervention by the State Council in, for example, the Huai River Basin (Wang & Ongley, 2004; Wang, 2007a). Trans-jurisdictional water pollution issues are usually dealt with administratively and many prove to be intractable and are never satisfactorily resolved.
The principles underlying shared use of transboundary watercourses and lakes are well known. These were first enunciated in the 1966 Helsinki Rules, then subsequently in the 1997 United Nations Convention on the Law of the Non-navigational Uses of International Watercourses. This body of customary law has been subsequently updated by the 2004 Berlin Rules on Water Resources which is applicable to shared fresh water resources and includes specific reference to water quality, groundwater and water ecology. Content of customary law that is especially applicable to China includes: equitable and shared use; avoidance of environmental harm; unified management; IWRM; reasonable access to information; sustainable use; rights of persons (public participation, right of access to water, duty to compensate); protection of aquatic environments (ecological integrity, ecological flows, pollution, water quality standards, enforcement, hazardous substances, alien species); co-operation and administration (shared information, harmonizing of laws and procedures, notification, minimum requirements for basin-wide management, compliance review) and dispute settlement. For discussion of the state’s rights with regard to water resources allocation and use and the criterion of ‘equity’ in water resources allocation, the reader is referred to Wolf (1999).

These principles are reflected in many international shared water bodies and related treaties. One of the earliest trans-jurisdictional arrangements is between Canada and the United States which established the International Joint Commission (IJC) in 1909 under the Boundary Waters Treaty of the same year, to oversee issues involving hundreds of transboundary lakes and rivers between the two countries. Typical of agreements between western countries, the IJC has no executive or enforcement powers. It has broad powers of investigation and reporting to governments and to the public. When asked by governments, it investigates specific trans-jurisdictional pollution problems along the Canada–United States border. The governments of the United States and Canada can also ask the Commission to monitor situations and to recommend actions. The IJC mechanism has proven to be a very successful framework for dialogue between the two national governments and has led to successful resolution of trans-national water quantity and pollution problems. Perhaps the most outstanding trans-jurisdictional accomplishment is the Great Lakes Water Quality Agreement of 1972 and 1978 and subsequent Action Plans that were developed, then implemented by the two national governments, eight Great Lakes states and the one Canadian province bordering the Great Lakes. The Great Lakes Water Quality Agreement sets water quality objectives for the Great Lakes and, through Action Plans agreed upon by national, state (USA) and provincial (Canada) governments, the jurisdictions fully implement remedial programmes that lead to fulfillment of the quality objective. The water quality objectives are recommended by a scientific board, then accepted by governments and have realistic timeframes that reflect the linkages between investment, implementation and predicted lake response. The satisfactory resolution of the 1970’s eutrophication crisis of the two lower Great Lakes of North America is undoubtedly the world’s earliest and largest example of successful international trans-jurisdictional water quality management.

Rivers in Europe cross many national boundaries. Water quality in Europe is managed both by national regulations and by the European Water Framework Directive (WFD; EU, 2000a). There is little in the WFD that applies directly to trans-jurisdictional water pollution management other than the obligation to develop a whole basin perspective through consultation. While there are no specific provisions in the WFD for managing trans-jurisdictional water pollution situations or disputes, nor explicit arrangements for monitoring for compliance other than national programmes, national governments are held to account by the EU which has punitive powers on member governments that violate the spirit or practice of its Directives. The WFD is still quite young and most member governments are still implementing this Directive. The 1999 Rhine River Convention (EU, 2000b) largely
focuses on water quality and ecosystem improvement; it predates the WFD and extends back to earlier agreements as far back as 1963. Under this convention there have been monitoring protocols and specific targets established by the five participating governments and the European Community. Under the convention water quality objectives are agreed upon, violations are reported and individual governments are held responsible for bringing their water quality into compliance. The convention and the Rhine Commission, like the IJC (see below) in North America, have no executive powers but do have the power to publicise poor performance of participating governments. Under this convention, the Rhine has been remediated to the point where salmon, which had disappeared from the Rhine, have returned to the river. The three conventions involving transboundary European river basins: the Danube Convention (1994), Albufeira Convention (1998: Spain & Portugal) and the Rhine Convention (1999) all invoke the principles of equitable use, co-operation, mutual action and administrative coordination.

Table 1. Enabling conditions for IRBM/IWRM.

<table>
<thead>
<tr>
<th>Enabling conditions</th>
<th>Chinese practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparency in governance</td>
<td>Opaque</td>
</tr>
<tr>
<td>Sharing of data</td>
<td>Almost none(^a)</td>
</tr>
<tr>
<td>Integrated action on water quality and quantity within and between jurisdictions</td>
<td>Almost none</td>
</tr>
<tr>
<td>Cooperative action between jurisdictions</td>
<td>Very little; recent progress in cooperation in some provinces is limited to cooperation within sectors</td>
</tr>
<tr>
<td>Public &amp; stakeholder involvement in basin governance</td>
<td>None at basin level; limited at municipal level</td>
</tr>
<tr>
<td>Full enforcement</td>
<td>Partial enforcement</td>
</tr>
<tr>
<td>Accountability</td>
<td>Limited accountability</td>
</tr>
</tbody>
</table>

\(^a\)A recent (2009) agreement between MWR and MEP to share essential data about the Haihe River is a landmark in cooperation between these two ministries.

