Ecological Economics of Water in China: Towards A Strategy for Sustainable Development

Khan, Haider and Liu, Yibei

GSIS, University of Denver

2008

Ecological Economics of Water in China: Towards A Strategy for Sustainable Development

Haider A. Khan
Professor of Economics
Graduate School of International Studies
University of Denver
Denver, CO 80208
USA
hkhan@du.edu

Yibei Liu
Graduate School of International Studies
University of Denver
Denver, CO 80208
USA
yibei.liu@du.edu

Abstract:

The main purpose of this paper is to analyze one important part of the emerging environmental problems in China--- water pollution. The importance of water for any nation is obvious. In case of China it acquires particular salience because of China's industrial needs as well as human needs. Particularly significant is the rapid deterioration of the water quality and development of water shortages. Unless effective policy interventions are made quickly, this can develop into a major ecological disaster.

We present arguments for taking the water resources problem in China seriously. The continuing and rapid deterioration of water quality poses grave health and other types of environmental threats. If these threats are not addressed in a timely manner, the situation will deteriorate even faster. The Chinese 11th five year plan acknowledges many of these problems. The analysis in this paper is consistent with the stated objective of addressing ecological issues via a new development strategy.

We consider the institutional and policy-making issues carefully. The complexities of the water resource administration system in China are challenging. Coordination among WMR, SEPA, MOC, MOA, SFA, MoC, MOH and many other branches of the government will tax even the most sophisticated administrative apparatus. Clearly some simplification and streamlining is called for. At the same time, decentralization--- with proper incentives and monitoring mechanisms--- that gives more resources at the local level to fund defensive measures can improve performance on the ground.

In the age of globalization, at least a significant part of China's environmental problems stem from FDI-led production for export markets. Many enterprises have lax environmental management practices. This, of course, applies to many domestic SOEs as well. In all these cases, both market incentives such as effluent fees and better regulations with proper enforcement are needed. Regional and International cooperation and sharing of responsibilities are necessary parts of an overall policy package.

JEL Classification :
Q25, Q28, O53

Keywords:

Water Quality, China, Emissions, Environmental Management, Environmental Laws, Policy-Making System, Globalization

I. Introduction

By now the rapid economic growth of China is acknowledged as the rapid pace of industrialization, infrastructure building and other economic activities continue. However, this very impressive economic process has also led to some severe environmental stress.

The main purpose of this paper is to analyze one important part of the emerging environmental problems in China. We focus on water pollution. The importance of water for any nation is obvious. In case of China it acquires particular salience because of its industrial needs as well as human needs. Particularly significant is the rapid deterioration of the water quality and development of water shortages. Unless effective policy interventions are made quickly, this can develop into a major ecological disaster.

The current practices of water management in China are inconsistent with sustainable development. We define sustainable economic development as maximizing income while maintaining constant or increasing stock of capital. As Repetto (1986) reminds us[1]:

> [T]he core idea of sustainability is that current decisions should not impaire the prospect for maintaining or improving future living standards. This implies that our economic systems should be managed so that we can live off the dividends of our resources.

Resources, including scarce water resources are to be considered as an endowment fund. Using the approach will allow us to evaluate the current state of water resource management in China and suggest appropriate policy measures.

Our paper is organized as follows: In the next section we discuss the general water situation in China. In section III, we look at the law, policy, management and institutional issues related to the water situation. This is followed by the policy suggestions in section IV. Summary and conclusions follow.

[1] See also Khan and Lippit (2007)

II. General Water Situation in China

The general water situation, especially the water quality, in China's extensive water system can be explained by its population scale, the country's geological conditions, its accelerated urbanization, and the water consumption patterns. The last two factors are related to the current development strategy of PRC. We consider some of these important factors below.

Population

Though the population growth rate of China is only about 0.6 percent in recent years, the current absolute number is nearly 1.3 billion,[2] which means a huge water consumption base and less water availability on average. And population growth continues and could reach 1.6 billion by the middle of this century. Though the total amount of water resources is in a relatively large scale, the water resources available per capita is low, and with a declining trend. (Table 1) According to the ministry of water of China, the nation's water availability per capita in 2006 was 2,098 cubic meters, which is only about a quarter of the world average and is expected to fall further. From the United Nation's report, the situation is more worrying, as total renewable water resource[3] per capita of China is 2,259 cubic meters per year, which ranks China the 128th on the list. (Table 2.) Such a big population base has put great pressure on the country's water resource supply.

Table 1. Water Resources of China

Year	Total Amount of Water Resources (100 million cu.m)	Surface Water Resources	Ground Water Resources	Duplicated Measurement Between Surface Water and Groundwater	Per Capita Water Resources (cu.m/person)
2000	27700.8	26561.9	8501.9	7363.0	2193.9
2001	26867.8	25933.4	8390.1	7455.7	2112.5
2002	28261.3	27243.3	8697.2	7679.2	2207.2
2003	27460.2	26250.7	8299.3	7089.9	2131.3
2004	24129.6	23126.4	7436.3	6433.1	1856.3
2005	28053.1	26982.4	8091.1	7020.4	2151.8

Source: *China Statistical Yearbook 2006*

Table 2. Water availability per person per year

[2] China Statistical Yearbook 2006, available online at http://www.stats.gov.cn/tjsj/ndsj/2006/indexeh.htm

[3] Renewable water represents the main water resource available to society. This is the water that is continuously recharged in the hydrological cycle.

