WATER DEMAND-MANAGEMENT POLICY
IMPLEMENTATION ISSUES IN BEIJING, CHINA

by

ELISA TSENG

B. Sc., Simon Fraser University, 1994

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENT FOR THE DEGREE OF
MASTER OF ARTS
in
THE FACULTY OF GRADUATE STUDIES
(Resource Management and Environmental Studies Programme)

We accept this thesis as conforming
to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

April 1997

© Elisa Tseng, 1997
In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the head of my department or by his or her representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Department of Resource Management and Environmental Studies
The University of British Columbia
Vancouver, Canada

Date Apr. 25/97
ABSTRACT

Many countries in the world suffer from water shortage. Continued population increases and overexploitation and pollution of existing water supplies mean that water shortage and its related consequences will likely increase worldwide. However, many believe that such negative prospects may be minimized with appropriate changes in present water management practices.

A review of the existing literature indicates that water demand-management methods are in many cases more cost efficient and environmentally and socially less harmful than more traditional forms of water demand-management practises. For such reasons, water planners and managers in the developed world are beginning to appreciate the many advantages of adopting a comprehensive water demand-management program. Most developing countries, like China, remain unaware or unconvinced about the benefits of water demand-management practices and continue to rely upon unsustainable water development methods.

This study investigates implementation issues related to current and potential water demand-management measures in the semi-arid, water deficient city of Beijing, China. Reviewed literature indicates that there exists various administrative, technical, economic, and social factors which presently affect all forms of environmental policy in China. This study, in its focus on water demand-management provides further insights into these issues in the water management area and also uncovers implementation issues specific to water demand-management policies.

This qualitative study consists of empirical field research conducted in Beijing, China. This research investigates perceptions and opinions regarding Beijing's water issues and more specifically water demand-management issues in Beijing from the perspective of two groups: (1) university students and (2) government officials. Methods of investigation included distributing a survey to the university students and interviewing the government officials.

Results of the survey indicates that students are concerned about the state of water quality and quantity in Beijing, although there are other societal problems students view as being more critical. Despite students revealing a lack of knowledge about some water issues in Beijing, the
results reveal that increasing the use of popular media to raise comprehension about water issues and demand-management would likely produce positive results. Students in the survey also rate specific water demand-management strategies. Students tend to regard those measures in which the government rather than the individual is most financially and operationally responsible to be not only more effective at saving water but also more personally and socially fair. Interestingly, the results show that the notions of personal and social fairness were viewed as similar concepts.

Results of the survey, official interviews, and additional information sources, reveal that there exists a variety of factors constraining the effective implementation of water demand-management strategies in Beijing, China. These include constraints described in this study as "ideological" and administrative constraints. Demand-management measures including: water pricing, domestic wastewater recycling, water pressure reductions, plumbing codes, retrofit programs, water quotas, water restrictions, and education measures are all affected by such issues as well as other issues unique to each strategy.

This study suggests that changes in Beijing's institutions and changes in society at large are needed in order that water demand-management become increasingly and more effectively integrated into water development practices in Beijing, China.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Objective of the study and Research Questions</td>
<td>3</td>
</tr>
<tr>
<td>The World's Water Resources</td>
<td>5</td>
</tr>
<tr>
<td>Water Availability</td>
<td>6</td>
</tr>
<tr>
<td>Outline of Study</td>
<td>15</td>
</tr>
<tr>
<td>2 THEORY AND BACKGROUND</td>
<td>18</td>
</tr>
<tr>
<td>Water Demand-Management</td>
<td>18</td>
</tr>
<tr>
<td>Environmental Policy in China</td>
<td>27</td>
</tr>
<tr>
<td>Environmental Policy Implementation Issues in China</td>
<td>31</td>
</tr>
<tr>
<td>3 RESEARCH APPROACH</td>
<td>42</td>
</tr>
<tr>
<td>The Study Populations and Background</td>
<td>42</td>
</tr>
<tr>
<td>Research Constraints</td>
<td>44</td>
</tr>
<tr>
<td>4 MAJOR CHARACTERISTICS AND ISSUES OF WATER RESOURCES IN CHINA</td>
<td>48</td>
</tr>
<tr>
<td>Unbalanced Distribution of Water Resources</td>
<td>48</td>
</tr>
<tr>
<td>Low Water per Capita and Hectare</td>
<td>49</td>
</tr>
<tr>
<td>Low Utilization Efficiency and Poor Management</td>
<td>50</td>
</tr>
<tr>
<td>Water Pollution</td>
<td>51</td>
</tr>
<tr>
<td>Groundwater Overexploitation</td>
<td>53</td>
</tr>
<tr>
<td>Current State of Water Shortage</td>
<td>54</td>
</tr>
<tr>
<td>Chapter</td>
<td>Section</td>
</tr>
<tr>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>5</td>
<td>CHARACTERISTICS AND ISSUES OF BEIJING'S WATER SUPPLY</td>
</tr>
<tr>
<td></td>
<td>Geography of Beijing</td>
</tr>
<tr>
<td></td>
<td>Origins of Beijing's Water Supply Capacity</td>
</tr>
<tr>
<td></td>
<td>Beijing's Water Supply</td>
</tr>
<tr>
<td></td>
<td>Water Management Institutions in Beijing</td>
</tr>
<tr>
<td>6</td>
<td>SUPPLY-SIDE STRATEGIES TO MEET BEIJING'S WATER DEMAND AND ASSOCIATED IMPLEMENTATION ISSUES</td>
</tr>
<tr>
<td></td>
<td>Proposed Strategies</td>
</tr>
<tr>
<td></td>
<td>Approved Strategy - The &quot;Middle Route Water Transfer Project&quot;</td>
</tr>
<tr>
<td>7</td>
<td>WATER DEMAND-MANAGEMENT IN BEIJING</td>
</tr>
<tr>
<td></td>
<td>History and Institutions</td>
</tr>
<tr>
<td></td>
<td>Institutional Responsibilities</td>
</tr>
<tr>
<td></td>
<td>Institutional Relationships</td>
</tr>
<tr>
<td></td>
<td>Water Demand Management Policies</td>
</tr>
<tr>
<td></td>
<td>The Satellite City Concept</td>
</tr>
<tr>
<td>8</td>
<td>A CASE STUDY ON PUBLIC OPINION AND PERCEPTION OF WATER DEMAND MANAGEMENT IN BEIJING'S PUBLIC SECTOR</td>
</tr>
<tr>
<td></td>
<td>Water Demand-Management Policies in the Public Sector</td>
</tr>
<tr>
<td></td>
<td>Water Demand-Management Strategies on University Campuses</td>
</tr>
<tr>
<td></td>
<td>Results of Survey</td>
</tr>
</tbody>
</table>
Chapter 9  WATER DEMAND MANAGEMENT IMPLEMENTATION
ISSUES IN BEIJING AND RECOMMENDATIONS 109
"Institutional Ideological Constraint" 109
Administrative Constraints 110
Water Pricing 112
Domestic Wastewater Recycling 115
Water Pressure Reduction 116
Plumbing Codes and Retrofit Programs 116
Water Quotas and Restrictions 117
Education Measures 119
Conclusions 123

REFERENCES 125

APPENDIX A. China's Environmental Protection Institutions 134
APPENDIX B. Student Survey 137
APPENDIX C. Summary of Survey Results 155
APPENDIX D. Students' Comments on Survey 161
APPENDIX E. List of Acronyms and Abbreviations 168
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>State Water Pollution Control Expenditure in China</td>
<td>32</td>
</tr>
<tr>
<td>2</td>
<td>Water Shortage Conditions Among Ten Major Cities in China</td>
<td>55</td>
</tr>
<tr>
<td>3</td>
<td>Industrial Wastewater Discharge in Beijing</td>
<td>66</td>
</tr>
<tr>
<td>4</td>
<td>Municipal Wastewater Treatment Plants Serving Beijing</td>
<td>68</td>
</tr>
<tr>
<td>5</td>
<td>Currently Available Water Resources and Water Demand in Beijing</td>
<td>70</td>
</tr>
<tr>
<td>6</td>
<td>Increase of Water Supply Capacity in Beijing</td>
<td>71</td>
</tr>
<tr>
<td>7</td>
<td>Increase of Domestic Water Use Per Person in Beijing</td>
<td>72</td>
</tr>
<tr>
<td>8</td>
<td>Future Water Demand and Total Amount Available in Beijing</td>
<td>73</td>
</tr>
<tr>
<td>9</td>
<td>Illustration of the Dispersion of Responsibilities of Water Management in Beijing Municipality</td>
<td>75</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The World's Renewable Water Supply</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>Arid and Semi-Arid Regions in the World</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>Water Demands by Continent 1940-2000</td>
<td>14</td>
</tr>
<tr>
<td>4</td>
<td>Regional Distribution of Water Resources in China</td>
<td>48</td>
</tr>
<tr>
<td>5</td>
<td>Beijing Municipality</td>
<td>58</td>
</tr>
<tr>
<td>6</td>
<td>Groundwater Table in Beijing Municipality</td>
<td>64</td>
</tr>
<tr>
<td>7</td>
<td>The &quot;Middle Route Water Transfer Project&quot;</td>
<td>79</td>
</tr>
<tr>
<td>8</td>
<td>Beijing's Water Demand-Management Administrative Institutions</td>
<td>84</td>
</tr>
<tr>
<td>9</td>
<td>Water Savings in Beijing Municipality</td>
<td>86</td>
</tr>
<tr>
<td>10</td>
<td>Costs of Conserving Water as an Alternative to Expanding</td>
<td>111</td>
</tr>
<tr>
<td></td>
<td>Supply in Beijing</td>
<td></td>
</tr>
</tbody>
</table>
ACKNOWLEDGMENT

This study would not have been possible without the generous assistance of many people in Canada and China.

First, I am grateful to Canada's Department of Trade and International Affairs and the Chinese State Education Commission for linking me to my Chinese collaborators and providing financial support.

On the "Canada side":

Special thanks to Dr. Les Lavkulich for believing in me and being patient with me throughout this endeavour. I am also indebted to my primary supervisor, Dr. Nina Halpern. I thank her for all her guidance and enlightening thoughts which continually challenged me throughout this undertaking. Many thanks to members on my thesis committee for their support and contributions: Dr. S.O. Russell, Dr. You-Tien Hsing, and Dr. Aprodicio Laquian. I also thank Nancy Dick for all her help and warmth.

On the "China side":

I am most grateful to my supervising professors at Qinghua and Beijing Universities and my other research collaborators at Qinghua and Beijing Universities and the Chinese Academy of Sciences. Many thanks also go to my friend, Jasmine. I thank her for her friendship and generous help with my research. Finally, I thank Matthew Cooper for his support and assistance throughout this endeavour.
I dedicate this to:

My parents with much love for all their support and wisdom.

and

Chinese Environmental Non-Government Organizations
whose compassion for the environment, dedication, and courage inspires me.
CHAPTER 1

INTRODUCTION

Water may be the most essential substance on earth. It seems that every conceivable process in human society and nature requires the use of water. The needs of humankind for six millennia have largely been met through the construction of water work supply facilities and water diversions to feed natural and artificially constructed reservoirs. However, in the process of satisfying our great demands for water, it seems that we have forgotten that water is also a fragile resource and is an essential ingredient to the well being of our earth's environmental systems; systems on which humankind is also dependant.

As a consequence of what Clarke (1993) terms our "water blindness", humankind suffers from water-related problems which in many cases have originated from, and continue to be exacerbated by, man's inappropriate use of the earth's water resources. One such problem is water shortage.

Water shortage is a problem experienced worldwide in many countries, in both developed and developing countries; but it is in the arid and semi-arid regions of such countries where water shortage is most acute.

Solutions to water shortage have traditionally focussed upon supply-side management strategies. There is no doubt that supply-side strategies have provided benefits to humankind over the centuries. For example, the construction of dams has been successful in "fulfilling the needs of surrounding communities: millions of people depend upon them for survival, welfare, and employment" (Goudie 1994). However, supply-side strategies are becoming increasingly unpopular due to their expense and the many related environmental and social costs1 associated with them. Clarke (1993) states, "Currently and for the future, the livelihood conditions for the

---

1For example, Goudie (1994) states that dam building may have a variety of consequences. These include: land subsidence, earthquake triggering, the transmission and expansion in the range of organisms, the build-up of soil salinity, changes in ground-water levels creating slope instability, and waterlogging.
burgeoning populations can only marginally be improved through such (supply-side management) measures" (Reuters 1997). Humankind's present water resource management practices also led Pierre Najlis, a senior U.N. official speaking at the World Water Forum in March 1997 to state, "For most of the world, the current pattern of water resource development and utilization is not sustainable". At the same time however, alternative water management methods, in particular, water demand-management, are not being embraced to the extent that supply-side management strategies traditionally have. In essence, there continues to be a troublesome "lag" or "void" in ideology and human will that is failing to bridge the "gap" that exists between water management methods that have been depended upon in the past, and new water management methods.

Factors explaining this lack of will and creativity in pursuing alternative water management methods such as water demand-management are rooted in and can be found in all facets of society; the administrative capacity of a nation's existing institutions, the state of science and technology in a nation, the financial capacity of the nation, and a society's perceptions and attitudes. It is therefore crucial, in a world of increasing water scarcity, that water planners and decision makers worldwide recognize and make attempts to understand each facets' roles in order that we find better, less damaging ways to satisfy humankind's water needs.

China is one country in the world suffering from water shortage and its many negative environmental, economic, and social consequences. However, it seems that recent economic and social conditions in China are conducive to improving China's water shortage problems. It is no doubt that China's development path is closely scrutinized by many other nations since it is, among other reasons, the most populous nation in the world, the most geographically vast nation in Asia, and the fastest developing nation in the world. Thus, since China's activities presently impact upon other nations socially, environmentally, and economically and these impacts will most likely increase, many believe that it is important that China pursues a development path that is able to avoid some of the negative consequences associated with an industrializing nation. China's increasing wealth, educated numbers of labour force, and technology and information exchanges
with other nations gives it many opportunities to utilize progressive, less harmful water management approaches that were not actively practiced by nations years ago.

1.1 Objective of the Study and Research Questions

The objective of this study is to gain insights into administrative, technical, economic, and social factors affecting the implementation of water demand-management measures in the city of Beijing, China. Although water demand-management already exists as part of water policy in Beijing, this study reveals that water demand-management measures do not play a significant role in the municipality's overall water supply development planning. Upon investigating the nature of the water shortage problem in the city, this study examines implementation issues concerning Beijing's predominantly supply-oriented water supply augmentation schemes and existing and potential water-demand strategies. In the end, the findings in this study suggest that Beijing authorities cannot afford to continue "overlooking" water demand-management as a viable supplement or alternative to supply-oriented water development schemes.

Thus, the pertinent questions investigated in this study are: what is the state of water supply in Beijing; what are the present and future water supply development plans; what is the state of water demand-management in Beijing; what are main administrative, technical, economic, and social constraints affecting the implementation success of various demand-management strategies in Beijing; and finally, which of these constraints may impact upon potential demand-management strategies in the city?

To answer these questions, this study analyzes information gathered from various documented sources, a water demand-management survey, and information obtained through interviews with Chinese authorities in Beijing.

Beijing, as the capital of China, not only has the potential to serve as a "model city" for water demand-management initiatives in China, but the entire Asia region. There are a number of factors which give it this opportunity. First, Beijing is classified by Chinese authorities as a city that is "seriously" short of water. Further, elements that exacerbate the water shortage problem in
Beijing are typical of many water short cities in China and other Asian cities such as Bangkok, Thailand (see Kraisorphang, 1994): a rapid growing economy, and a quickly rising population as a result of natural births and movements of migrants into cities. Also, Beijing is not only the seat of the national government, but it is also the administrative centre of China. With this political structure, Beijing is in a unique position to coordinate and implement water demand-management measures at the national and municipal levels. In addition, Beijing may serve as a model for coordinative efforts across bureaucracies.

Also, in looking at Beijing's relevance as a case study, it is apparent that similar to other cities in China, Beijing has witnessed considerable urban and rural development and economic change since the Communists came into power in 1949. For the duration of the 1949 -1976 period, the state's urban policy promoted cities as production, rather than consumption centers - "xianshengchan, houshenghuo" (production first, consumption later). Thus, during this time period, urban centres in China saw the majority of their budgets being invested into heavy industry. Investments into items such as housing and water networks to supply reliable water supplies for citizens were considered secondary priorities to industry's "productive" goods. With the gradual changes in political ideology which decentralized and liberalized the economy since the 1978 post-Mao market reforms, Beijing, as with other major cities, has witnessed significant gains in economic wealth and continues to attract considerable capital from within and outside the country. Today, the majority of such wealth is still invested into industry and commercial interests in urban areas. Invariably, such political and economic changes through the years have significantly impacted upon patterns of water use and allocation of water by the state. Indeed, one may argue that political and economic changes through the years have played key roles in the present water shortage problem in Beijing and other Chinese cities.

However, before a discussion about water shortage issues in China and more specifically Beijing is presented, a broader perspective concerning characteristics of the world's water resources and the nature of water shortage is warranted.
1.2 The World's Water Resources

The total volume of the world's global water resources is estimated to be approximately 1360 million km$^3$ (1.36 billion km$^3$). Of this amount, approximately 97% is seawater in the oceans and the remaining 3%, about 37 million m$^3$, is fresh-water. However, 2% of fresh-water supplies are "locked up" in the form of icecaps and glaciers and unusable. Further, it is estimated that a significant amount of the remaining 1%, about 8 million km$^3$, is inaccessible groundwater and about 0.126 billion km$^3$ are contained in lakes and streams (Clarke, 1993).

1.21 Renewable Freshwater Supplies

On an annual basis, rain that falls on the earth's land averages about 725 mm a year (Clarke, 1993). In some regions, there are light rains that fall throughout most of the year, and in other regions, there are torrential rains for one or two months a year and the remainder of the year is almost without rain. Rainfall is balanced every year by the world's run-off (the amount of water that flows out to the sea via the rivers and streams) and the amount of water that is evaporated from the land surface and released from plants (jointly referred to as evapo-transpiration). Much more rain is evaporated than ends up as flow through rivers to the sea. Total rainfall on land areas on the earth amounts to some 110,000 km$^3$ a year. Of this, about 70,000 m$^3$ is evaporated (Clarke, 1993). Thus on average, only about one third of all rainfall reaches a river or stream. In drier areas where there are high rates of evaporation, the proportion of rainfall that is transformed into run-off is significantly less. In Africa for example, only about one-fifth of all rainfall on the continent is transformed into run-off.

The world's total run-off is estimated at approximately 40,000 km$^3$ a year from the land surface, excluding the polar zones (Postel, 1992). This comprises the world's annual predicted reliable renewable freshwater supply.
1.3 Water Availability

According to Clarke (1993), if the world's water supply was evenly distributed throughout the globe, there would be enough water to support about ten times the world's 1993 population. However, run-off and rainfall supplies are unevenly distributed on the planet and the amount of water available to a country, including that which passes through its territory, is defined by its geographical position in the global water cycle (Falenmark, 1990). The unbalanced nature of water availability occurs both on large regional scales, such as among countries, and also among smaller regional scales, such as among regions within countries.

In addition to spatial factors, timing of rainfall events plays a crucial role in water availability in any given region. Timing of rainfall events is often uneven and at times difficult to predict. Areas that receive adequate rainfall during most years may find themselves with little during other years. Thus, rainfall that can be depended upon every year, without fail, is much
lower than total rainfall estimates. Clarke (1993) explains that planners use a value of "reliable rainfall" which is just 35% of total rainfall estimates.

Further, estimating the quantity of reliable supplies of run-off is a more complicated task than is estimating reliable rainfall. Tropical rainfall for example, cannot be classified as reliable run-off because the waters that come down from these events result in fast moving, flash flood waters that pass too quickly to be utilized. Approximately two-thirds of reliable run-off is dissipated in this way. Thus, this leaves about 14,000 km$^3$ of water that Postel (1992) deems the world's "relatively stable source of supply". Apart from being available for human consumption, a significant portion of this stable flow is vital for the protection of wetlands, deltas, lakes, rivers, and the quality of water supplies on the earth.

### 1.3.1 Water Availability and Population Growth

Another important characteristic of the world's water is that, although water is a renewable resource, it is also a finite one\(^2\). The nature of the global water cycle is such that only a certain amount of water is available each year in a given location. As a consequence, this means that water supply per capita, a broad indicator of water security, decreases as population increases. For example, Falenmark (1990) states that water stress is worsening in semi-arid Africa largely due to population growth. He explains that if such trends in population in the region continue, by the year 2025, two-thirds of the total population of this region will be living in water-stressed countries. Also, Postel (1992) illustrates the link between water supply and population growth by citing evidence that per capita water supplies worldwide are approximately a third lower now than in 1970 due to the 1.8 billion people added to the planet since then (Postel. 1992).

\(^2\) Falenmark (1990) suggests that this is a fact not widely recognized in water research because water researchers usually come from developed, water-rich temperate countries.
1.32 Signs of Water Shortage

"The world is not only hungry but also thirsty..." (Beijing student, 1996)

Imbalances in water availability lie at the root of many water stressed areas worldwide. On a global basis, Postel (1992) states that one of the most telling signs of water scarcity is the increasing number of countries in which population has gone beyond the level that can be comfortably sustained by the water that is available to that particular region. In more specific measured terms, hydrologists designate a "water-stressed" country as one in which annual water supplies is 1 000 to 2000 m$^3$ per capita. "Water scarce" countries are those countries having per capita water supplies of less than 1 000 m$^3$ a year. Due to water shortage, such countries most often are suffering from limitations in food production, economic development, and/or protection of natural systems.

Clarke (1993) gives another perspective to describe symptoms of water shortage in a region. He calculates that countries utilizing less than 5 % of their total run-off supplies have few water management problems and countries that utilize 10 to 20 % of their water supplies most often have fairly major water problems. When a country utilizes more than 20 % of its total runoff however, water supply is usually a pressing national issue and may be limiting the overall development of the country's economy.

1.33 Water Short Regions

On a global level, there are four regions in the world which are particularly short of water; Africa, the Middle East, North Asia, and Australia. These comprise the majority of the arid and semi-arid areas of the world.
As seen from the Figure 2, a few areas in North America and South America are also water short. Run-off available per capita in all these regions is either low or very low. India for example, is utilizing half its total available run-off already. It is predicated that, by the year 2025, Indian's water demands will reach 92 % of the country's total annual freshwater resources (Clarke, 1993).

1.34 Water Demands

Estimates of a society's water requirements may be based upon regional climate patterns and degree of industrial development (Clarke, 1993). Such estimates indicate that industrialized temperate zone countries' water needs can be satisfied with between 150 and 900 m$^3$. Semi-arid countries whose economies are largely dependant on agricultural activities in contrast, require approximately five times as much - between 700 and 3500 m$^3$ a year. Irrigated semi-arid industrialized ones demand the most water supplies, requiring 2700 to 7000 m$^3$ annually. However, it is important to note that such requirements may be reduced with proper management and recycling of water supply resources.
Agricultural Water Demand

At the end of the seventeenth century, the world's irrigated areas made up slightly over 2% of their present range and were mainly concentrated in the southern, eastern, and central areas of Asia, and between the Tigris and Euphrates rivers. In the 18th and 19th centuries, irrigated regions in the world on average saw not more than a 2% increase each year. During this time, a considerable portion of this growth occurred in North America. During the 19th century, irrigated area on the North American continent increased by almost ten times. By the 20th century, the amount of water used for irrigation worldwide increased 10 times and plans continue to extend irrigation to further areas (L'vovoich et al, 1990).

Irrigating crops worldwide currently consumes approximately 3300 km$^3$ of water annually, which is about six times the requirement for industrial and domestic uses (Postel, 1992). Water for irrigating fields comes from a variety of sources, not only from run-off; but an increasing amount worldwide is supplied by underground water reservoirs. Also, some regions in the world which irrigate crops depend heavily on rainfall events during monsoonal periods. In arid areas, irrigation is largely dependant upon flash flood events that may happen just two or three times a year.

Despite advancements in irrigation techniques, particularly in the 20th century, most societies in the world irrigate the way people did 5,000 years ago (L'vovoich et al, 1990). Flooding or channeling water by gravity across fields remains the world's dominant irrigation method. However, such irrigation practices are particularly wasteful of water and it is estimated that the average irrigation efficiency is about 40% worldwide. (Postel, 1992) This suggests that much of the water utilized for irrigation does not benefit designated crops. Some of the remaining water from agricultural activities is not wasted and finds its way back into an underground aquifer or a nearby river. Frequently, however, it is polluted by salts and nitrates first and when the water goes back into the water system, it disperses its pollutants further. Also, in cases where the drainage of excess water is inadequate, water logging occurs, and in instances where the application of water is insufficient to leach the soil, salinization or alkalinization follows. L'vovich et al (1990) states that in recent decades, due to the widespread application of fertilizers, pesticides, fungicides, and
herbicides, the return waters have become increasingly hazardous to the environment. Due to these problems, croplands are at times completely abandoned, but more commonly, they are partially abandoned or suffer from productivity decreases.

Although the agricultural sector consumes the majority of the world's reliable water supplies, it is nonetheless essential to developing countries to grow the food they need. Indeed, there exists a precarious relationship between intensity of water use, economic development, and water shortage. In many developing countries, agriculture is usually the largest economic sector. And irrigation is by far the most intensive use of water known. Further, the drier the country, the more water is needed to grow crops. Thus, some of the world's driest developing countries use nearly all their total run-off for irrigation. For example, 98% of all the water used in Egypt and 80% of China's water supplies goes into irrigating crops. To compare, the United States uses 40% of its water for agriculture (Clarke, 1993).

Many countries depend on groundwater supplies to irrigate croplands. Providing the ground water is not extracted faster than it is renewed, its use can be considered sustainable. However, in many regions around the world, extraction rates exceed renewal rates and this is causing many negative environmental consequences. Several major hydrogeologic impacts can occur when water is extracted from an groundwater aquifer more quickly than it can be replenished through the natural hydrologic processes. They include subsidence (sinking) of the ground surface, the lowering of the water table, and infiltration of saline waters into coastal aquifers. Intense abstraction of groundwater can lead to the loss of natural marshes and wetlands. Further, it becomes increasingly costly to pump groundwater when water levels drop. Many irrigation projects in California, China, and India, have been halted due to such problems.

Various measures have been developed to increase efficiency of water use in the agricultural sector. These include new and improved irrigation technologies, better management practices by farmers and water officials, and changes in institutions that govern the distribution and use of irrigation water. However, Postel (1992) points out that institutions worldwide have a long way to go in terms of seeing large scale benefits from such technologies, and states "...the vast
water-saving potential of these (agricultural) measures will not be realized until the economic policies, laws, and regulations that shape decisions about water use begin to foster efficiency rather than discourage it”.

**Industrial Uses**

The world's industries all together account for almost a quarter of the world's water use which equals at least twice the amount of domestic use (Postel, 1992). In the majority of developed countries, the industrial sector consumes a substantial amount of water supplies - most often making up approximately 50-80 % of total water demands. The industrial sector in developing countries in comparison, demands about 10-30 % of total water supplies. However, over time, developing countries require increasing amounts of water for their industries in order to advance their economies.

In contrast to the agricultural sector, a small proportion of water in the industrial sector is actually consumed. Most of the water is used for cooling, processing, and other activities that may increase the temperature or pollute the water, but not exhaust it. As a consequence, this has also created opportunities for industries to reuse water supplies in order to obtain greater output from each cubic meter of water supplied.

The incentive to recycle water in the world's industries mainly comes from the enactment of pollution control laws. The majority of developed countries now require that industries meet water quality criteria before they release their wastewater into the environment. As a consequence, industries have also discovered that reusing water supplies is a very economical and effective method to comply with these pollution control provisions. Thus, pollution control laws have played a key role in keeping rivers, lakes, and streams free of pollutants, and encouraging water use efficiency.
Public Needs

Water is needed by citizens in every society for essential human activities such as drinking, washing and cooking. Postel (1992) states that such needs combined can be satisfied everywhere in the world by less than 100 liters per capita per day. Further, of this proportion, one liter a day is essential to quench a human being's thirst. On an annual basis, this translates to one person requiring the equivalent of about 35 m$^3$ of water.

The actual withdrawal rates for domestic purposes, that is, water consumed in residences, ranges from 10-20 to 200-500 liters per day per capita. These figures vary significantly across space and tend to increase with time. In regions where residences do not have a piped in water supply and the water must be carried daily, per capita withdrawal daily rarely exceeds 20 liters. In 1989, such water consumption rates applied to approximately 60% of the world's population (L'vovich et al 1990).

Water supplies demanded by the public, although not as substantial as those required by agriculture and industry, are inextricably linked to and fundamental to human health. In fact, it is reported that about one third of all deaths and 80% of all diseases in developing countries are linked to contaminated water supplies. Also, there are many diseases that exist due to inadequate water supplies for washing and personal hygiene. For example, diarrheal diseases and contagious skin and eye infections exist in some regions due to low availability of water supplies. Overall, without access to clean and abundant water supplies, families, particularly in developing countries, are put under significant stress. Further, much of the stress rests upon women and children in these countries as they are largely responsible for fetching water. It is not only difficult physically, but also takes their precious time away from other, more productive tasks.
Total Demand

In 1940, total water use was estimated to be approximately 1000 m$^3$ per capita a year. By 1960, it had doubled, and in 1990, it doubled again (Clarke, 1993). Clarke further discusses that such increases in water use can not be sustained in the future, stating that, "The crux of the water crisis is that it probably cannot double again because geographical constraints would make it nearly impossible to use the equivalent of 88 % of total reliable runoff on a global basis". Further, he points out that countries that are already utilizing water at such rates are experiencing chronic water shortage problems during dry periods and their water supplies are becoming increasingly polluted.

