LUND UNIVERSITY MASTER'S PROGRAMME IN ENVIRONMENTAL SCIENCE

WATER PRICING TOWARDS SUSTAINABILITY OF WATER RESOURCES: A CASE STUDY IN BEIJING

MASTER'S THESIS

BY

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SUMMARY

The role of water pricing for managing water resources is widely recognized in many areas of the world because of the increasing scarcity of water resources, a high competition between water uses and environmental degradation. Based on the analysis of cost of water, this report explores which types of cost should be reflected in the water pricing which can enhance the sustainability of water resources. The principle of full cost pricing in which the cost should include supply cost, opportunity cost and externalities is proposed as a means to achieve the sustainability of water resources.

In a case study of Beijing, the situation of water resources is presented and the history of water price is reviewed. Based on the analysis of the problem existed in the water pricing, low water price is one reason for unsustainable water consumption. Thus water pricing justified is necessary and pressing. It is proposed to justify water price in phased manner and eventually towards full cost pricing. The assessment of impacts on water resources by raising water price shows water pricing could alleviate the conflict between water supply and demand. This report concludes that water pricing can play an effective role in enhancing the sustainability of water resources in Beijing.

Keywords: water resources, water price, cost, full cost pricing, sustainability, Beijing

LIST OF ABBREVIATIONS

BCM	Billion Cubic Meters
CEC	Commission of the European Communities
EEA	European Environment Agency
GDP	Gross Domestic Product
ICID	International Commission on Irrigation and Drainage
ICWE	International Conference on Water and the Environment
MB	Marginal Benefit
MC	Marginal Cost
MEC	Marginal Environmental Cost
MOC	Marginal Opportunity Cost
MOC	Ministry of Construction
MOWR	Ministry of Water Resources
MSC	Marginal Supply Cost
O&M	Operation and Maintenance
OECD	Organisation for Economic Co-operation and Development
P	Price
Q	Quantity
SDPC	State Development and Planning Commission
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organisation
US	United States
USOC	Unaccounted Social Cost
WEDC	Water, Engineering and Development Centre

1. Introduction

Water is life. Every human being, present and future, should have access to safe water. Water is the basis for all living ecosystems and habitats and part of an immutable hydrological cycle. It must be respected if the development of human activity and well being is to be sustainable. During the latter half of this century the pressure on natural water resources in many regions of the world has been increasing dramatically. In just a couple of generations the earth's population will reach an estimated nine billion people,[1] compared to around six billion today. How will this growing population be fed? Two-thirds of water consumption already goes to irrigation, and agricultural needs are increasing. Meanwhile, industrialization is also taking a heavy toll on our fragile water supplies, creating both new demands and risks of pollution. The standard response to water scarcity is to increase water supply. But soaring population, food needs, and industrialization will eventually outstrip this approach. The time has passed when abundant supplies of water were readily for development at low economic, social, and environmental cost. Now we are entering the period with increasing competition for access to fixed supplies, a growing risk of water pollution, and sharply higher economic, social, and environmental costs of development. For water management, the shift is from a supply orientation to emphasis on demand side management. An essential component of demand side management strategy is water pricing.

1.1 Background

A close look at the state of water resources to date reveals that the sustainability of the water system is at stake in many areas of the world. Many factors can be found behind this situation, such as limited incentives to reduce water use, inadequate institutional frameworks, and lacking or poorly implemented environmental policies etc. Increasingly, it is found that water price does not give the "right" signal for using water in a sustainable manner.[2]

Water pricing has been viewed primarily as an economic instrument for efficient water management, It is increasingly recognized that water pricing could improve use efficiency and conservation thereby improving both quantitative and qualitative state of water resources. Water pricing could play an effective role in enhancing the sustainability of water resources.[3] The question is what kind of water pricing precept could achieve the aim of sustainability of water resources.

China is the biggest developing country in the world with a large population and fast economic growth in recent years. Water scarcity in China is not in doubt: at least 400 of the largest 600 cities face water shortages, and population that continues to grow in size and affluence will place an enormous burden on water supply. Per capital water resources in China are only one-fourth world averages, and the government is being forced to consider large south-to-north water transfer projects, such as the potential US$12 billion diversion of upper reaches of the Yangtze river to the Yellow river, to avert a disaster. Solutions to water scarcity are often discussed in terms of three different aspects: water related regulations and policy, management systems, and awareness of water scarcity and water conservation. However, water pricing reform has been recommended by both academic and policy analysts as one of the main solutions for easing water scarcity that touches on all three areas. Thus, the study of water pricing under such situation should be

[1] World resources, 1998-99, World Resources Institute, 1998
[2] Pricing policies for enhancing the sustainability of water resources, Commission of the European Communities, 2000
[3] ibid.

significant and useful for water pricing reform. Since Beijing is the capital of China, it should also be significant to choose Beijing as the case study.