Ranking	Country	Water resources: total renewable per capita (m3/capita year)
1	Greenland	10,767,857
2	United States, Alaska	1,563,168
3	French Guiana	812,121
4	Iceland	609,319
5	Guyana	316,689
6	Suriname	292,566
7	Congo	275,679
8	Papua New Guinea	166,563
9	Gabon	133,333
10	Solomon Islands	100,000
128	China	2,259

Source: *The 1st United Nations World Water Development Report: Water for People, Water for Life* (2003)[4], Chapter 4

Looking at internal China, the water availability is uneven among different regions. The total amount of water resources available is generally more in Southern China than Northern part. And the water resources per capita distribution situation is similar, while the big cities, such as Beijing, Tianjin and Shanghai, have less water resource available in general.

Table 3. Water Resources – By Region

Year	**Total Amount of Water Resources**	**Per Capita Water Resources**
Region	**(100 million cu.m)**	**(cu.m/person)**
2005	28053.1	2151.8
Beijing	23.2	151.2
Tianjin	10.6	102.2
Hebei	134.6	197.0
Shanxi	84.1	251.5

[4] Available Online at http://www.unesco.org/water/wwap/wwdr1/table_contents/index.shtml

Inner Mongolia	456.2	1917.3
Liaoning	377.2	896.3
Jilin	559.7	2066.8
Heilongjiang	744.3	1954.2
Shanghai	24.5	138.0
Jiangsu	467.0	626.6
Zhejiang	1014.4	2077.2
Anhui	719.3	1178.8
Fujian	1401.1	3975.5
Jiangxi	1510.1	3513.2
Shandong	415.9	451.0
Henan	558.5	597.2
Hubei	934.0	1640.6
Hunan	1671.0	2649.5
Guangdong	1747.5	1906.4
Guangxi	1720.8	3703.8
Hainan	307.3	3722.4
Chongqing	509.8	1827.4
Sichuan	2922.6	3569.6
Guizhou	834.6	2244.4
Yunnan	1846.4	4161.7
Tibet	4451.1	161170.6
Shaanxi	490.6	1322.7
Gansu	269.6	1042.4
Qinghai	876.1	16176.9
Ningxia	8.5	143.6
Xinjiang	962.8	4808.9

Source: *China Statistical Yearbook 2006*

Urbanization

China's level of urbanization is striking. As shown in the table below, the absolute urban population has grown from about 170 million in 1978, accounting for 17.92% of the whole population then, to more than 560 million in 2005, constituting 42.99% of the total. The rapidly growing urban population has been companied by the fast establishment and expansion of city areas. As an illustration, the number of cities in China has increased from 190 in 1978 to 661 in 2000.[5] Such a great growth of

[5] The World Bank, "Water Quality Management – Policy and Institutional Considerations", September 2006: 16

urbanization has increased the demand for water and aggravated the water pollution situation in China. It is expected that China's urban areas will produce 650 km^3 of wastewater by 2010 and 960 km^3 by 2030.[6]

Table 3. Population and Its Composition of China

Data in this table exclude the population of Hong Kong SAR, Macao SAR and Taiwan Province. (10 000 persons)					
		By Residence			
	Total	**Urban**		**Rural**	
Year	**Population**	**Population**	**Proportion (%)**	**Population**	**Proportion (%)**
	(year-end)				
1978	96259	17245	17.92	79014	82.08
1980	98705	19140	19.39	79565	80.61
1985	105851	25094	23.71	80757	76.29
1989	112704	29540	26.21	83164	73.79
1990	114333	30195	26.41	84138	73.59
1991	115823	31203	26.94	84620	73.06
1992	117171	32175	27.46	84996	72.54
1993	118517	33173	27.99	85344	72.01
1994	119850	34169	28.51	85681	71.49
1995	121121	35174	29.04	85947	70.96
1996	122389	37304	30.48	85085	69.52
1997	123626	39449	31.91	84177	68.09
1998	124761	41608	33.35	83153	66.65
1999	125786	43748	34.78	82038	65.22
2000	126743	45906	36.22	80837	63.78
2001	127627	48064	37.66	79563	62.34
2002	128453	50212	39.09	78241	60.91
2003	129227	52376	40.53	76851	59.47
2004	129988	54283	41.76	75705	58.24
2005	130756	56212	42.99	74544	57.01

Source: *China Statistical Yearbook 2006*

Economic Drivers

China's robust economic growth has been continuing for more than 20 years. While economic growth has improved Chinese people's living standard economically, it also

[6] Olli Varis and Pertti Vakkilainen, "China's 8 Challenges to Water Resources Management in the First Quarter of the 21st Century," *Geomorphology*, 21(2001): 97

has brought great pressure on water resource use and environment. The total amount of water used all over the country in 2005 was 563.3 billion m^3, increased from 549.76 billion m^3 in 2000 (Table 4). According to the World Bank, China's economic growth will further lead to an increase in water demand of 6.5%, 32%, and 35% (2003-2020) from agriculture, industry and residential users respectively.[7] This indicates that a total increase of 83 billion cubic meters in water demand will be essential if China wants to maintain its current economic growth rate.

Table 4. Increase of Water Used in China

Year	Water Use (100 million cu.m)	Agriculture Use	Industry Use	Consumption	Biological Protection	Per capita Water Use (cu.m/person)
2000	5497.6	3783.5	1139.1	574.9		435.4
2001	5567.4	3825.7	1141.8	599.9		437.7
2002	5497.3	3736.2	1142.4	618.7		429.3
2003	5320.4	3432.8	1177.2	630.9	79.5	412.9
2004	5547.8	3585.7	1228.9	651.2	82.0	426.8
2005	5633.0	3580.0	1285.2	675.1	92.7	432.1