Figure 3 depicts the increase in global water demands by continent beginning in the year 1940 until the year 2000. There are two factors about water consumption patterns in particular which are causing the rise in water demands as illustrated in the graph. First, as discussed previously, continuing population increases translates into continuing increases in water demands. The other factor is that people are consuming water in greater amounts than in the past as societies, particularly in developing countries, develop higher standards of living. Thus, it is increased use and population growth which continues to intensify the world's water shortage.

Figure 3: Water Demands by Continent 1940 to 2000

Adopted from Clarke 1993
1.4 Outline of Study

This study consists of eight chapters. Chapter two begins with a review of the relevant literature pertaining to water demand-management. In particular, this chapter discusses the advantages and growing interest in water demand-management approaches in water resource planning. Also, it reviews the variety of water demand strategies and gives examples of demand-management programs in different countries. This chapter also lays the foundation for later analysis of Beijing's water demand-management programs by reviewing China's currently existing environmental policies. Finally, this part of the study summarizes major issues which are impeding the effective implementation of many of China's existing environmental policies.

The third chapter outlines the research approach taken in this study. It describes the various groups of people I interviewed and surveyed in Beijing and explains research constraints I faced in conducting this study. Also, I discuss how such constraints shaped the research process and results in the study.

Chapter four then draws attention to major characteristics of and issues concerning water resources in China. In particular, it focuses on the following topics: the unbalanced distribution of China's water resources, the low per capita and per hectare share of China's water resources, and the low efficiency level of water use and poor water management methods existing in the country. A discussion of these issues will emphasize their contribution to the continued chronic water shortage problems in China and the complex nature of water shortage, conveying that comprehensive solutions are required.

Chapter five carries on this theme on a local level through a detailed examination of Beijing's water supply issues. This chapter highlights the precarious nature of Beijing's water balance and the difficulties municipal authorities face in the city's on-going struggle to keep up with the growing water demands of the city. Also, this chapter introduces the myriad of bureaus managing Beijing's water resources and supply and presents the dispersed nature of their responsibilities. This section suggests that Beijing's water management institutions are too
disjointed to deal effectively with Beijing's water shortage problems along with other water issues in the municipality.

Chapter six begins to introduce solutions to Beijing's water shortage crisis. Specifically, this chapter outlines the supply-side water management strategies that have been proposed. In particular, it discusses the following topics; the artificial recharging of groundwater supplies, reusing wastewater, tapping into sea water, and a massive water transfer to bring water from the Yangtze River up to northern China called the "Middle Route Project". However, this part of the study points out that there exist many implementation constraints associated with each of these strategies, which is why they have not been employed to date.

Chapter seven then introduces the state of water demand-management initiatives in Beijing. It describes presently existing city-wide water demand-management policies implemented by authorities: water quotas, water metering and pricing, water saving technology and techniques, and education measures. In addition, this chapter includes a discussion of the institutions responsible for Beijing's water-demand-management initiatives. Following, this part outlines a municipal-wide planning project called the "satellite city concept" which is being implemented to help alleviate Beijing's water shortage problems.

In order that social issues regarding water demand-management in Beijing be analyzed in some depth, Chapter eight presents a summary of perceptions and opinions of Beijing university students regarding Beijing's water issues, and more specifically water demand-management in the city. As background for interpreting the results of the survey, this chapter also provides information about water demand-management measures existing in the public sector and within the surveyed institutions.

Chapter nine then synthesizes information in previous chapters to summarize implementation issues with respect to present and potential water demand-management measures in Beijing. More specifically, this chapter discusses economic, administrative, technical, and social factors affecting water demand-management initiatives in Beijing. Also, based upon some results
of the survey and discussions with Beijing authorities, some suggestions are made in order that steps be taken to mitigate the identified implementation constraints.
CHAPTER 2

THEORY AND BACKGROUND

2.1 Water Demand-Management

Water management practices may be divided into two groups: those that increase supply and those that reduce demand (sometimes called conservation). As stated by Frederick (1992), "Supply-side management involves activities and policies that increase the supply of freshwater available to the region". This typically involves withdrawing or diverting water from its source (such as a river) so that it is temporarily or permanently not available for other functions or users. In contrast, demand-management entails "...reducing the loss or waste of water, and increasing the recycling of water so that supply is conserved or made partially available for future or alternative uses" (Dziegielewski and Baumann, 1992).

2.11 Why Demand-Management?

Vickers (1992) explains the numerous reasons why there has been an increasing trend in the popularity of demand-management in developed countries and why demand-management practices, rather than supply-side management practices, are important to the long term sustainability of water supplies in both developed and developing countries:

First, although supply systems worldwide increasingly have the infrastructure capacity to deliver more water to a growing number of users, providing additional supplies will be difficult.

Extreme droughts that continue to be experienced worldwide in both developed and developing regions and intensify in some areas illustrates that reliance on historical rainfall yields is risky. Also, there is increasing evidence of global warming patterns which some scientists believe are already causing changes in the global hydrological cycle. This will also contribute to increasing water stress in certain regions.
The contamination of underground aquifers and overextraction practices worldwide negatively impacts not only the quality of water, but also accessibility to supplies. In situations where contaminated groundwater supply are untreatable, wells are closed and replaced by new sources. Further, degradation of surface water sources continues worldwide meaning that water supplies remain increasingly under threat, even if the best treatment systems are available.

2.12 The Benefits of Demand-Management

When a region adopts a well implemented, comprehensive water demand-management program, many economic, environmental, and social benefits are accrued.

For example, demand-management programs may result in a reduction in the short term and long term incremental costs of water supply and wastewater disposal. Short term incremental costs are those "...associated with the last units of water to be produced or bought in various years of a planning period, change immediately in response to changing use patterns, and are not associated with capital facilities" (Dziegielewski and Baumann, 1992). These costs involve the costs of chemicals, energy, labour, and materials. Long term incremental costs are "...those associated with providing capital facilities for water supply and wastewater disposal, and they vary as the design capacities of the facilities vary because of changes in patterns and levels of water use" (Dziegielewski and Baumann, 1992). Also, demand-management measures that reduce the use of heated water most often result in considerable energy-cost savings.

In addition, demand-management measures may cause indirect benefits\(^3\) to parties other than the water supplier and participants directly involved in the water demand-management program. For example, if a demand-management measure decreases overall water usage resulting in a rise in the groundwater table, pumping costs may decrease for people drawing out of the same water source who may not be directly participating in the program.

Demand-management measures as a whole tend to be less environmentally damaging than supply-oriented management practices. For example, poor supply-oriented practices which result in

\(^3\) This is termed a "positive water conservation externality" in some literature. See Jordon (1995)
the overpumping of groundwater resources may increase the infiltration rate of saltwater, septic leachate, leakage from underground storage tanks, and/or hazardous wastes, and other pollutants. Retarding this rate of infiltration by decreasing water demand can be an effective strategy to slow the migration of contaminants into an aquifer. Also, decreased extraction of groundwater and water from rivers increases the amount of water available for environmental purposes to benefit the flora and fauna ecology of a river basin. Water conservation also protects water quality since less water needs to be treated with chemicals. Finally, since water demand is inextricably linked to the quality of surface and groundwater quality supplies, decreased demands on surface water sources can help avoid or defer turning to inferior quality sources in efforts to supply increasing demands.

2.13 The Social Implications of Demand-Management Measures

Demand-management programs impact many different groups, including participants in the program, non-participating customers who pay water rates, water suppliers, and society in general. Each demand-management strategy impacts each group in different ways. The economic outcomes of demand-management programs may be evaluated in terms of five unique perspectives including those of the program participant, ratepayer, society, the cost of water supply, and the total resource cost.

The participant's perspective looks at the cost and benefits to those who participate in the demand-management program. Dziegielewski and Baumann (1992) state, "It provides information about the desirability of a specific alternative to customers and is especially useful for voluntary programs as an indicator of how willing people are to participate". However, the success of demand-management programs relies heavily upon the cooperation of individual water users and the task of evaluating social acceptability of a demand-management measure may be difficult. As stated by Reeser (1991), "The techniques of conservation are a science. You can predict what will happen if they (demand-management measures) are implemented. Motivating people to accept them is the art". Given this belief, many experts feel that it pertinent that public views be understood when undertaking a water demand-management program. Although it is recognized
that there are limits to the use of opinion surveys in policy making, for reasons of validity, reliability, and desirability, public opinion does have an important part in a successful, comprehensive, water management strategy and should not be disregarded (U.S. National Regulatory Research Institute, 1991). For example, if a water planner is cognizant of public opinions, he/she may avoid, or at least minimize, certain risks. Misinterpreting the public's views may result in the loss of significant amounts of time and energy on the part of the water planner and/or others and public expenditures may be lost. In addition, social acceptability4 is important to assess since "...with no assessment of acceptability, the risk of overestimating the potential effectiveness of conservation measures is greater" (U.S. National Regulatory Research Institute, 1991). In summary, Olsen et al. (1987) describes the role of societal views regarding successful water supply planning stating that "The successful implementation of a large-scale water conservation program depends on public awareness of the need for conservation and how conservation is perceived as a workable alternative to traditional development of new water supplies".

2.14 Water Demand-Management Strategies

Water demand-management comprises a range of measures, or strategies, which can be divided into three classification types: pricing strategies, education measures, and direct regulations.

**Pricing strategies**

The ultimate objective of pricing strategies is to give economic signals to water consumers, i.e. about the value of water. They include the use of uniform quantity charges (a fixed charge regardless of quantity used) to replace declining-block structures (i.e. lower rates with increasing quantities), inclining rates (i.e. higher rates with increasing quantities), higher rate charges for

---

4 "Social acceptability" includes the following: how economically equitable citizens perceive a water demand-management to be, how willing citizens would be in adopting a demand-management measure themselves, and how effective citizens perceive a demand-management measure to be in saving water.
water consumption during peak use periods called seasonal quantity (peak) charges, quantity surcharges, and various forms of incentive fees. An example of an incentive fee measure is the billing of homes which have not, for example, installed low-volume toilets and showerheads.

Studies in several countries, including Australia, Canada, Israel, and the United States suggest that household water use drops 3-7 % with a 10 % increase in water prices (Postel, 1992).

**Education**

Educational strategies are those that attempt to change consumers' attitudes and behaviour towards the use of water by means of education and public awareness programs. They include elementary and high-school education programs, mass media public information campaigns, and demonstration programs. The objective of education measures are to "...increase consumers' knowledge of the regulations and about conserving water whereby consumers are informed and encouraged to undertake alternatives that would result in water use efficiency" (Kraisoraphong, 1995).

Educational measures are viewed as an essential component in a comprehensive demand-management program. They are seen as a strong demand-management measure on their own and as a tool to reinforce and strengthen other types of water demand-management techniques. Tate (1994) lists three issues which underlie the need for and approaches to education programs.

First, the need for education is, in part, precipitated by the fact that there often exist implicit differences in the perception and understanding of water supply issues between and among users and water suppliers. Secondly, the success of an information campaign as a means of implementing water demand-management is closely linked to the ability of people to utilize such information in their decision making. Lastly, there exists a need for society at large to better understand the environmental, social, and economic implications of water management decisions. Not only is it important that people comprehend the environmental impacts associated with a specific measure, but it is also important for them to understand the economic and social costs and
benefits of alternatives. In this sense, Tate states (1994) that "...information campaigns should, in part, foster a systems view which is consistent with human activities and the hydrological cycle".

Examples of specific water demand-management education techniques involve informing domestic users about water-efficient devices which may be used in the home and the potential water and monetary savings which may result. In the agricultural sector, a similar type of education program may be implemented whereby farmers in the agricultural sector are given information about the environmental and financial benefits of water-efficient irrigation techniques and technology. An example that would compliment a regulatory type of measures is the implementation of an information campaign to inform people about times of community-wide water restrictions and penalties associated with those restrictions should they not abide by them.

**Direct Regulations**

Direct regulations involve the setting of standards by government to adjust water consumption and use patterns through authorities at the national, regional, and/or local level. The ultimate objective of standard setting in water demand-management is to achieve a desired level of water demand reduction or to sustain a certain level of environmental quality.

Examples of direct regulations includes the use of water quotas, which involve setting consumption limits on water users. Usually accompanying such limits are a set of penalties which specify economic fines for surpassing quota limits. Another example is the use of plumbing codes which involves specifying the use of required water efficient plumbing devices such as toilet dams, faucet aerators, and low-flow showerheads in residential and/or public buildings.

Although they are the most commonly employed type of demand-management measure, it is important that these measures be balanced with other types of demand-management measures in a successful demand-management program. On one hand Vicker (1991) states that "...if water suppliers and communities don't offer solutions, regulations may be needed". However, as Vickers also discussed, direct regulation measures are inherently negative in nature and if a conservation program focuses solely on these, people will inevitably develop negative feelings and feel alienated.
Another important aspect of direct regulations is that, in order to be effective, they must be backed up with adequate enforcement measures. Without adequate enforcement, the benefits of such regulations most likely will not be realized. This is a particularly contentious issue when direct regulation type demand-management measures are introduced in countries where environmental authorities, despite their best intentions, are strapped financially and are incapable of enforcing such regulations and/or they are politically motivated to "turn a blind eye" to infringements.

2.15 Water Demand-Management in the Public Sector

In the cities of developing countries, water consumed in the public sector (residences, public institutions such as schools and public washroom facilities and small family businesses) has in the past accounted for just a fraction of the world's total water use. However, historical patterns of urban development in many areas of the world illustrate that as a city industrializes, the public sector becomes a predominant water consuming sector. For example, in southern California, domestic water use, that is, water used by residential users, accounts for approximately 60% of total water consumption of the city (Postel, 1992).

Since in developing countries average public sector water use still remains a fraction of that in developed countries, demand-management measures in developing countries are often perceived as irrelevant or, at best, strategies to pursue in the future (Postel, 1992). Therefore, with a few exceptions, such as Mexico City and Bogor, Indonesia, cities in developing countries currently do not incorporate demand-management measures in their water supply development plans. In many cases, developing world governments remain preoccupied with the development of supply-side water management schemes and are unaware or are unconvinced about the benefits of water demand-management.

Postel (1992) states that with the developing world's urban population expected to grow to almost 2 billion by the year 2000 (compared to 1.3 billion in the year 1990), accompanied by shifts in water use patterns as these urban economies develop, the stage is set for huge and
sustained increases in public sector water demands. Further, she stresses that it is imperative to illustrate and then spread the word about water demand-management since "...for the developing world to adopt the water-intensive ways of industrial countries- which are now themselves finding their water practices unsustainable- would be a costly mistake" (Postel, 1992).

Current trends indicate that Asia remains particularly vulnerable to increased incidences of water stress and scarcity due to continuing increases in public sector water demands. Until the mid-nineteenth century, over half of the water for domestic withdrawals occurred in Asia which corresponded to its large population base. By the beginning of the twentieth century, Europe and North America comprised two-thirds of the world's use. Current trends indicate, however, that due to Asia's continuing growing large population base, Asia will undoubtedly approach this level of withdrawal and in the near future will surpass it (L'vovich, et al. 1990).

2.16 Examples of Water Demand-Management Programs Worldwide

There are cities in both the developed and developing countries which continue to implement multi-faceted water demand-management measures as a sound alternative to or supplement to existing water supply developments.

In particular, there are many cities and areas in the United States engaging in the most progressive and successful water demand-management programs in the world. These include Southern California; Austin, Texas; Boston, Massachusetts; Phoenix and Tucson, Arizona; Seattle, Washington; and Denver, Colorado. As stated by, Kraisoraphong (1994) "through water management strategies, which pursue demand-side alternatives as opposed to previous supply-side emphasis, many municipalities in the United States have been able to constitute their source of additional water supply".

Although water planners in developing countries have still not embraced water demand-management to the extent of developed countries, it is on the rise in some developing areas. Singapore, Jerusalem, Israel; Bogor, Indonesia, and Mexico city, Mexico are regions which are leading the way in this field in developing countries (Levy, 1993).
The benefits accruing to these regions in terms of water and financial savings have been substantial and well documented. For example, Boston Massachusetts' program includes the following measures: 1. educational programs; leak detection and repair; water metering projects; residential retrofitting projects; and changes in the existing plumbing code. The program had decreased total demand by 16% between the years 1987 and 1991 and resulted in the postponement of a major water supply expansion (Postel, 1992). In Waterloo, Canada, the per capita total water use in the municipality fell 10% between the years 1989 and 1992 with the implementation of retrofit programs, education measures, and industrial water conservation standards (Postel, 1992). In southern California, the Metropolitan Water District paid member agencies $125 for each 1,000 m³ they saved. As of June 1992, the estimated savings were estimated at 33 million m³/year, which was enough to supply 885,000 households and wastewater treated in the city was cut by 10% (Postel, 1992). Perhaps the most advanced demand-management programs may be found among urban water suppliers in California. By the year 2010, it is predicted that water saved through increased efficiency of water use in southern California will constitute the largest single source of additional water (Dziegielewski and Baumann, 1992).

Similar success stories have also been reported among developing countries practicing water demand-management strategies. In Singapore, leak detection and repair programs, higher water prices, and education programs cut unaccounted water losses by 10 % (Postel, 1992). Jerusalem, Israel, experienced a decline in water use by 15% in just three years (1989 to 1991) as a result of implementing leak detection and repair programs, installing water-saving devices throughout the city, and practicing water saving irrigating techniques in the city's parks (Postel, 1992). In Mexico city, the implementation of a residential retrofit program, public information campaign, and efficiency standards for household plumbing fixtures and appliances resulted in 28 million m³ of water saved between 1989 and 1991 (Levy, 1993). Finally, in Bogor, Indonesia, increases in water utility rates and a comprehensive education campaign resulted in a nearly 30% decrease in residential water use over an 11 month period (June 1988 to 1989) (Levy, 1993).
2.2 Environmental Policy in China

2.21 History and Overview

Although some environmental polices had been promulgated in the 1950s and 1960s, including regulations concerned with drinking water supplies and forestry, environmental protection did not become a prominent issue on China's national agenda until after the 1972 United Nations Conference on Human Environment (UNCHE) in Stockholm, Sweden. Subsequently, China's first national conference on environmental protection was held in Beijing in 1973. At this conference, an initial program for environmental protection and improvement was put forward. In particular, the significance of this conference was that China formally recognized that environmental problems existed in the country, and many of the problems were serious. The following year, in May 1974, the Environmental Protection Leading Group of the State Council was established.

In 1978, the status of environmental protection was elevated to a state responsibility and was provided a legal basis upon the adoption of Article II of the Constitution of the People's Republic of China in 1978. Article 11 declares that "The state protects the environment and natural resources and prevents and eliminates pollution and other hazards to the public" (Baruch, 1989). In 1979, the Environmental Protection Law of the People's Republic of China (for trial implementation) and a series of related decrees were promulgated. The significance of the Environmental Protection Law was that it created a statutory outline for the drafting of additional environmental laws and regulations, and was a reference point from which to improve upon existing pollution control and resource conservation laws and regulations.

Environmental protection and management efforts increased considerably in the 1980s. In 1981, the State Council issued the Decision for Strengthening Environmental Protection which emphasized that environmental protection should be viewed as an important component of economic development. For the first time in 1982, a separate chapter on environmental protection was included in the national five-year plan. This was evidence that environmental protection was
to be given a more prominent standing in the overall development of the economy. Following, the Second National Environmental Protection Work Conference held in 1983 proposed that every province, city, department and factory should set its own environmental protection goals (Li, 1990). For example, since 1984, the Beijing municipal local government has pledged to carry out ten specific environmental protection actions each year. During the 1980s, several further major laws, policies, and guidelines concerning environmental protection were issued.

In addition to the *Environmental Protection Law (EPL)*, which was amended in 1989, China has to date formulated a wide range of national environmental laws. These include the: *Law on Water Pollution Prevention and Control* (originally promulgated in 1984 and revised in 1996); *Law on Air Pollution Prevention and Control* (originally promulgated in 1987 and revised in 1995); *Law on Solid Waste Pollution Prevention and Control* (1995); *Law of Water and Soil Conservation; Law on Wildlife Conservation; Ordinance of Natural Reserves; Marine and Environmental Protection Law* (1982); *Noise Pollution Law* (1988), *Land Law, Forestry Law*, and the *Grasslands Law*. Other regulations and laws to be enacted in the future are *Radioactive Pollution Prevention and Control law, Regulations on Natural Reserves, and Regulations on Construction Projects Environmental Management* (NEPA and SPC, 1994).

In addition to these, provinces have supplemented national laws and regulations with their own statutes and regulations since the national laws set out only basic principles and administrative guidelines for environmental protection. China up to 1994 enacted in total 310 national environmental standards and 15 industry standards, 127 local laws, and 733 local regulations and standards by state and provincial governments (Zhang, 1997).

China is also a member country of a variety of international environmental protection pacts and conventions. As of 1995, these include the *Montreal Protocol on Substances that Deplete the Ozone Layer*, the *Basel Convention on the Control of Transboundary Movements of Hazardous Waste and their Disposal*, the *Treaty Banning Nuclear Weapons Tests in the Atmosphere, Outer"

China also has been a signatory to bilateral and multilateral agreements for the protection of wild fauna and flora. For example, they have signed the Sino-Japanese Agreement for the Protection of Migratory Birds, the Sino-Australian Agreement for the Protection of Migratory Birds and the Sino-American Nature Conservation Protocol. In 1995, China entered into the Tiger Protection Protocol with India (CCICED, 1996).

2.22 The Fourth National Environmental Protection Conference

In July 1996, the Chinese government held its Fourth National Environmental Protection Conference in Beijing. During the meeting, Jiang stated that "environmental protection is a strategic matter of overall importance and is vital for the country's long-term development" (Dian, 1996). Further, he stated that on-going efforts to achieve sustainable development in the country should be directed into the following general tasks: 1. Continued economizing on water, land, power, raw materials, grains and other resources; 2. Continued population growth control while simultaneously improving the quality of life for the existing population; 3. Rationalizing the consumption structure to contribute to the conservation of the environment and natural resources; and 4. Curbing and reversing both damages to natural resources and environmental trends towards deterioration in some regions (Dian, 1996).
Measures proposed during the conference to achieve such goals were: (1) to improve upon
the environmental protection legislative system and in particular to ensure that existing
environmental protection laws and regulations are enforced; (2) to improve environmental
monitoring and management and integrate environmental protection into macro decision making. It
was also stressed that leaders at all government levels should be responsible for the environmental
quality of their related regions; (3) to continue research in the area of technological improvements,
adjust the industrial structure and production mix; (4) to increase funds towards environmental
protection (The government proposed to put in 38 billion RMB towards environmental protection
projects in the subsequent five years); and (5) to strengthen public education on environmental
protection to improve awareness not only among the general public, but also government officials
(Zhang, 1997).

2.23 China's Main Environmental Protection Organs

State institutions currently overseeing most of China's environmental protection efforts at
the national and local level are the "environmental protection institutions". They are organized
hierarchically in the same manner as institutions in other Chinese government departments and
include organizational units at the national, provincial, city, district, and in some places, township
levels. In order to facilitate coordination with other government departments, they are systemized
along two lines: the environmental protection bureaus and offices (EPBs and EPOs), and the
environmental protection commissions (EPCs). See appendix A for a description of the
environmental protection institutions and the nature of information flows among them.
2.3 Environmental Policy Implementation Issues in China

On the surface, it appears that China is well endowed to deal with its environmental issues. Since the late 1970s, and continuing into the future, China pledges to add to its extensive environmental legislation and build upon its comprehensive environmental bureaucracy. Despite these efforts, there exist various factors inherent within Chinese institutions and Chinese society at large which are significantly constraining the ability of environmental institutions to effectively implement environmental laws and programs. The following is a summary of these issues.

2.41 From the national level down to the local level, economic growth, not sustainable growth, dominates China's development agenda

Although the central government continually declares environmental initiatives to be a fundamental national policy, China's environmental sensibilities still remain largely overshadowed by economic considerations. As in other industrialized and industrializing countries, economic measures such as GNP remain the dominant indicators of "progress" in China. Environmental costs have been largely excluded from the costs of national economic activities, and more often than not, "...environmental legislation and regulations have been suspended or ignored when they were seen as threatening economic growth" (Byrne et al., 1993).

The lack of national priority on environmental problems is reflected in the scarcity of funds devoted to them. In the early 1980s, Chinese specialists, aware of the environmental crisis China would be faced with in the future, presented Chinese leaders with several spending choices: 0.5 % GNP spent on environmental protection would not stop degradation, 1% would halt degradation but leave no room for improvement, 1% to 1.5% would lead to "modest improvements" such as improvements in urban water quality, and over 2.5% would allow for major improvements. China's central leaders, faced with these options, spent less than 1% of GNP on environmental protection in the 1980s.
Table 1: State Water Pollution Control Expenditure in China

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total expenditures (million yuan)</td>
<td>2 209</td>
<td>4 241</td>
<td>4 545</td>
<td>6 466</td>
<td>6 929</td>
<td>8 335</td>
</tr>
</tbody>
</table>

Adopted from Zhang, 1997

Although there was a doubling of funds being spent on pollution control between 1986 and 1992, the 1994 expenditures for pollution control were still only the equivalent to 0.7% of GNP.

In 1994, Qu Geping, head of China's National Environmental Protection Agency, stated that the "government should try to allocate 1 to 1.5 percent of its GNP to protecting the environment" (CEN March 1994). Further, he stated that environmental investment is very profitable, with every 100 yuan invested in environmental protection potentially earning 600 yuan worth of profits (CEN March 1994).

Local level impacts

Lack of commitment to environmental initiatives at the top continues to hinder environmental protection efforts at the local level.

As part of economic reform processes since the 1980s in China, decentralization has given the provinces and local governments much more decision-making power and control over resources. With their greater political and economic powers, Lieberthal (1994) states that "these governments generally want to maximize growth of local industry and commerce to fill their own coffers and expand the employment base for the growing working age population". In general, this type of mentality has contributed to continuing environmental degradation in the country. For example, in terms of initiatives to increase water prices to encourage water conservation, Lieberthal (1994) states that "the close ties between local industries and local governments often reduce the incentive effect to near zero" and that "local governments typically have many means to
maintain incentives that favor production rather than water conservation”. Also, while
decentralizing environmental regulations have had some desirable aspects, such as accommodating
the formulation of ambient quality and other targets to local circumstances, the departure from
uniform national standards and enforcement processes and implementing laws to regulate emission
standards according to local conditions is particularly complex and costly (Ross, et al., 1990).

Studies conducted by Barbara Sinkule (1993) and Abigail Jahiel (1994) found that a lack
of funding due to lack of top-level commitment to environmental initiatives was significantly
hindering implementation of local water pollution policies. As stated by Sinkule, local officials are
well aware that their limited resources stem from central attitudes about the environment. One
local level EPB director stated, "...while the official policy states that the economy and
environmental protection should develop simultaneously and in balance with each other, in reality
economic growth comes first"(Sinkule, 1993). Also, Sinkule and Jahiel found that a lack of funding
at local levels caused environmental staff shortages and a deficiency of necessary equipment to
carry out water pollution monitoring tasks.

Reforms undertaken since 1980 have also tended to increase enterprise autonomy which
has produced contradictory effects on the implementation and enforcement of environmental
policies. For example, in the area of water pollution, although enterprise managers may be held
responsible for excessive water pollution outputs, their search for profits (and competition with
rivals) has reduced their desire to control their emissions. In general, "managers and officials are
too caught up in the new lucrative opportunities created by market reform and opening to be
deflected by burdensome, regulatory tasks"(Shirk, 1994). In addition, since local enterprises often
account for up to 80 % of municipal government revenues, it has meant that local leaders are often
reluctant to impose penalties upon them for violating environmental policies (Lieberthal, 1995).

Interesting also, is the tendency of environmental protection staff to consider environmental
degradation as an unfortunate consequence of economic growth that must be tolerated for the
latter's sake. For example, in Jahiel's study (1994), many local environmental protection officials
implied that China was "justified" in its lack of commitment to environmental initiatives by
"rationalizing" that China is still at a low level of economic development and thus China is not prepared to make a significant commitment to environmental initiatives. Sinkule (1993) also discovered in her study that the perception, on the part of the local EPBs and the city government, that pollution regulations will hinder local economic growth, causes the EPBs to restrict their positions on pollution enforcement.

In addition, state industries provide valuable social welfare benefits for its employees such as housing, retirement benefits, health care, and education. Since "...local officials are (often) strongly motivated to pursue local interests, partly because they wish to minimize local discontent and partly because of their local patriotism." (White, 1993), local environment officials are often reluctant to close heavily polluting state enterprises (Gup, 1991). For example, Sinkule (1993) found that organized community opposition against closures of heavily polluting factories causes local environmental officials to restrict their positions on pollution enforcement.