1.2 Objectives

The objective of this research is to study the water pricing problems and methods so as to explore the precept of water pricing which can enhance the sustainability of water resources. From this point of departure, the research goes to the application of this theoretical framework and to see how it could be adopted in Beijing.

1.3 Material and methodology

The material used in the study is secondary academic sources such as papers, articles and books. With these as a point of start a study is conducted with the aim to establish a theoretical framework to facilitate the understanding of water pricing towards the sustainability of water resource. Furthermore, a case study has been conducted. Here the city Beijing is studied, with the aim to adopt the theoretical framework and draw lessons from international experience in water price reforms in order to enhance the sustainability of water resources.

1.4 Scope and limitations

This research has no intention to give a pure theoretical scientific contribution in water economics. It takes a look at the conceptual framework of water as an economic good with the aim to understand how to take full cost into water pricing.

In this report, water pricing is only limited in setting water price in the water supply services in stead of all water services. It means that concept of water price used here is defined as the marginal or overall monetary amount paid by users for water supply services they receive.

1.5 Theoretical structure

The theoretical structure of the logic of this research could be illustrated by using causal loop diagram. Causal loop diagram can facilitate understanding the relationship between the water pricing and sustainability of water resources. Since water price and sustainability of water resources are not isolating components, they are working within a system: the water management system. The components in this system interact and function together. It is helpful to conduct a system analysis and using causal loop diagram as a tool to understand the cause and effect of each component in the water management system.

Before we start to draw the casual loop diagram, it is useful to summarize explanation of the causal loop concept.

Table 1.1 Summarized explanation of the causal loop concept[4]

Symbol	Meaning
Arrow ——————▶ Tail Head	The arrow is used to show causation. The item at the tail of the arrow causes a change at the head of the arrow.
——————▶ +	The + sign near the arrowhead indicates that the item at the tail of the arrow and the item at the head of the arrow change in the *same* direction. If the tail *increases*, the head *increases*; if the tail *decreases*, the head *decrease*.
——————▶ –	The - sign near the arrowhead indicates that the item at the tail of the arrow changes in the opposite direction. If the tail *increases*, the head *decreases*; if the tail *decreases*, the head *increases*.

The theoretical structure of this research's logic is presented in figure 1.1 (overleaf) by causal loop diagram which can be illustrated as follows:

Increasing water demand causes the water over-extraction and waste water discharge increasing which result in the decrease in water quantity and the deterioration of water quality. Both decreased quantity and worsened quality of the water decrease the sustainability of water resources thus raising public awareness to investigate the reasons and to take the proper actions. The artificially low water price is found being the reason behind the unsustainable water use. Based on the principle of full cost pricing, costs that should be reflected in the water price include not only the supply cost but also opportunity cost (i.e. resource cost) and externalities. Increased water price will improve the efficiency of water use and conservation which leads to reduction of the pressure on water resources thereby improve the sustainability of water resources. Meanwhile, decreased water demand and waste water discharge lead to obviate the need for construction of additional infrastructures such as reservoirs, water treatment facilities and waste water treatment plant which result in more money mobilized to improve the environment, this also improve the sustainability of water resources as well. In addition, cost recovery of water supply leads to financial sustainability of water suppliers thus could supply more reliable services to users.

[4] Introduction to causal loop diagrams, Haraldsson, H., Lecture Materials, LUMES 1999