Source: *China Statistical Yearbook 2006*

Besides the water demand rising from the industries' development and expansion, the water quality is also deteriorating. China has long put the pure economic growth in the very central part of its development policy framework, the environment protection issue has been somewhat ignored. While the country is continuously establishing and expanding the industries, there is a lack of corresponding rule system to regulate enterprises, individuals, and even the governments' environment-related behaviors. Thus, heavily polluting companies often do not install or use waste-water treatment equipment in order to reduce cost, and local government might not want to force them to do anything because government has established "pure local economic growth" as its central task. As statistics show, China's industry waste water discharge volume steadily increased from 19.7 billion tons in 1999 to 24.3 billion tons in 2005. Also, within the same time frame, the non-industrial waste water discharge volume went up from 20.4 billion tons to 28.1 billion tons. (Table 5)

Table 5. Waste Water Discharge in China

Waste Water Discharge (100 million tons)			
Year	Industry	Non-industrial	Total
1995	222	--	--
1999	197	204	401
2000	194	221	415
2001	203	230	433
2002	207	232	439

[7] The World Bank, "Water Quality Management – Policy and Institutional Considerations", September 2006: 4

2003	212	247	459
2004	221	261	482
2005	243	281	524

Source: China Statistical Yearbook 2001 and 2006.

Water Quality Situation in China

China has established a water quality classification system based on purpose of use and protection target, following Environmental Quality Standard GB3838-2002:

Grade I – Mainly applicable to the source of water bodies and national nature preserves.

Grade II – Mainly applicable to class A water source protection area for centralized drinking water supply, sanctuaries for rare species of fish, and spawning grounds for fi sh and shrimps.

Grade III – Mainly applicable to class B water source protection area for centralized drinking water supply, sanctuaries for common species of fish, and swimming zones.

Grade IV – Mainly applicable to water bodies for general industrial water supply and recreational waters in which there is not direct human contact with the water.

Grade V – Mainly applicable to water bodies for agricultural water supply and for general landscape requirements.

Grade V+ - Essentially useless.

Based on continuing water quality monitoring, it can be shown that the chemical and biological quality of China's water resources is generally poor. As shown in Table 6, in 2005, only 41% of monitored river water was in categories I to III, 32% belonged to IV and V categories, and as much as 27% was in the worst category – V+. The quality of lake water in China is even worse. In 2005, only 7% of monitored lake water was up to category II, and 43% was classified as category V+ (Table 7).

Table 6. Comparison of Water Quality in the Seven Major Rivers in 2005

Seven Major Rivers	Grade I & II (%)	Grade III (%)	Grade IV (%)	Grade V (%)	Inferior to Grade V (%)
Yangtze River	56	20	11	2	11
Yellow River	7	27	34	7	25
Pearl River	55	21	18	0	6
Songhua River	5	19	45	12	19
Huaihe River	3	14	38	13	32
Haihe River	17	5	18	6	54
Liaohe River	14	16	22	8	40
Total	24	17	25	7	27

Source: *Report on the State of the Environment in China 2005* [8]

[8] State Environmental Protection Administration, *Report on the State of the Environment in China 2005,* Available online at http://english.sepa.gov.cn/ghjh/hjzkgb/200701/P020070118528407141643.pdf

Table 7. Water Quality of Major Lakes and Reservoirs in 2005

No. / River system	Number	I	II	III	IV	V	Worse than V	Major pollutants
Three major lakes	3	0	0	0	0	0	3	TN, TP
Large freshwater lakes	10	0	1	2	2	2	3	
Urban lakes	5	0	0	0	0	2	3	
Large reservoirs	10	0	1	4	1	1	3	
Total	28	0	2	6	3	5	12	
Percentage (%) in 2004		0	8	18	15	22	37	
Percentage (%) in 2005		0	7	21	11	18	43	

Source: *Report on the State of the Environment in China 2005*

The main pollutant of China's seven primary river systems is organic pollutants. Indicators include ammonia, oils, volatile phenolic materials, etc. Relatively, the main rivers have similar pollution structure, while ammonia accounts as the primary pollutant in rivers. China's lakes are also experiencing declining water quality. Main lakes of China are all undergoing eutrophication, though they are different in the extent. Concentrations of organic matter and nutrients show high level and are still increasing. As data below show, the ammonia nitrogen discharge amount has been fast increasing, and the COD (Chemical Oxygen Demand) discharge is also with an upward trend (Table 8).

Table 8. Discharge Amount of Wastewater and Major Pollutants in Recent Years across China

Item / Year	Discharge amount of wastewater (100 million tons)			Discharge amount of COD (10,000 tons)			Discharge amount of ammonia nitrogen (10,000 tons)		
	Total	Industrial	Domestic	Total	Industrial	Domestic	Total	Industrial	Domestic
2001	432.9	202.6	230.3	1404.8	607.5	797.3	125.2	41.3	83.9
2002	439.5	207.2	232.3	1366.9	584.0	782.9	128.8	42.1	86.7
2003	460.0	212.4	247.6	1333.6	511.9	821.7	129.7	40.4	89.3
2004	482.4	221.1	261.3	1339.2	509.7	829.5	133.0	42.2	90.8
2005	524.5	243.1	281.4	1414.2	554.8	859.4	149.8	52.5	97.3

Source: *Report on the State of the Environment in China 2005*

These pollutants basically come from two classes of sources: point source and non-point source emissions. Point source mission is made up of industrial and municipal emissions. Due to the water regulation efforts these years, the percentage of industrial water meeting discharge standards has risen from 76.9% in 2000 to 91.2%

in 2005.[9] The discharge amount of COD from industrial sources has also decreased. But municipal sources of pollutant are increasing, as population and economic growth leads to more wastewater. Non-point sources are mainly related to agriculture activities, including increasingly usage of fertilizer and pesticide and their run-off from farmland.