The enabling requirements for full IRBM/IWRM identified in international law and in practice in other countries are noted in Table 1 however, none of these are evident in China. River basin governance continues to be a divisive issue. While the Ministry of Water Resources (MWRs) claims that China practices IRBM, it is, in fact, limited to water quantity management. This arises, in large part, from the institutional and legal separation of water quantity (MWR, with its Water Law) and water quality (MEP, with its Water Pollution Prevention and Control Law (WPPC Law) and lack of effective horizontal cooperation between ministries both at national and local levels of government. This results in overlapping and sometimes competitive mandates in almost all areas of water planning, operational management, permitting systems, water function zoning, and so on. MWR is represented at the basin level by a basin agency but whose powers are mainly limited to water quantity management including flood control and basin planning (which consults with, but is not binding, on other ministries). MEP is not represented at the basin level and implements its plans and programmes through provincial Environmental Protection Bureaus (EPBs) which operate separately from the provincial water bureaus. While many writers, both foreign and Chinese, have advocated a single agency, this is unlikely to happen in the foreseeable future.

As an alternative, the World Bank together with the Global Environment Facility (GEF), the MEP and the MWR have undertaken a comprehensive joint programme in the Hai River basin to demonstrate methods for achieving integrated water and environmental management under the current institutional and legal framework. Our work within that project suggests that this initiative is
paying off, with coordinated approaches to planning, data sharing and new operational measures that involve much closer coordination between these two ministries both at ministerial and local levels. Indeed, the national government has paid much attention to this GEF programme and is advocating inclusion of key recommendations of the programme in the 12th FYP that is to begin in 2011.

In response to the national water quality situation, the government has taken a number of important steps to tackle water pollution. These include:

1. China’s five year planning system underwent major changes in the 11th FYP (2006–2010) reflecting a shift from ‘getting rich first’ to ‘common prosperity’ (Fan, 2006) that included explicit recognition of environmental quality as a national goal.
2. Commencing in 2007, the total (waste) load control program was greatly strengthened and provinces were assigned strict annual targets for reduction of COD and ammonia loads into surface water.
3. In 2007, an annual environmental performance criterion was imposed on local (provincial and lower) officials.
4. In 2008 the WPPC Law was amended.
5. Construction of wastewater treatment facilities across the country. According to the Asian Development Bank (AFP, 2008) about 40% of urban wastewater was treated in 2008 although other values are often cited in the literature. The 11th FYP calls for 70% treatment by 2010 although it is known that a substantial number of wastewater facilities work only poorly, or not at all.
6. Substantial government support has been provided for introduction of market measures to deal with water quantity and quality.

In the past few years, a number of southern provinces have developed protocols for inter-provincial dialogue and management of water resources (Cardno-Acil, 2009). A trans-jurisdictional water pollution control system and a communication mechanism for water environment information were established in Jiangsu and Zhejiang provinces in 2002. This has led to a package of mechanisms to facilitate a coordinated approach to water pollution. The package of mechanisms includes:

- joint monitoring of boundary waters;
- basin information dissemination;
- joint enforcement of laws;
- constructing and sharing infrastructure jointly;
- ecological compensation;
- pollution rights trading.

The (Pan) Pearl River Delta includes nine provinces plus Hong Kong and Macau and trans-jurisdictional water and pollution conflicts have been a continuing problem. In 2007 environment officials from six jurisdictions approved the Administrative Management Measures for Trans-jurisdictional Environmental Pollution in the Pan Pearl River Delta. The measures lead to a cooperative approach among these provinces based on the common need to address trans-jurisdictional pollutions. Notably, in both the Jiangsu and Zhejiang and the Pearl River examples, the focus is on water pollution and involves only officials from EPBs. While these address water pollution, they are not full examples of IRBM.
3. Zhangweinan River Basin

Against this backdrop, we have examined the potential for water quality improvement in the Zhangweinan (Canal) River Basin (Figure 1). The Zhangweinan is one of the five large water systems of the Haihe River basin and is composed of the Zhanghe River, Weihe River, Wei Canal, Zhangweixin New River and South Canal. The basin is within the four provinces of Shanxi, Henan, Hebei and Shandong and Tianjin Municipality and empties into the Bohai Sea. Zhangweinan is typical of most basins in this water scarce and dry part of China but has received special attention from the central government owing to its (a) high level of water pollution, (b) the fact that it crosses the eastern line of the South to North Water Transfer scheme from the Yangtze River to north-east China, (c) its severe water scarcity (240 m³/capita/year) and (d) because of continuing and often acrimonious trans-jurisdictional disputes between the four provinces over water quantity and quality. Zhangweinan provides a useful reference for examining policy, planning, management, technical and economic options for improving water quality management throughout this part of China and that are consistent with the current institutional management system.

The physical situation in Zhangweinan Basin is not typical of North American or of European river basins. It is typical of rivers that cross the North China Plain; flow is completely artificial and is controlled by more than 300 reservoirs, countless gates and weirs and is almost 100% canalised. Internal runoff is mainly from upstream Shanxi Province and is supplemented by transfer of water from the

![Fig. 1. Zhangweinan River (Canal) Basin.](https://iwaponline.com/wp/article-pdf/13/5/624/405844/624.pdf)
Yellow River. Flow declines downstream owing to water extraction along its length and there are no
natural inputs. Because the upstream area (Henan Province) is heavily polluted, there is no gain in
assimilation capacity downstream and for much of the year assimilation capacity in the middle and
lower reaches is near zero. In many years there is little or zero flow to the Bohai Sea. The groundwater
table has been pumped to the point where there is virtually no natural baseflow. ‘Baseflow’ during dry
seasons is artificially managed and is often nearly 100% wastewater.

The management system in the Zhangweinan Basin is typical of large river basins in China. A sub-
office of the Hai River Basin Commission of MWR develops comprehensive basin-wide plans but has
no jurisdiction for implementing these plans except for water quantity management. The commission
represents only MWR and has no representation from basin stakeholders. Each of the provinces
develops and implements its own water and water pollution control plan (also developed separately)
 according the requirements of the FYP.