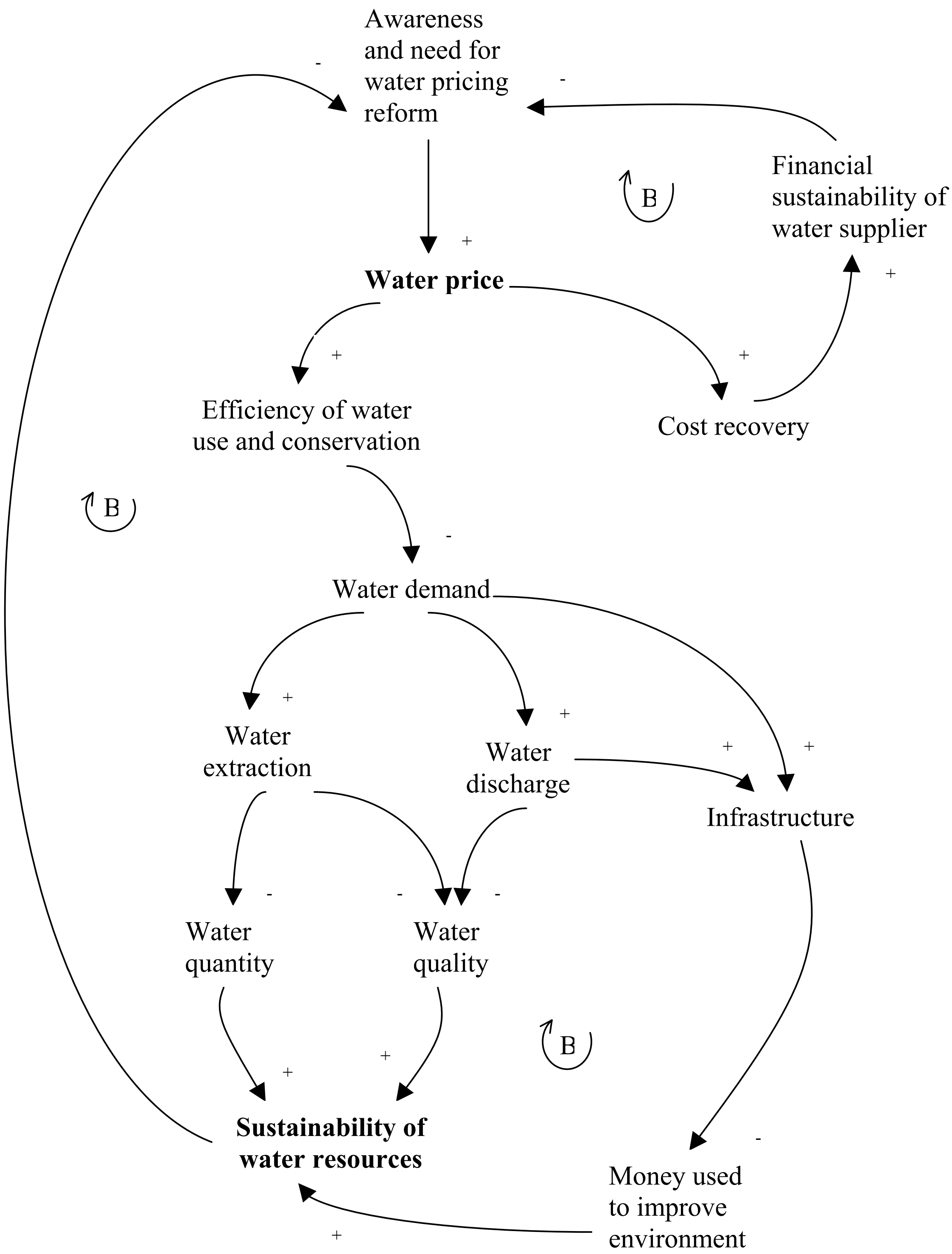

Figure 1.1 Causal Loop Diagram of water management system

2. The theory of water as an economic good

The concept of water as an economic good can be derived from the definition of economics, which is the study of "*how people and society choose to employ scarce resources that could have alternative uses in order to produce various commodities and to distribute them for consumption, now or in the future, among various persons and groups in society*."[5] Water is an economic resource since it can not only meet the basic need of human being but also has many alternative uses such as industry and agriculture. Water is scarce since it can not meet the demands of all the alternative uses simultaneously. Therefore, it is needed to study how to economize on water. The trend to treat water as an economic good developed in the economic literature already in the early 20th century. It culminated in the 1990s especially after the International Conference on water and the Environment in Dublin, Ireland in 1992. In the conference report which has been known as famous "The Dublin Statement", it states as the fourth guiding principle that "water has an economic value in all its competing uses and should be recognized as an economic good".[6]

The conceptual framework of treating water as an economic good is comprised of two components: the value of water and the cost of water. The interaction of these two components contributes to the foundation which the realistic pricing of water resources is based on.

2.1 The value of water

Water has different value to different users. As schematically illustrated in figure 2.1 (overleaf), the total economic value of water is the sum of use values and non-use values.

Use value is derived from the utility gained by an individual from direct or indirect use of water.

Non-use value is predicated on the notion that people often appreciate water even when they are not actually using it. It consists of bequest value and existence value. Option value is based on how much individuals are willing to pay today for the option of preserving the water for future use. Bequest value, while excluding individuals' own use values, is the value that people derive from knowing that others (perhaps their own offspring), will be able to benefit from the water in the future.[7] Existence value means that an individual places value on the fact that water, and the functions it supports, exist.[8]

So far we have understood why individuals value water, now the more interesting question is *what is the value of water in different sections of the marketplace*?

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[5] Economics, Samuelson, P.A. et al., 1985, p4
[6] The Dublin Statement on Water and Sustainable Development, conference report, 1992
[7] Environmental economics and natural resource management in developing countries, Munasinghe, M.,1993, p30
[8] The economic value of water: an introduction, Marcouiller, D., et al.,1999