Emission Situation:
From 1990 to 2005, the total volume of waste water discharged in China has risen from about 35.4 billion tons to 52.5 billion tons,[10] indicating an average annual increase rate of 2.6%. Sources of waste water can be divided into two categories: industrial waste water discharge and non-industrial waste water discharge. In the same time frame, the industrial waste water discharged keeps at a relatively steady level, with a slight decrease, from 24.9 billion tons in 1990 to 24.3 billion tons in 2005.[11] But non-industrial waste water discharge accounts for the main source of the total waste water discharge's increase, with 10.5 billion tons in 1990 to 28.1 billion tons in 2005.[12]

While industries are rapidly expanding in China, the steady level or even slight decrease in industrial waste water discharge is mainly the result of Chinese government's focus on industrial pollution in recent years. In 1990s, industrial waste water was the major part of the total waste water discharge. Therefore, starting in 1990s, Chinese government started to focus its main attention on the problem. Through the adjustment and optimization of Chinese industrial structure and layout, the economies of scale is developing rapidly in the country, thus making centralized industrial pollution control feasible. By encouraging the application of new and less-polluting technologies, Chinese government has been trying to reduce the average industrial waste water discharge level. Especially, those industries with the highest pollutant level, such as dyeing industry, paper industry and chemical industry, are paid special attention to. Chinese government raised the level of waste water discharge standards for certain industries and thus eliminated those companies with a higher water pollution level or forced them to improve their waste water control system to meet the standards. With the measures, not only the total industrial waste water discharge volume is under certain control, the percentage of industrial waste water meeting discharge standards is also increasing, from 76.9 percent in 2000 to 90.7 percent in 2004, indicating a overall better industrial waste water quality. The discharge amount of COD from industry has been reduced from 7.05 million tons in 2000 to 5.5 million tons in 2005.[13]

While industrial waste water discharge is under control, waste water from non-industrial sources has been increasing rapidly. As mentioned earlier, the total

[9] China Statistical Yearbook 2006, available online at http://www.stats.gov.cn/tjsj/ndsj/2006/indexeh.htm
[10] China Statistical Yearbook, various years, available online at http://www.stats.gov.cn/english/statisticaldata/yearlydata/#
[11] Ibid.
[12] Ibid.
[13] Ibid.

non-industrial waste water discharge volume has more than doubled in the 15 years from 1990 to 2005. Discharge amount of COD now mainly comes from non-industrial water pollution. One can observe the same situation with respect to the ammonia and other nitrogen compounds discharge.

Together with economic development and urbanization in China, municipal waste water discharge is rapidly increasing. Swelling urban population brings growth in flushing toilets and washing machines, but the sewage reticulation systems are not keeping up with treatment capacity, which indirectly increase the wastewater discharge. Education on the water-saving and water-protection aspects does not keep pace with the actual water consumption and pollution situations. Together with the government's main attention paid on industrial water pollution, municipal waste water situation keeps on deteriorating in China. Apparently, Chinese public agencies have just realized that municipal waste water is becoming a serious problem more quickly than they expected.

Other important non-industrial waste water sources are those related to agriculture activities, including fertilizer and pesticide run-off from farmland, and infiltration of livestock waste. Increasing fertilizer use has been a major factor in the remarkable increase in grain and food consumption in China over the last half century. Total fertilizer consumption increased by more than 250 percent between 1980 and 2005, by which time it amounted to about 48 million tons a year.[14] Such an intense use of fertilizer also contributes to the water quality degradation, as the possibly excessive use of fertilizer, poor quality of fertilizers, inefficient application methods, and excessive soil erosion all make water contaminated worse. Similar to fertilizer, the use of pesticide is also a primary cause of the growing agricultural water pollution problem. Especially, pesticide usage sometimes do not give the expected results, and then peasants tend to use more of them to gain a better effect, which makes the potential water pollution situation more serious. To certain extent, it is like a vicious circle, while fertilizer and pesticide are not that efficient, peasants use more to gain better result, but then the soil and water are polluted to a worse situation and the chemicals will be less effective, which drives people to use even more of them. And this is what is happening. Moreover, compared with industrial and municipal waste water, which are point pollution sources and thus can be better centrally controlled by using treatment facilities, agricultural water pollution is non-point and hard to be "treated," thus making the problem more difficult to resolve. In particular, a large part of Chinese agricultural population and rural areas do not have adequate access to capital and technologies to update their production methods. Thus, the whole agricultural water pollution problem is increasingly serious and it is not only an environmental problem but closely connected with the availability of economic and technological resources.

[14] Ibid.

III. Law, Policy, Management, and Institutional Issues of China

Water resource issues have become an important limiting factor in the sustainable development of China. As the country has recognized this problem, it has established a public regulations system and corresponding government agencies to enforce and implement the laws and regulations.

Legal Context

China is considered to have a relative good set of modern water laws and regulations compared with many other nations.(discussion paper) The country promulgated the Water Law in 1988 and revised it in 2002. It is the key legal instrument accommodating general principles of how to manage water resources in China. The law includes sections dealing with strategic planning, water conservation, water pollution control, etc, which establish a basis for other water resource related regulations and policies, as well as the relevant public agencies' functions.

On the foundation of the basic Water Law, China country has set up a law system regulating the water-protection issue. Its Environmental Protection Law includes water environmental protection regulations. And the nation promulgated the particular Law on the Prevention and Control of Water Pollution and further amended it in 1996. Other laws and regulations related to the issue include the Law on Water and Soil Conservation, Regulations on Management of Water Abstraction Licenses and Water Resources Charges, etc. Table 9 summaries the system of water laws and regulations in China. The legal system supports China's institutional framework for water policy. But the issue most often raised by water experts is that the existing laws are not adequately enforced. The non-enforcement of the water laws continues to put China's water assets in danger and raises questions about the nation's capacity to tackle water problems.