4. Methodology

This study is drawn from work carried out under the Australia China Environment Development Part-
nership (ACEDP) programme, conducted over the period 2008/9 with the MEP. Some data are from
2004, which is the baseline year in the GEF project ‘Hai Basin Integrated Water and Environment
Management Project’. At that time comprehensive estimates of pollutant loads, groundwater withdra-
wals, basin water balance and river discharge to the Bohai Sea and other socio-economic factors,
were based on measured values in 16 pilot counties in the Haihe River Basin and for the Haihe
River as a whole, including the Zhangweinan sub-basin. These measures were the basis for establishing
targets for beneficial change in water and environmental management over the life of the GEF project
and into the future.

While a variety of parameters are measured both in-river and in wastewater, the principal measures of
pollution control in China are COD and ammonia; these are used here for our assessment. Some data for
2007 were released to us by local agencies as part of the present study but other data subsequent to 2004
were not accessible and considered ‘sensitive’ by local agencies. 2007 is the second year of the 11th
FYP (2006–2010) and is indicative of conditions close to the beginning of this FYP.

Field investigations included river section observations in our study area to determine site-specific
issues with regard to local hydrological management, function zoning and upstream/downstream and
left bank/right bank trans-jurisdictional issues of local or regional concern. We carried out extensive dis-
cussions with local officials of the four provinces on trans-jurisdictional water quality issues and related
management problems and had extensive interactions with other local officials during training sessions
on trans-jurisdictional water pollution management carried out under this ACEDP project. Comparative
trans-jurisdictional experience was conveyed to Chinese participants in the project during an Australian
study tour. Finally, we have drawn on the extensive and cumulative experience of the authors in Chinese
water pollution management over many years in order to place our observation in a suitable context and
within a practical framework that could be adopted under the present Chinese water and pollution man-
gament system.

The economic component of this work is based mainly on practical experience in Zhejiang Province
where one of us (Shen) developed an economic framework for water markets that are now operating in
that province (Shen et al., 2009). There is also a large literature in China on modernisation of water

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management through economic reform (Shen, 2006a, b) and on the use of ‘payment for ecological services (PES)’ systems (Bennett, 2009). Economic reform in the water sector tends to be based on the issuance of ‘water rights’ and, although this has not been decided in law, ‘rights’ are being implemented in practice in many parts of China (Liu, 2003; Wang, 2007b). Similarly, PES systems are being widely discussed in China as a framework on which to base compensation for loss of beneficial use. Our intent was to quantify pollution costs and treatment options in the four provinces as a means of developing a quantitative basis for an inter-provincial trading scheme in which several economic options could be used. However, as these data were not available in sufficient detail for much of the Zhangweinan Basin, our approach has been to provide a structure for a pollution trading system that reflects the Zhangweinan Basin situation and into which detailed quantitative data and institutional decisions on costs and charges could be inserted when these are known.

5. Results and discussion

5.1. Types of inter-provincial trans-jurisdictional dispute

5.1.1. Upstream–downstream. Within the entire river basin, water pollution disputes go hand in hand with disputes over water resource (quantity) utilisation. Some of these disputes have gone on for more than a decade without resolution. Of particular concern is the long-term dispute between upstream Shanxi and the rest of the basin over construction of a dam and reservoir. As the Constitution gives provinces the right to manage water resources within their territory, there is no clear legal answer as to whether a province can unilaterally make decisions that impact on other provinces, or if this right is the prerogative of the central government.

5.1.2. Left bank–right bank. Some sections of the Zhang River are shared by Henan and Hebei provinces; Wei Canal is a trans-jurisdictional river between Hebei and Shandong provinces. The Zhangweixin River in the lower reaches of the basin separates Hebei and Shandong provinces. Because watercourses in the Zhangweinan Basin are narrow, sewage discharged from one side inevitably pollutes the other side. As a consequence there are many disputes between right and left bank jurisdictions.

5.2. Legislation and policy for trans-jurisdictional water pollution management

Notwithstanding a new section in the amended (2008) WPPC Law (Article 15) on trans-jurisdictional water pollution management at the basin level, the legislative and management (‘responsibility’) framework for trans-jurisdictional water management remains incomplete (Chen & Huang, 2008) and, apart from brief reference to ‘administrative resolution’ (Article 28), the relevant regulations and policies for water environment management do not include specific procedures for resolution of trans-jurisdictional issues. This inadequacy has been widely noted by Chinese authors (Xing, 2004; Wang, 2007a, b).

In recent years, there have been a number of local regulations promulgated on trans-jurisdictional issues. The Administrative Treatment of Trans-jurisdictional Pollution Disputes in Pan Pearl River Delta was approved in May of 2007 by all relevant jurisdictions. In 2008, Hebei Province developed an official position on city-boundary water quality objectives with a linked responsibility system and a trial of an ecological compensation payment system for the major rivers of the Ziya Basin. It calls
for strict penalties for infringement of trans-jurisdictional water quality standards. Water quality along the Ziya River improved shortly after the regulation was put into place. These examples are not, however, unified water quality and quantity management systems as they focus only on pollution and are implemented by provincial EPBs. There is no such system for the Zhangweinan Basin and none is contemplated at this time by any of the four provinces.

5.3. Planning systems

Pollution planning is part of the FYP in which total load reduction quotas are assigned to each province. Currently the five year planning process is primarily a centrally directed administrative process, is not science-based and does not pay much attention to the particular physical and ecological conditions of each basin. For water pollution, this means that provincial total load reduction quotas are not linked scientifically to the water quality targets in the same FYP even though the FYP sets these targets, especially at provincial boundaries. Therefore, we find a situation where an upstream province may have implemented its full load reduction quota, but water quality still fails to meet the FYP water quality standard at the boundary. Downstream provinces initiate administrative actions against the upstream jurisdiction on the basis that the water quality standard has been violated when, in fact, the standard has no technical link to the load reduction required in the plan. Most disputes created by these issues are never fully resolved because of lack of both a sound technical basis for resolution and a clear administrative process.