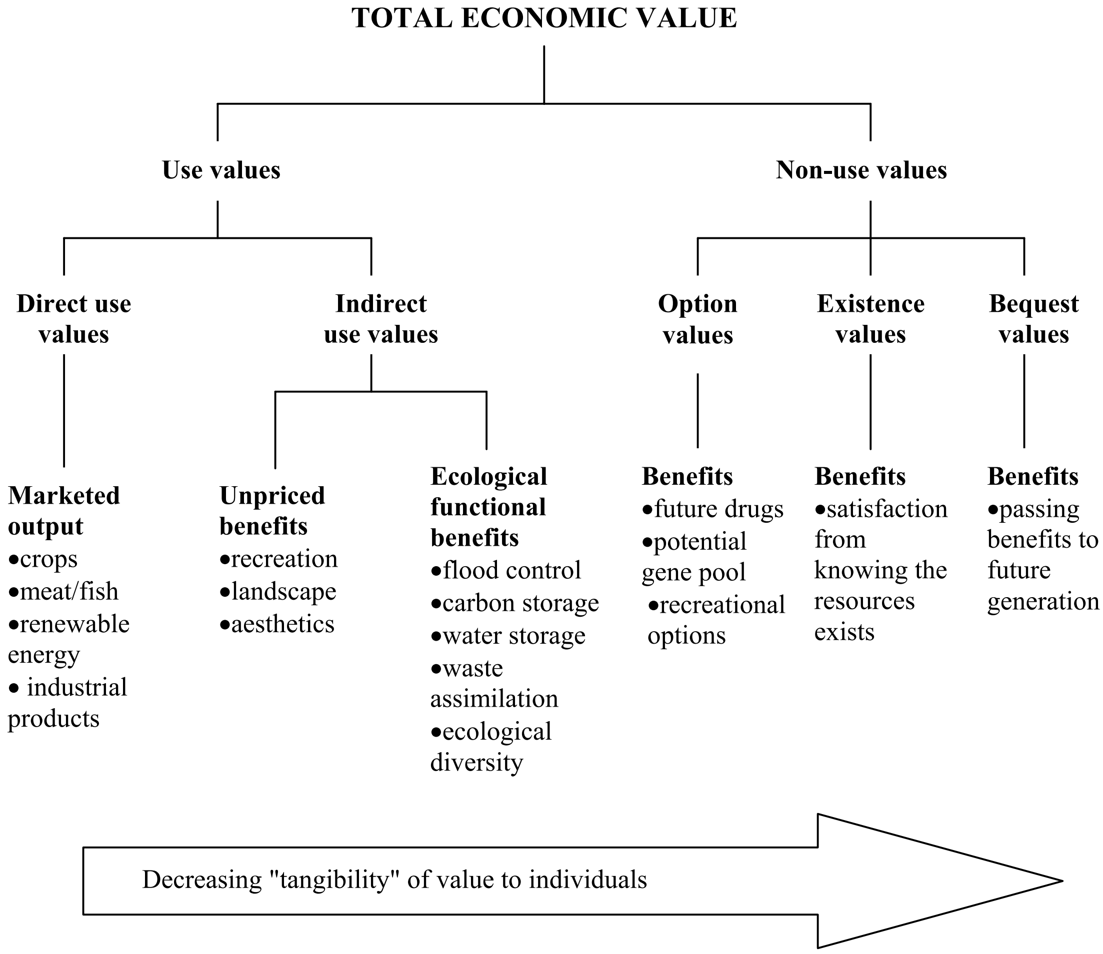

Figure 2.1 Total economic value[9]

Water has a value to users, who are willing to pay for it. Like any other good, consumers will use water so long as the benefits from use of an additional cubic meter exceed the costs incurred. The value of water to a user is the maximum amount the user would be willing to pay for the use of the resource. For normal economic goods which are exchanged between buyers and sellers under a specified set of conditions, this value can theoretically be measured by estimating the area under the demand curve. Since markets for water either typically do not exist or are highly imperfect, it is not simple to determine what this value is for different users of water.[10] There are numerous studies that attempt to compute the marginal value of water use by different sectors, mainly in agriculture, industry and domestic use. Here the conclusions from some studies are presented.[11]

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[9] Valuing rural amenities, Hodge, I. Et al., 1992
[10] Water as an economic good: the idea and what it means in practice, Briscoe, J., 1996
[11] Data extracted from following sources:
A. Water as an economic good: the idea and what it means in practice, Briscoe, J., 1996
B. Determining the value of water: the role of risk, infranstructure constrains, and ownership, Stephen C., B., 1998
C. The value of water, McGuckin, J., et al., 1997

Irrigated agriculture accounts for about 70 percent of water consumption world worldwide, and the United Nations projects a 50- to 100-percent increase in irrigation water demand by 2025.[12] The value of water for many low-value crops (such as foodgrains and fodder) is universally very low. Where reliable supplies are used on high-value crops, the value of water can be high, sometimes of a similar order of magnitude to the value of water in municipal and industrial end use.

The value of water for household purposes is usually much higher than the value for most irrigated crops. The value for "basic human needs" and for household uses is much higher than the value for discretionary uses. Reliable supply water has higher value than that of the intermittent and unpredictable supply water.

The value of water for industrial purpose is typically of a similar order of magnitude to that of supplies for household purposes.

The value of environmental purposes such as maintenance of wetlands, wildlife refuges and river flows also vary wildly, but typically fall between the agricultural and municipal values.