In terms of pollution control efforts at the local level, the drive for "economic growth over sustainable growth" means that many older industries are still permitted to operate heavily polluting equipment in order that locals remain employed. Higher levels of pollution at older factories are often tolerated (Edmonds, 1994) and other industries often adopt relatively low-technology production processes that are not particularly environmentally friendly (Lieberthal, 1995). Evidence of the "protectionist attitude" towards industrial interests is reflected in a study which discovered that there exist many discrepancies among water use among industries; between 6 and 1,500 tones of water consumed per ton of ammonia produced in ammonia plants, and between 0.3 to 30 tones of water consumed per ton of oil produced in oil refineries (Edmonds, 1994).

On a regional scale, such practices and attitudes about the environment at the local level result in a "free rider problem" in which it is logical for industries in a county to add pollution to the system in the process of maximizing its own employment and financial gains. Lieberthal (1994) states that this unfortunately, is the status quo of a very large numbers of Chinese townships, counties, and cities.
2.42 Low bureaucratic representation, rank, and power of environmental institutions

In addition, upon closer examination of the Chinese bureaucratic structure, it seems easy to speculate why environmental initiatives and environmental state organs have been underfunded. Shirk (1993) states that a general trend exists within Chinese institutions; "...underrepresented sectors receive a relatively small share of resources, while overrepresented sectors receive the lion's share". The industrial sector is overwhelmingly represented within the Chinese bureaucratic structure through ministries which possess full ministry status right under the State Council such as the Ministries: of Geology & Mineral Resources, Construction, Power Industry, Coal Industry, Machine-Building Industry, Electronics Industry, Metallurgical Industry, and Chemical Industry. NEPA, China's leading environmental protection organ, in contrast, is listed as an "Organization under the State Council", existing only as a sub-ministerial level organ. Thus, since the ministries and provinces have higher bureaucratic rank, they also have greater political power. Thus, although NEPA can bring forth issues and draft regulations, it cannot issue binding orders either to the ministries or to the provinces. NEPA remains "...thoroughly outgunned by the industrial ministries and provinces it is supposed to supervise" (Shirk, 1994).

In addition, Environmental Protection Commissions at the national and local levels are largely unable to influence decisions made by other bureaucratic institutions because EPCs "generally lack direct influence over agency budgets and operational procedures" (Sinkule, 1993). Thus, their power probably more often rests on persuasion and consensus building strategies. However, since the Chinese bureaucracy at both central and local levels remains dominated by economic and more specifically industrial interests, persuasion and consensus tactics most likely do not guarantee that ECs' concerns are heard at the center and localities.

At the local level, local environmental protection institutions do not possess any influence over the agency budgets and operation procedures of industries. Thus, "coupled with the weakness of the procuratorial and judicial institutions, that has left the local environment protection bureau

---

5 Within the Chinese bureaucratic structure, consensus building is key to decision making processes since any policy initiative requires the cooperation of many units at various levels of government.
without independent recourse in the event of noncompliance" (Zhang, 1997). Thus, most often, local environmental protection institutions, as with NEPA, must resort to using persuasion and consensus building strategies. Further, Zhang (1997) states that, in situations in which a local EPB pursues a violation in which the offending polluter claims that they are also acting for the sake of national growth, the local EPBs have to resort to approaching the local leadership for assistance, or look to media coverage (Zhang, 1997).

2.43 Fragmentation and lack of coordination among environmental institutions

Lampton (1987) states that, "policy implementation in China is shaped by an uneasy combination of central decision-making, fragmented authority, and consensus-building". Further, "while most policy decisions are made centrally in China, the authority over most of the country, in all policy areas, is highly fragmented". Indeed, the number of different institutions and the complexity of the relationships among China's environmental institutions seem significantly greater than in other countries such as Canada and the United States.

Authority is "fragmented" in the sense that various government departments have jurisdiction over their individual functional areas. For example, an environmental protection bureau has authority with regard to environmental initiatives, and the Ministry of Light Industry has authority over issues relating to light industries, but specification of authority does not exist when different functional areas overlap. This is also the case for the development and implementation of policies and programs related to water issues in China. At present, various bureaus, largely working independently, manage Beijing's water. For example, the local municipal water saving office undertakes water conservation initiatives, the Beijing Municipal Bureau of Environmental Protection collects effluent fees, and the public utility company, the Beijing Water

---

6 Lampton (1987) coins this phenomena existing in the Chinese bureaucracy as "independent kingdoms". He discusses that it is a fundamental objective of every unit and territorial jurisdiction to achieve complete independence from others. Each of these "independent kingdoms" ideally controls its own supply and budgetary systems, personnel, planning, and operation as much as it can. In China, forming an independent kingdom is not only a goal of individual units such as an environmental protection institution, but also may be a goal of a city under the leadership of its mayor.
Tap Company, collects water fees. The fragmentation and lack of coordination among these institutions continues to hinder the effectiveness of Beijing water policies.

Further, since environmental systems are interlinked and highly complex, environmental initiatives demand horizontal integration between environmental institutions at both vertical and horizontal levels. However, coordination among Chinese environmental institutions remains difficult because although information and resources may move somewhat smoothly vertically within systems, they do not move well horizontally, or across systems (Sinkule, 1993).

Outside of China's environmental protection institutions, environmental management initiatives are hampered by a lack of cooperation and coordination among institutions which conduct research and develop environmental programs. Edmonds (1994) states that Chinese Academy of Sciences, the Chinese Academy of Social Sciences, the environmental protection organs, and universities are all working on environmental problems with less institutional cooperation than there should be (Edmonds, 1994).

2.44 Multiple and often conflicting authority and loyalties which is weakening the role and influence of environmental institutions

Implementation policies in China not only are hindered by lack of coordination and cooperation across systems, but also because a unit may be expected to satisfy demands from various higher authorities with different priorities. Lampton (1987) describes this pervasive characteristic in the Chinese bureaucracy as having "too many mothers in law".

The existence of this phenomena continues to make implementation of environmental policies a cumbersome and difficult task at the local level. For example, a small enterprise is under the jurisdiction of several environmental institutions as well as institutions involved with the production aspects of the enterprise; the city or county environmental protection department (EPB or EPO), the city or county government industry environmental protection department (for the particular industry), the local environmental protection commissions, the city or county industry bureau (for the particular industry), as well as other departments and commissions that may be
involved with the production facets of the enterprise. Sinkule (1994) coined the existence of "too many mothers in law" possessed by local EPBs and EPOs as "the dilemma of dual track authority". While local level EPBs and EPOs are part of a hierarchical environmental protection system, they are also organs of their respective local government. That is, local EPBs and EPOs are under the "dual track of authority" of the NEPA and local government. For example, although a city EPB is an organ of the municipal government, its policy mandates and programs come from the NEPA (Sinkule, 1993).

Also, since local governments fund local environmental protection institutions, (e.g. a city EPB receives its budget allocation from the municipal government), it is logical that local EPB/EPOs do not want to jeopardize their funding relationship with the local government (who are largely focused on economic growth) by actively enforcing environment legislation. Sinkule (1993) found in her study that the fiscal relationship between local governments and local environmental protection organizations constrained the competent enforcement of water pollution policies. As stated by Sinkule (1993), this is because "...the EPB must strike a balance in its regulatory efforts: it must cooperate with the municipal government as a whole to assure that economic growth is not slowed by environmental regulations".

2.45 There is a low level of environmental awareness among all facets of Chinese society

The low level of environmental awareness among Chinese society at large and government officials including environmental protection officials continues to stymie the effective implementation of environmental policies. As stated by Xie Zhenhua, official of NEPA at the second national conference on environmental publicity and education in December 1996, "the development of environmental protection and improvement of environmental quality (in China) are just empty words without an improved national awareness" (Li and Ye, 1997).

Two major environmental surveys conducted recently in China highlighted the low state of environmental awareness among the Chinese public. The first was the first large-scale environment-related poll to be conducted in China which was conducted in November 1994 by the
China Science and Technology Promotion and Research Center in cooperation with the Institute of Asian Economies of the Japanese ministry of Industries. A total of 3,200 people living in old urban areas, industrial districts or areas with a concentration of schools and rural areas in Beijing and Shanghai were surveyed. Although more than 50% of the respondents believed that atmospheric, river, and noise pollution are serious and the quality of the drinking water was worsening, they claimed to know nothing about other types of environmental problems. Also, 43.1% said that they did not have any knowledge about forestry destruction, 55% have no knowledge about desertification, and 45% had little concern about the reduction of wild species (Yuan and Wang, 1995).

The second survey, probably the most comprehensive environmental survey conducted to date in China, was initiated in January 1995 by the China Environmental Protection Foundation and conducted by the Social Survey Center in cooperation with People's University in Beijing. Upon its completion, in October 1995, a total of 4,000 people above the age of 18 in 22 provinces and cities had been surveyed. The results of this survey showed that, although 70% of those surveyed perceived the nation's environmental problems as "serious" or "very serious", over 80% of them said that they had little concrete knowledge about the details of these issues (Li, 1996). Further, 60% believed that since China is abundant in natural resources and that being concerned about the state of these resources is unnecessary, which revealed an "unpleasantly low sense of sustainable development" (Li, 1996).

### 2.46 Influence of non-government organizations and general public participation in environmental initiatives remains minimal

There is increasing evidence and belief that individuals and "people based" community efforts taken together can make a real difference in improving environmental quality. These acts may include organizing local groups, teaching literacy, educating people about family planning, and engaging in the simplest of acts to raise environmental awareness such as planting trees. Environmental non-governmental organizations (ENGOs) in many countries have been engaged in
research lobbying, education, and public demonstration activities to raise the status of environmental issues in government policy making. In addition, ENGO media campaigns have been successful in influencing public opinion and policy-making often beyond the national level.

Public participation in environmental initiatives in China remains limited since the Chinese government largely does not tolerate and continues to suppress the formation of any type of "civil organizations", including those of an environmental nature. However, this continues to be a detriment to environmental protection efforts within the country. This situation has been well summarized by Edmonds (1994), who states: "An open society has a much better chance of responding to environmental crises than a closed one...[and that] the Chinese government must be made to realize that for the country's [environmental] situation to improve there will have to be open access to information".

Conclusion

Despite the many benefits of water demand-management measures, the literature to date indicates demand-side management strategies cannot be viewed as a complete replacement for new source development with the current state of humankind's water management practices and technology. However, at a minimum, demand-management measures, whether they involve pricing, education, or direct regulation measures, can help defer construction of capital-intensive, supply-oriented projects, which reduces impacts on the environment, saves finances, and allows water suppliers more time to develop long-term supply plans. Also, the literature reveals that water planners, the environment, and citizens in a community incur benefits when authorities plan water demand-management projects with citizens' interests in mind.

Chinese authorities have made considerable and some noteworthy efforts to develop environmental processes and regulations to deal with China's many environmental issues. To some degree, China's environmental policies and the existing network of environmental protection institutions have contributed to the improvement of China's environmental situation. However, in the overall analysis, there are many social, political, and political-economic factors existing in
Beijing society that continue to significantly hinder Chinese authorities' and citizens' efforts to deal efficiently and effectively with China's many environmental issues.
CHAPTER 3

RESEARCH APPROACH

3.1 The study populations and background

The field research component of the study was largely made possible through an exchange program sponsored by the Canadian International Trade and Foreign Affairs Department and the Chinese State Education Commission called the "Canada-China Scholars Exchange Program". The time frame for the field research totalled approximately ten months, from March to December 1996.

The research in this study incorporated mainly qualitative methodologies. In order to satisfy the objectives of this study (as outlined in chapter 1) in a consistent and efficient manner, this study focussed its efforts on investigating the perceptions and opinions of two main study groups with regard to water issues and water demand-management measures in Beijing.

To achieve insights into the social feasibility of water demand-management measures, specifically in the public sector in Beijing, one aspect of this study involved the dissemination of a survey to Beijing university students through non-probabalistic sampling techniques. Given various research constraints endemic to social survey research in China (which are later discussed in this chapter), students chosen to be surveyed were at three of Beijing's largest and most prominent campuses - Qinghua university and Beijing universities which are both located in the northwest part of Beijing, and the Chinese Academy of Sciences, which is located in the southwest part of Beijing. This part of the field research was made possible and performed via collaborative efforts between myself and university personnel on each of the surveyed campuses. I created most of the survey during the months of September to December 1995. However, it was not until April 1996 that the final version was completed, after receiving comments about the survey's content and format from professors at Qinghua and Beijing universities and translating the survey from English
into Chinese. In terms of selecting students to distribute my survey to, my goal was to survey a diverse group of students which varied in terms of discipline, gender, and level of study (i.e. undergraduate and graduate students). I then communicated such criteria to my Chinese collaborators who helped me to distribute the surveys on the campuses. Upon receiving the surveys back, I felt the goals I had set for the survey had been fulfilled quite well (Chapter 8 details the results).

The other study group consisted of government officials who were involved (directly or indirectly) in water management in Beijing. Their perspective was important to this study because they were able to provide information about administrative, economic, technical, as well as additional social issues (to compare/contrast with the survey) which are or may be hindering the implementation of current and potential water demand-measurement measures. I performed fifteen interviews with eight authorities at the National Ministry of Water Resources, the Beijing Municipal Institute of City Planning and Design, the Beijing Municipal Environmental Protection Bureau, and the Beijing Municipal Water Saving Management Office. My access to these officials for interviewing purposes was largely made possible by referrals from professors at Qinghua and Beijing universities.

In addition, in order to adequately assess the responses to the campus survey, university personnel on each of the campus sites were sought out for information about the present water supply and water demand-management initiatives existing on each campus. Again, such interviews were made possible through referrals from professors at Qinghua and Beijing universities.

Also, throughout this study, I talked to students that have previously attended or were at the time attending the three surveyed campuses on an informal basis in both Vancouver and Beijing. I found such discussions to be valuable in terms of verifying and/or adding a different perspective to statements made by school and municipal authorities. For instance, discussions with students helped to determine how widespread water demand-management measures were on each campus. Such discussions were very helpful in terms of identifying water demand-management strategies existing on the CAS campus since I was unable to locate the appropriate CAS school
authorities during the course of my stay in Beijing. Also, students gave helpful comments in terms of the state of demand-management measures on campus. The real value of asking students for their opinions and ideas about water management in Beijing is in part illustrated through the many interesting and valuable comments students made on the survey which are documented in Appendix D.

Foreign environmental consultants working on projects in Beijing during the time of my field research also proved to be good sources of additional information. My informal discussions with them provided me with additional insights into Chinese environmental management and in particular, water management in Beijing.

There are a number of reasons why I chose Beijing as my research location for this study. In terms of research logistics, since this study focuses upon policy related issues, in this case, water management policies, it is advantageous to conduct this study at the location where most of the significant policy decisions are made. The government administration centre of China, Beijing is an ideal location to gain access to national and local water authorities and official documents about China's water issues. Another reason for my location choice is that I feel significant efforts are further needed to assess and rectify Beijing's water shortage problems since authorities predict water shortage problems will considerably worsen in this city in the future. Also important to note however, is that these projections are based upon current, conventional water management approaches. This is another reason why research about alternative water management methods such as demand-management are needed.

3.2 Research constraints

Although one aspect of this study looks at the social acceptability of demand-management measures in the public sector, one might naturally ask why I did not obtain a probabilistic sample among Beijing's general public. There are a number of reasons why I surveyed university students as opposed to members of the general public.
Firstly, as previous researchers have found, there are significant risks - political and other, in performing social survey research in China. Manion states (1994), "From a political perspective, many (Chinese) authorities do not understand or trust the scholarly objectives of survey researchers, especially if questions touch on politics (broadly defined) and researchers are foreigners". In addition, researchers in China have found that site negotiation with government officials can be very cumbersome and time consuming, and public access problems are not uncommon (Henderson, 1993). As a single researcher faced with time and financial constraints, naturally, I wished to minimize such problems. During the course of the survey dissemination aspect of my study, although some problems were encountered, I believe I would have experienced a greater number of setbacks had my survey site selection been different. In addition, since the general Chinese population is unfamiliar with surveys, and would probably be wary of such research (due to political reasons), it was highly questionable whether or not I would receive an adequate number of surveys back from a general sample of the Beijing population in order to perform any type of analysis. Further, my Chinese collaborators were supportive of my site selection given that they too were well aware of the risks to such research and my limited resources. Finally, I knew that there have been social surveys distributed among university students in Beijing with good results. Thus, in the final analysis, I felt I had made logical and practical decisions in terms of my sample selection given the constraints researchers continue to face in China.

However, such matters aside, surveying a student population as opposed to taking a sample of the general domestic population is a very worthwhile undertaking for various reasons. As they are the "educated elite" of China, they have the potential to hold influential positions in society, and thus make significant decisions about water use as leaders in business and industry and perhaps government officials in the future. Thus, their opinions are a significant indicator of the future direction of water demand-management policies in Beijing. Also, although their

---

7 For example, Stanley Rosen (1990) successfully surveyed 3000 university students in Beijing about their attitudes towards communist party membership and the party's image.
awareness level can not be viewed as representative of Beijing society as a whole, determining their perceptions and opinions about water issues and more specifically demand-management in Beijing is important to authorities and others involved in water management in Beijing. As the "educated elite", it seems very logical to assume that students, particularly in these three elite institutions, would possess a relatively high level (i.e. compared to the rest of Beijing society) of environmental consciousness and understanding of Beijing's water issues. Given this, their acceptance level of various water demand-management strategies in the public sector is highly significant.

Another aspect of the field research worth discussing which affected all aspects of my field research was the language factor. Since I had limitations in my Chinese, my Chinese collaborators at the universities graciously offered to translate the questionnaire from English to Chinese for me. In addition, at times I required an assistant to accompany me to government official interviews. I found however, that most of the government officials I interviewed were fairly fluent in the English language. Thus, with these officials, I did not require an assistant, and the interviews were conducted in both Chinese and English.

**Conclusion**

In summary, I believe that collecting information for this study from different groups of Beijing society, in particular, students, government officials, and school officials, contributed unique but complementary perspectives on issues related to water demand-management in Beijing. I also believe that it was advantageous to gather information from two types of processes, a survey and personal interviews. Surveying students allowed me to gather a large amount of information (as the survey was 14 pages in total) from many students to make statistically significant observations about my student sample group (which probably would not have been possible due to financial and time constraints had I interviewed them one by one). Perhaps also, the "impersonal nature" of a survey gave reassurance to students about their anonymity. The interviews, aside from allowing me to gather information about official government policy, also gave me the
opportunity to gain more detailed information and further insights about responses I had received on the survey. Finally, other factors which played a significant role in shaping and influencing my field research strategies and results were: language and culture, and the degree of cooperation from my Chinese collaborators and government official and school officials interviewed.
CHAPTER 4

MAJOR CHARACTERISTICS AND ISSUES OF WATER RESOURCES IN CHINA

The following are major characteristics and issues surrounding the state of water resource distribution and use in China. These characteristics and issues will be presented to highlight their role in the water shortage problem in the country. At the end of this section, observations will be made about the state and extent of China's water shortage.

4.1 Unbalanced distribution of water resources

"China suffers a major imbalance in water resources, both in time and space" (Jowett, 1986) Figure 4 illustrates the uneven geographical distribution of water.

Figure 4 : Regional Distribution of Water Resources in China

Adopted from Jowett 1986
In most regions in China, precipitation is concentrated during four months of the flood season (July to October). Within this period, the precipitation accounts for 60%-80% of total annual precipitation. Such monsoonal climactic patterns generates summer floods and springtime droughts (ADB, 1996).

On a regional basis, there exists a considerable decline in rainfall from the south to north and from east to west. The result of this regional rainfall pattern is a water surplus in the southeast and a water deficiency in the north and western areas of China. 53% of China is considered arid or semiarid; i.e. precipitation averages less than 500 mm a year (Jowett, 1986). The Yangtze River (Chang Jiang) and other drainage basins in southern China discharge 75% of China's total surface run-off while the rivers of the North China Plain - the Huai He, Huang He, Hai He and Luan He - account for only 5% of the country's total discharge (Edmonds, 1994).

The unevenness of water resource distribution in China may also be explained in terms of regional total population percentages and arable land distribution. Although 81% of China's water resources is distributed in the area around the Yangtze river and southern regions, the population in these regions accounts for 54.7% and arable fields account for 35.4% of the whole nation (CCEN, June 1995). In contrast, regions to the north of the Yangtze river account for 45.3% of the national population and 64.1% of arable fields, but are endowed with 19% of the country's water resources (CCEN, June 1995). River basins of the Huang, Huai, Hai Luan and Liao in the north contain arable fields which comprise 42% of the country's total while water resources account for 9% (CCEN, June 1995).

4.2 Water per capita and per hectare land are low in China

In terms of total precipitation in comparison to other countries, China ranks sixth in the world. Its total ownership of water is estimated to be 2,812 billion m³, of which river runoff amounts to 2,712 billion m³. However, with respect to precipitation per hectare of cultivated land, China possesses only one quarter of the world average, at 2,477 m³.
4.3 **Low utilization efficiency of water resources and poor management**

Aside from uneven environmental weather patterns, water shortages exist in China as a result of anthropogenic factors. A substantial amount of water supplies are lost annually in China due to poor management, including weak scientific planning, decision making, and outdated irrigation technology.

In general, water use efficiency in China is fairly low compared to most other countries (CEN, March 1994) and this problem is endemic in all facets of Chinese society.

4.31 **Agriculture**

Irrigated agricultural fields in China produce 74% of the country's grain, 60% of cash crops, and 80% of vegetables. On an annual basis, approximately 48% (49.3 million hectares) of China's arable lands are irrigated and the amount of water consumed amounts to an estimated 400 billion m$^3$ of water annually (CCEN, June 1995). This accounts for 80% of the country's total water consumption. However, utilization ratios are quite low when compared to the irrigation efficiency of other countries. Water use efficiency in the agricultural sector in China is currently estimated at 40% (Xi, 1996). That is, the majority of water supplied, i.e. 60%, is not consumed by crops but rather flows overland as runoff or seeps underground into aquifers.

4.32 **Industry**

The National Environmental Protection Agency of China continues to view policies and programs to raise the efficiency of resource use in China's industries as a critical, but contentious issue in China's environmental initiatives. Qu Geping of NEPA stated that "priority has been given to increasing the input of raw materials and energy, but little has been done to encourage firms to save energy and reduce pollution" (CEN, March 1994). In terms of water efficiency, Postel (1992) points out that China's paper, steel, and other major industries are very inefficient and consume five to 10 times as much water per unit output as their counterparts in developed countries.
About 70% of water supplies used in industries in China is for cooling and much of this water has the potential to be recycled. Luo (1993) of the Beijing Municipal Planning Bureau stressed the potential of China's industries to recycle water by stating "...general industries should target a recycling rate of above 80%".

4.4 Water Pollution is increasing Water Shortage and Vice Versa

Water pollution remains a serious problem in China, which continues to foul usable surface and ground water resources, thus exacerbating water shortage problems in China. At the same time, since water shortages mean that less water is available to dilute polluted waters, concentrations of pollutants in usable water resources are increased which further render once usable water supplies unusable. In addition, in coastal regions where there exists excessive pumping of groundwater supplies, healthy water resources become polluted due to the incursion of sea water (Zou and Xu 1991).

The present seriousness of water pollution in China and the rate at which it continues to increase is disturbing. China's 1996 State of the environment report states that "The pollution of surface water in cities is universally serious and tended to worsen in 1995" and that "the overwhelming majority of the rivers running through cities were polluted to varying degrees" (CEN, July 1996). A survey of the country's 532 rivers found that 436, that is, 82% of the total, were polluted and that the main pollutants in China's water resources include ammonia nitrogen, biochemical oxygen demand, and volatile phenols (Xi, 1996).

Rivers in northern cities are on the whole polluted to a greater extent than rivers running through southern cities (not surprisingly since in general there is less water in the north to dilute pollutants). In addition, extensive amounts of total phosphorus and total nitrogen were found to be polluting city lakes. Serious eutrophication exists, pollution of oxygen-consuming organic substances is extensive, and heavy metal pollution is a problem as well (Edmonds, 1994).
4.41 Pollution sources

A significant share of these pollutants comes from untreated sewage discharges. In the 1970s, the country's daily discharge of sewage was 30-40 million m$^3$ and in 1980 it doubled to 75 million m$^3$. Now, it is more than 100 million m$^3$, with 80% flowing directly into rivers without treatment. (Xi, 1996)

Also, much of the polluted water originates from industries that are concentrated in and around China's cities. Industries in China produce much more polluted water per unit of product than industries in developed countries. Coal-fired power plants are major polluters emitting an estimated fifteen million tons of ash annually into rivers (Edmonds, 1994). Other major water polluters include pulp and paper, printing and dyeing, and leather tanning industries. Along with other industries, they emit organic wastes, oil products, chlorinated hydrocarbons, nitrates, sulfates, phenolic compounds, cyanides, arsenic and heavy metals such as lead, chromium, cadmium and mercury (Edmonds, 1994).

Besides heavy industry, township industries and rural enterprises are also cited as heavy polluters. During the years 1989-1994, a pollution survey was conducted by the National Environmental Protection Agency which covered 570,000 enterprises in almost every province in China except Tibet (CEN, March 1994). The survey revealed that the discharge of industrial wastewater around Tianjin, Shanghai, and Beijing and in the worst-hit provinces accounted for almost 60% of the total from China's townships.

Soil erosion has also polluted water supplies. China's annual loss of soil and sand due to erosion totals 5 billion m$^3$, which accounts for one-twelfth of the world total (Xi, 1996). Silt deposition caused by human activities is significantly affecting rivers and lakes in the provinces of Hunan, Jiangxi, and Fujian.
4.42 National pollution mitigation efforts

Due to the severity of such problems, six of China's polluted rivers and lakes were recently chosen (1996) as the targets of a nationwide environmental project. Called the "National Cross-Century Green Project", the project targets the Huai, Liao, and Hai rivers and the Tai, Chao and Dianchi lakes as priorities for water-pollution abatement under the Ninth Five-Year Plan, which started in 1996 and ends in 2000 (Li, 1996). The Haihe River flows through Hebei province and the cities of Beijing and Tianjin. Clean-up efforts planned are focused mainly on the river sections in Tianjin and Hebei.

4.5 Groundwater Overexploitation

Unsustainable extraction rates of groundwater supplies have not only caused many problems to the environment, but also harmed the development of China's regional economies, particularly in the north.

A few statistics illustrate the massive volumes of groundwater supplies extracted in China over the years. From the late 1980s to 1990, the total amount of groundwater extracted in China was estimated at 87 billion m³. In 1995 alone, a total volume of groundwater extracted from the urban districts of 77 large and medium-sized cities amounted to 8.1 billion m³ (CEN, July 1996). Of this total, excessive pumping of groundwater supplies was most severe in the cities of Xi'an, Taiyuan, Nanjing, Shijiazhuang, Suzhou, Wuxi, Changshou, Datong, Tangshan, Baoding, Qingdao, Zibo, and Yantai.

Numerous negative environmental impacts have occurred due to the overpumping of groundwater resources in China. For example, contamination of urban groundwater supplies due to sea water intrusions from lowered groundwater tables increased in the coastal cities of Dalian, Qingdao, Yantai, and Beihai. In the North China plain, the content of fluorine ions in underground water resources has been on the rise, and salt water has tainted underground fresh water resources (Zhu, 1996). Hebei Province since 1975 has consumed almost 500 billion m³ of underground
water as river water levels have dropped (CCEN, June 1995). Thus, an area measured to be 5,000 km\(^2\) has been exploited to the point where little underground water supplies are left. Already, about 5\% of the motor-pumped wells in Hebei province are abandoned each year due to declines in the groundwater table. Further, an area of 34,000 km\(^2\) in the province has subsided to depths between 100-600 mm; and 5,000 km\(^2\) of this area has fallen between 400-1,100 mm (Zhu, 1996). Scientists estimate that if this trend persists, areas in Hebei province without nearby underground water resources in the mountain plains will increase to over 10 000 km\(^2\) and that the total amount of earth subsidence in the region may double in the next 10 to 15 years (Zhu, 1996).

4.6 The Current State of China's Water Shortage

The total amount of water supplied by hydrological works in China is currently 500 billion m\(^3\) annually. However, factors outlined above have contributed to a total water shortage amounting to 40-60 billion m\(^3\) per year in the country (Zhang, 1996).

In the agricultural sector, the total area yearly affected by drought in China has been estimated to be approximately 0.3-0.4 billion mu (one mu equals one-fifteenth of a hectare) (Zhang, 1996).

In China's urban areas, available per capita urban water supply is only about one-half the level of that in advanced countries (194 liters per capita). Also, of the 517 cities in China (20\% of which have population of more than one million, 80\% more than 0.3 million, and 98\% more than 0.1 million), 300 suffer from water shortages to varying degrees (Xiong, 1994). Projections for water shortfalls in ten of China's major cities in the year 2000 is shown in Table 2.