In 2002 the National Development and Reform Commission and MWR required the development of a national water resources comprehensive plan to be completed within 3 years at the provincial level. In Hebei province the comprehensive plan was developed by Hebei Water Resources Department and EPB, in conjunction with other relevant local governments and agencies. However, this plan has not significantly resolved the problem of trans-jurisdictional water pollution disputes and does not deal effectively with the range of administrative, institutional and legal issues that make integrated water management so difficult in China.

At the basin level, MEP is authorised to develop basin pollution control plans. MWR creates ‘comprehensive’ basin plans for the seven major basins in China, including the Hai Basin of which the Zhangweinan River is a component. The last full set of basin plans was developed in the early 1990s and revisions began in 2007 but may take up to 5 years to complete. The comprehensive basin plans are developed for/by basin agencies of MWR and consider not only water quantity, but also pollution loads, ecological environment (arguably an MEP responsibility), soil conservation, wetlands, and so on. While there is feedback between these various planning processes and a legal requirement for ‘consultation’ between the two ministries, the nature and process of that consultation is not defined. As a result, the objectives for water quantity and the water quality plans can be substantially different. Indeed, basin level environment (pollution) plans and water resources (quantity) plans are submitted separately to the State Council for approval.

Legislation for both water quantity and quality calls for ‘unified’ and ‘comprehensive’ planning and management. However, in practice, planning by each agency leads to many problems and inconsistencies that exacerbate rather than resolve inter-provincial conflicts over water. These include inconsistent objectives between water and environment plans at the provincial and basin levels, different assimilative values for water function zones assigned by the two agencies, water quality targets at boundaries that may have a poorer quality target on the upstream side and a higher quality target on the downstream...
side of the boundary and differences about how much water and pollution load should be transported downstream.

All of these institutional, planning and legislative inconsistencies are at play in the Zhangweinan Basin. An output of the GEF Haihe IWRM project is articulation of a Strategic Action Plan for IWRM in the Zhangweinan Basin. The key issue is that, at this time, there is no permanent integrating mechanism for basin-wide pollution and water resources planning or management in the Zhangweinan Basin.

5.4. Water pollution and load control

Water quality in China is measured on a five-point grade scale where Class 1 is the best quality and Class 5 is the worst, with water exceeding Class 5 occupying a de facto 6th category. In the Zhangweinan Basin the percentage of Class 5 water quality has gone from zero in 1980 to 76.8% of total river length in 2004. Although total nitrogen (TN) is measured and reported in China, it is not regulated as a control indicator; total phosphorus (TP) or phosphorus species are reported for surface waters, especially for lakes and reservoirs that are subject to eutrophication. The inadequacy of TN data is a particular problem in assessing the impact on coastal seas of land-based pollution (here, the Bohai Sea). With the 11th FYP, total (pollution) load control of COD and ammonia has become a central part of pollution management. Three specific problems of total load management in the Zhangweinan Basin, as elsewhere in China, include data accuracy and compliance and the linkage of load control with water quality standards.

5.4.1. Data accuracy. Determination of total load is difficult in China owing to many factors including unmonitored dischargers, erroneous or false reporting by industry, illegal discharges, protectionism by local government of polluting industries for economic reasons, corruption, and so on. There is relatively little direct monitoring of waste discharges by local environmental agencies. Consequently, there is much under-reporting of total loads by local EPBs. Wang (2009) reports that national total wastewater discharge published by MWR for 2005 is 36.8% higher than that reported by MEP for the same year. Anecdotal evidence suggests that this difference can be up to a factor of 2. There is little analysis in the Chinese scientific literature of the problem of accuracy and uncertainty in official data and local agencies generally refuse to discuss error in their reported loadings data. We assume that the actual loadings in Zhangweinan are probably considerably higher than those reported.

5.4.2. Compliance. Successful IWRM requires a high level of compliance with pollution regulations. However, compliance remains a substantial problem in much of China and the Zhangweinan Basin is no exception. In the 2004 baseline year, all 16 administrative areas in the basin, with one exception, had non-compliant discharge. Non-compliance for each industry group for COD and ammonia is compared in Table 2 for 2004 and 2007. The performance, by the industry sector, relative to the 2007 wastewater standards is shown in Figure 2 and by province (Table 3).

When the non-compliant discharges are weighted by volume of discharge, paper-making contributes almost one-third of the non-compliant COD discharge in 2004 and 65.8% in 2007. Most importantly, our calculations show that if full compliance was enforced, total COD and ammonia loads in the basin would be reduced by over 30% without recourse to other options such as advanced treatment, industrial restructuring, plant closures, and so on. This is significant for IWRM insofar as local EPBs are reluctant...
to discuss enforcement failure, often preferring to focus on technical solutions (treatment options) or administrative solutions (e.g. industrial restructuring).

5.4.3. Methods of total load control. The principal issue for basin-wide management is how to assign loading targets that make sense in terms of trans-jurisdictional water quality. As the gap between load control quotas and in-stream water quality objectives remains very large, especially in rivers of the North China Plain, there is currently much discussion in China about introducing the American ‘total maximum daily load’ (TMDL) approach (US-EPA, 2008) in the 12th FYP. In the United States TMDL is required where in-stream water quality is non-compliant with the in-stream water quality objective. As there has been little informed discussion in the Chinese literature of how this might work in practice in China, our study examined the conditions under which TMDL might be applied to the Zhangweinan Basin. There is a substantial difference between the two countries both in the physical conditions in which TMDL is used and in the enabling conditions necessary to implement TMDL. The enabling conditions are identified in Table 4. Perhaps the most important difference is that TMDL in America provides the technical link between load reduction at source and achieving the in-stream water quality objective. This is achievable because waste loads are relatively small and river flows are relatively large in much of America. In north-eastern China, the situation is the reverse, with waste loads extremely high and flows extremely small. We estimate that in the Zhangweinan Basin, loads in upstream Henan province would have to be cut by over 60% to achieve the target objectives.