2.2 The cost of water

In thinking about the cost of water, it is necessary to know that there are three different types of costs incurred in providing water to a household, a field or an industry. The first cost is that of constructing and operating the infrastructure necessary for storing, treating and distributing the water. It is *supply cost*. The second cost is the *opportunity cost* incurred when one uses water and, therefore, affects the use of the resource by another user. The third cost is the externalities. As a fugitive resource, water results in pervasive externilities. These costs are discussed in the following section.

2.2.1 Supply cost

Full supply costs are composed of two separate items: Operation and Maintenance (O&M) cost, and Capital cost. O&M Cost are associated with the daily running of the supply system. Typical costs include purchase of raw water, electricity for pumping, labor, repair materials, and input cost for managing and operating storage, distribution, and treatment plants. In practice, there is little dispute as to what are considered O&M costs and how they are to be measured. Capital costs include capital consumption (depreciation charges) and interest costs associated with reservoirs, treatment plants, conveyance and distribution systems.[13] There are two kinds of accounting methods to calculate this cost which are historical cost pricing and replacement cost pricing respectively. Historical cost pricing is using the historical cost to measure the value of goods. It is a backward accounting stance. Replacement cost pricing is using replacement cost to measure the value of goods. It is a forward looking accounting stance and look for the costs associated with replacement of the capital stock with increasing marginal cost supplies.[14] Marginal cost denotes the extra or additional cost of producing another unit of output. The cost of raw water is almost always rising since the closest, cheapest sources are those that are used first. For example, a recent review of

[12] World Resources, 1998-1999, world resources institute, 1998, p189
[13] Water as a social and economic good: how to put the principle into practice, Rogers, P., et al., 1997
[14] Urban water demand management and planning, Baumann, D., 1997

domestic water supply projects indicates that the cost per cubic metre of water for the next generation of projects is often two to three times higher than the for the present generation.[15] Thus the marginal costs of water are greater than average costs.[16]

2.2.2 Opportunity cost

In economics, opportunity cost is defined as the value of the best available alternative.[17] Opportunity cost addresses the fact that by consuming water, the user is depriving another user of the water. If that other user has a higher value for the water, then there are some opportunity costs experienced by society due to this mis-allocation of resources. The opportunity cost of water is zero only when there is no alternative use; that is no shortage of water. Ignoring the opportunity cost undervalues water, leads to failures to invest, and causes serious mis-allocations of the resource between users.

The precondition for opportunity costs existed is that water must be physical scarce. In theory, there are two types of scarcity: economic scarcity and physical scarcity. Economic scarcity refers to the fact that the absolute quantity of water is abounding and can meet the needs of humankind in long run, but available water is finite because of the limitation of production cost. Physical scarcity refers to the fact that the absolute quantity of water is finite which can not meet the needs of humankind in long run. Economic scarcity can be alleviated by exploit water with higher production cost, thus it does nothing to the opportunity cost. Only the physical scarcity is relevant to opportunity cost. In practice, the delimitation of economic scarcity and physical scarcity is relative. For example, in the water scarcity area, the absolute water quantity could not meet the needs of humankind no matter how much production cost is inputted. Therefore, water is physical scarcity in this area. However, if some means are adopted such as water transfer from other basin, storm rainfall utilization and sea water utilization in order to increase the quantity of water resources, there is only economic scarcity in the basis that production cost is rather high. Since water is distributed unevenly in various areas, the opportunity cost is various. In water abound area, there is no shortage of water, the opportunity cost of water is zero. In water scarcity area, the opportunity costs exist. It differs for various users.

It is obvious that measuring of the opportunity cost of water is difficult. What we have known is that the opportunity costs imposed by extraction by the high-value user (the city) will be much lower than the opportunity costs imposed by extraction by the low-value user (the irrigation district). Opportunity cost increase substantially as the water becomes scarcer.

2.2.3 Externalities

All human activity has an impact on the environment, either positively or negatively. However, the prices of goods bought and sold in markets tend to exclude environmental costs and benefits. Where the market price fails to take into account such costs and benefits, they are termed 'externalities',[18] since they are external to the market.

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[15] Water for sustainable development in the twenty-first century, Biswas, A.K., 1993
[16] Water as an economic good: the idea and what it means in practice, Briscoe, J., 1996
[17] Water as a social and economic good: how to put the principle into practice, Rogers, P., et al., 1997
[18] Politics and the environment: from theory to practice, Connelly, J., et al, 1999

Water resources exhibit externalities in the sense that they have the property of "mutually interfering usage".[19] Individuals take the valuable commodity of clean water from the same environment that they then use to dump wastes, thus interfering with the use of no-longer-clean water by themselves and others. In economic parlance these aspects are referred to as externalities. The most common externalities are those associated with the impact of an upstream diversion of water or the release of pollution on downstream users. There are also externalities due to over-extraction from or contamination of common pool resources such as lakes and underground water.