Water scarcity ranks as a serious problem in 50 cities and has left five million urbanites short of clean water supplies. A total of approximately 80 million people in the whole nation still do not have access to adequate drinking water supplies (Xi, 1996).
### Table 2: Water Shortage Conditions Among Ten Major Cities in China

<table>
<thead>
<tr>
<th>City</th>
<th>Water Demand in 1990 (billion m³)</th>
<th>Estimated Water Demand in 2000 (billion m³)</th>
<th>Estimated Water Shortage (billion m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing</td>
<td>0.97</td>
<td>3.35</td>
<td>2.38</td>
</tr>
<tr>
<td>Tianjin</td>
<td>0.63</td>
<td>2.74</td>
<td>2.11</td>
</tr>
<tr>
<td>Shanghai</td>
<td>2.87</td>
<td>5.55</td>
<td>2.68</td>
</tr>
<tr>
<td>Shenyang</td>
<td>0.56</td>
<td>1.04</td>
<td>0.48</td>
</tr>
<tr>
<td>Lanzhou</td>
<td>0.36</td>
<td>0.73</td>
<td>0.37</td>
</tr>
<tr>
<td>Guangzhou</td>
<td>0.86</td>
<td>2.24</td>
<td>1.38</td>
</tr>
<tr>
<td>Xi'an</td>
<td>0.35</td>
<td>0.75</td>
<td>0.40</td>
</tr>
<tr>
<td>Nanjing</td>
<td>1.02</td>
<td>1.87</td>
<td>0.85</td>
</tr>
<tr>
<td>Wuhan</td>
<td>0.85</td>
<td>1.66</td>
<td>0.81</td>
</tr>
<tr>
<td>Chengdu</td>
<td>0.41</td>
<td>0.92</td>
<td>0.51</td>
</tr>
</tbody>
</table>

Adopted from Zhang 1995

### 4.6.1 Economic Impact of Water Shortages

So far, water shortages in China have caused significant economic losses. In the agricultural sector, water shortages cause an approximately 15-20 billion kg decrease in agricultural production yearly (CCD, April 1996). Annually, the industrial sector sees a loss of 120 billion yuan from water shortages (CCD, April 1996).

Water shortages have had their greatest impact in the urban-industrial centers of North China. Some believe that water shortages are the major constraint on economic development in northern China (Lide, 1990).
Conclusion

As illustrated in this chapter, water shortage in China is a multi-faceted problem. It is a problem whose causes vary among regions in China and which exists as a consequence of both natural and human-induced factors and processes. In the south, water shortage is a problem that exists largely as a consequence of human activities which have polluted once healthy, usable, water resources. In the north, water shortage is mainly caused by human activities in addition to climactic factors. Further, problems arising from water shortage and the continued overexploitation of water resources continues to cause negative environmental, social, and economic consequences.

Given the severity and widespread nature of water shortage in the country, China's development will no doubt continue to be impeded by water shortage in the near future.
CHAPTER 5

CHARACTERISTICS AND ISSUES OF BEIJING'S WATER SUPPLY

5.1 Geography of Beijing

Beijing, the political and cultural capital of China, is the second largest city in China after Shanghai (until the recent expansion of Chongqing) with an "official" population of approximately 11 million and an additional "unofficial" population of approximately 3 million migrants (official interview, 1996).

The Beijing administrative area totals 16,808 km$^2$ and consists of 18 district and counties. Four of these urban districts (Dongcheng, Xicheng, Chongwen and Xuanwu) cover an area of 87.1 km$^2$; four suburban districts (Chaoyang, Haidian, Fengtai, and Shijingshan) cover 1,282.8 km$^2$; and 10 outer suburban counties (Mentougou, Fangshan, Changping, Shunyi, Tongxian, Daxing, Pinggu, Hairou, Miyun, and Yanqing) occupy 15,437.9 km$^2$. The four urban districts contain the densest population and industrial levels, followed by the suburban districts and outer counties (ADB, 1996 and MEIP, 1994).

In terms of geographic location, Beijing is situated at the northern apex of the North China Plain, surrounded in the north by the Jundu mountain (part of the Yan mountain range) and in the west by the Xi mountain (part of the Taihang mountain range). Of Beijing's total administrative area, 6,390 km$^2$ (38%) is flat and 10,418 km$^2$ (62%) is mountainous. Also, over 120 streams and rivers run through the Beijing administrative area covering a total length of over 2700 km. The rivers originate in the mountainous areas to the northwest part of the city and flow southeast forming the five river systems: Haihe; Jiyun, Chaobai, Beiyun, Yongding, and Daqing (ADB, 1996 and MEIP, 1994).
Figure 5: Beijing Municipality
In terms of climate, Beijing lies in a semi-arid monsoonal climate zone and receives only a modest amount of precipitation, averaging 626 mm per year, more than 85% of which is concentrated in July, August, and September. Beijing has four distinct seasons: dry, windy springs; hot, rainy summers; cool, humid autumns; and cold, arid winters. Winds generally blow from the north all year, with the strongest monthly wind velocities occurring in April. Dust from the loess plateau to the northwest blows into the city, which, during more arid periods, produces a "sandstorm" climate (MEIP, 1994).

5.2 Origins of Beijing's Water Supply Capacity

Emperor Hai Ling of the Jin Dynasty (1115-1234) established his capital in Beijing in 1153. The city remained the capital from the Yuan Dynasty (1271-1368) to the Qing Dynasty (1644-1911). Governors during these dynasties found water lacking in the area and devoted great efforts and resources to continually seek out new water supplies as the city grew. Large reserves of labour were mobilized to increase water work facilities through digging ditches, and to build large numbers of small scale reservoirs. Despite such efforts, during that period, no substantial, "permanent" solution was found to the problem of lack of water supplies in Beijing (Nickum, 1994).

However, after the Communists took over China in 1949, the water supply capacity of Beijing was significantly increased with the construction of the two largest reservoirs in Beijing; the Guanting and Miyun reservoirs. The largest rivers in the region, the Yongdinghe, Chaohe, and Baihe were diverted to supply them with water. Also, the Communists built an extensive series of canals in Beijing to transport the water from these reservoirs to the people (Nickum, 1994).

In 1957-8 the water supply capacity of Beijing was again significantly raised with the adoption of a large scale water supply campaign involving the mobilization of over 100 million people to construct ditches, reservoirs, and irrigation works (Nickum, 1994).
5.3 Beijing's Water Supply

Presently, the Miyun, Guanting, and Huairou reservoirs are the largest surface water reservoirs serving the two major surface water supply systems of Beijing, the Guanting-Yongding and Miyun-Huairou-Jingmi systems.

The Yonding diversion canal brings water supplies from the Guanting reservoir to the municipality and the Jigmi diversion canal transports the Miyun-Hairou waters to the municipality. In addition, 81 smaller reservoirs provide water to the city (ADB, 1996).

5.31 Surface Water Supplies

Guanting-Yonding System

The Guanting Reservoir has a total storage capacity of 2.27 billion m$^3$ (Liang, 1989). It was constructed in 1958 to provide water supplies to industries located in the western part of Beijing and certain large-scale industries in the city. Also, it served as the major drinking water resource for the Men Tou Gou District located in the north-west part of Beijing (ADB, 1996).

A considerable portion of the river flow into the Guanting reservoir originates from Hebei and Shanxi Provinces. However, a growing amount of industrial and waste water discharges into rivers feeding the reservoir - in particular the Yang and Yongding rivers have polluted waters in the Guanting reservoir. Since the 1980's, the water of the Guanting reservoir has not been up to acceptable water quality criteria (ADB, 1996). One study showed that the chemical oxygen consumption of the reservoir water and the content of ammonia and nitrogen were greater during the 1987-1991 period than during the period between 1975-1977 (Zhao, 1995). Also, it was estimated that severe silt deposition had reduced the storage capacity of the Guanting reservoir by 24 % (Xi, 1996). Further, water extractions upstream of the Guanting Reservoir, mainly for agricultural activities, and unfavourable weather patterns have decreased the Guanting reservoir's water supply (ADB, 1996).
Thus, since 1995, the Guanting reservoir has no longer been used as a drinking water source serving local supply systems, including the Men Tou Gou District of Beijing. Presently, the water of the Guanting reservoir is used primarily as a source of cooling water for major steel producing plants in northwest Beijing, along with various other industrial uses (ADB, 1996).

It is reported that other reservoirs in the municipality are also declining in water storage capacity. By the beginning of April 1996, it was reported that the total volume of water stored by the 16 middle or large-size reservoirs has been reduced by 120 million m\(^3\) compared with that of last year during the same period (Liu, 1996).

Miyun-Hairou-Jingmi system

Finished in 1959, the Miyun reservoir controls a watershed area of 15,371 km\(^2\) of the Chaobai River. The Miyun reservoir itself covers an area of 188 km\(^2\) and has a total storage capacity of 4.375 billion m\(^3\). Approximately 65% of the inflows, coming mainly from the Chaobai river, originates from beyond the administrative boundary between Beijing Municipality and Hebei Province (ADB, 1996). The reservoir is connected to the Hairou reservoir and to the Jinmi Canal that is linked to the rivers that flow through and from Beijing. The Hairou reservoir was originally constructed in 1958 and has a total storage capacity of 98 million m\(^3\).

The Miyun reservoir has been the largest single source of drinking water for the Beijing municipality since 1984. However, when it was originally constructed in 1958, its major functions were flood protection, irrigation and power generation. Until about 1990, the capacity for supply, treatment and distribution of this system was 0.67 million m\(^3\)d\(^{-1}\). A capital programme to be conducted in several phases until the year 2000 will add to raw water transmission and treatment facilities, which will, upon completion, increase the capacity of this system to approximately 1.67 million m\(^3\)d\(^{-1}\) (ADB, 1996).
5.32 Groundwater Supplies

Large scale exploitation of China's groundwater resources began in the 1970's (Edmonds, 1994). During that time, Chinese authorities carried out a vast water supply oriented campaign in which people were mobilized in the North China Plain to drill hundreds of thousands of tube wells. These wells played a major role in the expansion of irrigation in northeast China. As a result of this campaign, paddy area in Beijing and Tianjin municipalities increased from 21,000 hectares in 1973 to 102,000 hectares in 1980 (Edmonds, 1994).

Groundwater reservoirs and flow have been tapped for centuries through the use of hand-dug wells, but over the past several decades, machine-dug deep tube wells with electrical or diesel pumps have been used to extract water from aquifers. These mechanized tube wells are generally 30-40 meters deep but may reach depths of up to 200 meters (Edmonds, 1994).

The average annual groundwater reserve of the city is estimated to be approximately 2.5 billion m$^3$. Groundwater continues to be the primary source of water for agricultural (including rural industrial and domestic) and industrial use. Also, in the urbanized areas of Beijing, a substantial amount of domestic water use is supplied by groundwater.

The largest and most significant groundwater sources in Beijing are located in the western and north-eastern basins, and most of the wells are in the north-western suburbs of the municipality: 1. The western basin is the water source for Nos. 3, 4, 7 WTWs, located in the urban areas; 2. The basin in the north-east is the water source of to Nos. 1, 2, 5 and 8 WTWs. The treatment capacity for WTWs 1-5, 7 and 8 in total amounts to 1.34 million m$^3$d$^{-1}$ (ADB, 1996).

The rate at which groundwater is extracted in Beijing is in part controlled by seasonal factors to compensate for the variability in surface waters availability (ADB, 1996). In the 1970s, the annual rate of extraction was approximately 1.0-1.1 billion m$^3$y$^{-1}$ while in the 1980s, it was 2.7-2.8 billion m$^3$y$^{-1}$. Presently, the total volume extracted is 2.5 billion to 2.9 billion m$^3$ (ADB, 1996). However, these are unsustainable rates of extraction and authorities have stated that annual groundwater extraction should be no more than 2.45 billion m$^3$ (Porter, 1996). It is
estimated that the overexploitation of the municipal area's underground water has reached approximately 40% (Porter, 1996).

**Impacts of overexploited ground water supplies in Beijing municipality**

Wang (1994) states that the more than 10,000 wells in Beijing can now only yield half or less than half of the water needed for farms and residents. As a result, the 100,000 farmers and 10,000 draught animals in the city's mountains, which account for about 62% of its area, are now finding drinking water a scarcity. Much resources must be mobilized to fetch water (which is often a few kilometers away) for more than 10,000 farmers in the region (Wang, 1994). For example in Seshuwen Town of Fangshan District, villagers have to fetch water using two cars with water tanks six to nine times throughout the day and it is still not enough to feed the village population of 360 and satisfy the needs of a small coal mine (Wang, 1994).

Another village in Fangshan district called Wanglapu Village of Shitu Town used to be a famous scenic spot for its hill-girdling streams. However, as of 1994, the 130 pools and 282 ponds and three of its four wells have all dried up (Wang, 1994). Longquanwu village, in the plain in Mengtougou district, is hemmed in by the Yongding river on three sides. However it too is finding it difficult to supply its 5000 villagers with drinking water. Wang (1994) explains that it used to have a well 300 meters deep that pumped 240 m$^3$ of water a day and another that supplied 130 m$^3$ of water an hour. However, at the end of 1993, both sources had virtually dried up.

Overextraction of groundwater resources in Beijing has also caused negative environmental impacts. For example, Beijing's water table has been dropping at an alarming rate. It is estimated that water levels city wide are dropping at a rate of 0.5 meters per year, and some areas are decreasing at a faster rate of over 1.0 meters a year (Nickum, 1994). In some areas of Beijing, the groundwater tables are now more than 4 meters lower than original levels. Figure 6 shows the decline in the groundwater table over a cross-section of Beijing between the Yongding and Chaobai rivers during the years 1959 to 1983.
Overextraction of groundwater supplies has also caused the ground in Beijing to sink an estimated 60 cm over the past 40 years (Porter, 1996). The city is reported to be continuing to sink at a rate of one to two centimeters a year; a rate which has increased since 1987 (Nickum, 1994). Such problems are most severe in the northeast and eastern part of the city. In the southeastern part of Beijing, a 'cone of depression' exists where there are many chemical factories. It is also reported that a considerable area of central Beijing is also sinking.

Figure 6: Groundwater Table in Beijing Urban District

![Groundwater Table in Beijing Urban District](image)

Adopted from Nickum 1994

5.33 Water Pollution in Beijing

"The problem of water shortage and water pollution is becoming serious in Beijing" (Beijing student, 1996)

Pollution has drastically reduced usable water resources and aggravated water shortages in Beijing. Qu Geping, head of the National Environmental Protection Agency in China, stated that pollution of Beijing's rivers and streams is one of the three worst environmental problems in Beijing (CEN, March 1994).
It was estimated in 1990 that 90% of the total stream length in Beijing and its immediate suburbs was polluted (Lide, 1990). Many of the rivers emit noxious odors and are heavily polluted with organic materials and agricultural wastes, and, in the urban areas, with industrial waste. Four of Beijing's rivers - the Qing, Ba, Tonghui and Liang Shui Rivers that drain into the municipal planning area are solely viewed as means for disposing wastewater. One official interviewed suggested that three to four decades of sustained and genuine effort would be needed to adequately clean up Beijing's water channels.

**Industrial Pollution Sources**

During the fourth national environmental protection conference in May 1996, Qu Geping stated the problem with the large concentrations of industry in Beijing: there exists an "..overproportion of industries with high consumption in energy and water and with heavy pollution,...there is an incongruity between the industrial structure and the function as a capital" (Li, 1996). Further, he discussed that the continual growth of industries in Beijing persists in undermining environmental efforts in the capital.

Presently, there are an estimated 21,000 industrial units in Beijing municipality (ADB, 1996). They comprise large state level industries as well as very small operations at the private and village level. Metallurgy, chemical, and building materials industries, which consume large amounts of energy and materials, and are heavy polluters, comprise a large percentage of these industries. Built up industrial areas in Beijing cover one fourth of Beijing's urban constructed areas and many of the polluting factories are located in urban residential areas.

Industrial wastewater discharges (presumed to exclude cooling water) in 1994 totalled approximately 0.37 billion m³ (ADB, 1996). Although approximately 89% of this wastewater is treated in some way, pollutants discharged still contribute significantly to water pollution in Beijing (ADB, 1996). In 1992, it was reported that 47 % of total sewage water in Beijing was from industrial sources, accounting for over 60 % of pollutants in the sewage water (Yang, 1993). Table 3 shows Industrial Waste Water Discharge amounts in Beijing in 1992.
Many industries in Beijing still utilize old, inefficient technologies and equipment, consuming high amounts of water. Cleaner, pollution preventative production methods have been promoted at about 40 factories since 1992, but the overwhelming majority still utilize end-of-the pipe treatment methods (ADB, 1996).

Table 3: Industrial Wastewater Discharge in Beijing

<table>
<thead>
<tr>
<th>Items</th>
<th>1992</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wastewater (mil. m³)</td>
<td>397</td>
</tr>
<tr>
<td>Pollutants</td>
<td></td>
</tr>
<tr>
<td>Hg</td>
<td>0</td>
</tr>
<tr>
<td>Cd</td>
<td>0.09</td>
</tr>
<tr>
<td>Cr</td>
<td>1.06</td>
</tr>
<tr>
<td>As</td>
<td>1.10</td>
</tr>
<tr>
<td>Phenol</td>
<td>32.7</td>
</tr>
<tr>
<td>Cyanide</td>
<td>15.0</td>
</tr>
<tr>
<td>Mineral Oil</td>
<td>1501.3</td>
</tr>
<tr>
<td>COD</td>
<td>102613</td>
</tr>
</tbody>
</table>

Adopted from Yang 1993

Agricultural Sources of Water Pollution

In 1993, the total agriculture area in Beijing covered approximately 6.08 million mu (1 hectare equals 15 mu). The main crops are grain (rice, wheat, corn) on 4.16 mu, vegetables (0.53 million mu), vegetable oil (0.18 million mu), and fruit (0.082 million mu). Approximately 49% of vegetables are grown in urban areas in Beijing (ADB, 1996).

A major source of pollutants entering water resources in Beijing comes from the rampant and improper use of fertilizers and pesticides in the agricultural sector. However, the full impact of the use of agrochemicals in Beijing is not known since there has been no research to link agrochemical use and surface and groundwater quality. Fertilizer use figures for 1990-94 are: 18-22 kg N mu⁻¹, 1.3-6.6 kg P mu⁻¹, and 0.3-0.6 kg K mu⁻¹. Also, approximately 4000 tones per
year and 0.79 kg per mu on average of pesticides are applied on Beijing's agricultural lands (ADB, 1996).

5.34 Sewage treatment in Beijing

Compounding water problems in Beijing is that the city lacks adequate sewage treatment facilities to treat the large amounts of waste water. This has contributed to the continued contamination of surface and groundwater sources.

Before 1990, Beijing was discharging mostly untreated sewage at a rate of 2.2 million m$^3$d$^{-1}$. In 1990, city sewage amounted to 1.1 billion m$^3$, but only 12% was receiving primary screening, septic tank collection, or secondary sewage treatment, while the rest was mostly discharged into the Beijing's two major rivers, the Tonghui and Liangshui. Also, only half of Beijing's urban population at the time was connected to a sewer. By 1990, a sewerage system totalling 2 165 km was built and served about 55% of the population in the City Planning Area (CPA). Since then, the urban sewerage system has been extended to a current 3 346 km (ADB, 1996).

Currently, Beijing produces about 2.3 million m$^3$ of industrial and domestic sewage daily, of which the majority is still discharged untreated into the Tonghui and the Liangshui rivers (Porter, 1996).

**Gaobedian Sewage Treatment Project**

In 1990, the Beijing municipal government decided to construct a MWWTP (Municipal Wastewater Treatment Plant) in Gaobedian village located in the eastern suburb of Beijing. The first phase of the Gaobedian MWWTP, which is based upon conventional mechanical/biological treatment, was completed in December 1993. It is served by a 97 km$^2$ sewage collection system; 76 km$^2$ residential and 11 km$^2$ industrial area which covers most of the eastern suburb (King, 1995). Over 500,000 m$^3$d$^{-1}$ of combined sewage and industrial wastewater is treated and it also supplies 200,000 m$^3$d$^{-1}$ of treated sewage for reuse by industry in Beijing's eastern suburb and
200,000-300,000 m$^3$d$^{-1}$ for afforestation and agricultural irrigation (ADB, 1996). With its completion, the treatment rate of sewage in the city increased to 20-26%. Table 4 lists the four MWWTP that currently serve Beijing.

**Table 4 : Municipal Waste Water Treatment Plants Serving Beijing**

<table>
<thead>
<tr>
<th>Plant</th>
<th>Level of Treatment</th>
<th>Treatment Capacity (m$^3$d$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaobedian</td>
<td>Secondary</td>
<td>500,000</td>
</tr>
<tr>
<td>Beixiaohe</td>
<td>Secondary</td>
<td>40,000</td>
</tr>
<tr>
<td>Fangzhuang</td>
<td>Secondary</td>
<td>40,000</td>
</tr>
<tr>
<td>Juxianqiao</td>
<td>Primary only</td>
<td>10,000</td>
</tr>
</tbody>
</table>

Adopted from ADB 1996

The second phase of the Gaobedian MWWTP is expected to be completed in 1997 with an additional capacity of 500,000 m$^3$d$^{-1}$. This will increase the treatment rate of collected sewage in the city to about 40%. By the year 2000, the third phase of the Gaobedian MWWTP is expected to be completed bringing the treatment rate of collected sewage in Beijing to about 60% (official interview, 1996). Eventually, by the year 2010, municipal authorities hope to complete 16 sewage treatment plant projects which would result in a total daily capacity for secondary sewage treatment of 3.4 million m$^3$d$^{-1}$ (ADB, 1996).

Finding financing for such projects however, continues to be a problem. Normally, 20 to 30 % of financing for such projects comes from foreign government loans and development institutions (official interview, 1996). The funding for the Gaobedian project for example, was supplied initially from Japanese sources, in conjunction with soft loans from Nordic Investment Bank and the Swedish 'BITS' (Board of Investment & Technical Support) soft loan funding program for developing countries (King, 1995). The difficulties in obtaining funds for such projects are increased by the fact that there are many other priority projects competing for foreign
funds. The following statement summarizes this dilemma: "The central government employs a preferential policy for the use of foreign funding in sewage treatment. But there are many things which need foreign funding. Infrastructure construction, power plants, all are priorities." (Porter, 1996). In addition, an effective sewerage system depends on infrastructure to support such facilities. One official interviewed stated that some urban areas in Beijing still do not have complete sewer systems in place which is also costly to rectify.

5.35 Beijing's Water Supply Balance

Beijing is currently one of the 50 cities in China suffering from a serious shortage of water. With Beijing's huge population base of 14 million, Beijing's share of available water resources, at 400 m³ per capita, is only one 28th of the world's average, and one-seventh of China's average (Fan, 1996). Chronic water shortage problems are becoming a serious impediment to the development of the city. Officials interviewed expect that, at least in the short term, water quality and quantity problems will worsen due to increases in urban growth, living standards, and population increases from natural births and movement of migrants into the city.

Supply

Annual total water resources available to the Beijing municipality are dependant upon rainfall quantities that can vary significantly every year. Average rainfall in Beijing amounts to between 620 and 640 mm a year. In other terms, this amounts to approximately 10.5 billion m³ y⁻¹ over a municipal area of 16 800 km². As discussed previously, the majority of rainfall events occur during the months of August-September.

Table 5 illustrates available Beijing water resource estimates for rainfall probability levels of 50%, 75% and 95%.

Table 6 illustrates the increase of water supply capacity of Beijing between the years 1949-1995. It is evident that the water supply facilities have been expanded by a large margin: the water supply capacity increased from 86,000 m³ per day in 1949 to 2.3 million m³, which is an
increase of almost 26 times (Fan, 1996). In 1949, there was just one water supply factory in the municipal area, and currently there are 10 (Fan, 1996).

Table 5: Currently Available Water Resources and Water Demand in Beijing

<table>
<thead>
<tr>
<th>Municipality Available Resource</th>
<th>Probability %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50%</td>
</tr>
<tr>
<td>Surface water</td>
<td>2.08</td>
</tr>
<tr>
<td>Ground water</td>
<td>2.36</td>
</tr>
<tr>
<td>Total</td>
<td>4.44</td>
</tr>
</tbody>
</table>

Adopted from Nickum 1994

Over the next 10 years, the Beijing municipal government plans to build new water supply facilities. However, it is a challenge for authorities to keep up with growing water demands of the city since it takes about 4 years to build a water work factory. As in the case of sewage treatment plants, the city is always challenged in its efforts to find funding for projects to build new and upgrade existing water supply facilities.

It is also important to point out that significant quantities of water supplies are "lost" as a result of poor maintenance and repair of the existing water infrastructure in Beijing. Officials interviewed stated that a considerable portion of Beijing's water pipes are in a state of disarray since they are so old, with some being up to 60 years old. Interviewed Beijing authorities gave two estimates of leakage rates in Beijing's public water supply system. One estimate of 8% means that 0.32 billion m³ are leaked of the total 4 billion m³ per year. Another estimate of 5% means that 0.2 billion m³ leaked per year. The varying estimates most likely indicate that insufficient data is presently collected to determine more precise leakage rates. However, such estimates may be on the "conservative side" and leakage rates may be 20% at the minimum.
### Table 6: Increase of Water Supply Capacity in Beijing

<table>
<thead>
<tr>
<th>Year</th>
<th>Water supply m³/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1949</td>
<td>86,000</td>
</tr>
<tr>
<td>1960</td>
<td>300,000</td>
</tr>
<tr>
<td>1970</td>
<td>600,000</td>
</tr>
<tr>
<td>1980</td>
<td>1,300,000</td>
</tr>
<tr>
<td>1990</td>
<td>1,700,000</td>
</tr>
<tr>
<td>1995</td>
<td>2,300,000</td>
</tr>
</tbody>
</table>

Adopted from Fan, 1996

**Demand**

According to the municipal authorities, the demand for water in Beijing increased, on the average, 29% in the 1950s, 4.9% in the 1960s, 6.7% in the 1970s, 3.1% in the 1980s, and 5.8% since 1990.

The total water demand for the city presently lies in the region of 3.8 to 4.0 billion m³ yr⁻¹ (ADB, 1996). Of this amount, the agricultural sector is the largest water consumer in the municipality consuming approximately 60% of the total demand a year, the industrial sector consumes about 20%, and the municipal and public sectors consume approximately 10% of the total demand (official interviews, 1996).

Overall, it is evident that the available resources are generally inadequate to meet the current demand. "This observation is made more acute once it is appreciated that the figure for the groundwater resource is not the sustainable yield but the (larger) volume abstracted annually" (ADB, 1996).

**Domestic sector demand in Beijing**

In 1949, when the population was 1.5 million, about 40% of the residents were using running water and the average domestic water use at the time was 28 l/day per capita (Fan, 1996). Since that time, there has been a considerable increase in urban domestic water demand due to population increases and rises in the standard of living. Presently, average water use per capita in Beijing is 228 l/day (Fa, 1996). This figure includes daily water consumption at the home and at public facilities. However, in higher standard apartments, it has been calculated to be between 300
liters and 450 liters and in tourist hotels, per capita consumption was calculated to be as much as 2000 liters per day (Changming, 1983).

A family of three in Beijing presently consumes approximately 5 to 10 m$^3$ water a month depending on the season; about 5 m$^3$ are consumed during winter months and a maximum of 10 m$^3$ are consumed in the summer months (official interviews, 1996). The peak water demand occurs during the months of June, July, and August. Table 7 illustrates the increase of domestic water use per capita from 1949 to 1995 in Beijing.

<table>
<thead>
<tr>
<th>Year</th>
<th>litres/per person/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1949</td>
<td>28</td>
</tr>
<tr>
<td>1960</td>
<td>75</td>
</tr>
<tr>
<td>1970</td>
<td>80</td>
</tr>
<tr>
<td>1980</td>
<td>141</td>
</tr>
<tr>
<td>1990</td>
<td>173</td>
</tr>
<tr>
<td>1995</td>
<td>228</td>
</tr>
</tbody>
</table>

Adopted from Fan, 1996

5.36 Future Supply and Demand Projections

Since Beijing is currently at a high point of development and urban construction, the demand for water will increase significantly in the coming years (Fan, 1996). Specifically, water demand during the 1995 to 2000 period is estimated to continue increasing at a rate of 6% per year (Fung, 1996).

During the years 2000 to 2010, the water demand is estimated to increase at a rate of 3% (Fan, 1996). Annually, by the year 2000, Beijing will require 4.3 billion m$^3$ of water in a normal rainfall year or 4.6 billion m$^3$ of water in a dry year. The amount of water supplied in the year 2000 in a normal rainfall year is expected to be 4.1 billion m$^3$, and if a dry year, 3.4 billion m$^3$. Calculating by year according to average water demand and supply, the total deficit in the year 2000 is predicted to amount to approximately 0.2 billion m$^3$ (Fan, 1996). However, one
interviewed official predicts that the gap between water supply and demand in the year 2000 will be substantially greater than has been "officially" predicted.

As seen from Table 8, in the year 2010, in an average rainfall year, the amount of water supplied is estimated to be 3.9 billion m$^3$ and demand will reach 4.9 billion m$^3$. In such conditions, a total deficit of 1 billion m$^3$ will result. (Fan, 1996).

<table>
<thead>
<tr>
<th>Table 8 : Future Water Demand and Total Amount Available in Beijing</th>
</tr>
</thead>
<tbody>
<tr>
<td>billion m$^3$</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Total Supply Capacity</td>
</tr>
<tr>
<td>Total Demand</td>
</tr>
<tr>
<td>Total Shortage</td>
</tr>
</tbody>
</table>

Adopted from Fan 1996

Increases in water demands in the city will be accompanied by shifts in water consumption patterns among the sectors. As the city expands, agricultural water demands will continue to decline and there will be an increase in water consumption by the industrial, public, and municipal sectors. In the year 2010, planning officials predict that 46% of Beijing's water supplies will be consumed by the agricultural sector, 30% will go towards industry, and 24% will be consumed by the public and municipal sectors.