### Table 2. Non-compliant wastewater discharge by industry type, Zhangweinan River Basin.

<table>
<thead>
<tr>
<th>Industry group</th>
<th>COD 2004</th>
<th>% of total non-compliance Rank</th>
<th>COD 2007</th>
<th>% of total non-compliance Rank</th>
<th>Ammonia (NH₃-N) 2004</th>
<th>% of total non-compliance Rank</th>
<th>Ammonia (NH₃-N) 2007</th>
<th>% of total non-compliance Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textile</td>
<td>5</td>
<td>3.2</td>
<td>6</td>
<td>2.1</td>
<td>6</td>
<td>2.7</td>
<td>7</td>
<td>1.8</td>
</tr>
<tr>
<td>Paper</td>
<td>2</td>
<td>31.1</td>
<td>1</td>
<td>65.8^b</td>
<td>a</td>
<td>a</td>
<td>6</td>
<td>2.4</td>
</tr>
<tr>
<td>Steel</td>
<td>6</td>
<td>1.9</td>
<td>0</td>
<td>0.0</td>
<td>4</td>
<td>3.2</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Food</td>
<td>4</td>
<td>3.9</td>
<td>2</td>
<td>10.1</td>
<td>7</td>
<td>2.0</td>
<td>5</td>
<td>3.9</td>
</tr>
<tr>
<td>Pharmacy</td>
<td>7</td>
<td>0.7</td>
<td>3</td>
<td>7.5</td>
<td>9</td>
<td>0.0</td>
<td>3</td>
<td>13.2</td>
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<tr>
<td>Mining</td>
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<td>0</td>
<td>0.0</td>
<td>5</td>
<td>2.8</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Chemistry</td>
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<td>42.2</td>
<td>5</td>
<td>4.9</td>
<td>1</td>
<td>78.6</td>
<td>1</td>
<td>34.8</td>
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<tr>
<td>Thermal power generation</td>
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<td>0.5</td>
<td>0</td>
<td>0.0</td>
<td>3</td>
<td>4.3</td>
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<tr>
<td>Machine</td>
<td>8</td>
<td>0.6</td>
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<td>0.0</td>
<td>8</td>
<td>0.1</td>
<td>10</td>
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<tr>
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<td>10</td>
<td>0.1</td>
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</tr>
<tr>
<td>Wood processing</td>
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<td>0</td>
<td>0.4</td>
<td>a</td>
<td>9</td>
<td>1.2</td>
<td>0.5</td>
</tr>
<tr>
<td>Leather</td>
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<td>8</td>
<td>1.2</td>
<td>2</td>
<td>a</td>
<td>11</td>
<td>0.5</td>
<td>9.7</td>
</tr>
<tr>
<td>Others</td>
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<td>15.7</td>
<td>4</td>
<td>6.0</td>
<td>2</td>
<td>6.3</td>
<td>4</td>
<td>9.7</td>
</tr>
<tr>
<td>Total</td>
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<td>100</td>
<td>100.0</td>
<td>100</td>
<td>100.0</td>
<td>100</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: GEF baseline (2004); our 2007 investigation.

^aNo data.

^bIncrease in compliance failure for the paper industry reflects a lowering of the discharge standard from 150 (2004) to 100 (2007) mg L⁻¹.
water quality class at the Henan–Shandong boundary. Clearly this is not feasible in the short term and probably not in the long term either, implying that the water quality targets in the FYP are quite unrealistic in this river system and that this is not a candidate region for application of a full TMDL procedure. An improved planning system, as we note above, with rational and targeted load reductions by industry sector and for provinces as a whole, coupled with strong enforcement, would achieve good results without the distraction of trying to make TMDL fit the conditions of the Zhangweinan Basin.

5.4.4. Non-point source loads. Increasing attention is being directed in China to the role of non-point sources (NPSs) of pollution, especially rural and agricultural NPSs. NPS studies are relatively recent in China and many use unreliable estimating techniques (Ongley et al., 2010). As noted above, the MEP recently announced that COD levels were approximately twice as large as previously reported in 2007 owing, mainly, to agricultural pollution. For the Zhangweinan Basin, a SWAT (USDA, n.d.) modelling study undertaken for the GEF Haihe IWRM project found that runoff is virtually zero in the middle and lower parts of the basin and recent NPS studies there indicate very low agricultural NPS pollution (Haihe GEF Project, personal communication). This is consistent with our own investigations in which

Table 3. Non-compliance by province for COD and ammonia, 2007.

<table>
<thead>
<tr>
<th>Province/region</th>
<th>COD</th>
<th>Ammonia</th>
<th>Principal non-compliant industries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-compliant load/10^6 tonne</td>
<td>% Non-compliance</td>
<td>Non-compliant load/10^6 tonne</td>
</tr>
<tr>
<td>Shanxi</td>
<td>0.35</td>
<td>49.2</td>
<td>0.08</td>
</tr>
<tr>
<td>Henan</td>
<td>6.68</td>
<td>59.6</td>
<td>0.12</td>
</tr>
<tr>
<td>Hebei</td>
<td>1.83</td>
<td>67.8</td>
<td>0.20</td>
</tr>
<tr>
<td>Shandong</td>
<td>1.44</td>
<td>59.3</td>
<td>0.01</td>
</tr>
<tr>
<td>Tianjin</td>
<td>0.05</td>
<td>53.6</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td>10.35</td>
<td>58.4</td>
<td>0.41</td>
</tr>
</tbody>
</table>
local agricultural officials have confirmed that it has been many years since there has been runoff from this dry environment. We conclude that, in the absence of runoff, agriculture and rural NPS pollution is probably quite small, with the main contributor being family and communal livestock raising (characteristically done on the edges of canals to facilitate cleaning of solid and liquid wastes). As there is no easy way to assess the impact of raising animal on water quality at the basin level we have excluded NPS pollution from further analysis in this study.