Table 9. Water Laws and Regulations in China – A Summary

	Title	Year	Revision
National Level	Environmental Protection Law	1989	
	Solid Waste Environment Pollution Prevention & Control Law	1995 1988	 2002
	Water Law	1991	
	Water & Soil Conservation Law	1984/96	2006 (under consideration)
	Water Pollution Prevention Law	2002	
	Environmental Impact Assessment Law	2002	
	Cleaner Production Law		
	Water & Soil Conservation Law Implementation Regulations	1993	
	Municipal Water Supply Regulations	1994	
	Water Pollution Discharge Permit Management Measures	1988	
	Drinking Water Protection Area Pollution Prevention Management Rules	1989	
	Water Pollution Prevention Law Implementation Measures	2000	
Ministerial Level	Municipal Water Supply Companies Qualification Management Rules (Ministry of Construction)	1993 1996	
	Drinking Water Sanitation Monitoring Management Measures (Ministry of Construction and Hygiene)	1999	
	Municipal Water Supply Water Quality Management Regulations (Ministry of Construction)		

Source: Lee (2004)

Policy-making and Institutional System

The water resource administration system is composed of several government agencies in China. Only on the highest level of the central government agencies, there are 8 departments that have certain degree of responsibilities concerning water resource management. (Table 10)

The Ministry of Water Resources (MWR) is the Department of the State Council of China that is responsible for water administration at the nation level. The State Environmental Protection Administration of China (SEPA) is the main agency one of whose responsibilities is to administer the prevention and cure of the water pollution. The Ministry of Construction (MOC) takes charge of urban water supply and discharge, as well as the municipal waste water treatment. The Ministry of Agriculture's (MOA) functions include the non-point pollution control, fishery water protection, and the wild animal habitat protection. The State Forestry Administration (SFA) is with responsibility for protection of drainage basins' ecological and water resources, as well as the wetland management. The Ministry of Communications (MoC) manages and controls the waste discharge by the inland river navigation. The

Ministry of Health (MOH) administers the standard of the sources of drinking water. And the National Development and Reform Commission (NDRC) participates in the planning of water resource exploitation and environmental protection. In the local level, the 8 central governmental agencies' corresponding local departments are all responsible for the water resource management to certain degree, on certain aspects. Besides these 8, other local governmental departments, such as the Bureau of Exploration and Development of Geology and Mineral Resources and electricity management departments in every province, all have certain responsibilities. The complex mechanism seemingly congregates different departments' authorities, but the actual effect is not satisfactory. The system actually encourages different regions and departments more concentrated on their own self-interests.

Table 10. Water Administration-- Governmental Agencies of China

Department	Scope of water administration responsibilities	Major functions
Ministry of Water Resources	Surface and ground water management, river basin management, flood control, water and soil conservation	The planning of water development and conservation, flood control, water and soil conservation, designation of water function regionalization, unified water administration
State Environmental Protection Administration	Prevention and treatment of water pollution	Water environmental protection, water environmental function regionalization/ zoning, to establish national water environmental quality standards and national pollutant discharge standards
Ministry of Construction	Urban and industrial water use, urban water supply and drainage	Planning, construction and management of water supply projects and drainage and sewage disposal projects
Ministry of Agriculture	Water uses for agriculture (irrigation), fishery aqueous environment protection	Non-point source pollution control, protection of fishery water environment and aquatic environmental conservation
State Forest Bureau	Water resources conservation	Forest protection and management for protecting watershed ecology and water resources
State Electric Power Company	Hydro-power Development	Construction and management of large and mid-scale hydro-power projects
State Reform and Development Commission	Participation in the planning of water resource development and ecosystem building	Planning of water resource development, allocation of production force and ecological environment construction, coordinating the planning and policy of agriculture, forest and water resources, development
Ministry of Communication	Pollution control related to navigation of ships on rivers	Pollution control and management of inland navigation
Ministry of Health	Supervision and management of environmental health	Supervision and management of the drinking water standard

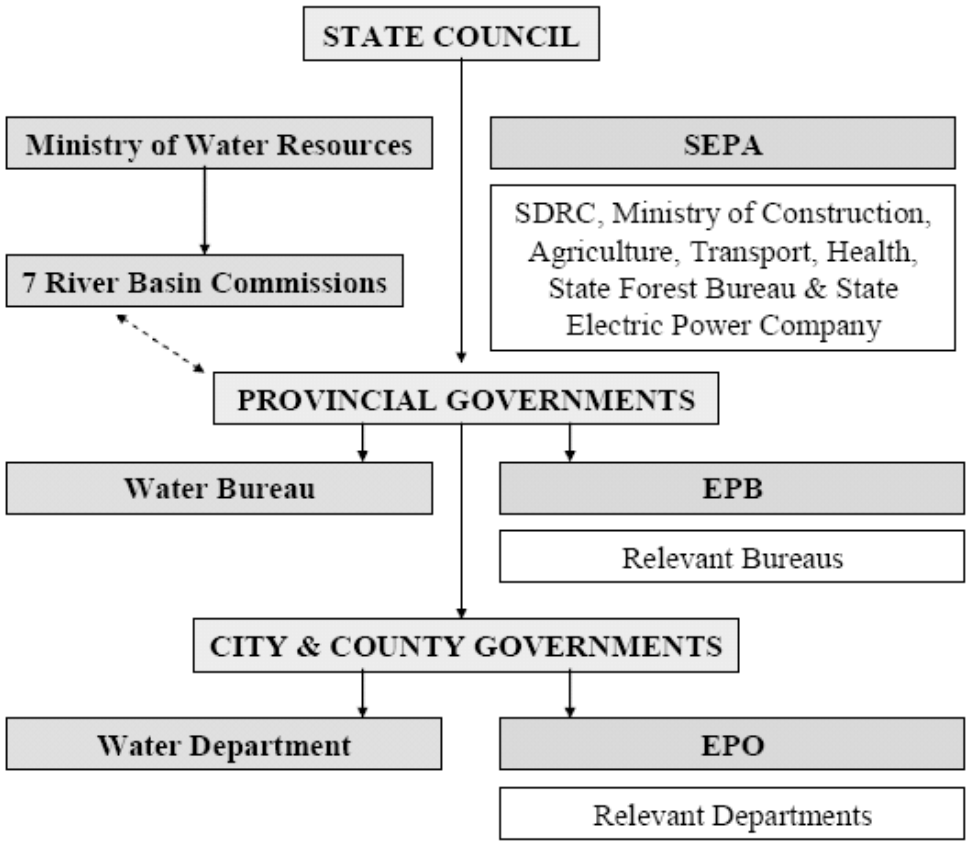
Source: Feng, He and Kinne (2005)