Among residential users, it is predicted that total domestic water consumption will increase to 240 litres per capita per day in the year 2000. (Liang, 1989).
5.4 Water Management Institutions in Beijing

As stated by the ADB (1996), "One of the most striking aspects of water management in Beijing is the dispersal of responsibilities across numerous institutions in the Municipality." This notion is illustrated in Table 9. The table, still, however, is not a full, comprehensive list of all institutions involved in water management in Beijing.

Typical of the relationship among Chinese institutions existing at the same bureaucratic level, interbureau cooperation and coordination of these institutions is poor, which continues to significantly inhibit Beijing's efforts to manage its water resources effectively. Also, although in theory, most of the institutions fall directly under the Beijing Municipal Government at the same level and therefore should retain the same amount of power, in reality some are more powerful than others (official interviews). Thus, environmental institutions in Beijing most often resort to persuasion tactics to push their priority initiatives through. And the use of "persuasion tactics" does not guarantee that environmental authorities' ideas will be met with approval from other bureaus.
Table 9: Illustration of the Dispersion of Responsibilities of Water Management in Beijing Municipality

<table>
<thead>
<tr>
<th>Responsibility</th>
<th>Organization(s) Involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation of City Master Plan</td>
<td>Planning Bureau, BMEPB</td>
</tr>
<tr>
<td>Provision of sufficient water resources</td>
<td>Water Conservancy Bureau (WCB)</td>
</tr>
<tr>
<td>Supply, treatment, and distribution of water</td>
<td>Public Utilities Bureau (PUB)</td>
</tr>
<tr>
<td>Protection of river water quality</td>
<td>BMEPB</td>
</tr>
<tr>
<td>Protection of surface water quality</td>
<td>BMEPB, WCB</td>
</tr>
<tr>
<td>Monitoring surface reservoir water quality</td>
<td>WCB</td>
</tr>
<tr>
<td>Protection of surface reservoir water quality</td>
<td>BMEPB, WCB</td>
</tr>
<tr>
<td>Protection of groundwater quality</td>
<td>BMEPB, PUB</td>
</tr>
<tr>
<td>Monitoring groundwater quality</td>
<td>Quarantine station, PUB</td>
</tr>
<tr>
<td>Monitoring groundwater near landfills</td>
<td>Quarantine station, PUB</td>
</tr>
<tr>
<td>Promotion of &quot;water conservation measures&quot;</td>
<td>WCB</td>
</tr>
<tr>
<td>Promotion of water demand-management measures</td>
<td>Water Saving Office (WSO) under the PUB</td>
</tr>
<tr>
<td>Municipal wastewater treatment (MWWT)</td>
<td>Office of Municipal Works (OMW)</td>
</tr>
<tr>
<td>Monitoring discharges from MWWT</td>
<td>OMW</td>
</tr>
<tr>
<td>Control of industrial wastewater discharges</td>
<td>BMEPB, Industry Bureaux</td>
</tr>
<tr>
<td>Monitoring of industrial wastewater discharges</td>
<td>BMEPB</td>
</tr>
<tr>
<td>Promotion of cleaner industrial production</td>
<td>Industry Bureaux</td>
</tr>
<tr>
<td>Control pollution from animal husbandry</td>
<td>Animal Husbandry Bureaux</td>
</tr>
<tr>
<td>Control use of fertilizers and pesticides</td>
<td>Agricultural Bureau</td>
</tr>
<tr>
<td>Collection of water usage fees</td>
<td>PUB</td>
</tr>
<tr>
<td>Collection of industrial effluent fees</td>
<td>BMEPB</td>
</tr>
<tr>
<td>Water leak inspections</td>
<td>WSO (PUB)</td>
</tr>
<tr>
<td>Repair and maintenance of public water infrastructure</td>
<td>PUB</td>
</tr>
</tbody>
</table>

Adapted from ADB, 1996
Conclusion

Factors causing water shortage in Beijing are typical of many cities in China. These include: overburdened water works and infrastructure facilities, a lack of sewage treatment facilities, the continued existence of polluting industries, increasing amounts of domestic sewage and agrochemicals, and increasing standards of living. As discussed in this chapter also, water shortage continues to harm Beijing's environment, economy, and the daily lives of citizens. These problems are expected to intensify rather than diminish since future demand and supply projections made by local authorities predict that water shortage in Beijing will become more acute. However, despite municipal authorities' attempts to cope with water shortage and other water-related problems in the city, there exists a lack of financing for water projects in the city. Also, political-economic and organizational factors existing within Beijing's government institutions continue to inhibit authorities' efforts.
CHAPTER 6

SUPPLY-SIDE STRATEGIES TO MEET BEIJING'S WATER DEMAND AND ASSOCIATED IMPLEMENTATION ISSUES

Given the increasing seriousness of Beijing's water supply situation, there are a number of supply-side strategies that have been proposed by Chinese scientists and authorities. However, due to the technical complexities and large financial costs associated with such projects, the Beijing municipal government is not actively pursuing the majority of them. Even for the one project that does appear to have widespread approval among Chinese authorities - the south to north water transfer project - many uncertainties remain.

6.1 Proposed Strategies

Some scientists believe that artificial recharge of groundwater could be one method to raise low groundwater levels and prevent further land subsidence in Beijing (Ma, 1985). This technique is thought to be feasible in areas of Beijing where the alluvial material could be channeled from the hilly regions to appropriate lowland localities during the flood season for artificial recharge. For example, in a year when rainfall is plentiful, sand pits and dry river-beds in the western suburbs may store flood water and the overflow from the reservoirs; these waters could then be instilled into the underground for reserve. Ma (1985) revealed that experiments conducted in Beijing demonstrate that artificial recharge is feasible, although more research is needed to solve a number of theoretical and technical problems.

Luo (1993) of the Beijing Municipal Planning Bureau believes that Beijing's wastewater is a valuable resource, ideally to be treated and reused for a variety of purposes. For example, he proposes that after treating wastewater supplies, industries in Beijing could use such supplies for cooling water. In addition, these water supplies could be used as a reliable water source for tree
planting, rivers, and lakes in the city (Luo, 1993). Luo estimates that potentially treatable wastewater supplies may be able to satisfy 11% of the projected demand in the year 2000.

Desalinization technologies have been developed in China since the 1950s. Since the 1950s, several desalination stations have been established in the country in Tianjin, Shanxi Province, Gansu province, and Hong Kong. It is believed that sea water could be used for flushing waste, washing, and drainage purposes in Beijing (Laquian, unpublished). However, such projects are very costly which is probably why there are no definite plans to determine its potential in Beijing presently.

6.2 Approved Strategy - The "Middle Route Water Transfer Project"

The "Middle Route Water Transfer Project" is one of the largest supply-oriented water infrastructure projects in the world. It involves diverting water from China's southern Yangtze river and transferring this water up to the northeast.

The "Middle Route Water Transfer Project" consists of a short-term plan for diverting water from the Danjiangkou reservoir on the Hanjiang river, which is a tributary of the Yangtze River, in Hubei and Henan provinces, and a long range plan for supplementing of water supplies from the main stream of the Yangtze River.

When the Three Gorges dam on the Yangtze river in southern China is completed, it will significantly raise the water level of the Danjiangkou reservoir. Water from the Danjiangkou Reservoir will then be transferred from the Three Gorges along the generally by-gravity water conveying stem canal on the western side of the Beijing-Guangzhou railroad, pumped over the Yellow River - Yangtze Divide, and then will be siphoned underneath the Yellow River to Beijing, Tianjin, Hubei, Henan, and Hebei provinces. Upon completion, the water transfer canal will total a length of 1246 km with an annual transferable quantity of approximately 14.5 billion m$^3$ of water (Ministry of Water Resources, 1995).

This project is estimated to cost at least $3 billion and on average supply Beijing with 1.2 to 1.3 billion m$^3$ of water annually (Laquian, unpublished).
However, there is no approved timetable for the execution of this massive project (official interview, 1996). Much of the uncertainty centers upon the lack of capital investment for the project. The ADB(1996) describes the situation in these words: "Given the great need of the Chinese National and local Governments for capital investment in a wide range of projects, there is a real risk that the water transfer scheme will not be implemented in time to avert a major water shortfall in Beijing". Also, there exist many other concerns besides those of a financial nature surrounding the water transfer project.

For example, water in the Yangtze river is becoming seriously polluted. It was reported in 1995 that there were more than 3,000 industries discharging one billion m$^3$ of waste water with more than 50 pollutants a year in the Yangtze river and that the shoreline of the Yangtze river is piled with heaps of garbage and industrial sludge (Du, 1995). Thus, much capital will also have to be obtained to treat such polluted waters that are transferred up to the north.
Also, since soils of the North China Plain are loosely packed loess soils, it is feared that a mass transfer of water from the south will considerably increase soil erosion in northern China (Jowett, 1986).

Further, the area to be irrigated along most of the Middle Route is situated in the fluvial-alluvial plain zone. The original water table is relatively high and rather serious salinization has already occurred. The import of a large amount of water would most likely cause the water table to rise and the area of saline soil will expand correspondingly (Jowett, 1986).

The long main canal of the central transfer route would also cross 168 rivers and may cause much disturbance to the natural flows of those rivers. Where the canal intercepts the river flows, it would affect the flood discharge and sediment patterns in those channels (Jowett, 1986).

Finally, there are concerns that this project will increase incidences of diseases in the south and result in the transfer of such diseases up to the north. For example, the Chinese Anopheles mosquito is a carrier of contagious malaria. Its larvae propagate mainly in static water bodies such as reservoirs, paddy fields, and puddles. The considerable enlargement of the static water surface of the Danjiangkou reservoir that is necessary for the northward water transfer could not only cause an increase in the incidence of malaria in the region, but also bring the disease to the north (Changming and Nickum 1983).

There also exist many environmental, social, technical, and economic issues related to the damming of the Three Gorges, which is an integral part of the Middle Route project and officially started construction in December 1993. These include changes in sedimentation patterns of the Yangtze River, the potential for increased frequency of landslides and earthquakes around the Three Gorges Dam area, potentially devastating changes in the ecosystem of the three gorges, losses in cultural relics and sites, and the relocation of up to 1.2 million residents (Zhang, unpublished).

Even with the completion of the "Middle Route project", some feel that the benefits of this project have been exaggerated and question the ability of this project to ease water shortage problems in northern China. Liu (1996) states that, even with the successful completion of the
proposed south to north water transfer, the amount of water to be supplied to Beijing will not be substantial enough to support continued development of the city. One government official interviewed expressed a similar view and stated that it is likely that, by the time the project is completed, population increases and the continued in-migration of approximately 60,000 to 100,000 migrants to Beijing per year will blunt the ability of this project to significantly alleviate Beijing's worsening water crisis.

Conclusion

This chapter outlined the various supply-side strategies proposed by Beijing authorities to alleviate water shortage problems in the city: the artificial recharging of groundwater reservoirs, tapping sea water supplies, reusing Beijing's wastewater for purposes where freshwater supplies are not necessary, and transferring water from the Yangtze river in southern China to Beijing. However, this part of the study suggests that authorities and Beijing society in general cannot be complacent by thinking that supply-side strategies will significantly alleviate Beijing's water shortage problems. Many technical and financial uncertainties associated with such measures remain. Also, serious negative environmental and social impacts may result with the execution of the "Middle Route Water Transfer Project". In bringing such issues to light, this chapter suggests that authorities need to give more consideration to demand-management based strategies.
CHAPTER 7

WATER DEMAND-MANAGEMENT IN BEIJING

7.1 History and Institutions

Beijing's water demand-management efforts began in 1976 when a "water saving leading group" was established by the Beijing municipal government. In 1981, controlling water demands in Beijing was declared an important task to be undertaken by municipal authorities, and a policy titled "Economization, exploitation, and protection of water resources should come together" was incorporated into the general plan of urban development. Subsequently, the Beijing Municipal Administration Committee was given the responsibility to act as head organization in charge of Beijing's conservation efforts. In 1981, authorities established the The Beijing Municipal Water Saving Office under the Beijing Municipal Public Utilities Bureau to act as the main administrative organ to carry out water demand-management initiatives in the city.

7.2 Institutional responsibilities

Provisions relevant to the responsibilities of existing water demand-management administrative organs are included in Article 8 of the Beijing Municipality Regulations on Economical Use of Water (1986), which states,

The Beijing municipal administration committee is the leading organ of the city's water conservation initiatives, consisting of the municipal public utility bureau and the municipal water saving office which are responsible for daily tasks. District and county departments set up water conservation offices, divide duties, and perform different tasks for their own district and county. Their work is reported to and under the direction of the Beijing municipal water saving office.
Different industries should also set up management departments and divide up duties to perform water conservation tasks and they should report to the municipal water conservation office.

Further, Article 4 *Beijing Municipality Regulations on Economic Use of Water (1986)* stresses that,

Different levels of government should emphasize leadership for water conservation work, and incorporate water conservation programs into the country's economic and social development plans.

Municipal city planning design department should, according to *Beijing Municipality's Overall Construction Regulation requirements* incorporate water conservation into specialized planning and detailed planning.

The major tasks of the Municipal Administration Committee are to: 1. Integrate management of operations and maintenance of municipal infrastructure and public utilities; 2. Guide, co-ordinate, supervise and inspect the rooms, land, environmental protection, water supply, gas supply, thermal supply, gardens, afforestation, city appearance, environmental sanitation, transportation, and other infrastructure *(ADB, 1996)*.

The main responsibility of the Public Utilities Bureau is to: draw up and implement plans regarding tap water supply and central heating in the city *(ADB, 1996)*.

The responsibilities of the Beijing Water Saving Office are: 1. To allocate water quotas to units (danwei). To charge units for extra use of water beyond their allocated quota based on a progressive rate system. 2. To supervise and manage the development, metering, etc for self-dug wells. 3. To inspect water leakages. 4. To organize, research, and develop new technologies and installations, and 5. To publicize the importance of water conservation and to raise residents' awareness of water conservation *(BMWSO, 1996)*.

In 1991, the Standing Committee of the Beijing's Municipal People's Congress adopted the *Beijing Municipality Regulations on the Economical Use of Water in Beijing (1986)* and a network of water demand-management administrative organs was established.
As seen from Figure 8, there exist two three-level management networks; one being water saving management bodies on the level of municipality, district, and residential community, and the other on the level of municipality, administrative bureaus and individual institutions. The municipal and district-level governments are in charge of joint efforts (BMWSO, 1996).

7.3 Institutional Relationships

According to officials, the Water Saving Office carries out its responsibilities largely as an independent unit, not possessing any consistent relations, formal or informal, with the other municipal bureaus involved in water management in Beijing such as the Beijing Municipal Environmental Protection Bureau and the Water Conservancy Bureau. As is the case for other environmental institutions such as the Beijing Environmental Protection Bureau, the Beijing
Municipal Water Saving Office does not have formal relations and engage in significant cooperative efforts with water management bodies at the National level such as the Ministry of Water Resources. The continuing lack of coordinated efforts at the municipal and national level has no doubt held back effective implementation of water demand-management policies in Beijing.

7.4 Water Demand-Management Policies in Beijing


In general, the regulations include provisions related to economic, administrative, and technological aspects of water demand-management. The main subject areas the laws and regulations focus upon are: principles of urban water demand-management, awards for saving water, punishment provisions for wasting water, the use of special funds for groundwater reserves, the collection of extra charges for excessive use of water, provisions concerning industrial water quotas, requirements for the construction of individual water-saving devices, requirements for
water balance testing in consumer institutions, requirements for the use of cooling towers, technical specifications for water-recycling equipment, requirements for the construction of toilet-water treatment devices and the use of residential toilet water tanks (BMWSO, 1996).

Municipal authorities report that between the period of 1981-1995, i.e. over a 14 year period, the amount of water cumulatively saved in Beijing was 1.1 billion m$^3$ (Fan, 1996). In the overall picture, however, this does not appear to constitute a significant amount, considering that in just one year the city now consumes about 4 billion m$^3$. In addition, as seen from Figure 9, highly variable water savings rates per year perhaps suggests that water demand-management programs have not yet resulted in any significant, consistent water savings in the city.

Figure 9: Water Savings in Beijing Municipality 1981-1995

![Bar chart showing water savings in Beijing Municipality 1981-1995](chart.png)

Adopted from Fan 1996

The following section details the current water demand-management strategies existing in Beijing municipality. In addition, this section discusses a policy called the "satellite city concept", which is not a water demand-management strategy in the conventional sense, but rather a city-wide planning program to ease water shortage problems in the city.
7.41 Water Quotas

Water quotas are a demand-management strategy pertaining to Beijing's industrial and public sectors. General provisions for both the industrial and public sectors include Article 5 of the Beijing Municipality Regulations on Economic Use of Water (1986), which states that,

This city has started to carry out water usage planning and water conservation. For any new users, a limit to water quantity should be set and the user should not go beyond the set upper limit. Quantity control to strictly limit water usage for larger construction projects requiring water in different industries and residential water usage carry out step by step water regulation control.

Further, according to Article 7 of the Management regulation on Beijing Water Conservation (1989),

Planned management of water shall be carried out by water-using units. Annual water quotas shall be given by the water saving offices of city, district, county according to the management competence of water. Water-using units must strictly adhere to the quota.

A progressive rate system ranging from double to one hundred the normal water rates will be introduced if a water-using unit surpasses its quota. Specific regulations shall be established by the urban water saving office and submitted to the municipal people's government for approval.
Units that utilize groundwater resources are assigned water quotas according to a permit system. Article 10 of the *Management regulations on Beijing Water Conservation (1989)* states that,

The municipal water saving office shall conduct unified supervision and management of water saving work of units which fetch groundwater by self-provided wells. Any unit which needs newly-built self-provided wells must report to and obtain approval in accordance with the provisions of the municipal government; after self-provided wells are completed, no permission shall be given for them to be used until the wells are examined and considered up to the standard by the planning management bureau of the municipal and the municipal water saving office and the units are given a license by the water saving office to use the self-provided well. Units fetching groundwater by self-provided wells should pay water resource fees and groundwater resource maintenance funds in accordance with the provisions of the municipal government.

### 7.42 Education Measures

The importance of education measures in Beijing's water demand-management strategies is stressed in Article 9 of the *Beijing Municipality Regulations on Economic Use of Water (1986)* which states that "Different levels of government units and industrial units should emphasize increasing awareness and education among the public about water conservation".

The main bureaus involved in education measures include the Beijing Water Tap company under the Public Utilities Bureau, and the Beijing Water Saving Office. Methods to educate and build awareness in Beijing's general population about water demand-management have been largely through the use of popular media such as television, radio, and newspapers (official interviews). Also, the environmental protection bureau develops teaching materials concerning water issues for distribution among primary and secondary school teachers. The Beijing Municipal Water Saving Office produces posters that are distributed to shopowners in popular shopping districts. In addition, there exists a widely publicized one week media campaign about saving water and other water related issues called "Water week". "Water week" is a program which has been held annually in the month of June since 1993.
7.43 Water Saving Technology and Techniques

There are two general provisions which encourage Beijing units to adopt water saving technology and techniques: Article 5 of the Management regulations on Beijing Water Conservation (1989) states,

Water-using units should adopt advanced technologies in water saving to reduce water consumption and improve the rate of the recycling utilization of water, and appoint a specific organ or persons to be responsible for the daily management work of water saving of the units and accept the professional guide of the municipal water saving office.

Article 6 of the Beijing Municipality Regulations on Economic Use of Water (1986) adds,

This city encourages and supports the development of science and technology research on water conservation. The city encourages the use of modern technology and increasing scientific and technological standards in water conservation work. Water using units should emphasize the use of modern technology and encourage the consumption of less water and increase the rate of recycling.

According to the Beijing Water Saving Office in their document titled "Approaches to Effective Control of Urban Water Demand" (1996), for several years, they have been working to develop and popularize the technique of reusing wastewater in the paper-making industry, printing, dyeing industries, and encourage wastewater treatment in the electroplating, and building materials industries. The Beijing Terrazzo Plate Plant and the Capital Automobile Company are two companies that have been successful in saving significant amounts of water by adopting more efficient technology and techniques. The Beijing Terrazzo Plated Plant now treats its waste water from grinding and polishing processes for reuse and has reduced the per square meter output of water consumption from 1.4 m\(^3\) in 1985 to 0.67 m\(^3\) presently (BMWSO, 1996). Technical innovations to recycle and process water in carwashing projects carried out in the Capital Automobile Company in Beijing resulted in the amount of water for washing each car falling from 1 m\(^3\) to 0.15 m\(^3\) (BMWSO, 1996).
7.44 Water Metering and Pricing

Historical Perspective

Water fees in China were originally introduced in the early 1950s to serve as the primary source of revenues for system maintenance and management of China's urban water supply. State run water enterprises and irrigation districts by law collected service fees. However, in the agricultural sector, since fees were assessed on the basis of area irrigated rather than volume consumed, operators applied water inefficiently. Also, in the domestic and industrial sectors, flat rates rather than volume based rates were paid (Ross, 1988).

Greater attention was given to market methods in water policy in the post-Mao era of the late 1970s. This happened for a number of reasons. For example, economists were freer to advocate market methods in water policy; and there were severe droughts in the early 1980s which led to factory shutdowns for periods of time (Ross, 1988). To avoid further disruptions to economic development, the government was willing to seek out other types of solutions.

In 1981 the national government ordered an end to flat rate pricing throughout the country. All residential and urban consumption was to be metered, and flat-rate pricing was replaced by volume-based pricing. New construction projects incorporated household meters, while existing housing each had meters installed. In 1982, 58% of the households in the 15 largest cities in China were reported to be served by individual water meters.

In 1984, the State Council issued a new directive focusing on urban water conservation stressing that "water be regarded as a commodity rather than gift of nature". The new policy was put into operation in a set of regulations on water utility rates in 1985. In 1985, all large municipalities such as Beijing and medium sized municipalities adopted progressive rate schedules. That is, public utilities began charging for water in terms of incremental block pricing. Usage norms were calculated and consumption of water above the norm was priced higher. This type of pricing was to encourage conservation and recycling while ensuring social equity with low flat rates for ordinary consumption (Ross, 1988). Article 24 of the Management Regulations on
Beijing Water Conservation (1989) reflects this new policy and states that "Residential water use should be charged according to calculated fees and flat rates mustn't be used".

**Water prices in Beijing**

Currently, the price of water in Beijing in the agricultural sector is generally 4 fen (.006 Cdn) per m³, while water used for growing grains is 2 fen (0.002 Cdn) per m³. In industry, the water price depends on the water source; water from tap sources is 8 mao (0.11Cdn) per m³, river water costs 2.3 mao (0.03 Cdn) per m³, and groundwater is 1.6 mao (0.02 Cdn) per m³. Domestic users pay 5 mao (0.07 Cdn) per m³, a recent increase of 2 mao (0.03 Cdn) per m³ in the summer of 1996 (official interviews, 1996).

**Water Metering in Beijing**

Interviewed officials stated that the majority of residential users living in the urbanized areas of Beijing are metered. However, in the outer rural areas, metering of residences is minimal, which causes significant amounts of water to be wasted in rural Beijing; and this needs to be remedied.

One demand-management strategy is the installation of water meters. Another strategy is the act of performing regular inspections of such water meters and repairing them if they are faulty. Provisions for regular inspections of water meters and repairing poorly working ones is mentioned in Article 11 of the Management Regulations on Beijing Water Conservation (1989) which states,

Water-using units should fix the water meters of water consumption. Water-using units using beyond 2,000 m³ every month must carry out a water balance test based in accordance with <Management regulations on water balance test of watering units in Beijing>. If situations are discovered where water is wasted, water-using units must immediately adopt measures of control and improvement.
7.5 The Satellite City Concept

"Water supply in Beijing is becoming shorter and shorter as the scale of the city expands and the population increases. Most of all, controlling the scale of the city is the important and necessary step to relieve the shortage of water supply" (Beijing student, 1996).

Another policy (although not considered a conventional demand-management measure) to ease pressures on water infrastructure due to the large and growing population base in Beijing is the "satellite city concept". Planners in Beijing have adopted a plan for urban development which calls for the development of existing county towns outside the inner city and suburban areas of Beijing. Aspects of this plan include the relocation of present and future residents, and the relocation of industries and development of future industries into these "satellite towns".

Presently, a total of fourteen county towns are being planned as satellite cites. One interviewed official reported that approximately 300 factories have been moved into such satellite regions to date. However, this was accomplished over a considerable time period, 10-20 years. Also, another official pointed out the fact that factories that have been moved out to date are actually a very small fraction of the total factories in Beijing (recall that the total number of industries in Beijing is presently 21 000). In general, several authorities discussed that although this policy "looks good on paper" in reality it has not been very successful. As discussed earlier, there are still an estimated 60 000 to 100 000 migrants flocking into Beijing annually. Also, many people currently living in the inner regions of Beijing are reluctant to move out to the satellite areas in part due to a lack of amenities in the satellite towns (official interview, 1996).
Conclusion

To summarize, the main water demand-management strategies which currently exist in Beijing include: the use of water quotas, water metering pricing strategies, water saving technology and techniques, and public education programs. For each of these measures, authorities have promulgated a set of regulations which are comprehensively summarized in the documents, *Management Regulations on Beijing Water Conservation (1989)*, and *Beijing Municipality Regulations on Economic Use of Water (1986)*. Municipal planning authorities are also managing the "satellite city concept" project which aims to restrict population growth and industrial development of the city to ease water shortage problems in the core municipal region. Although such measures have resulted in water savings in the city, the amount of water savings incurred by each measure is unknown. Also, based on figures supplied by authorities, it appears that collectively, water demand-management measures in Beijing are not yet resulting in significant and consistent water savings in the city.
A CASE STUDY ON PUBLIC OPINION AND PERCEPTION OF WATER DEMAND-MANAGEMENT IN BEIJING'S PUBLIC SECTOR

This chapter discusses the results of the survey distributed to university students at Beijing and Qinghua universities, and the Chinese Academy of Sciences. (Refer to appendix B for a copy of the survey and appendix C for a tabulation of the results). In order to gain some insights into the "social acceptability" of water demand-management measures in Beijing's public sector, questions in the survey were designed to answer the following primary questions:

1. What is the nature of survey respondents' environmental ideology?

   This is a logical starting point from which more specific questions about Beijing's environmental and more specifically, Beijing's water issues may be approached.

2. How important are Water Quantity Issues to survey respondents?

   An investigation of how important Beijing's water issues are perceived to be by survey respondents relative to other societal issues is important. Merely focusing on water issues provides no context as to how respondents will prioritize water demand-management initiatives in their daily living.

3. What are survey respondents' perceptions and knowledge about Beijing's current and future water supply?

   It is important to be cognizant of survey respondents' perceptions about and knowledge level of Beijing's water supply problems since "...perception plays an important role in how people react to demand-management programs" (U.S. National Regulatory Research Institute, 1991).
4. How much do survey respondents know about water conservation and what are their information sources regarding water demand-management initiatives?

As discussed earlier, education about water saving techniques one may practice in the public sector is a current demand-management strategy in Beijing. Information which gives insights into the effective/ineffective aspects of these programs will help to improve them.

5. How acceptable are current and/or potential water demand-management strategies in the public sector to survey respondents?

These are the essential questions to be investigated in the survey. The answers to such questions will provide valuable suggestions to ensure the continued success of currently existing demand-management strategies and insights into potential strategies which may warrant further studies into their feasibility to be pursued as a viable water demand-management strategy in the public sector for the city of Beijing.

8.1 Water Demand-Management Policies in the Public Sector

In summary, water demand-management strategies that exist in the public sector include: water quotas, water metering and pricing, education measures, and water techniques and technology. Here, more specific details about water demand-management regulations in the public sector will be outlined, and strategies that have been adopted in the surveyed university campuses will be described.

Provisions specifically relevant to the management of water quotas in the public sector include Article 9 of the Management Regulations on Beijing Water Conservation (1989) which states:

Quota management shall be carried out regarding industrial and residents' domestic water consumption. The specific measures shall be prescribed by the municipal water saving office and relevant departments of the municipal government and be submitted to the municipal people's government for approval.
The role of technology in the public sector is outlined according to Article 13 of the *Management Regulations on Beijing Water Conservation (1989)* which states that,

> Water-using units and individuals should choose water saving equipment and wares up to quality standards... Shower instruments in public bathrooms and bathrooms of units should use water saving devices...

Specific technologies the Beijing Water Saving Office have been researching, developing, and encouraging the use of are accessories for water-saving tanks, toilet water controllers, water-saving shower nozzles, water-saving taps and time-delay automatic-off equipment (BMWSO, 1996).

### 8.2 Water Demand-Management on University Campuses

Authorities at Beijing and Qinghua university campuses were interviewed to determine which types of public sector demand-management strategies existed on their respective campuses. As I was unable to locate the appropriate authorities to interview about water demand-management strategies on the CAS campus, I interviewed a group of students who had recently lived on the campus or attended the attention.

#### 8.21 Institutions in charge of water demand-management initiatives on Beijing and Qinghua university campuses

The institutions responsible for formulating, developing, and administering programs and regulations related to water demand-management measures at Beijing and Qinghua universities include the University Resources Savings Office and the Environmental Protection Office at Beijing University, and the Water Management Office at Qinghua University.