5.5. Market-based systems for pollution control

Market-based economic measures for water pollution control and water management are relatively new in China but are consistent with the economic policies of the government. Market-based mechanisms require strict enabling conditions such as strict adherence to total load controls, enforceable rules regarding market transactions and transfers of water and pollution ‘rights’, defined limits of interference by government agencies, rights of appeal, and so on. At this time, none of these are defined in law, however the government is actively promoting markets for ecosystem/environmental services and is driving some of the largest public payment schemes for ecosystem services in the world (Bennett, 2009).

There are three types of market mechanisms that apply to water pollution control now under consideration and/or experimentation. A fourth, water rights transactions, is not focussed on pollution control but is a precursor to similar discussions that will be held over pollution discharge ‘rights’. Because the government owns all water rights, the legal definition of a marketable water ‘right’ is still a subject of intense discussion (Wang, 2007a, b; Speed, 2009). There is limited use of water rights transactions in southern China and amongst irrigation districts in western China, but none in the Zhangweinan Basin.

5.5.1. Pollution discharge ‘right’ transactions: (discharge permit trading). A pollution discharge ‘right’ is the right to use environmental capacity by wastewater dischargers. It is linked both to discharge...
pollutant concentration and to total volume in that users can reduce either or both of the pollutant concentration or volume discharged in order to reduce their total load. Like water markets, enterprises with good waste treatment can sell their excess discharge entitlement. In this way, the market encourages greater efficiency in waste treatment so that enterprises can either grow within their waste discharge allocation, or can sell excess discharge entitlement. At present this is not used in China owing to lack of guidelines or legal basis on implementation of such a system and frequent lack of enforcement on enterprises that discharge above their permitted levels. Nevertheless, Shanghai announced plans to introduce a market for COD water emissions in late 2009 as part of a larger carbon market that will include SO₂ and will involve the 300 enterprises that produce 80% of that city’s pollution (People’s Daily, 2009).

5.5.2. Pollution compensation. This is paid by lower jurisdictions to upper jurisdictions to maintain water quality at some prescribed level. It is unrelated to ecological services and is based purely on maintaining a prescribed water quality class at a defined location(s), often for maintaining quality for municipal water supply purposes. This is often (and incorrectly) referred to as ecological compensation in many Chinese studies. Recently, this approach is being tried in a number of river basins in China, including the Pan Pearl Delta region and in Hebei Province.

5.5.3. Ecological compensation. This is also known as Payment for Ecological Services (PES). PES is based on the premise that water ecology has value. It is similar to payment for pollution entitlements but is calculated based on quality (and flow) of water required to maintain a specified ecological function of the water body. Fundamentally, this means that downstream jurisdictions that need higher (water) ecological conditions and that can get this from upstream jurisdictions that have higher quality water, should pay the upstream jurisdiction for that increase in ecological value. Similarly, if upstream water quality is poor and causes loss of ecological function downstream, the upstream jurisdiction should indemnify the downstream jurisdiction for that loss. For the time being PES is used when two jurisdictions see it in their mutual interest as there are no regulations that prescribe when it is to be used or how it should be calculated and implemented. PES systems are being widely discussed in China as a framework for basing compensation for loss of beneficial use. The type of ‘ecological services’ is often not specified either in the literature or in practice, but is based on water quality class where class is a surrogate for ecological function, or on maintaining sufficient flow volume especially during low-flow months, which will maintain ‘ecological’ viability (often meaning ‘assimilative capacity’). Given the extremely poor condition of water quality in many Chinese rivers, this is a reasonable approach at the current stage of national development.

5.6. Methods for implementing a market in pollution discharge rights

In river basins that have abundant water, pollution management can be based on environmental capacity that will support a designated ecological or social function. However, in water scarce areas such as here, the pollution level is so severe that all water quality is far worse than in the planned objective, so that capacity-based total load is not an option in the nearer term. Therefore, a pollution right for the Zhangweinan Basin must initially be based on total load allocated in the FYP until such time as the pollution level and planned water quality targets are more meaningfully connected. At that point, capacity load control can be used.
The determination of total pollution rights by jurisdiction (province/Tianjin Municipality) for COD and ammonia (and any other pollutant) can be based upon population, total production value (GDP) and total pollution load discharged in a baseline year. For the Zhangweinan Basin, GDP should include farm production so that, in the future when rural pollution is better quantified, rural and agricultural NPSs can be brought into the pollution rights system; we would not, however, expect this to be captured in a pollution trading system for at least a decade. We note that inclusion of total pollution discharged in a baseline year penalises jurisdictions that have made substantial progress in load reduction and rewards those that have not. The history of load reduction must be taken into account in assessment of the baseline year and, therefore, weighted according to a formula that accounts for different levels of progress in each jurisdiction.

*Users* of pollution rights will include:

- all enterprises subject to discharge regulation;
- municipal wastewater treatment facilities: the pollution cost should be built into wastewater tariffs that are passed back to residents;
- large-scale animal and poultry feedlot operators that fall under the regulations brought into force in 2002: in time, village and community enterprises should be brought into the rights market system as these are the largest component of agricultural pollution of water.

The pollution discharge right system proposed for the Zhangweinan Basin is shown in *Figure 3*. We have not determined the cost of the initial (first-level) market allocation as this will greatly depend on economic and political factors. Jiaxing City in Zhejiang Province, which has the earliest example of a fee-based pollution rights use system, used a contemporary price for COD of 80,000 RMB/...
tonne with a term of 20 years, or about 4,000 RMB/year/tonne. Zhuji City which is also in Zhejiang Province treats old (before 2007) and new (after 2007) companies differently, with a price of 800 RMB/year/tonne for old companies and 2,000 RMB/year/tonne for new ones.