The externalities may be negative or positive. Negative externalities means that use of water by one user has negative impacts on other users. For example, pollution from a upstream means that downstream users have to incur additional treatment costs. Drainage water from irrigation fields often carries high levels of salts, nutrients and pesticides, leading to losses of aquatic habitats. Positive externalities occur, for example, when surface irrigation both meets the evapotranspiration needs of crops, and recharges a groundwater aquifer. Irrigation is then effectively providing a "recharge service".[20] The standard economic approach to externalities is to *internalize the externalities*, which means to put a price on the externalities, then buyers and sellers on the market will take the externalities into account thereby the externalities are then internalized into the market.

2.2.4 Full cost of water

The overall cost of water is the sum of supply cost, opportunity cost and externalities. In order to ensure that users take the full cost of using water into account, it is useful to combine these three components of cost. In order to illustrate clearly, we only combine the supply cost and the opportunity cost at first which is illustrated schematically in figure 4.2 (overleaf). Then on this basis, externalities including negative and positive is combined. These are schematically shown in figure 4.3 and figure 4.4 respectively. Therefore, figure 4.3 represents the full cost of water with negative externalities, and figure 4.4 represents the full cost of water with positive externalities.

[19] Managing water as an economic good: rules for reformers, Briscoe, J., 1997
[20] Water as a social and economic good: how to put the principle into practice, Rogers, P., et al., 1997

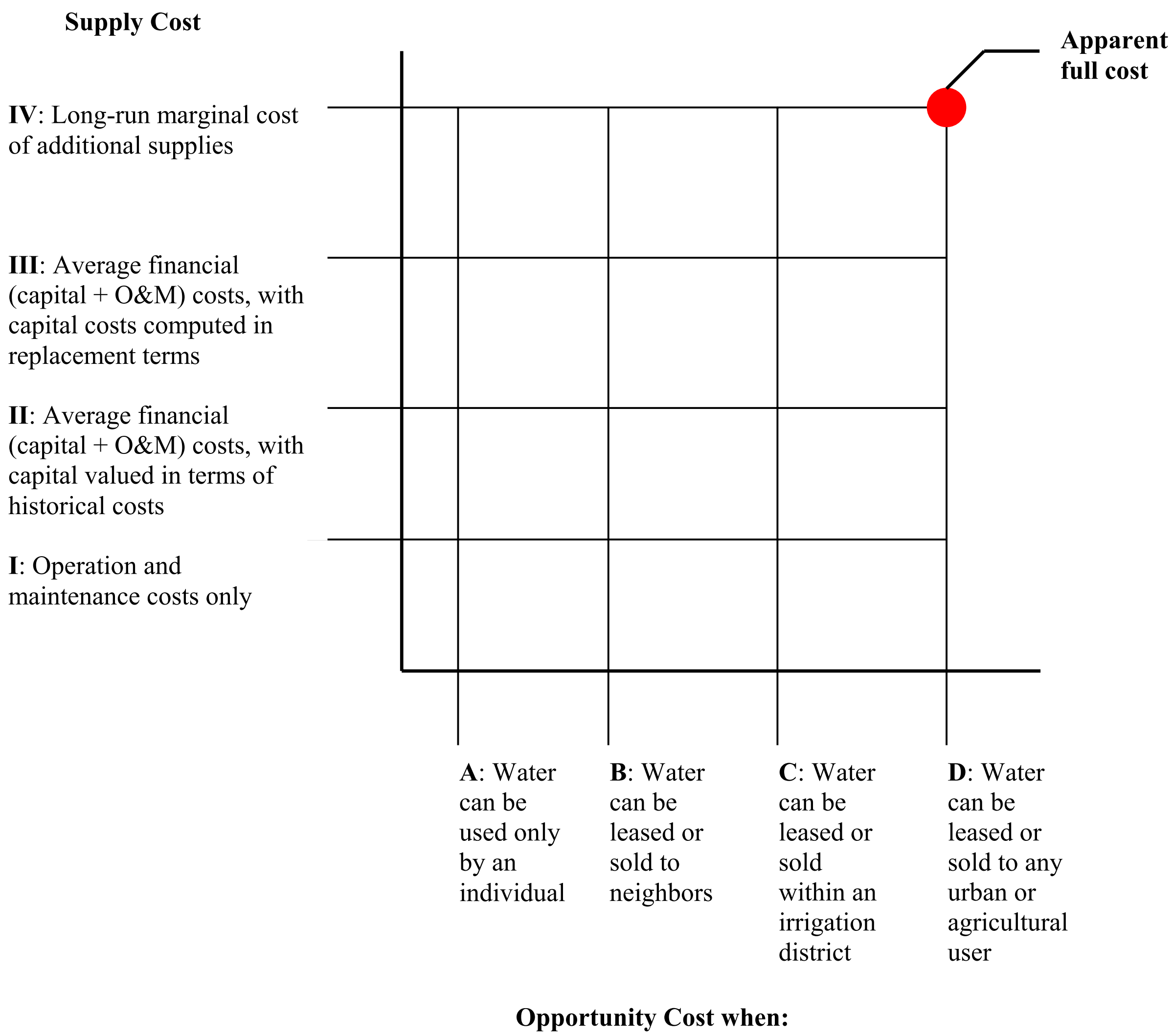

Figure 2.2 Schematic representation of the definition of use cost and opportunity cost[21]