School authorities formulate many of the regulations at Beijing and Qinghua university campuses according to guidelines provided by the Beijing Municipal Water Saving Office. For example, water quotas exist on the Beijing and Qinghua university campuses. At Qinghua
university, 3 m$^3$ per month of water is allocated to each person living on campus (dormitories and apartments). At Beijing university, there are varying water quotas. Teachers and their family members living on campus are rationed 3.5 m$^3$ per person a month. Usually, teachers living in apartments have individuals water meters and if their consumption is beyond their designated quota, then they are charged a higher water price. Undergraduate students are rationed 2.5 m$^3$ of water a month and graduate students 3.5 m$^3$ of water a month (official interviews, 1996). However, such rations in reality are obviously difficult to monitor and it is unclear as to how students' water quotas are actually policed.

According to authorities interviewed, other demand-management strategies on the Beijing and Qinghua universities include water efficient technology such as infrared controlled water fixtures on taps and urinals. However, when students who have lived at the campuses for several years were questioned as to their exposure to such technologies, they replied that they had not come across them. Also, on Qinghua university campus, showers contain "water-saving, pressure controlled shower boards" which, when stepped on, allows water to spray from the overhead shower tap. However, students on the campus mentioned that although they exist, they no longer function since they have broken down due to a lack of maintenance over the years.

Educational programs are in place on both campuses to teach campus residents techniques to save water. A popular slogan is promoted on Qinghua campus; "There is glory in saving water, and shame in wasting water". During "Water week", Beijing university's undergraduate and graduate students are very active in putting up posters, making speeches, and making television and radio broadcasts about environmental issues. Also, at Beijing university, students, in cooperation with the National Environmental Protection Agency, are engaging in projects to produce educational films about environmental issues. Units and individuals on Qinghua campus who have made notable achievements in saving water are designated as "models" and are given awards and their achievements are publicized on television, radio, and/or in newspapers (official interviews, 1996).
CAS students stated that the only water demand-management strategies they were aware of was a campus regulation which restricted showering to six days a week. Although I was unable to locate school authorities at the CAS campus, I believe it is unlikely that other strategies were implemented on campus since students at the other campuses proved to be very reliable sources for information regarding water demand-management measures on the campuses.

8.3 Results of Survey *

In total, 339 students were surveyed from the Beijing University, Qinghua University, and Chinese Academy of Science campuses. A diverse group of arts, science, and technical students from various departments were selected at each institution. Students surveyed at Qinghua university included those in the architecture, economics and management, foreign language, and mechanical engineering departments. At Beijing university, urban and environmental studies, geology, information management, and law students were surveyed. Finally, at the Chinese Academy of Science, students in the computer science, electronics, atmospheric environment, ecology, biology, geology, chemistry, aeronautics, and foreign languages departments were surveyed.

Out of the 339 students surveyed, 38 % were female and 62 % were male. 47.3 % were bachelor students, 49.1 % master, and 3.6 % were studying for Ph.D degrees. The average age of the students surveyed was 24. In terms of their living conditions in Beijing, 65.8% of the students lived in dormitories on campus, 21.5% lived in apartments (either on campus or outside), and 12.7% lived on campus but also had opportunities to stay with relations or friends at an apartment in Beijing.

* Refer to appendices B and C.
8.31 Environmental Ideology

In order to gain a general sense of students' attitudes towards the environment, four statements, albeit abstract, were put forward to students describing different kinds of relationships between man and the environment. Respondents highly rated all statements which conveyed a sense of protection and preservation for the environment, and efficient utilization of resources. These three statements rated 8.0 or higher on a scale of 1 to 9. The students, thus not surprisingly, strongly opposed the statement, "People should be free to use the environment to increase their standard of living" (rating this statement a 2.2 mean out of a scale of 9).

8.32 Relative importance of environmental issues

In section III of the survey, a total of a possible 11 societal issues were presented to students to rank in terms of their importance. The issues presented to students were energy supplies, unemployment/jobs, crime/corruption, health care, inflation, quality and access to education, competence of the political leadership, air pollution, water quality, water quantity, and other. The "other" category was included to give the student freedom to include and rank another issue which he/she thought to be important and rank. "Other" societal issues students considered to be imperative included: housing (5 responses), birth or population control (3 responses), traffic (13 responses), people's morality (4 responses), media (2 responses), social stability (1 response), cultural life and entertainment (4 responses), the floating population (1 response), living standards (1 response), forestry (2 responses), political reform (1 response), and city planning and transportation (1 response). The most important issue, that is, the most highly rated issue in this section, in the view of student respondents, was jobs/unemployment. Following, from second most important to least important were: education, crime/corruption, inflation, air pollution, energy

---

9 Refer to survey Section II. in appendices B and C.

10 Refer to survey Section III. in appendices B and C.
supply, competence of the political leadership, water quality, health care, water quantity, and other. It is probably not surprising that jobs/unemployment and education are top concerns of students at their stage in life and the pressures they face in seeking employment upon graduation. It is interesting that, although air pollution ranked in the top five issues, water issues were ranked relatively low. However, results in the next section of the survey suggest that the low ranking of water issues should not be interpreted as meaning Beijing's water supply issues are not of concern to survey respondents. In fact, as described in the following section, students as a whole are pessimistic about the water supply situation in Beijing. It seems that an appropriate interpretation is that, although the state of Beijing's water supply is a worrying issue, there exist other issues in Beijing which are even more disturbing and immediate to students.

8.33 Perceptions about Beijing's current and future water supply

Students in general did not exhibit a strong tendency to hold a positive or negative position on the two statements, "I'd like you to characterize the water supply in Beijing" and "What about the water quality?" In addition, the students viewed water shortages as having little impact on their lives. This is surprising given that, as discussed in previous chapters, Beijing is one of the driest cities in China and the city's development has suffered significantly as a result of water shortages. This may suggest that there is a lack of information on the seriousness of Beijing's water issues. Other reasons for such responses may be that, compared to other institutions in Beijing, these universities are "fairly well endowed" with adequate water supplies. One student interviewed suggested that authorities are motivated politically to keep these institutions well supplied with water since students might "make trouble" if they are not content. Also, students may have answered such questions by comparing the water supply situation in Beijing to other cities in

---

11 Refer to survey section III in appendices B and C.
China. In terms of water quantity, there exist other cities in northern China, such as Xian, that experience worse water shortage problems than Beijing does.

However, it is evident that students are pessimistic about the future prospects of Beijing's water supply. Four statements which solicited their opinions about the short term and long term expectations for Beijing's water supply in terms of quality and quantity all rated on the negative side (i.e. less than five on a scale of one to nine).

An unexpected finding was that students are unaware of the fact that agriculture is the major water consuming sector in Beijing. Rather, they mistakenly view industry as the largest water consumer in Beijing. (As discussed in chapter 5, in reality, approximately 60% of water in Beijing is consumed by the agricultural sector, 20% by industry, and 20% by municipal and public sectors). Further, respondents held the view that in the year 2010, the industrial sector will remain the major water consumer in Beijing, with agriculture coming in second, followed by the municipal and public sector. As discussed earlier in Chapter 5, estimates by the municipal planning bureau project that agriculture will remain the largest consuming sector followed by the industrial sector.

Another significant finding was that many students are unaware that there is a basic relationship between water quality and water quantity (that being an increase of water supplies means better water quality and vice versa). Respondants were presented with three choices to indicate their position on the question, "Will improvements in the water quantity situation help improve the water quality in Beijing?": yes, no, and unsure. 50.8 % chose "no", believing that improvements in water quantity will not bring improvements in water quality, and 32.1 % chose "unsure", uncertain as to whether or not this relationship exists.

In terms of students' views about the efficiency of water use in Beijing, they rated all sectors as being inefficient water consumers. On a scale between one and nine, with one being very inefficient and 9 being very efficient, averages for the industrial, agricultural, public, and municipal sectors were 3.19, 3.70, 3.36, and 3.62 respectively. I thought it was unusual that students rated the industrial sector as being most inefficient since it is in this sector that authorities are concentrating the majority of Beijing's water saving measures. It is my belief that students'
responses in this question is an indicator of which sector they believe should be held most responsible for saving water in the city. In other words, students, by ranking industries as the least efficient water users, indirectly communicated their opinion that industries should make the most efforts (as opposed to other sectors) to adopt water demand-management strategies in the city.

In this section, the public sector was further broken down into categories and students were asked to rate the efficiency of water use in: public washroom facilities, public institutions such as schools and hospitals, residences, and small private businesses such as private restaurants, tailor shops, hair salons, etc. Here, students perceived public facilities as being more wasteful of water than residential users and private establishments. Again, on a scale of one to nine, with one being very inefficient and nine being very efficient, water use in public washroom facilities was rated 3.39, water use in public institutions 3.56, water use in residences 5.45, and water use in small private businesses 5.34. Although water efficiency percentages in the public sector is unknown, authorities interviewed revealed similar, albeit more general, perceptions. An authority stated that people are more conscious about saving water in residences and in small businesses than in public facilities.

8.34 Knowledge about water conservation

Students were next asked to rate how much they feel they know about water conservation and to give their input about the availability of information regarding water conservation. In general, respondents felt that they possessed a "reasonable amount of knowledge about saving water". That is, on average, they did not show a strong tendency to claim that they "know nothing at all" or "know a lot" about water conservation. Also, as a group, they believed there is a "reasonable amount of information about water conservation". That is, there was not a tendency for the students to claim that "there is a lot of information about water conservation" or "there is no information at all about water conservation".

12 Refer to survey section IV in appendices B and C.
Students' main information sources for gaining knowledge and awareness about water conservation are through the popular media: the newspaper (88.7% surveyed), television (86.4 % surveyed), radio (71.8% surveyed); school courses (60.8% surveyed); posters in public areas (45.7% surveyed); discussions with friends (47.8% surveyed); and posters on campus (39.2% surveyed).

Students were also asked how confident they were in their ability to improve Beijing's water shortage problems if they, as individuals, adopted water demand-management practices. On a scale of one to nine with one corresponding to "won't help at all" and nine corresponding to "will help a lot", the average rating was 5.4. That is, they did not feel that as individuals they possessed significant power to change the water situation even if they adopted water saving practices; nor, however, did they feel their individual efforts would be completely in vain.

The next part of the survey asked students to rate various water demand-management measures in the public sector. The measures were divided into two groups; those which could be practiced by individuals, called "individual conservation measures" and those which may be implemented on a larger regional scale by government and were referred to as "community conservation measures" on the survey. Included in the "Individual conservation measures" were: 1. the use of water efficient fixtures (for example, the use of water efficient faucets and showerheads), 2. changes in washing habits (for example, individuals take shorter showers to use less water), 3. turning off water fixtures (for example, turning off the faucet when washing clothes or brushing teeth) 4. the use of water efficient appliances in the home (for example, the use of water efficient washing machines), 5. regular checking/maintenance of water system in the home (that is, leaks are checked on a regular basis and leaky pipes and fixtures are repaired and/or replaced), and 6. regular inspections of water meters (that is, water meters are checked regularly to see if they are working properly).

"Community conservation measures" that students were asked to rate included: 1. water restrictions; for example, the government implements restrictions on water use to certain hours during the day; 2. water quotas; that is, the government allocated specified amounts of water
according to unit; 3. reducing water pressure in "water adequate" areas in Beijing; that is, for areas in Beijing which do not experience many problems with water shortages, the water pressure is reduced. The lower water pressures can save water by reducing water loss from leaky pipes and faucets. 4. Building plumbing codes; that is, the construction of new residences and buildings, regulations are implemented which require that builders install water efficient plumbing fixtures and appliances such as water efficient toilets, showers, and faucets, 5. Retrofit program; that is, for existing residences and public institutions, the government implements a program of technical and financial assistance to help public users reduce water use by replacing existing water fixtures with water efficient fixtures, 6. pricing techniques; that is, the government raises the price of water so that people are encouraged to save water, 7. education; for example, the implementation of public awareness and information campaigns in schools and the media 8. domestic wastewater recycling; that is, wastewater from public uses is treated and reused for other non-consumptive purposes such as industrial processes and irrigation of crops, and 9. restrictions on urban growth; that is, the government actively implements policies (such as the satellite city concept) to control the rate of urban growth and thus the demand for water.

The students were instructed to rate each conservation measure in terms of three parameters: 1. how effective they perceived each measure to be in saving water in the public sector; 2. whether or not the measure was personally acceptable to the individual. That is, students were asked whether or not they would consider adopting (in the case of an individual measure) or would be in favour (in the case of a community measure) of such a measure; and 3. whether or not the measure was a "socially fair" water conservation strategy. That is, students were asked whether or not it was fair that all people in Beijing, regardless of socio-economic status, participate in such a strategy.
8.35 **Individual conservation measures**\(^{13}\)

Students were confident that all water conservation measures would be effective ways to save water. When respondents were asked to rate the effectiveness of each measure, on a scale of one to nine with one being "not effective at all" and nine "being very effective" all averaged at least a 5.3. Of these, in the eyes of students, the most effective methods to save water were: 3. turning off water fixtures (which scored an average of 7.0), 4. the use of water efficient appliances (which scored an average of 6.9), and 5. the regular checking and maintenance of domestic water systems (which scored an average of 7.0).

In terms of students' perceptions regarding the personal acceptability and social fairness of individual conservation measures, an interesting pattern emerged. The computed averages for each measure in both categories were very close numerically. In essence, it appears that students did not make a distinction between "personal" acceptability and "social fairness". For example, the students as a group viewed the first measure, the use of water efficient fixtures, as being quite an acceptable water conservation measure for them to adopt as individuals (average score measured at 7.38). Similarly, they perceived this measure, on a societal level, to be quite "socially fair" (average score measured at 7.19). This type of pattern continued and was consistent for not only the individual conservation measures, but also the community conservation measures.

All measures except number two, change in washing habits, were rated highly as being personally acceptable and socially fair strategies to save water. Measure two averages for personal acceptability and social fairness were 4.3 and 4.86 whereas averages for numbers three, four, and five were 7.74 (personal acceptability )/7.83 (social fairness), 7.3/7.10, and 7.64/7.66. I hypothesize that the unpopularity of measure number two may be due to the fact that students' showering conditions in university environments are already restricted to showering at certain times of the day and showering facilities are usually very crowded. Also, university students, being more educated than the general public, are more likely to be aware of the benefits of proper sanitation.

\(^{13}\) Refer to survey Section V.A in appendices B and C.
and health risks associated with a lack of water supplies. Thus, it is understandable that students would be less accepting of such a measure.

### 8.36 Community conservation measures

A noticeable pattern is evident from the results of this aspect of the survey. Conservation measures which would largely require the government to be responsible for implementation and maintenance were rated highest in terms of effectiveness in saving water, personal acceptability, and social fairness.

With respect to each measure's effectiveness in saving water, all except the first measure, water restrictions, were voted as being effective ways to save water in the city. Ratings for measures deemed to be effective in water saving were, number 8, domestic wastewater recycling which rated an average of 7.77, number 4, building plumbing codes, which rated an average of 7.10, and number 5, retrofit programs which rated an average of 7.09.

Specific measures which were rated most highly in terms of their personal acceptability and social fairness were: 8. domestic wastewater recycling, which scored averages of 7.82 for personal acceptability and 7.73 for social fairness, 4. building plumbing codes, which scored averages of 7.37 and 7.26, 7. education programs, which scored averages of 7.45 and 7.66, and 5. retrofit programs, which scored averages of 7.26 and 7.09.

Most of the measures showed no strong tendency for the students to view them as being fair or unfair. Average ratings for measure 2, water quotas, were 4.69 and 4.62; for 3, reducing water pressure, they were 6.05 and 6.07; for number 9, restrictions on urban growth they were 5.49 and 5.15; and for 6, pricing techniques, they were 4.98 and 4.92.

The only community conservation measure to which students showed strong opposition was the first measure, water restrictions.

---

14 Refer to survey Section V.B in appendices B and C.
In the first part of the survey, students were also asked to express their degree of support for the notion of continuing to implement supply oriented solutions such as diversion of rivers into water reservoirs and accessing more ground water aquifers. On a scale of one to nine with one being strongly disagree, and nine being strongly agree, the average rating was 4.60. In other words, students in the survey, on the whole, tended to mildly disagree with the statement.

Students, however, do support the idea of implementing more water demand-management policies in the city. The average score to the question, "To increase the water supply in Beijing, the government should implement more water conservation policies" was 6.67.

In terms of what kinds of water saving measures the respondents practiced, the overwhelming majority, 96.7 % of the students, reported being conscious of turning off water fixtures. However, for the remaining techniques listed, the response was not so enthusiastic. 29.1 % reported being conscious of changing their water use habits to use less water, and 36.5 % said that when they saw leaky fixtures, they would alert school officials to the problem. Students reported using virtually no additional "other measures."

With respect to students living in apartments on campus or outside of campus (a total of 116 out of the total 339 students) just 6.4 % reported using water saving fixtures, 18.1% used water efficient appliance(s) in the home, and 14.6 % check water meters regularly. However, more positively, 46.5% reported checking their plumbing system on a regular basis. However, again in this section, "other measures" students reported to be practicing in their homes were negligible.

Respondents were also surveyed about their awareness of the currently existing water demand-management policies and programs implemented by the government. This section of the survey gave mixed and some "foggy"results. For most of the implemented measures, the overall awareness of the existence of such water demand-management measures was low. 29.6% reported being aware of water quota policies, 36.4% reported being aware of water restrictions, 34.6% were aware of wastewater recycling initiatives, 27.5% reported being aware of urban restriction programs, and 34.9% were conscious of price increases to encourage water conservation. However, the majority of students surveyed, 70.4% of them, were aware that educational programs
exist about saving water. Strangely, however, 31.9% reported being aware of plumbing codes and 17% of retrofit programs. Although the use of water efficient technology is encouraged in Beijing's existing water demand-management policies, there are no enforced plumbing codes or retrofit programs. Also, 9% reported being aware of a policy to lower water pressure in the city to save water. Although no such policy currently exists, students may have mistakenly thought that chronic low water pressures in the city, which exists for reasons such as poor maintenance of leaky water infrastructure, is an "official policy".

Conclusion

In summary, it appears that for Beijing students, although they are concerned about environmental issues and more generally water issues, there exist other societal issues in the present which they believe are of greater concern. The survey results also show that students believe that Beijing's water problems will worsen over time. In terms of overall knowledge level of water issues, respondents generally showed a lack of knowledge about basic facts regarding Beijing's water issues. However, the results revealed that the popular media is a promising method to inform and educate students and perhaps all of Beijing's citizens about water issues and water demand-management methods. With respect to individual conservation measures, technological and operational measures were more popular than a measure that required a personal change in water-use habits. Further, in current practice, students generally showed a low level of enthusiasm in adopting water demand-management strategies. In terms of water conservation methods that can be practiced on a community-wide level, the results showed that students generally favoured measures in which the government is most financially and operationally responsible. Also significant in this part of the survey was that students did not distinguish between the concepts of "personal acceptability" and "social fairness" of both individual and community-type demand-management measures. Finally, for the majority of presently existing community-type demand-management strategies in Beijing, approximately one-third of respondents consistently reported being aware of such measures.
CHAPTER 9

WATER DEMAND-MANAGEMENT IMPLEMENTATION ISSUES IN BEIJING AND RECOMMENDATIONS

This chapter summarizes issues surrounding the implementation aspects of water demand-management measures in Beijing. Specifically, insights will be presented about the technical, administrative, economic, and social feasibility of currently existing and potential water demand-management strategies in Beijing. However, the chapter first begins by discussing an "institutional ideological constraint" that exists within Beijing's water management institutions that is causing a lack of attention to be paid to water demand-management initiatives in Beijing. Also, general administrative constraints existing within water management institutions will be discussed. The following is a discussion about various implementation constraints for specific demand-management strategies in Beijing, with an additional focus upon constraints existing for strategies in the public sector. Throughout this chapter, where appropriate, recommendations will be suggested in order to rectify such implementation constraints. Insights presented here are based upon a synthesis of the survey results as well as conversations with both national water authorities and municipal authorities involved in water management in Beijing.

9.1 "Institution Ideological constraint"

The "status" of water demand-management remains low in the municipality's overall water management policies and supply development plans. Although water demand-management policies do exist to some degree in Beijing, officials interviewed admitted that there is a lack of emphasis on water demand-management compared to supply-side measures. Part of the problem lies in the fact that water demand-management is not a priority stressed within even the nation's highest environmental institution, the National Environmental Protection Agency. In addition, the Ministry
of Water Resources, the most comprehensive water governing body at the national level, does not yet view water demand-management initiatives as a significant alternative to supply-oriented projects. Officials expressed the feeling that, although central authorities have approved the "middle transfer project", there definitely needs to be more discussion and studies about water demand-management options, especially considering there exists many potential negative impacts of this project. One official suggests that perhaps funds for such "mega-projects" should be distributed at the local level for sustainable development initiatives in the agricultural sector. This seems to be good advice considering that it was estimated that "... an increase in irrigation efficiency of 20% in Northern China would supply North China farmers with at least as much water as promised by two of the three routes for the South-North transfer, and more than 100 times the volume to be supplied by that portion of the eastern route" (Lampton, 1988).

In addition, the cost savings of water demand-management over supply side management methods would likely be substantial. Preliminary studies performed by Hufschmidt and Dixon, et al. in 1987 show that a mix of water demand-management measures if successfully implemented in the public and industrial sectors, could potentially release large quantities of water at a considerably lower unit cost than that of the next supply oriented project. (See Figure 10)

Further, raising the status of water demand-management, and further studies into their feasibility, are very important to the development of the city considering that none of the supply-oriented solutions suggested, including the "middle-transfer project", will be employable in the near future to help ease Beijing's water shortages.

9.2 Administrative constraints

Although on paper, many regulations exist to encourage water users in Beijing to save water, in reality, many significant areas are not included in these regulations. For example, there are no explicit regulations concerning water demand-management measures in the agricultural
sector. This is a major drawback for water demand-management efforts in Beijing since the majority of water consumed in Beijing is in this sector.

Figure 10: Cost of Conserving Water as an Alternative to Expanding Supply in Beijing

![Graph showing cost of conserving water as an alternative to expanding supply in Beijing.]

Adopted from Hufschmidt and Dixon et al. 1987

Also, enforcement and thus the largely ineffective implementation of regulations in the public sector remains weak, to the point where one official stated that, in practice, "there exists no water demand-management regulations in the public sector". Also, for the majority of demand-management measures that do exist in the industrial sector, it is uncertain to what extent these policies and regulations are enforced. Indeed, there still exist various economic reasons, as outlined in Chapter 2, why authorities enforcing demand-management policies, like authorities enforcing other environmental policies, may not actively enforce such regulations. Fragmentation and a lack of coordination among Beijing's water management and environmental protection
Institutions will continue to be a barrier to the success of demand-management initiatives unless improved. Thus, it is pertinent that a significant amount of effort to coordinate water demand-management initiatives be pursued among the many bureaus managing Beijing's water resources and supply. For example, the largest environmental protection body in the city, the BMEPB, and the Beijing Water Saving Office must engage in cooperative efforts. In particular, coordinated efforts are essential to see that water demand-management strategies are implemented in a cost-effective manner and duplication of efforts is avoided.

Finally, a major problem which will continue to undermine water management efforts, particularly the success of water efficient technology installation throughout the public sector, is that interviewed sources indicated infrastructure planning, which includes water infrastructure, does not coincide with the population realities of the city. Authorities plan water infrastructure for just the "official" population count of 11 million. Overburdened and significantly undermaintained sanitation facilities in Beijing's public washrooms are perhaps evidence of this circumstance.

### 9.3 Water Pricing

Despite the existence of water pricing policies in China's cities, it is widely believed that water in all sectors including; the agricultural, industrial, public, and municipal, remains significantly underpriced, which has contributed to the overuse and pollution of water resources in China. It is believed that a substantial portion of China's budgetary expenditure is consumed by wasteful water subsidies. Agricultural fees for irrigation, for example, are reported to cover less than half of the costs of supplying the water (Xi, 1996).

Officials interviewed in Beijing agreed that the price of water remains too low and the subsidization of Beijing's water supplies must be decreased. An official also stated that the operating cost for the Beijing water tap company to supply surface water in Beijing has increased significantly over the years not only because of inflation, but also because water now has to be transported from farther sources and because it costs more to treat the water since pollution levels
in water sources have increased. Presently, the monthly water fee for residents is a very small proportion of a family's monthly income\(^{15}\). This statement sums up this reality: "In the domestic sector, several yuan for a month is nothing in a family budget and compared to the cost of food, water is seldom seen as a valued good" (Ben, 1996). In the public sector, although the price was recently raised in 1996 to 0.5 mao per m\(^3\), an official stated that it should have been raised to 7 or 8 mao at a minimum. Also, Xi (1996) states that authorities are "unable" to collect about half of the water fees owed in China's largest water consuming sector, the agriculture sector. In Beijing municipality, this no doubt stems from the fact that the overwhelming majority of rural residences are not metered and the fact that many farmers in Beijing's rural areas are still sinking their own wells without permits, and obtain water at no cost (official interviews, 1996).

9.31 Constraints to water price increases

Although the majority of officials interviewed believe that increasing water prices will lead to a decrease in water use and the reuse of wastewater, it appears that raising water prices so that they encourage Beijing water consumers to conserve water will remain a contentious issue, largely resting on political will at the national and municipal level. Environmental officials interviewed expressed sincerity in their desire to see that water prices are raised in the municipality, but they voice their opinion that other, more powerful institutions at both the municipal and national levels frustrate such efforts.

In general, in decisions to increase resource prices, as with other types of decisions in which environmental policy is perceived to potentially harm the economic development of a region, environmental protection institutions do not carry weight (official interviews, 1996). The "chain of command" in the decision to raise water and electricity prices involves the Public Utilities Bureau, which reports to the Municipal Price Bureau; the Municipal Price Bureau then reports to the Beijing Municipal Government; finally, the Beijing Municipal Government reports to the Central Government.

\(^{15}\) For example, the current income of an urban resident in Beijing is about 550 yuan ($82.59 Cdn). A family of 3 consumes on average 7.5 m\(^3\) of water annually. At a price of 5 mao per cu\(^3\), the cost for water for this family is approximately 3.75 or 0.56 Cdn a month.
Government. An official interviewed revealed that although some municipal government authorities are in favour of price increases, the central government ultimately has the final say and continues to veto such ideas. Interesting, also, it was reported that increasing water prices in Beijing is a particularly sensitive subject to central authorities as they are interested in keeping China's political and cultural center "stable". This seems to be a relatively unrecognized constraint in environmental policy implementation which may be termed an "image" constraint. One interviewee also said that due to Beijing's status as the capital, and the central government's desire to see that it remains "stable", central intervention into sensitive areas such as resource pricing tends to be greater in Beijing than for other cities. For example, it was stated that Xian, another city in China listed as being "seriously" short of water, generally is allowed greater autonomy in its decisions to increase water prices. One scenario authorities fear is that raising water prices may set off a significant domino effect of price changes throughout the economy, i.e. cause higher inflation which in turn would cause "discontent" in the form of wage and budgetary demands. Such a scenario is undoubtedly threatening to authorities who would not only view such events as being "harmful" to Beijing's image as a capital, but also because authorities are presently very intent on attracting foreign investment and fear such events may actually deter foreign investors from the city. Municipal environmental officials interviewed however, refute such notions, believing that further price increases probably would not be met with such consequences since the proportion of income paid for water use would still be a minute fraction of expenses of users. Coupled with the fact that many of China's urban economies are growing strongly and urbanites' salaries as a whole are increasing, rational price increases in water prices are much overdue. Further, authorities at the national and local level must realize that the "social instability" feared is much more likely to happen as a result of a serious, irreversible water crisis in the future rather than from a long overdue increase in water prices.

From a social feasibility standpoint, results of the survey suggests that, although water pricing may be viewed as an effective method to save water, Beijing residents are uncertain that prices increases would be equitable among all members of Beijing society. Residents' hesitations
about price increases would likely be minimized with an economic study which includes a survey to investigate agreement in the various sectors of Beijing with different percentage increases in water prices. In addition to seeing that water pricing policies are effective in Beijing, authorities need to continue placing meters in rural residences in Beijing.

An official also mentioned that the successful implementation of other water demand strategies in all sectors depends upon the success of effective water pricing. In the public sector, it was said that, without further price increases, residential users will lack an important, but necessary, economic incentive to purchasing water saving technology and adopting water saving habits.

9.4 Domestic wastewater Recycling

Domestic wastewater recycling on a large scale is not a viable option in the near future given that the cost of such a project would be very high (Nickum, 1994). Officials mentioned that wastewater recycling initiatives currently only exist within hotels and have been implemented by the hotels' own initiative rather than from a law (since one doesn't exist). Authorities also pointed out that at present, there exists a lack of technology, hindering the widespread adoption of this type of demand-management initiative. However, some residential users do currently practice "low tech" methods to recycle water in the home; for example, reusing washing water in the toilet. Thus, for the near future at least, educating people about the specific "low tech" ways to reuse water in the public sector would be a very useful and viable alternative to a large scale domestic wastewater recycling scheme. However, if funds in the future are available for a larger scale project, it appears that, based on the survey, students at least would be supportive of such a project, and the broader public may be willing to support such an effort as well.