We propose two options for determining fees, one is based on a five-year right that is automatically rolled over into the next 5 years (using the FYP as the basic 5-year timeframe). In this option, fees would be based on the total of wastewater fees collected during this period from all dischargers and the initial rights fee replaces the current pollution discharge fee. The fee may be amortised over the 5-year life of the pollution right. The right would be required to be repurchased in subsequent 5-year intervals. In the second option, pollution discharge fees are maintained and the pollution right fee is a much smaller amount. The right should also have a lifespan of at least 5 years and will be repurchased in successive 5-year intervals. Five years is a reasonable length of time for a pollution right which, together with a guaranteed rollover for each user, allows the user to make longer term plans for pollution management that optimise their choices in the pollution rights market. A 5-year framework also allows the government to ensure that the rights market is consistent with the objectives of each FYP.

Initially we envisage the rights market to be restricted to COD and ammonia in the Zhangweinan Basin, with TN and TP added to the trading system within several years. Because of gross pollution in the Zhangweinan Basin, the total pollution load will be reduced over successive FYPs. This has implications for the pollution trading system insofar as because the total load is reduced according to FYP targets, the quantity of allowable load in each pollution right will also decline.

5.6.1. Enforcement. A specific condition of a pollution rights market is that the rights system must be enforced. This has two levels: one is the inspection and enforcement of pollution right conditions on enterprises; the second is a verifiable quantitative measure of load reduction at boundary locations to ensure compliance by upstream provinces. Failure to meet the boundary targets should incur penalties and/or sanctions that will be established as part of the rules system. Under this system the basis of an upstream–downstream trans-jurisdictional pollution dispute should be based on the designated annual load at the boundary location and not on the water quality objective which, in the case of the Zhangweinan Basin, is not achievable under the current waste loads and river flows. This ensures that disputes are based on planned load reductions and on a verifiable load measurement.

5.6.2. Rights management system. This system has two main components. The first is a set of stable and enforceable rules and conditions. Important components of the rules will be the non-encroachment of ecological rights, sustainable groundwater levels, strict enforcement on users and provinces, provisions for extraordinary situations (emergencies, droughts, etc.) and limitations on arbitrary intervention by government. The second component is a management system established to implement the rules through an orderly market process and implemented through a rights trading center.

6. Conclusions and recommendations

This study has focused on the challenges of bringing water pollution control of a water-scarce, multi-jurisdictional river basin, into an IWRM framework. Our conclusions and recommendations, while developed specifically for the Zhangweinan Basin are, however, broadly applicable to most river systems in China and especially in water-scarce north eastern China.
6.1. Detailed regulations, standards and institutional clarity for trans-jurisdictional water pollution management

These include the following key issues:

- Dispute settlement: In the Zhangweinan Basin, as elsewhere, basin governance lacks a clear and transparent process, the technical requirements and the procedural steps to resolve water and pollution disputes. These will include: (1) a technical basis for identifying a trans-jurisdictional water pollution violation: this may be one or both of a violation of a transboundary standard (by how much, for how long, etc.) and/or failure of the upstream jurisdiction to implement the required load reduction. Violations should be based on target loads at boundary locations; and (2) procedural steps involving timelines and avenues of appeal, the legal basis for use of data from both jurisdictions involved in the dispute and steps that can be taken for mediation and/or binding arbitration of the dispute.

- Strengthen waste discharge permitting system: The permitting system in China has been in flux over many years, yet remains quite inadequate both for local and basin-level pollution management. The entire permitting system needs an overhaul, with strict requirements for implementation by local government.

- A legal basis for pollution enforcement: The legal system should be amended to include judicial review and the authority to enforce both administrative and judicial decisions.

- Institutional roles and responsibilities: The overlapping roles and responsibilities of MEP and MWR at the basin level, especially in terms of planning, unified administration, water pollution monitoring and reporting, need to be clarified.

- Revision of Standards: The Technical Principle and Methods To Develop The Local Load Discharge Standard (GB 3893-83) and The Calculation Framework to Determine Water Body Pollution Assimilative Capacity (SL348-2006) need to be revised in order to reduce, at the planning stage, the likelihood of trans-jurisdictional disputes.

6.2. Integrated basin planning as a basis for eliminating trans-jurisdictional water pollution disputes

- Scientific relevance: Basin planning should be based on scientific assessment of basin conditions.

- Function zoning: Planning for water quality at function zones at the boundaries of jurisdictions should be linked so that the water quality leaving one jurisdiction is not worse than that designated in the receiving jurisdiction. Planning should include the premise that all function zones within the basin should comply with the standards rather than only a sub-set of functional zones being in conformance. Water function zones and water environment function zones need to be either integrated, or harmonised during the 12th FYP so that water quality and quantity can be managed in an integrated way. Transit zones and pollution discharge control zones should be eliminated. Buffer zones should be placed wholly within a province rather than at provincial boundaries.

- Integrated plan: For the Zhangweinan Basin, the water resources and water environmental plans should be fully integrated and submitted as a single integrated plan for State Council approval. The plan should contain the provisions for a coordinated control of water flow and water quality so that flow can be adjusted when assimilative capacity is reduced owing to a change in natural or artificial flows.

- Pollutants: To improve water quality further and alleviate trans-jurisdictional disputes, the 12th FYP for the Zhangweinan Canal Basin should contain: (1) an increase in the quota of compulsory NH$_3$
reduction in the Henan and Hebei provinces so that NH₃ at the Henan–Shandong boundary becomes the third indicator parameter to be rehabilitated to Class IV; (2) TN reduction be added as an indicator for achieving TN load control insofar as this also captures NH₃ and allows authorities to reduce TN entering the Bohai Sea.