At the same time, China has established some drainage basis management institutions. The first category includes 7 national River Basin Commissions (RBCs) responsible for the seven main drainage areas' water resource management. The RBCs are all the lower-level units of the MWR. The other category comprises the drainage areas' water resource protection institutions, managed by the MWR and SEPA collectively. As the institutions are at a lower level compared to the central governmental agencies, it is in fact very difficult for them to coordinate different central departments' activities in the

drainage areas. And they do not have sufficient power to organize water resource allocation among different regions.

From above introduction, it is clear that a number of departments are involved in the water administration system. (Figure 1) The complexity has caused the fragmentation and conflicts of responsibilities. As MWR is the main body taking charge of the whole water resource management in China, it has legitimate power to regulate all the water-related issues. But many other ministries also have certain responsibilities related to water. Thus, the overlaps and intersections of responsibilities undertaken by different departments are had to avoid. Concerning the water pollution issue, the two main bodies regulating it are MWR and SEPA. While both of them are responsible for water quality monitoring, they may simultaneously execute certain functions that may lead to conflicts. Therefore, these bodies will need to coordinate their policy implementations and other actions as there is some waste of valuable administrative resources currently. Concerning specific issues or cases, there is also a need for other departments to participate. For example, the protection and management of urban water resources is the responsibility of MWR, SEPA and MOC, which means the coordination of efforts is more complex and resource-and-time-consuming without some mechanism for efficient and timely decision making..

Figure 1. Water Administration System in China



Source: Lee (2006)

The complex system has made the policy-making and implementation difficult. The lack of a real central and upper-level government agency that can take charge of the whole issue without conflicts and overlaps has deterred the further improvement of water quality in China. Besides this problem, there is another question about which part of water resource the government is more concerned with and pays more attention to.

Due to the former emphasis on industry establishment and expansion, the water pollution caused by industries has been paid more attention to. As mentioned earlier, because of the focus on industrial sector, the policies have gained some success in industrial waste water management. But the problem may be also due to the fact that the legal system is less able to account for newly emerging water pollution systems, such as rapidly increasing pollutants from municipal use and agricultural sources. The approach to law enforcement is by and large dependent on government agencies, especially the local ones. The grand civil society and private sectors are mostly put on a passive seat to "abide by" the rules, rather than "actively" to improve the environment situation in China. Besides, the system is heavily reliant on command-and-control tools rather than guiding tools. For the sake of lack of an active encouragement mechanism, as well as the nation's stress on wealth growth, Chinese private enterprises and individuals do not have enough water saving and water protection consciousness, thus they may be not willing to sacrifice their economic benefits for environmental protection.

Another major issue here is also the nation's *lack of effective enforcement* of its regulatory system. The first problem is that the actual power to enforce policies is in the hands of local governments, which indicates an imbalance of the extent of policy enforcement among different regions. Generally, western part of China has looser actual policy restriction on water pollutions, which makes industries with high water pollution "move" to those areas. The second problem is that as central government has long made economic growth the central task of the whole country, local governments focus more on the local economic development, thus they might frequently ignore the environmental issues, intentionally or unintentionally. Even more seriously, some local governments are even collaborating with private enterprises or individuals on the waste water discharge issues. In order to keep the GDP growth and their tax sources, local departments may give up the environmental protection considerations, or even "protect" the enterprises even if they are highly polluting the environment. This problem is connected to the Chinese central government's attitude. Though the central government has begun to realize the importance of protecting the natural environment, when it evaluates local governments' performance, it still mainly focuses on the GDP growth. The third problem is concerned with the "trans-boundary" water pollution. Since the pollution of water, especially the river basins, can influence different regions along the water,

different local governments may have different evaluations of the problem and policy responses may vary more than is necessary for decentralization with efficiency. If a factory in City A located upriver discharges heavy water pollutants thus brings negative impacts on City B which is downriver, then it may be hard for City B to persuade City A to close or limit the factory since A is not heavily impacted by the pollution and it depends on the factory for taxes. This is clearly a classical externalities problem as the Coase theorem indicates. In this case, the market solution is not forthcoming and transactions costs are high in the absence of higher level coordination. While local governments are perhaps understandably more concerned with their own self-interests, there is an urgent need for a comprehensive government performance evaluation system that covers environmental protection, encouraging lower-level governments more concerned with the problems. Ultimately, a federal agency consisting of higher bodies with adequate power to enforce relevant settlements on lower bodies when they cannot reach settlements by themselves, may need to be set up.

IV. Policy Problems and Necessary Reforms

Based on the above clarification and discussion of the problems, the following policy recommendations can be offered. These are not meant to be exhaustive or final but can be used as a basis for further discussion for policy formulation.

Policy-Making and Implementation System Reform

China needs to improve its law and policy-making and implementation system, to address and resolve the new water pollution problems in a more timely and comprehensive manner. It includes three changes –idea change, agency reform and enforcement improvement.