16 This is one type of environmental economic methodology known as "contingent valuation". See Folmer and Ierland (1989) for further reference.
9.5 Water Pressure Reduction

Officials unanimously felt that the water conservation strategy of "reducing water pressure in certain areas of Beijing" is not a technically feasible water demand-management option to implement in the municipality for the foreseeable future. The main reason for this lies in the fact that for such a measure to work effectively and safely, the existing water infrastructure must be relatively "leak free" and well maintained. However, authorities mentioned that a considerable portion of Beijing's water infrastructure is already leaky (although estimates vary as to the degree) and thus the technical feasibility of such a measure is very poor when applied to the case of Beijing (as is the case in many other developing countries with leaky water infrastructure). An undesired consequence from this type of strategy when applied inappropriately is that water from the outside can leak into the pipes, and contaminate the water when the pressure in the water distribution system drops (Briscoe, 1993).

9.6 Plumbing Codes and Retrofit Programs

Although plumbing codes and retrofit programs are widely known and accepted water demand-management programs in various cities worldwide (for example, Mexico City, and Denver in the United States both adopted plumbing code and retrofit programs) it was evident from interviews conducted with authorities that little consideration has been given to such measures. It appears that there is simply an unawareness of such demand-management measures on the part of authorities. Thus, educating officials about such measures is an obvious task. And once they were explained to officials, many thought that they would be worth researching as viable water demand-management options. Although from a "social acceptance" standpoint respondents in the survey rated plumbing codes highly, believing that they would be effective at saving water as well as personally and socially fair demand-management measures, there are a number of other issues to be addressed before the benefits of such policies could be realized. Firstly, retrofit programs will
only work if they are economically feasible. One official doubted that a retrofit program would be successful since existing fixtures currently are so cheap and water prices so low. In this sense, building plumbing codes may be a more viable option than retrofit programs since building plumbing codes are mandatory, regulated measures (providing they are enforced adequately) rather than a strategy that relies upon the participation of public users. According to officials, another constraint on the implementation of retrofit programs and plumbing code policies in Beijing is that there exists a lack of water efficient technology currently in the market for public users in China.

9.7 Water Quotas and Restrictions

The use of water quotas has been the most widely introduced demand-management policy in Beijing. There exist various penalties associated with surpassing water quotas, for example, Article 3 of the *Beijing Municipality Regulations on Economic Use of Water (1986)* states that,

> Water using units violating municipal urban water conservation regulations, according to the circumstances of the case, shall be warned, be ordered to correct in a fixed date, have a reduced water quota and be fined by the municipal water conservation management department; in a serious case, subject to the approval of the people's government, water-using units shall be suspended water supplies or their wells will be blocked up...

Another provision concerning penalties associated with surpassing water quotas is Article 7, *Management Regulations on Beijing Water Conservation (1989)*, which states,

> A progressive rate system ranging from double to one hundred times the normal water rates will be introduced if a water-using unit surpasses its quota.

However, discussions with officials indicate that the actual penalties associated with surpassing such quotas are currently too low and need to be raised in order that integrity of the water quota policies be upheld. One recent report supports such claims, stating that "...factories prefer to be fined for overuse of water rather than pay more to adopt water saving technology" (CCEN, May 1996). The root of such behaviour may lie in the fact that, like local environmental
protection bureaus, the Water Savings office must maintain a good relationship with the municipal government, which funds it, and thus is reluctant to "offend the economic aspirations" of the municipal government by fining industries too highly when quotas are surpassed.

Water restrictions, although not a municipality-wide policy, currently exist in some areas such as post secondary facilities as a method to control water use. Authorities interviewed indicated that water restriction policies at least initially, may have potential to be applied in the municipal sector for activities such as public street cleaning and watering of the city's plants through further feasibility studies. Such an idea is certainly worth exploring.

A 13 year study in Boulder, Colorado in the United States revealed that water restrictions do not reduce public water use permanently (Rogers, 1986). Thus, it is important that Beijing authorities combine regulatory type demand-management approaches such as water restrictions and water quotas with other types of demand-management such as educational measures.

Also, educating the Beijing public about the need for water restrictions and water quotas may perhaps alleviate some of the "negative feelings" that are associated with regulatory-based water demand-management measures. And results from the survey certainly showed that at least on university campuses, there exists some public aversion to such measures, as both measures, in particular water restrictions, were viewed as being socially unfair policies. Negative scenarios which may happen as a result of public opposition to water quota and restrictions policies may involve water users siphoning off water illegally from public water pipes and/or sinking wells illegally. Also, customers may "cheat" by building storage systems on the roofs of their homes, a practice which already is known to occur, but still on a relatively limited scale in Beijing. Thus, educating the public about the benefits and necessity for such programs is essential to ensure that actual practices do not undermine the regulatory-type policies.

Another very important aspect of water restrictions, like water quotas, is that they must be backed up with adequate enforcement. However, it appears that adequate enforcement of these, and other regulatory type water demand- management measures will remain largely uncertain until
sufficient funding is available for such tasks and perhaps even more crucial, a sufficient amount of political will is present.

9.8 Education Measures

If we adopt the methods such as "restrict water" and so on, we can only solve temporary problems and can't absolutely solve the final problems. Therefore, we should also depend on education and propaganda to solve the problems (Beijing resident, 1996).

The best way to protect water resources is education...(Beijing university student, 1996).

The previous statements eloquently express the crucial role that education plays in Beijing's water demand-management initiatives. It is not only a powerful water demand-management measure in its own right, but also a necessary "foundation" measure upon which the successful implementation of other demand-management measures depends. Also education is an innocuous measure, and based on the results of the survey, is would seem to be highly "socially acceptable" and one which the public would be quite "in tune with" (since the survey showed that a large percentage of the students had been exposed to government education campaigns). Thus, it seems highly worthwhile for the municipal government to invest more resources into this area as the returns on such programs will likely be substantial.

Since water efficient technology is in short supply presently, and those available tend to be costly (so that the public has no economic incentive to purchase them), authorities need to put more research into finding specific,\(^\text{17}\) appropriate (to urban cities in China), "low tech" (and less costly) ways to save water and educate the public about them.

Also very important is that environmental officials themselves obtain training in the area of water demand-management. This point is based on the observation that officials interviewed for this study were unfamiliar with demand-management measures such as retrofit programs and

\(^{17}\) Interviews conducted with officials suggested that some of the messages about water shortage in Beijing are vague and do not offer concrete water-saving suggestions for residents.
building plumbing codes. In addition, since many local officials are presently motivated to perform activities based upon economic incentives, it is important that they be educated about the economic benefits that are known to accrue from the successful implementation of a comprehensive demand-management program in the city.

The attitude of people is forever the most important...with a non-efficient government...it is hard to make any progress (in the environment) (Beijing student, 1996).

As government "non-efficiencies" will most likely remain in the near future, this is more reason to step up education efforts since an "educated public" will be able to "fill in gaps" and serve as an ally to environmental protection efforts. In particular, public pressure may be able to improve enforcement of demand-management measures. Indeed, there are pockets of evidence that indicate the Chinese public has the will and resources to participate in environmental efforts and that China's leaders are beginning to show some signs of tolerance (albeit still limited) for public demands for environmental improvements. For example, in 1995, 300 people in Beijing held a vigil to draw the public's attention to the plight of a unique monkey species in Yunnan province, and specifically the loss of its virgin wilderness habitat. The final result of this was that supporters of this movement successfully halted local logging plans in the region early in 1996 and now there exists a plan to develop the area as a wildlife refuge (Wehrfritz, 1996). In addition, in June 1996, public outrage precipitated authorities to close down one thousand paper mills along the Huai River (Wehrfritz, 1996). Residents in Tangshan, a small industrial city east of Beijing, were also recently successful in pressuring municipal authorities to stop operations of a polluting tire-recycling factory (Wehrfritz, 1996).

Also encouraging is that avenues for public participation in environmental initiatives are beginning to open up somewhat with the formation of environmental NGOs in China. China's first official environmental NGO, Friends of Nature, was registered in the Spring of 1993. Its activities are largely in the area of environmental education. Its mission statement is "to promote environmental protection and sustainable development in China by raising environmental
awareness and promoting a green culture" (Friends of Nature, 1996). As of the end of 1996, it had about 400 members and continues to engage in a variety of activities to raise the environmental awareness level among the mostly Beijing general public. Another group, "Women and the Environment", officially formed in September 1996 aims to "...promote green awareness and women's participation in sustainable development" (Yip, 1996). Also, March 1996 saw the formation of another NGO called the "Green Students' Forum which links students in some 16 universities in the country. Priority concerns for the "Green Students' Forum" are wildlife and forestry issues as well as environmental issues surrounding the Three Gorges Dam on the Yangtze River (Yip, 1996).

Overall however, since the formation of Chinese ENGOS is a relatively new phenomenon, it remains to be seen how much influence they can exert on environmental policy development and implementation in China.

9.81 The role of the media

A study conducted in 1995 on Environmental Reporting in Chinese Newspapers stated that although there has been an increase in reporting of environmental topics, the overall coverage in Chinese newspapers still remains minimal. In 1995, only 25 of the newspapers surveyed devoted 0.46% of their news coverage to environmental topics (Friends of Nature, 1996).

Results of the survey in this study suggested that the popular media, i.e., newspaper, television, and radio, are particularly powerful avenues to send messages about water demand-management practices. Thus, it is very important, for the sake of building an "environmentally aware public" that would provide greater support for and cooperation with present and potential water demand-management initiatives in Beijing that "..the role of environmental reporting through such media be strengthened, widened and given more freedom" (Friends of Nature, 1996).
9.82 Information constraints

I don't think the government has done their best to let people know how serious the problem is facing them (Beijing student, 1996).

Many people think there's enough water to use (Beijing students, 1996).

...the public knows little about the importance of saving water. I think most important is to let people realize that there is a lack of water (Beijing university student, 1996).

As public users react to water demand-management management programs largely based upon their perception of the water shortage problem, and perceptions are formed largely by information that is available to them, educational programs will only be successful to the extent that the public is given sufficient, accurate information about the seriousness of Beijing's water shortage problems. Although Beijing municipal authorities are legally bound to provide environmental quality information, in practice, authorities are often reluctant to do so.

In fact, it was stated by Mei et al. (1997) that "the biggest obstacle on the way to making environmental quality public is the fears of local governing authorities and governments". One reason why such "information constraints" exist is fears that foreign investors, who "demand ever higher standards for their investment environment," will be turned away by poor environmental conditions in localities (Mei et al, 1997). Also, authorities fear that Beijing's image as a capital will be damaged (what I previously referred to as an "image constraint") and fear that "social instability" due to public outcry about poor environmental conditions may hurt the Chinese economy. A few officials at the national level, however, realize that such views have been very damaging to environmental efforts and continue to speak out to refute such notions. Qu Geping, head of NEPA, stated that "concealing facts about environmental quality from foreign investors is cheating and will damage Chinese credibility" and that "Public release of environmental quality is indeed a means to promote public awareness of the environment, and it is not right to conceal environmental facts from the public... such a practice is a policy designed to fool the masses" (Mei, 1997).
In general, although it is more common now than in previous years for the Chinese government to publicize information about China's environment, many more efforts are required to ensure that such information is reliable (interviewed sources indicated that the accuracy of environmental information is in many cases questionable) and readily available when requested by members of the Chinese and international public.

**Conclusions**

As discussed in this chapter, implementation and practice of all types of water demand-management measures remain limited in their success due to a number of issues. Such problems include institutional, political, economic, and social issues. First, water planners and management in Beijing need to rethink and reform the current "institutional ideology" which overwhelmingly favours supply-side water development strategies over water demand-management measures. Also, improvements in existing water demand-management regulations are needed which include: more detailed, comprehensive regulations incorporating all sectors of society, stronger enforcement of existing measures, better coordination and cooperation among Beijing's myriad of water management institutions, and improved planning methods. This chapter also detailed elements within the political economic system that are constraining the success of water demand-management methods, and indeed other forms of environmental policy. Further, it was revealed that authorities hold unfounded perceptions such as: free environmental information distribution and active enforcement of environmental policy will hinder the economy.
This study has attempted to reveal the major, general constraints affecting water demand-management methods and some specific constraints affecting various specific demand-management measures in Beijing, China. However, it was not possible in this study to address the economic, political, technical, and social feasibilities in detail for each individual water demand-management measure. Certainly, further studies are needed to address these detailed issues in order that current and future demand-management strategies be implemented effectively. It is hoped that this study at the least has served as a "base" to further research regarding water demand-management in Beijing.

In addition, this study stresses that a necessary precondition for positive changes in water development practices in Beijing, and indeed all of China, is a better informed society. However, information and education of citizens is ultimately in the hands of authorities who, as discussed earlier, may hold false perceptions regarding the impact of free and accurate environmental information upon the economy. Thus, in the final analysis, perhaps one can say that, in such a centralized information system, significant changes in water development practices will result only to the extent that authorities in power are better educated and trained themselves. One may view such prospects for a more enlightened bureaucracy as indeed positive since China continues to open its economy and citizens to international influence. It seems to be a matter of time before authorities realize that a freer media and a greater flow of reliable information will not only benefit their water development plans, but in a larger sense, contribute significantly to a path many countries in the world are trying to follow - the path of sustainable development.
REFERENCES


Fung, Yi Xian (1996): "Ba Beijing Jian Cheng Shi Shui Xing Cheng Shi Shi Zai Bi Xing" (It is necessary to make Beijing into a Water Efficient City), *Town and City Water Supply*, Vol. 4, 28-30.


Xi, Mi (1996): "Water can bring bonanza or disaster", *China Daily*, No. 4974, Oct. 29.


APPENDIX A

CHINA'S ENVIRONMENTAL PROTECTION INSTITUTIONS

Jahiel (1994) and Sinkule (1993) describe the structure of China's environmental protection institutions and the nature of information flows between them.

The National Level

At the top of the China's environmental protection hierarchy exists the national environmental protection agency (NEPA). It falls directly under the jurisdiction of the State Council and is responsible for environmental policy and program formulation.

Below the National Level

Environmental Protection Bureaus and the Environmental Protection Offices are environmental protection institutions which exist at each level of government below the national level: provincial, city, county, district, town, and village. In general, EPBs and EPOS vary with respect to the level of government and size. For example, provincial and city level departments are most often designated bureaus, while county and lower level environmental protection departments are designated as offices. EPBs' and EPOS' funds come from the local governments to which they belong (for example, a city EPB is allocated largely financed by the municipal government). The main responsibilities of the EPBs and EPOs are to implement national and local environmental laws and programs and to enforce the laws through a variety of means (for example, they collect water pollution fees). Many EPBs and EPOs were established during the 1980s, with each province having its own environmental protection bureau, along with the majority of large cities. Numerous counties and towns in China also have their own environmental protection offices, although they may be staffed by only a handful of workers.
Industrial Environmental Protection Bureaus

Finally, each industrial ministry at the national level also has its own EPB. This type of arrangement extends downwards to provincial and local levels. These bodies are responsible for implementing pollution control measures to ensure that industries meet regulatory requirements by, for example, assisting factories of the specific industry to develop waste treatment technologies. For example, an EPO of a chemical bureau gives technical assistance to petrochemical factories in the area of waste management and treatment. In addition, larger factories have their own environmental departments. Although these bodies are not a formal component of the environmental institutional structure, they often act as very important liaison in implementation of environmental policies put forward by the local EPB in the factory.

Information flows within the environmental protection institutions

Information flows within China's environmental protection institutions move vertically between higher and lower-level environmental protection units through the issuance of documents and policy statements. Also, there are exchanges that occur informally between Environmental Protection Bureau officials from different cities and provinces. Such interactions occur via nationally and provincially organized meetings or through individual initiatives spurred by news reports on the activities of a particular EPB.

Although the environmental institutions are hierarchically organized, there exists no direct line of command between NEPA and local EPBs (or EPOs). Instead, the relationship between central and local environmental protection organs is only of a professional nature. The NEPA has no formal power to ensure that local EPBs and EPOs follow through with the implementation of environmental policies. The NEPA's influence upon local EPB's and EPO's activities extends as far as playing an advisory role to localities' environmental initiatives.

Instead of NEPA, the EPBs and EPOs possess a formal leadership relationship (lingdao guanxi) with and are under the leadership command of the local government corresponding to their
level (i.e. municipal EPBs are directly responsible to city governments, and county EPBs to county
governments). This arrangement is very significant in terms of policy implementation. Since local
EPBs and EPOs rely on local government leaders for funding, they must be careful not to
"interfere" with the economic interests of the local government. For example, local EPBs and
EPOs are in many cases reluctant to impose heavy fines upon state owned industries since such
industries provide valuable revenue to the local government.

At each level of government, China's environmental protection institutions are supported
by bodies called Environmental Protection Commissions. They exist both at the national and local
level and essentially exist "to facilitate interaction between the EPB and other government organs at
the same level of government in a political system in which horizontal integration (communication
between government organs at the same administrative level of government) is difficult to achieve"
(Jahiel, 1994). The National EPC (NEPC), established in 1984, is headed by China's Vice-Premier
and includes leaders from 24 other ministries and commissions. There also exist environmental
protection commissions at the provincial and lower levels of government. As with the NEPC,
members of local level EPCs come from different ministries and commissions at the same level of
government. Local EPCs are responsible for: studying, examining and determining the principles
and policies governing environmental protection; putting forward the requirements of the
programmes; and directing and coordinating national environment protection.

Monitoring stations complement China's environmental protection bodies. At the local
level, each EPB and EPO is supported by its own monitoring station. The purpose of local
monitoring stations is to provide environmental quality data within a locale. At the national level,
directly under NEPA's command, is a separate system of monitoring stations. Similar to local
level monitoring stations, the main function of the national system monitoring stations is to
assimilate data on local conditions which gives NEPA oversight of localities.
APPENDIX B

STUDENT SURVEY

SECTION I. BACKGROUND INFORMATION

Gender: Male __ Female __

Year of birth: _________

Education:

How many years have you attended this university (excluding this year)? _______

Current department: _______________________________

Current and previous degree(s):

Bachelor's _______ Master's _______ Ph.d _______

Residence(s) in Beijing (please check one or more and specify years):

Type: Dormitory ___ > From (year) ________ To (year) ___________

Apartment ___ > From (year) ________ To (year) ___________

Total number of years lived in Beijing (excluding this year) _________
SECTION II. ENVIRONMENTAL IDEOLOGY

Here are 4 statements describing different kinds of relationships between man and the environment. I'd like you to express your opinion with each one of them by circling one number on each scale.

1. People should be free to use the environment to increase their standard of living.

   1  2  3  4  5  6  7  8  9
   strongly disagree strongly agree

2. The natural environment is pure and beautiful. People are obligated to protect and preserve it.

   1  2  3  4  5  6  7  8  9
   strongly disagree strongly agree

3. In its natural state, the environment is in harmony. Men should beware of disturbing this ecological balance.

   1  2  3  4  5  6  7  8  9
   strongly disagree strongly agree

4. The environment must be seen as the base of all economic resources and should be used efficiently, not wastefully.

   1  2  3  4  5  6  7  8  9
   strongly disagree strongly agree
SECTION III. IMPORTANCE OF WATER CONSERVATION

Here is a list of issues important to Beijing society. I would like to know how important these issues are to you personally. Please order these issues from most important to least important. Do this by placing a number 1 in front of the issue that concerns you most, then a number 2 in front of the next most important issue, and so on until you place the highest number (10 or 11) in front of the issue which concerns you the least.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Issue</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Energy supply; ex. electricity and coal</td>
</tr>
<tr>
<td>2</td>
<td>Unemployment/jobs</td>
</tr>
<tr>
<td>3</td>
<td>Crime/Corruption</td>
</tr>
<tr>
<td>4</td>
<td>Health care</td>
</tr>
<tr>
<td>5</td>
<td>Inflation</td>
</tr>
<tr>
<td>6</td>
<td>Quality and access to education</td>
</tr>
<tr>
<td>7</td>
<td>Competence of Political Leadership</td>
</tr>
<tr>
<td>8</td>
<td>Air Pollution</td>
</tr>
<tr>
<td>9</td>
<td>Water Quality</td>
</tr>
<tr>
<td>10</td>
<td>Water Quantity</td>
</tr>
<tr>
<td>11</td>
<td>Other (please specify)</td>
</tr>
</tbody>
</table>

Other (housing, traffic)

The following is a list of questions and statements about the importance of water conservation in Beijing. Please indicate your opinion by circling one number on each scale.

1. I'd like you to characterize the water supply in Beijing:

   1  2  3  4  5  6  7  8  9
   very very scarce abundant

2. What about the water quality in Beijing? It is...

   1  2  3  4  5  6  7  8  9
   very good poor

3. To what degree have water shortages affected your life in Beijing?

   1  2  3  4  5  6  7  8  9
   not affected very negatively
4. To what degree have water quality issues in Beijing affected your life?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>not</td>
<td>affected</td>
<td>very</td>
<td>negatively</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. I feel that, in 5 years, the water supply in Beijing will be....

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>very</td>
<td>scarce</td>
<td>very</td>
<td>abundant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. I feel that, in 15 years, the water supply in Beijing will be...

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>very</td>
<td>scarce</td>
<td>very</td>
<td>abundant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. I feel that, in 5 years, the water quality in Beijing will ....

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>become much</td>
<td>worse</td>
<td>become much</td>
<td>better</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8. I feel that, in 15 years, water quality in Beijing will...

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>become much</td>
<td>worse</td>
<td>become much</td>
<td>better</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9. To address water supply issues in Beijing, the government should exploit more water resources; ex. rivers and/or streams for diversion into water reservoirs and/or access more ground water aquifers.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>strongly</td>
<td>disagree</td>
<td>strongly</td>
<td>agree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
10. To address water supply issues in Beijing, the government should decrease water demand by implementing more water conservation policies.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>strongly disagree</td>
<td>strongly agree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

11. Will improvements in the water quantity situation help improve the water quality in Beijing? (please check one)

   Yes ______  No ______  Unsure ______

Water use in Beijing may be categorized according to the following sectors:

a. Industry - Both state and collective industries
b. Agriculture
c. Public - Residences, public institutions, (ex. schools, public washroom facilities), and small private businesses.
d. Municipal - Commercial users (ex. hotels, offices, and shopping malls) and non-commercial users (ex. water for cleaning the city and watering parks, for construction)

Approximately how much water do you think is utilized in each sector? Please indicate a percentage of water use for each sector to add up to 100% water use in Beijing. Please remember that "Beijing" is defined as including all 18 districts; 8 inner city districts and 10 suburban districts.

<table>
<thead>
<tr>
<th></th>
<th>Industry</th>
<th>Agriculture</th>
<th>Public</th>
<th>Municipal</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>Agriculture</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>Public</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>Municipal</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>Total</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td></td>
<td>= 100 %</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How much water do you think each sector will utilize in the year 2010?

<table>
<thead>
<tr>
<th></th>
<th>Industry</th>
<th>Agriculture</th>
<th>Public</th>
<th>Municipal</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>Agriculture</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>Public</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>Municipal</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>Total</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td></td>
<td>= 100 %</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
How efficient do you feel water is presently utilized in each sector? Please circle one number to complete each statement.

1. Water use in the industrial sector is....

1 2 3 4 5 6 7 8 9

very inefficient

very efficient

2. Water use in the agricultural sector is.....

1 2 3 4 5 6 7 8 9

very inefficient

very efficient

3. Water use in the public sector is....

1 2 3 4 5 6 7 8 9

very inefficient

very efficient

4. Water use in the municipal sector is....

1 2 3 4 5 6 7 8 9

very inefficient

very efficient

How efficient do you feel water is utilized within the public sector? Please circle one number to complete each statement.

5. Water use in public washroom facilities is...

1 2 3 4 5 6 7 8 9

very inefficient

very efficient

6. Water use in public institutions such as schools and hospitals is....

1 2 3 4 5 6 7 8 9

very inefficient

very efficient
7. Water use in residences is...

   1 2 3 4 5 6 7 8 9

   very               very
   inefficient        efficient

8. Water use in small private businesses (ex. private restaurants, tailor shops, hair salons, etc) is....

   1 2 3 4 5 6 7 8 9

   very               very
   inefficient        efficient
SECTION IV. KNOWLEDGE ABOUT WATER CONSERVATION

1. How much do you know about water conservation in general?

1 2 3 4 5 6 7 8 9
know nothing know
at all a lot

2. How much do you know about what you, as an individual, can do to conserve water?

1 2 3 4 5 6 7 8 9
know nothing know
at all a lot

3. How much information do you feel is available to the public to learn how they, as individuals, can save water?

1 2 3 4 5 6 7 8 9
none a lot
at all

4. Here is a list of information sources. Which sources, if any, have informed you about water conserving practices? Please check any (or none)

Newspaper _____
Radio _____
Television _____
School courses _____
Posters on campus _____
Poster in a public area (ex. shopping area) _____
Announcement or speech from school authorities _____
Information pamphlet from school authorities _____
Announcement or speech from a government official _____
Information pamphlet from government _____
Informal discussion with friends _____
Informal discussion with family members _____
Informal discussion with colleagues at work _____
Other (please specify) ____________________________________________

5. Do you think changes in your personal water practices towards water conserving practices will help contribute to alleviating water quantity problems in Beijing?

1 2 3 4 5 6 7 8 9
won't help will help
at all a lot
SECTION V. WATER CONSERVATION IN THE PUBLIC SECTOR

A. Individual conservation measures

There are various ways an individual can conserve water in the public sector in Beijing. They include:
(*please note these categories will be defined in greater detail throughout this section):

1. Use of water efficient fixtures
2. Changes in washing habits
3. Turning off water fixtures
4. Use of water efficient appliances
5. Regular checking/maintenance of water system
6. Regular inspections of water meter

For each of these categories, I would like to know (to be answered on upcoming scales numbered 1-9):

a. How effective do you feel each measure is in saving water in the public sector?

b. Is the measure personally acceptable to yourself? That is, would you consider adopting this measure if possible in Beijing?

c. Do you think the measure is "socially fair". That is, do you think it is fair that all people in Beijing (ex. of varying socioeconomic status) adopt this measure where possible to do so?

Please indicate your opinions by circling one number on each scale.

1. Use of water-efficient fixtures. This involves the installation of water efficient toilets, water efficient faucets and showerheads.

a. Effectiveness in saving water?

   1  2  3  4  5  6  7  8  9
   not effective at all
                                very effective

b. Personal acceptability?

   1  2  3  4  5  6  7  8  9
   not acceptable at all
                                very acceptable

c. Social fairness?

   1  2  3  4  5  6  7  8  9
   not fair at all
                                very fair
2. Changes in washing habits: For example, individuals take shorter showers/shallower baths thus using less water.

a. Effectiveness in saving water?

1 2 3 4 5 6 7 8 9

not effective
at all

very effective

b. Personal acceptability?

1 2 3 4 5 6 7 8 9

not acceptable
at all

very acceptable

c. Social fairness?

1 2 3 4 5 6 7 8 9

not fair
at all

very fair

3. Turning off water fixtures: That is, individuals always try to turn off faucet while brushing teeth, washing dishes, washing clothes, etc. so water is not kept running.

a. Effectiveness in saving water?

1 2 3 4 5 6 7 8 9

not effective
at all

very effective

b. Personal acceptability?

1 2 3 4 5 6 7 8 9

not acceptable
at all

very acceptable

c. Social fairness?

1 2 3 4 5 6 7 8 9

not fair
at all

very fair
4. Use of water efficient appliances: For example, the use of water efficient washing machines and water recycling air conditioners.

a. Effectiveness in saving water?

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>not effective at all</td>
<td>very effective</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b. Personal acceptability?

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>not acceptable at all</td>
<td>very acceptable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

c. Social fairness?

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>not fair at all</td>
<td>very fair</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. Regular checking/maintenance of water system: That is, leaks are checked on a regular basis in a water system (ex. in a home) and leaky pipes and fixtures are repaired and/or replaced.

a. Effectiveness in saving water?

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>not effective at all</td>
<td>very effective</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b. Personal acceptability?

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>not acceptable at all</td>
<td>very acceptable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

c. Social fairness?

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>not fair at all</td>
<td>very fair</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6. Regular inspections of water meter: That is, water meters are checked regularly to see if working properly

a. Effectiveness in saving water?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>not effective</td>
<td>very effective</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>at all</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b. Personal acceptability?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>not acceptable</td>
<td>very acceptable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>at all</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

c. Social fairness?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>not fair</td>
<td>very fair</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>at all</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Which conservation methods do you practice if any? Please check any (or none):

1. Changed washing habits

2. Always turned off water fixtures

3. Alert school official about leaky water fixtures (ex. taps, toilets)

4. Other (please specify) ________________________________________

If your family lives in Beijing, which of these water conservation measures does your household practice?

1. Used water-saving fixture(s).

2. Used water efficient appliance(s)

3. Acted to minimized leakage in water system

4. Regular water meter inspections

5. Other (please specify) ________________________________________
B. Community conservation measures

There are a variety of programs and regulations the government may implement to encourage water conservation in the public sector in Beijing. They include (*please note these categories will be defined in greater detail throughout this section):

1. Water restrictions
2. Water quotas
3. Reducing water pressure in "water adequate" areas in Beijing
4. Building plumbing codes
5. Retrofit program
6. Pricing techniques
7. Education
8. Domestic wastewater recycling
9. Restrictions on urban growth

Again, for each of these categories of measures, I would like to know (to be answered on upcoming scales numbered 1-9):

a. How effective you feel each is in saving water in the public sector?

b. Is the measure personally acceptable to yourself? That is, would you be in favour of this measure?

c. Do you think the measure is socially fair? That is, do you think it is fair that this measure be widely implemented among society in Beijing?