[21] Water as an economic good: the idea and what it means in practice, Briscoe, J., 1996

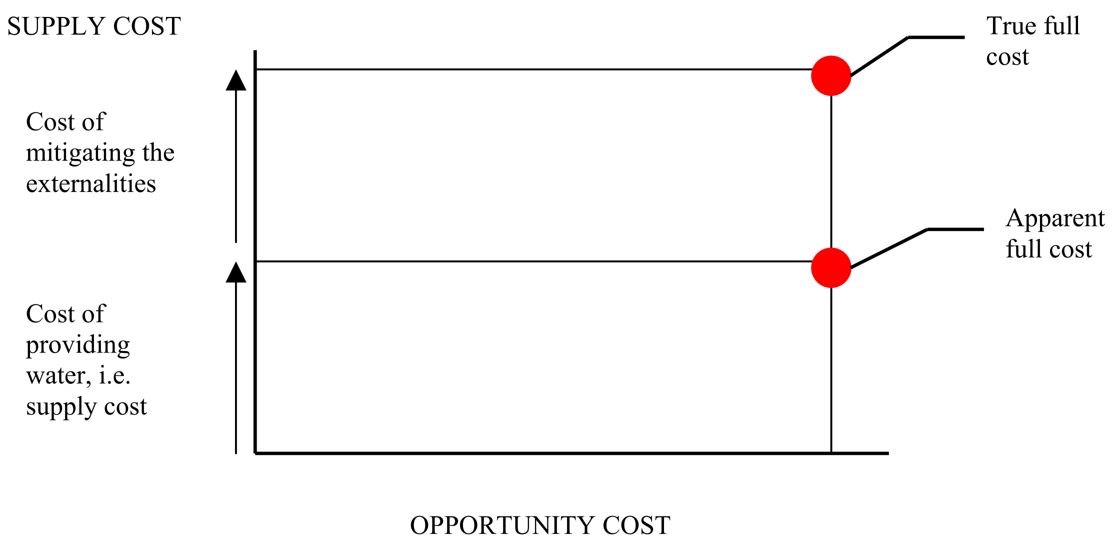

Figure 2.3 Full cost with negative externalities

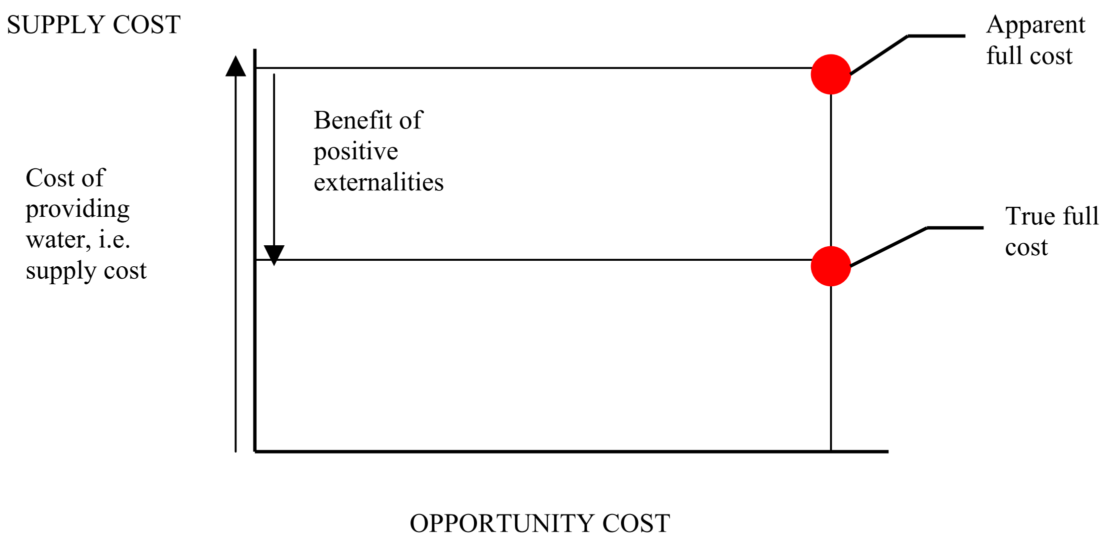

Figure 2.4 Full cost with positive externalities

3. Water pricing in theory and in practice

3.1 Properties of water as an economic good

Water is a gift of nature, it also has socie-economic properties since it is utilized by human beings. When water is treated as an economic good, it has some unique properties. The main properties include: nonsubstitution, renewal, scarcity, regional water supply and market monopoly, multi-sources of water supply, economic and social good.