The change of basic idea is the most fundamental necessity. Currently, China is somewhat still on the path of "treatment after pollution." But this policy-making and implementation scheme is short-sighted and not reasonable, since contaminated environment can hardly recover to the original situation. The UK has spent almost 100 years on treating the polluted Thames, with plenty of capital and resources. And it is easy to see that the cost of treatment always far exceeds the cost of prevention before pollution is formed. Thus, it is important and necessary to change the current policy-makers mindset, letting them to understanding the long-term impact of environmental pollution on every aspect. It is glad to see that the Chinese central government now is switching its policy center to "sustainable development," from the former "pure economic accumulation," but there is still much work to do, especially how to change the local governments' opinions fundamentally.

The second important reform is to restructure the government agency system for water administration. The first necessary work is to distinctively separate the functions of different departments, especially to separate the functions of water resource management and the supervision of management. As MWR has the legal authority to supervise the water resource management, it should be clarified by the central government that MWR's function is to "supervise," and if certain issues need other departments' contribution, then MWR should be the one that has the final decision right. Concerning water pollution issue, WMR's role should be to supervise SEPA, to provide overall and directive policies and regulations, etc. And SEPA's water-related functions should be clearly defined as "management," meaning it is a real executive actor on water quality monitoring. Other departments such as MOC would need to "assist" MWR or SEPA on certain issues. For drainage basin management, RBCs are still feasible, but the key here is give them sufficient power to coordinate different departments and regions' efforts.

Third, enforcement system needs improvement. But this change needs deep-level changes in the society's basic orientation and emphasis in development. The society needs to make changes towards a more comprehensive development route not only

stressing economic growth but also keeping an eye on environmental issues. This is a long-term procedure, thus in the short-term, it is important to build up a powerful incentive mechanism to push the society, especially the local governments, to focusing more on environment protections.

Attention on Different Wastewater Sources

During the past decades, China has long put most of its efforts on treating industrial waste water. It is important to control industrial wastewater sources. But the other sources of contamination such as municipal water problem and agriculture water pollution are not adequately addressed. When these problems are accumulating to a relatively high level, it is more difficult for the government to deal with them, while investment and regulations in previous phase are not adequate.

For example, in the last decade, China did not pay adequate attention to municipal waste water discharge and treatment. As a result, construction of municipal waste water treatment facilities, now, in many places, is out-paced by the development of the cities. Besides municipal wastewater, agricultural pollution is also becoming serious and it might be more difficult to deal with the non-point contamination. Thus, the country needs to be more concerned with different wastewater sources, except for industrial source. More investments are necessary to promote the treatment capacity. And more practical policies and resources are needed to help alleviate the pollution problem. For example, the peasants may need more technical assistance to reduce their low-quality fertilizer and pesticide's usage.

Involvement of the Whole Civil Society into the System

It is essential to involve the whole civil society into the water-protection system. And certain guiding and encouraging tools need to be created and made into effect.

As mentioned above, the fundamental measure to reverse or improve the current environmental pollution situations is to change people's mindsets. Thus, a civil education system accentuating environmental protection is necessary. It is not only to add the environmental protection contents into the formal school education system, but it should be to foster the whole society's consciousness and involvement concerning this issue.

To achieve the goal, the first tool people can use is the mass media. Through continuously propagandizing environmental protection and actions people can take to contribute, mass media can be powerful to educate the whole society on this issue. And the information disclosure such as the "blacklists" can put great pressure on irresponsible individuals, firms and even governments, impelling them to modify their behaviors. The second is the organizations, especially the NGOs and NPOs. Through

these organizations, people can get together and express their opinions in a more effective and efficient way. While the opinions get heard by the public as well as the governments, then they might be easier to be implemented. In September 2006, the Institute of Public and Environmental Affairs established a website called "China Water Pollution Map" (http://www.ipe.org.cn/), which is a public-interest online database gathering water pollution information across China. Currently, nearly 5,000 enterprises with high water pollution situation are published on this website, including famous multinational corporations such as Pepsi and Panasonic. While the civil society is increasingly concerned with the water pollution situation, those enterprises feel pressure from public to improve their behaviors. And local governments may also be impelled to take measures to these entities on the "black list." Thus, attendance of the public may have significant effect on changing behaviors of both firms and government agencies.

While Chinese civil society is starting to recognize the serious water pollution problem in the country and taking actions towards its alleviation, there are also serious obstacles along the way. One problem is the uneven expansion of environmental consciousness and related information . In more developed regions of China, people can get such information easily and are more aware of the problems, This is in part due to the higher education level in these areas. But in other less-developed regions, especially the western part of China, people are still without much consciousness about environment and it is difficult for even those who are interested to get relevant information. Part of the solution is an increased amount of investment into education and information infrastructure to promote people's environmental protection awareness, but these areas are lacking requisite economic resources to invest. To hasten economic 'development', the local policy makers tend to sacrifice environment. Thus, it is essential for the central government to provide the investment in education and information infrastructure in these areas, rather than require the local government to take the burden upon themselves. Another obstacle here is the lack of organization in the civil society for addressing such problems. Even when individuals feel the urgency to improve the pollution situation, they do not have the means to gather together, organize and express their opinions. It is an encouraging sign that in recent years, environmental NGOs and NPOs, such as the *China Water Pollution Map* mentioned above, are rapidly developing in China. Chinese people have started to band together to make their voices heard by governments and companies. As alluded to already, yet another problem is concerned with Chinese local governments. How these local governments react to people's concern about environment is becoming an important issues. On many occasions, local governments have put people's concern aside and let highly polluting enterprises continue operations.