Please indicate your opinions by circling one number on each scale.

1. Water restrictions: The government implements restrictions on water use in an area - for example, to certain hours during the day.

   a. Effectiveness in saving water?

      1 2 3 4 5 6 7 8 9

      not effective
      at all

      very
      effective

   b. Personal acceptability?

      1 2 3 4 5 6 7 8 9

      not acceptable
      at all

      very
      acceptable

   c. Social fairness?

      1 2 3 4 5 6 7 8 9

      not fair
      at all

      very
      fair
2. **Water quotas**: The government allocates specified amounts of water according to unit (danwei).

a. **Effectiveness in saving water?**

   1 2 3 4 5 6 7 8 9

   not effective  very effective
   at all

b. **Personal acceptability?**

   1 2 3 4 5 6 7 8 9

   not acceptable  very acceptable
   at all

c. **Social fairness?**

   1 2 3 4 5 6 7 8 9

   not fair  very fair
   at all

3. **Reducing water pressure in "water adequate" areas in Beijing**: That is, for areas in Beijing which do not experience much problems with water shortages, the water pressure is reduced. Lower water pressures can save water by reducing water loss from leaky pipes and faucets.

a. **Effectiveness in saving water?**

   1 2 3 4 5 6 7 8 9

   not effective  very effective
   at all

b. **Personal acceptability?**

   1 2 3 4 5 6 7 8 9

   not acceptable  very acceptable
   at all

c. **Social fairness?**

   1 2 3 4 5 6 7 8 9

   not fair  very fair
   at all
4. Building plumbing codes - For the construction of new residences and buildings, regulations are implemented which require that builders install water efficient plumbing fixtures and appliances such as water efficient toilets, showers, and faucets.

a. Effectiveness in saving water?

1 2 3 4 5 6 7 8 9

not effective
at all

very effective

b. Personal acceptability?

1 2 3 4 5 6 7 8 9

not acceptable
at all

very acceptable

c. Social fairness?

1 2 3 4 5 6 7 8 9

not fair
at all

very fair

5. Retrofit program - For existing residences and public institutions, the government implements a program of technical and financial assistance to help public users reduce water use by replacing existing water fixtures with water efficient fixtures.

a. Effectiveness in saving water?

1 2 3 4 5 6 7 8 9

not effective
at all

very effective

b. Personal acceptability?

1 2 3 4 5 6 7 8 9

not acceptable
at all

very acceptable

c. Social fairness?

1 2 3 4 5 6 7 8 9

not fair
at all

very fair
6. **Pricing techniques** - The government raises the price of water so that people are encouraged to save water.

a. **Effectiveness in saving water?**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>not effective at all</td>
<td>very effective</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b. **Personal acceptability?**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>not acceptable at all</td>
<td>very acceptable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

c. **Social fairness?**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>not fair at all</td>
<td>very fair</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. **Education** - Public awareness and information campaigns. That is, education of school children about water conservation and the use of media such as TV, radio, and newspaper to persuade and teach individuals how to conserve water.

a. **Effectiveness in saving water?**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>not effective at all</td>
<td>very effective</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b. **Personal acceptability?**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>not acceptable at all</td>
<td>very acceptable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

c. **Social fairness?**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>not fair at all</td>
<td>very fair</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
8. **Domestic wastewater recycling** - Wastewater from public uses is treated and reused for other non-consumptive purposes such as industrial processes and irrigation of crops.

a. Effectiveness in saving water?

1 2 3 4 5 6 7 8 9

not effective very effective
at all

b. Personal acceptability?

1 2 3 4 5 6 7 8 9

not acceptable very acceptable
at all

c. Social fairness?

1 2 3 4 5 6 7 8 9

not fair very fair
at all

9. **Restrictions on urban growth** - The government adopts policies to control the rate of urban growth and thus the demand for water by issuing only a limited number of building and housing permits; particularly for water deficient areas in Beijing.

a. Effectiveness in saving water?

1 2 3 4 5 6 7 8 9

not effective very effective
at all

b. Personal acceptability?

1 2 3 4 5 6 7 8 9

not acceptable very acceptable
at all

c. Social fairness?

1 2 3 4 5 6 7 8 9

not fair very fair
at all

Now, which of these community measures, to your knowledge, currently exist in Beijing? (during the time you lived there)? Please check any (or none):

1. Water Restrictions
2. Water quotas
3. Reduced water pressure in some areas in Beijing
4. Established building plumbing codes
5. Retrofit program
6. Increased water prices
7. Education programs
8. Domestic wastewater recycling initiatives
9. Restrictions on urban growth

Please write down any further comments you have about Beijing's water or this survey on the back of this page.

Thank you very much for your participation and cooperation!
APPENDIX C

SUMMARY OF SURVEY RESULTS

Total number of students surveyed = 339

Section I. Background Information

<table>
<thead>
<tr>
<th>Gender</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>61.7</td>
</tr>
<tr>
<td>Female</td>
<td>37.8</td>
</tr>
</tbody>
</table>

Birth Year (mean) 24

<table>
<thead>
<tr>
<th>Residence</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>dormitory</td>
<td>65.8</td>
</tr>
<tr>
<td>apartment</td>
<td>21.5</td>
</tr>
<tr>
<td>both dormitory and apartment</td>
<td>12.7</td>
</tr>
</tbody>
</table>

Years attended current university (mean) 2.83

<table>
<thead>
<tr>
<th>Department</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing University</td>
<td></td>
</tr>
<tr>
<td>urban and environmental studies</td>
<td>69</td>
</tr>
<tr>
<td>geology</td>
<td>4</td>
</tr>
<tr>
<td>information management</td>
<td>32</td>
</tr>
<tr>
<td>law</td>
<td>34</td>
</tr>
<tr>
<td>Qinghua University</td>
<td></td>
</tr>
<tr>
<td>architecture</td>
<td>29</td>
</tr>
<tr>
<td>economics and management</td>
<td>27</td>
</tr>
<tr>
<td>foreign languages</td>
<td>2</td>
</tr>
<tr>
<td>mechanical engineering</td>
<td>11</td>
</tr>
<tr>
<td>Chinese Academy of Sciences</td>
<td></td>
</tr>
<tr>
<td>computers</td>
<td>50</td>
</tr>
<tr>
<td>electronics</td>
<td>1</td>
</tr>
<tr>
<td>atmospheric environment</td>
<td>1</td>
</tr>
<tr>
<td>ecology</td>
<td>4</td>
</tr>
<tr>
<td>biology</td>
<td>12</td>
</tr>
<tr>
<td>geology</td>
<td>18</td>
</tr>
<tr>
<td>chemistry</td>
<td>18</td>
</tr>
<tr>
<td>aeronautics</td>
<td>1</td>
</tr>
</tbody>
</table>

155
Number

<table>
<thead>
<tr>
<th>Field</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>automation</td>
<td>2</td>
</tr>
<tr>
<td>math</td>
<td>1</td>
</tr>
<tr>
<td>foreign languages</td>
<td>15</td>
</tr>
<tr>
<td>unknown (not identified)</td>
<td>8</td>
</tr>
</tbody>
</table>

Degree type  

<table>
<thead>
<tr>
<th>Degree type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelor</td>
<td>47.3</td>
</tr>
<tr>
<td>Master</td>
<td>49.1</td>
</tr>
<tr>
<td>Ph.d</td>
<td>3.6</td>
</tr>
</tbody>
</table>

Years living in Beijing (mean)  

| 5.15 |

Section II. Environmental Ideology

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>2.22</td>
</tr>
<tr>
<td>2.</td>
<td>8.74</td>
</tr>
<tr>
<td>3.</td>
<td>8.30</td>
</tr>
<tr>
<td>4.</td>
<td>7.98</td>
</tr>
</tbody>
</table>

Section III. Importance of Water Conservation

Issues Ranking

1. jobs/unemployment
2. education
3. crime
4. inflation
5. air pollution
6. energy supply
7. competence of political leadership
8. water quality
9. health care
10. water quantity
11. other *

* housing - 5 responses, birth or population control - 3 responses, traffic - 13 responses, people's morality - 4 responses, media - 2 responses, social stability - 1 response, living standards - 1 response, forestry - 2 responses, political reform - 1 response, city planning and transportation - 1 response)
<table>
<thead>
<tr>
<th>Question</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>4.76</td>
</tr>
<tr>
<td>2.</td>
<td>5.36</td>
</tr>
<tr>
<td>3.</td>
<td>3.26</td>
</tr>
<tr>
<td>4.</td>
<td>4.43</td>
</tr>
<tr>
<td>5.</td>
<td>3.66</td>
</tr>
<tr>
<td>6.</td>
<td>3.16</td>
</tr>
<tr>
<td>7.</td>
<td>4.14</td>
</tr>
<tr>
<td>8.</td>
<td>4.25</td>
</tr>
<tr>
<td>9.</td>
<td>4.75</td>
</tr>
<tr>
<td>10.</td>
<td>6.67</td>
</tr>
</tbody>
</table>

11. Relationship between water quantity and water quality

<table>
<thead>
<tr>
<th>Response</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>17.1</td>
</tr>
<tr>
<td>No</td>
<td>50.8</td>
</tr>
<tr>
<td>Unsure</td>
<td>32.1</td>
</tr>
</tbody>
</table>

Water use by sector in the present

<table>
<thead>
<tr>
<th>Sector</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Industry</td>
<td>36.9</td>
</tr>
<tr>
<td>b. Agriculture</td>
<td>27.4</td>
</tr>
<tr>
<td>c. Public</td>
<td>21.2</td>
</tr>
<tr>
<td>d. Municipal</td>
<td>14.4</td>
</tr>
</tbody>
</table>

Water Use in year 2010

<table>
<thead>
<tr>
<th>Sector</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Industry</td>
<td>34.9</td>
</tr>
<tr>
<td>b. Agriculture</td>
<td>24.9</td>
</tr>
<tr>
<td>c. Public</td>
<td>24.2</td>
</tr>
<tr>
<td>d. Municipal</td>
<td>16.1</td>
</tr>
</tbody>
</table>

Water Use Efficiency

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>3.19</td>
</tr>
<tr>
<td>2.</td>
<td>3.70</td>
</tr>
<tr>
<td>3.</td>
<td>3.36</td>
</tr>
<tr>
<td>4.</td>
<td>3.62</td>
</tr>
<tr>
<td>5.</td>
<td>3.39</td>
</tr>
<tr>
<td>6.</td>
<td>3.56</td>
</tr>
<tr>
<td>7.</td>
<td>5.45</td>
</tr>
<tr>
<td>8.</td>
<td>5.34</td>
</tr>
</tbody>
</table>
Section IV. Knowledge about water conservation

4. Information sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newspaper</td>
<td>88.7</td>
</tr>
<tr>
<td>Radio</td>
<td>71.8</td>
</tr>
<tr>
<td>Television</td>
<td>86.4</td>
</tr>
<tr>
<td>School courses</td>
<td>60.8</td>
</tr>
<tr>
<td>Posters on campus</td>
<td>39.2</td>
</tr>
<tr>
<td>Poster in a public area</td>
<td>45.7</td>
</tr>
<tr>
<td>Announcement or speech from school authorities</td>
<td>24.3</td>
</tr>
<tr>
<td>Information pamphlet from school authorities</td>
<td>22.6</td>
</tr>
<tr>
<td>Announcement or speech from government official</td>
<td>44.2</td>
</tr>
<tr>
<td>Information pamphlet from government</td>
<td>31.8</td>
</tr>
<tr>
<td>Information discussion with friends</td>
<td>47.5</td>
</tr>
<tr>
<td>Information discussion with family members</td>
<td>25.8</td>
</tr>
<tr>
<td>Information discussion with colleagues at work</td>
<td>24.6</td>
</tr>
<tr>
<td>Other*</td>
<td>5.9</td>
</tr>
</tbody>
</table>

* Other : books, internet, surveys, magazines, contest, commonsense

<table>
<thead>
<tr>
<th>Question #</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.</td>
<td>5.37</td>
</tr>
</tbody>
</table>

Section V. Water Conservation in the Public Sector

A. Individual conservation measures

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.a</td>
<td>6.40</td>
</tr>
<tr>
<td>b</td>
<td>7.38</td>
</tr>
<tr>
<td>c</td>
<td>7.19</td>
</tr>
<tr>
<td>2.a</td>
<td>5.27</td>
</tr>
<tr>
<td>b</td>
<td>4.30</td>
</tr>
<tr>
<td>c</td>
<td>4.86</td>
</tr>
<tr>
<td>3.a</td>
<td>6.96</td>
</tr>
<tr>
<td>b</td>
<td>7.74</td>
</tr>
<tr>
<td>c</td>
<td>7.83</td>
</tr>
</tbody>
</table>
### Conservation methods practiced

<table>
<thead>
<tr>
<th>Practice</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Changed washing habits</td>
<td>29.1</td>
</tr>
<tr>
<td>2. Always turned off water fixture</td>
<td>96.7</td>
</tr>
<tr>
<td>3. Alert school official</td>
<td>36.5</td>
</tr>
<tr>
<td>4. Other</td>
<td>1.8</td>
</tr>
<tr>
<td>1. Used water-saving fixture</td>
<td>6.4</td>
</tr>
<tr>
<td>2. Used water-efficient appliance</td>
<td>18.1</td>
</tr>
<tr>
<td>3. Acted to minimize leakage</td>
<td>14.6</td>
</tr>
<tr>
<td>4. Regular water meter inspection</td>
<td>46.5</td>
</tr>
<tr>
<td>5. Other</td>
<td>0.3</td>
</tr>
</tbody>
</table>

### B. Community Conservation Measures

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.a.</td>
<td>4.76</td>
</tr>
<tr>
<td>b.</td>
<td>3.16</td>
</tr>
<tr>
<td>c.</td>
<td>3.70</td>
</tr>
<tr>
<td>2.a.</td>
<td>6.16</td>
</tr>
<tr>
<td>b.</td>
<td>4.69</td>
</tr>
<tr>
<td>c.</td>
<td>4.62</td>
</tr>
<tr>
<td>3.a.</td>
<td>6.04</td>
</tr>
<tr>
<td>b.</td>
<td>6.05</td>
</tr>
<tr>
<td>c.</td>
<td>6.07</td>
</tr>
<tr>
<td>4.a.</td>
<td>7.10</td>
</tr>
<tr>
<td>b.</td>
<td>7.37</td>
</tr>
<tr>
<td>c.</td>
<td>7.26</td>
</tr>
<tr>
<td>5.a.</td>
<td>7.09</td>
</tr>
</tbody>
</table>
Mean
b. 7.26
c. 7.09

6.a. 6.34
b. 4.98
c. 4.92

7.a. 6.30
b. 7.45
c. 7.66

8.a. 7.77
b. 7.82
c. 7.73

9.a. 6.22
b. 5.49
c. 5.15

Awareness of currently existing community demand-management measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. water restrictions</td>
<td>36.4</td>
</tr>
<tr>
<td>2. water quotas</td>
<td>29.6</td>
</tr>
<tr>
<td>3. reduced water pressure</td>
<td>9.0</td>
</tr>
<tr>
<td>4. plumbing codes</td>
<td>31.9</td>
</tr>
<tr>
<td>5. retrofit program</td>
<td>17.0</td>
</tr>
<tr>
<td>6. increased water prices</td>
<td>34.9</td>
</tr>
<tr>
<td>7. education programs</td>
<td>70.4</td>
</tr>
<tr>
<td>8. domestic wastewater recycling</td>
<td>34.6</td>
</tr>
<tr>
<td>9. restrictions on urban growth</td>
<td>27.5</td>
</tr>
</tbody>
</table>
APPENDIX D

STUDENTS' SURVEY COMMENTS ABOUT WATER RESOURCES IN BEIJING

1. The most important thing is that the government should control and plan more efficiently and educate people widely. Using economic measures such as increasing water fees is not a bad way. At the same time we should improve technology and recycle water.

2. To solve Beijing's water problems, first we should start with the water source, second should reduce industrial water use and renew and repair water installations.

3. Price measure, in my opinion, is the eventual key to the water shortage crisis. Resources was, is and will be limited. Appropriate allocation of those resources including water can only be achieved by the mechanism of "market directing". Life is unfair, so is resources consumption. Have you ever heard of the theory of "Natural Selection (Darwin)"? I embrace it and apply it to human society.

4. I think the main problem is the water sector is the price distortion. Therefore, any technical improvement or social movement lack economic incentives.

5. We should recycle the polluted water. To offer enough water, we shouldn't waste water and renew the installations. We should not depend on limiting the water use.

6. It's difficult to carry out some methods of saving water because the low knowledge level of some people.

7. Move the capital to some other place where water is not in shortage.

8. Very useful (survey)!

9. The adoption of new techniques and the implementation of economic leverage will be more helpful.

10. Ways to improve the water supply situation in Beijing should be:

    i. strengthen water saving conception of people.
    ii. economic fines
    iii. reuse recycle of waste water
    iv. improve efficiency of water use.

11. Officials must be the example, or else it is impossible to improve the situation in the present.
12. This research has been mainly concerned on personal opinions of objective methods. However, in China, politics should have been included in this research, at least I think so.

13. To solve Beijing's water problems, we should depend more on industry and agriculture instead of individual citizens.

14. I thought the water resource is very short in Beijing. We ought to do something positively instead of negatively. The first thing we can do is the waste water recycling.

15. I estimate that the investigation will not cause any change of the present situation of water supply in Beijing.

16. I personally think the quality of the water in Beijing should be improved much.

17. It's a good investigation. But the answers made by the investigation may be vague. We all realized the problem of scarcity of water, but maybe didn't pay enough attention to it. And I think most Beijingers also behave like us. So we're very glad to know that someone is doing research in this area and we're also very willing to do something to settle this problems.

18. There isn't any use about this kind of problem.

19. It's very good! (survey)

20. Water supply in Beijing is becoming shorter and shorter as the scale of the city expands and the population increases. Most of all controlling the scale of the city is the important and necessary step to release the shortage of water supply.

21. Not bad (survey)

22. The survey is necessary. It should benefit Beijing's today, tomorrow, and future. The quantity and the quality of water supply in Beijing has not been and is not satisfying. The role of government in controlling water supply is very important. The recycling of water in industries must be strengthened.

23. I am glad this investigation exists!

24. The ideas are guide to actions. The best solution is to let everybody understand the importance of saving water and cultivate a good habit of saving water.

25. Solutions: 1. protect the in environment over a large area 2. use economic measures such as rising the price of water.

26. The best way to protect water resources is education. I don't think the government has done their best to let people know how serious the problem is facing them. And people don't know much how to protect water resources.
27. I think this investigation is good and necessary. To fulfill these questions is difficult for me because of my shortage of knowledge in this area. This exposed the problem of education and government propaganda about economizing on water and protecting resources of water. Also, I think the quality of water in Beijing is very bad. This problem is worse than the quantity of water.

28. To solve Beijing's water problems we should start with controlling the large water users and divert water from other provinces which are rich in water.

29. The investigation is very necessary. It will warn us that the lack of water in Beijing is very serious. Perhaps in 5 or 10 years North China will be in a frightful situation that there is no water that can be used if we do nothing. I think the government should enhance their ability of saving water and the broadcasting of saving water. Everyone should be strict with himself, saving every drop of water. It will do a great deal.

30. I think this survey didn't take into consideration the economic feasibility of measures. This is a very regretful aspect because social and people's acceptance is not the most important one, money talks!

31. This survey is helpful. 2. Too much is wasted on irrigation. The traditional agriculture should be improved. 3. Institutional improvement should be implemented. At least the price should be increased to it's cost. A sense of water resource crisis should be infused into the citizens of Beijing.


33. Since (economic) development is considered as the most important problem at the current period in China, environmental protection not given much practical attention.

34. It is important and necessary to make people pay more attention to the use of water. As a university student, it is our duty to protect the water and make good use of it. Furthermore, we should advise more people to join us. But I think strict and fair policy is the most important. Controlling means and the sense of making full use of water is the fundamental way.

35. To completely accept doesn't mean to carry out. To carry out doesn't mean it is equal.

36. There is no use for it! (survey)

37. The problem of water is really a big problem. As a native of Beijing, I am anxious to have this problem settled. I will do all I can do.

38. Please pay attention to the problem of population. More people more water are wasted.

39. Inefficiency in water use, there are lots of ways improve the efficiency. I prefer to save water and recycle.
40. After answering these questions, I leaned a lot about water. And now I realize that water is so important and valuable. This investigation is active and constructive for us to solve the problem. Let's try our best!

41. As a student living in campus, I didn't realize the water shortage, but in fact water problems have become quite serious in Beijing. Because of some geographical reasons, we can't solve water problems completely. The conditions for the city to develop are to save water and improve the efficiency of water use.

42. It's very important for us to protect the resources of water. Although there's plenty of water to use now and we needn't worry about it. But we must see that there isn't many usable water sources in Beijing. What's more public knows little about the importance of saving water. Many people think there's enough water to use. So I agree with plans to protect water. I think the most important think is to let people realize the importance of lack of water.

43. Try our best to use advanced technology. Now education may not improve people's consciousness greatly.

44. This is the first time that I've taken a survey about water resources. It's not easy to change people's attitudes. We should educate people and conduct some propaganda. But the more important things is to improve technology.

45. We can't just depend upon propaganda.

46. Hopefully there is a solution which will convenient for people to effectively save water.

47. Saving water is a permanent solution. It isn't proper to use short-term solutions such as limiting water use to a number, controlling development, or increasing water fees. We should enhance the quality and cognition of people, spread advanced installation of water saving technology, encourage people to conscientiously use all kinds of measure to save water and raise efficiency. And industry and agriculture should change the attitudes towards wasting water. They should innovate technology and recycle water. Only in this way can we protect and use water resources properly.

48. I think it is important to let people know that Beijing is very lack of water. And making good use of water is a task of all the people for ourselves and further generations. And the leaders should take steps to make the use of water science. If necessary, strict policies should be used.

49. 1. The installations (technology) are too old and have not been kept in good repair. 2. In public places nobody manages the water infrastructure.

50. Water is important for us. World is not only hungry but also thirsty, especially in the north of China. Water is lacking. I think not only the government will try to do something to solve this problem but also everybody must try his best to do. So education and advertisement on saving water are important. Everybody must try.

51. Regulation of price is necessary
52. It is important social engineering to save water resources. In my opinion, the best way to
develop the engineering is to give more education about the importance of water and the
危机 of water resources we are facing.

53. You can make more research about how people realize the importance of water in
everyday life and to what extent they realize the seriousness of the shortage of water.

54. I think the supply of water in Beijing is sufficient. Your investigation may do some thing
for saving water.

55. Meaningful! (survey)

56. Water is the blood of life. Water supply is sufficient, however, it's quality is worth
improving.

57. I think the water resource problem is a very serious matter it is not just Beijing, but also all
over the world will have to face it. I am glad to join in this investigation and give my
suggestion and advice. I wish that you can find out the best solution of this problem, for
Beijing, for our earth, through this fine investigation. God bless you!

58. Water is an important resource of nature. Everyone in our society should pay much
attention to this problem (shortage of water).

59. Education and promoting efficiency of water use in industry is paramount.

60. Today the usage efficiency of Beijing's water resource is badly low. People have no
realization and recognition of saving water. Government and social measures has not
been effective in appealing to the people to save water.

Another important reason of people's wasting water is that a high quantity of people do
not have not knowledge about how to save water, and the issue of protecting the
environment resources has not made an impression in their mind. Society and
government should take public media such as newspapers, TV, broadcasting, or series of
activities to warn people from wasting water. In addition, the water-provision installations
should be revised to save water, and take ways to recycle water.

61. I hope people could get more and more clean non-contaminated water! We should
protect nature and live a happy life!

62. I feel that water supply for ordinary living is good in Beijing. However, quality of water
seems bad. There are many fine white particles settled down after the water boils. We
do not know whether drinking such milk like water everyday has harmful effect on our
health in the long term. I think it is the government's responsibility to show the public the
level of risk to drink such water. I have never heard such clarification of risks.

63. In my opinion, during my studies in Beijing, I didn't notice the water supply question. But
the phenomena of wasting water are widespread. So I think it is very necessary to teach
the public how to save water, to protect water sources.
In fact, every city in China should save water. Our nation will benefit a lot from it. In the policies for saving water, I think are of the most important thing is education. China is a country whose water source is not abundant, so everyone should save water. I think this investigation can also carry on in the middle school and in the factory. I think your investigation is very good for us to consider this problem.

I really appreciate your great eagerness about our country's most serious problem. I hope you to make great progress on your research. Thank you so much!

I think it is unfair only to pay attention to saving water in public. If possible, please investigate how much water are industries and agriculture used, and whether there are some methods to save water.

The problem of saving water urgently needs a solution, which requires the immediate action of the whole nation.

Strictly control the size of the city. Enhance education and popularity and promote the techniques of saving water and energy.

Water supply is a social problem. Although the investigation means well, the solution of the problem is finally decided by the government. It has little to do with the ordinary investigator. Therefore we should be practical.

This is helpful to improve the awareness of saving water among those investigated

I think this investigation will be more helpful. If the government pays more attention to the problem of water, I hope your work will do some helpful work.

On the other hand, there are many problems besides what you have mentioned, one of the biggest and difficult problems is that some departments consume too much water. In fact, now our country pays more heed to develop our economy and pays little heed to the serious pollution, and this may cause the bad quality of water. Let's do our best to make our life quality better.

I think the basic way to solve the problem is to control the quantity of water being used by the extravagant restaurants and the low profit industry factories. The former wastes most of water to afford unnecessary expensive living conditions while the second wastes a lot of water only to produce some polluted water such as paper factory.

The most effective way I think is to propagate the ongoing situation on the water for drinking in Beijing and take compatible measurements to increase the using efficiency. If every citizen has the idea to save water, the hard problem will be solved gradually.

The problem of water shortage and water pollution is becoming serious in Beijing. I hope that the result of this paper can help our government do some real things to modify this situation.

In my opinion this investigation is necessary and very important.
76. I think the most urgent and important measures taking to alleviate the shortage of water resources is how to improve the low efficiency of water usage.

77. Beijing is facing a serious problem of lacking water and it will be more serious in the future, if everybody is still wasting the limited water resources. One of the reasons for this is that water resources' value is very low for each citizen (low water price). Increasing the pricing for water resources and appropriate equipment should be facilitated. Hope your success.

78. Water shortage is the most serious problem of Beijing. It is due greatly to the lack of intention of saving water of the citizens and the incapability of leaders at all levels so this problems becomes more and more serious.

Only two ways can be effective: education and a more perfect law system which is able to deal with corrupt officials.

79. It is of great significance for everyone to be informed of the deficiency of our water resource. Since the issue is very serious with the development of our city construction, we must be well aware of it and do our best of improve the situation that we are in. I hope the government takes some possible method to satisfy our demand of water.

80. It's important for everyone to know about water shortage in Beijing so that people will try to save every drop of water. On the other hand the city government should manage to develop new sources of water to ensure the sufficient water supply for education, industry, agriculture, and everyday life.
APPENDIX E

LIST OF ACRONYMS AND ABBREVIATIONS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADB</td>
<td>Asian Development Bank</td>
</tr>
<tr>
<td>BMEPB</td>
<td>Beijing Municipal Environmental Protection Bureau</td>
</tr>
<tr>
<td>BMWSO</td>
<td>Beijing Municipal Water Saving Office</td>
</tr>
<tr>
<td>CCD</td>
<td>Beijing Municipal Water Saving Office</td>
</tr>
<tr>
<td>CCEN</td>
<td>Environment News - Chinese version</td>
</tr>
<tr>
<td>CD</td>
<td>China Daily - Chinese version</td>
</tr>
<tr>
<td>CEN</td>
<td>China Daily - English version</td>
</tr>
<tr>
<td>CCICED</td>
<td>China Environment News - English version</td>
</tr>
<tr>
<td>EPB</td>
<td>Environmental Protection Bureau</td>
</tr>
<tr>
<td>EPC</td>
<td>Environmental Protection Commission</td>
</tr>
<tr>
<td>ENGO</td>
<td>Environmental Non-Governmental Organization</td>
</tr>
<tr>
<td>EPO</td>
<td>Environmental Protection Office</td>
</tr>
<tr>
<td>MWWTP</td>
<td>Municipal wastewater treatment plant</td>
</tr>
<tr>
<td>NEPA</td>
<td>National Environmental Protection Agency</td>
</tr>
<tr>
<td>NGO</td>
<td>Non-governmental Organization</td>
</tr>
<tr>
<td>OMW</td>
<td>Office of Municipal Works</td>
</tr>
<tr>
<td>PUB</td>
<td>Public Utilities Bureau</td>
</tr>
<tr>
<td>SPC</td>
<td>State Planning Commission</td>
</tr>
<tr>
<td>WCB</td>
<td>Water Conservancy Bureau</td>
</tr>
<tr>
<td>WSO</td>
<td>Water Saving Office</td>
</tr>
</tbody>
</table>