6.3. Full compliance to total load control systems

Compliance should be quantifiably verified by load reductions at trans-jurisdictional locations on a month by month basis, then aggregated to an annual indicator of compliance.

6.4. Economic measures that provide incentive for pollution reduction

- Ecological rights: These need to be recognised within the framework of water rights. In the absence of a viable ecological system in the Zhangweinan Basin, ecological rights in the Zhangweinan Basin should initially be assessed as a percentage of historical low flow as a basis for future ecological recovery. This is often considered to be 60–70% of historical low flows and sets the stage for future regeneration of ecology using ‘environmental flows’ assessment. Ecological rights cannot be bought and sold or traded and are retained by the government to ensure future ecological objectives.

- Pollution discharge ‘rights’ market: A pollution rights market should be implemented in conjunction with a total load control policy for the entire basin and within each province. Our detailed proposal for this market is noted above.

- Pollution compensation: An inter-provincial compensation mechanism should be established at key trans-jurisdictional sections as a basis for economic resolution of trans-jurisdictional pollution issues. The mechanism should be based on price per tonne of, initially, COD and NH₃ that exceeds the limit imposed by the 12th FYP at key trans-jurisdictional sections. The upstream jurisdiction would compensate the downstream jurisdiction when the load exceeds the allowable amount. The downstream jurisdiction will compensate the upstream jurisdiction when the load is less than the allowable amount. The allowable amount will be reassessed in each 5 year planning period to reflect changes in total load across the basin.

6.4.1. ‘Rights’ management system. For a rights market to function effectively there are certain enabling conditions that are required, as follows:

- Market mechanisms must be established in law and/or local regulations so that rights, obligations and trading conditions of government and users are clearly defined.
- There must be strict enforcement of compliance to permitted right.
- Acceptable audit, public disclosure and supervision mechanisms must be in place.
- Total load control must be fully implemented and enforced at all levels of government in the basin.
- Current illegal or non-compliant dischargers should not be rewarded with extra pollution rights unless this is part of a programme of reduction targeted at these industries.
- Large and inefficient water-intensive or polluting industries should not be rewarded during the initial rights distribution.
In addition to clear rules and procedures, a Rights Trading Centre is required to manage the entire process.

6.5. Meaningful consultative mechanisms amongst jurisdictions in Zhangweinan Basin

Based on experience elsewhere in China and as a first step, a basin-level inter-provincial consultative mechanism (in China this is known as a ‘liaison meeting system’) should be established specifically for the Zhangweinan Basin. Consultation procedures should be developed that encourage public and stakeholder participation and ensure effectiveness and fairness amongst the participants. At this first step, the role of the liaison meeting system has no specific executive or administrative powers and exists primarily to ensure that there is a vehicle for trans-jurisdictional consultation. This has shown to be effective in other countries (Barrios et al., 2009).

As a future second step, a basin management committee comprising all four jurisdictions and with public and industry input, would be established with specific responsibilities, including coordinating the development of basin comprehensive plans, rational layouts for industries, water resource planning and management of waste water discharged into the river, and so on. It would also coordinate the process of resolving trans-jurisdictional conflicts, harmonise monitoring and function zones and promote data sharing. It should be responsible for ensuring that fees for the basin for water extractions, flood control and for drainage and waste water discharged into the river and penalties levied, are consistent with integrated basin management requirements. Such a committee would be independent of the current basin agency, but would work through the existing institutional framework within the basin.

Whether at the first or second step consultative mechanism, there is a necessity to develop: (1) requirements for routine reporting and feedback about water quality within the basin; (2) basin-wide emergency plans and how each jurisdiction should respond in cases of emergency; (3) regulations to guide day-to-day joint monitoring and co-enforcement work by the jurisdictions; (4) joint review and approval mechanisms involving all stakeholders for proposed projects in the upper reaches that may have trans-jurisdictional environmental impacts and projects in the lower reaches that may place excessive burdens on the upper reaches to supply an adequate quantity and quality of water; (5) agreement on water quality objectives and loads in trans-jurisdictional function zones for inclusion in successive basin plans and FYPs and for plans that involve the Bohai Sea; and (6) an ‘incentive and penalty’ mechanism, based on the compensation framework noted above, which rewards jurisdictions that provide water quality that exceeds the planned target and places penalties that will apply when water quality fails to meet the planned target in trans-jurisdictional function zones.

6.6. Monitoring and data sharing within the basin

IWRM in this basin requires strengthened capacity in monitoring and data sharing. To assess changes in pollution assimilative capacities at key sections and trans-jurisdictional locations, water quality and quantity monitoring should be in real time and available on-line to the public through the Internet. We note that a 2009 agreement between MWR and MEP on data sharing for the Haihe Basin sets a precedent in China for inter-ministerial data sharing. Public disclosure of monitoring data, according to the 2007 Law on Open Government, should be fully implemented by all EPBs and water bureaus (or water affairs bureaus) by the beginning of the 12th FYP.
Acknowledgements

The authors acknowledge the support of the Australia China Environment Development Partnership programme (ACEDP; http://www.acedp-partnership.org) of AusAID, the Australian Government Aid Programme that provided funds for this study under Project P0008, 2008-9. The cooperation of the leaders and staff of Environmental Protection Bureaus in Henan, Shanxi, Shandong and Hebei provinces and the Tianjin Municipality and of the Haihe Water Conservancy Commission is gratefully acknowledged. The project was managed by Robert Anscombe of Cardno-Acil Pty Ltd (Australia). Administrative and logistical support were supplied by the Chinese Research Academy of Environmental Science (CRAES) and the Foreign Economic Cooperation Office (FECO) of the Ministry of Environmental Protection. Some of the baseline data are drawn from the World Bank’s ‘Hai Basin Integrated Water and Environment Management Project’ of the GEF, MWR and MEP.

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Received 28 January 2010; accepted in revised form 14 September 2010. Available online 26 April 2011