Regional and International Cooperation Mechanisms

Both regional and International cooperation mechanisms are essential to improve

China's current situation. It not only can bring to the nation investment and advanced technologies to alleviate the current pollution problems, it can also make China more involved in discussing and implementing the international standards of pollution control. In this context, Japan can be an important regional partner. More generally, an environmental cooperation regime in Northeast Asia will help mitigate cross-border pollution problems. In addition, it will help to reduce regional political tensions.

Since 1990s, China has developed various arrangements for international cooperation with many countries and international institutions. The country has also entered into many international treaties and conventions concerning environmental protection. China has long been cooperating with the United Nations Environment Programme (UNEP) on various environmental issues, such as flood control, ocean protection, etc. It is also a member of the Commission on Sustainable Development of the United Nations (CSD), whose main responsibility is to review and enhance the progress of global environmental protection . In addition, China has developed cooperation with many other international institutions such as the World Bank and the Asian Development Bank (ADB). Taking the World Bank as an example, the Bank invested heavily in water, wastewater and sewage treatment in China. The Bank committed finance equal to 30% of $11 billion cost for 24 urban environment projects, primarily for wastewater treatment plants, but also including water supply and some other components. China is also strengthening its bilateral and multilateral environmental cooperation relationships with other countries and regions, such as the European Union, the United States, Japan, Germany, Canada, etc. These countries can provide new technologies and investments to China to help it deal with environmental problems. Thus, international cooperation has become an important aspect of China's environment pollution.

V. Summary and Conclusions

In this paper, we have presented the arguments for taking the water resources problem in China seriously. The facts are all too clear in this case. The continuing and rapid deterioration of water quality poses grave health and other types of environmental threats. If these threats are not addressed in a timely manner, the situation will deteriorate even faster. The Chinese 11th five year plan acknowledges many of these problems. The analysis in this paper is consistent with the stated objective of addressing ecological issues via a new development strategy.[15]

In order to address the problems properly, we have, therefore, tried to consider the institutional and policy-making issues carefully. While some of the quantitative dimensions of the problems are amenable to economic modeling[16], it is also important to emphasize that along with economic modeling to derive such quantitative estimates, it is equally important to understand the qualitative issues of policy challenges within the existing institutional framework.

The complexities of the water resource administration system in China are indeed challenging. Coordination among WMR, SEPA, MOC, MOA, SFA, MoC, MOH and many other branches of the government will tax even the most sophisticated administrative apparatus. Clearly some simplification and streamlining is called for. At the same time, decentralization that gives more resources at the local level to fund defensive measures can improve performance on the ground. But a carefully designed incentives and monitoring mechanism must be put in place in order to make such a decentralized system work.

In the age of globalization, at least a significant part of China's environmental problems stem from FDI-led production for export markets. Many enterprises have lax environmental management practices. This, of course, applies to many domestic SOEs as well. In all these cases, both market incentives such as effluent fees and better regulations with proper enforcement are needed. There is some indication that policies are moving generally this direction. However, more precise formulation of policies in light of rigorous analysis and reliable data along with institutional reforms can accelerate this process considerably.

[15] See Khan(2007) for a discussion of this new strategy which along with capital deepening, innovation and new energy technologies is intended to address serious ecological and distributional issues that have arisen.

[16] Economy wide modelling is being undertaken by the first author in order to simulate various policy scenarios for alleviating water pollution.

References

Boxer, Baruch. “”Global Water Management Dilemmas – Lessons from China,” *Resources*, 2002 (146): 5-9.

China Statistical Yearbook, various years.
Available online at http://www.stats.gov.cn/english/statisticaldata/yearlydata/#

Feng, Yan, He Daming and Beth Kinne. “Water Resources Administration Institution in China.” *Water Policy*, 2006(8): 291-301.

Giordano, Mark. “Agricultural Water Policy in China: Challenges, Issues, and Options.” *Water Policy 9 Supplement 1, 2007*: 1-9.

Institute of Public and Environmental Affairs, People’s Republic of China. “China Water Pollution Map.”
Available online at http://www.ipe.org.cn/

Khan, Haider A. and Victor D. Lippit. “Sustainability and Surplus.” No. CIRJE-F-464, CIRJE F-Series from CIRJE, Faculty of Economics, University of Tokyo.
----------, "Ecology, Inequality and Poverty", Asian Development Review, August, 1997.
----------, " China's Development Strategy and Energy Security", paper presented at thw Southern Engines of Growth Conference, UNU-WIDER, Helsinki, Finland, Sep. 2007.

Lee, Seungho. China’s Water Policy Challenges. Discussion Paper 13 of China Policy Institute of the University of Nottingham, 2006
available online at http://www.nottingham.ac.uk/china-policy-institute/publications/documents/Discussion_Paper_13_LEE_China_Water_Policy_Challenges.pdf

Nickum, James E.. “Is China Living on the Water Margin?,” *The China Quarterly,* No. 156, Special Issue: China’s Environment. (Dec. 1998): 880-898

Repetto, Robert C.. *World Enough and Time: Successful Strategies for Resource Management*, New Haven: Yale University Press, 1986

Shen, Dajun. “The 2002 Water Law: Its Impacts on River Basin Management in China.” *Water Policy*, 2004(6): 345-364

State Environmental Protection Administration, People’s Republic of China. *Report on the State of the Environment in China 2005*

Available online at http://english.sepa.gov.cn/ghjh/hjzkgb/200701/P020070118528407141643.pdf

United Nations (2003). *United Nations World Water Development Report: Water for People, Water for Life.*
Available Online at http://www.unesco.org/water/wwap/wwdr1/table_contents/index.shtml

Varis, Olli and Pertti Vakkilainen. "China's 8 Challenges to Water Resources Management in the First Quarter of the 21st Century," *Geomorphology*, 2001(41): 93-104.

World Bank (2001). China – Air, Land, and Water – Environmental Priorities for a New Millennium. Washington D.C.: World Bank