3.1.1 Non-substitution

Water is life. It is indispensable for survival and development of human beings, and has no substitute. Other natural resources, such as petrol and coal, could have substitutes, but nothing can substitute water. If there is no water on the earth, then human being would lose the basis of survival and development. In fact, without water the earth would have no life as we know it, and no people.

3.1.2 Renewal

Water is a potentially renewable resource because of its natural ability to replenish itself by means of the hydrological cycle, or water cycle. Rain and snowfall bring to earth freshwater which is harvested for numerous activities. This water runs on the ground, flows in the rivers and lakes and oceans, infiltrates the soil, then evaporates to create clouds which condense to form rain and snowfall again. These processes are interlinked in a complex, continuously evolving global system called the hydrological cycle, or water cycle.[22] The water cycle is powered by energy from the sun and by gravity. On a global scale, the amount of water vapor entering the atmosphere is equal to the amount returning to the earth's surface as precipitation.

3.1.3 Scarcity

Although water is a renewable resource, only a tiny fraction of our planet's abundant water is available to us as fresh water. Only 3% of earth's water is fresh water. About 2.997% of it is locked up in ice caps or glaciers or is buries so deep that cost too much to extract. Only about 0.003% of the earth's total volume of water is easily available to us as soil moisture, usable groundwater, water vapor, and lakes and streams.[23] Global water consumption rose sixfold between 1900 and 1995 - more than double the rate of population growth - and continues to grow rapidly as agricultural, industrial, and domestic demand increases. The World Resources Institute has reported that the world's thirst for water is likely to become one of the most pressing resources issues of the 21st Century. [24] Thus, on one the hand, the available fresh water is limited. On the other hand, the consumption is increasing rapidly. Both of these contribute the situation that water becomes scarcer.

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[22] Living in the environment, Miller, G.T.,2000, p111
[23] ibid., p311
[24] World resources, 1998-99, World Resources Institute, 1998, p188

3.1.4 Regional water supply and market monopoly

Because of the limitation of regional natural conditions, water supply is usually in the region. This means that water resources can only be developed at the local level and utilized within the scope covered by the water supply network. Water can not circulate extensively in the market like other commodities. Water market is characterized by regional water supply. Because of the regional water supply, and since there is no substitute for water, water market is consequently monopolized.[25] There is only one or a few water enterprises or producers to handle water supply in a region. Water price is monopolistic instead of free competitive price. Water market is almost supply-side market. There is only regional water price, no national and international price. Transaction of water usually takes place in the region.

3.1.5 Multi-sources of water supply

Although precipitation is the sole source of fresh water, water supply could be from multi-sources because of the various types of water existed. At present, the water resources that people mostly develop and utilize are surface water and groundwater, the remaining is sewage reuse, ocean water desalination and storm rainfall utilization, etc. Different water quality in different sources and different ways of development and utilization can result in different water price. Because of water cycle, some of these water sources can be transferred to each other, such as surface water and groundwater, storm rainfall and runoff. Multi-sources of water supply can result in different development of water resources and different costs, and eventually influence water price.[26]

3.1.6 Economic and social good

Treating water as economic good means to monetarise water. The price of water is a response to the economic reality posed by the need to create and maintain a supply network, including treatment of the water. However, water isn't just a commodity, it also has social significance. Water is not free, but access to it is a human right essential for life itself. There is no point in thinking of water as free or unprofitable because this would greatly limit investment in distribution in many poor countries where water is only available for an hour each day. However, there is no point either in going to the other extreme and regarding it as a normal commodity. Water can not be reduced to just a matter of business.[27] People die if they have no water or if what they have is dirty.

3.2 Water rate structures

There are many different water rate structures that are adopted in different regions and countries. The design of water rate structures is the reflection of the goal of pricing, and it could influence the development of water resource. The selection of various water rate structures will decide whether it encourages consumption or conservation; whether it satisfies the "basic needs"; whether it promotes the efficiency of water resource use; and whether it ensures the operation of water suppliers.

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[25] Economics, Samuelson, P.A. et al, 1985, p509
[26] Theory of water resource value, Jiang, W.L., 1998
[27] The real price of water, Patrick, B., UNESCO Sources, 1998, No.5, p4-6

3.2.1 Types of water rate structure[28]

- **Flat rate**

Flat rate means that consumers pay a special sum of money regardless of how much water they use. The revenue could be collected according to dwelling unit or irrigating area. The objective met by this system is revenue stability. It is simple and easy to implement. The accounting costs are minimal. The big problem of flat rate is that it does not provide incentive for customers to conserve water, therefore result in wasting water severely.

- **Uniform-rate**

Uniform-rate is one where the amount paid per unit of consumption is the same over all units consumed. The advantage of uniform-rate is that it is simple and easy to calculate, administrate and implement. Some conservation is promoted. But in the consideration of cost of water supply, since there is difference between the cost of unit water supply, uniform-rate will result in cross-subsidies between users with various quantity of water use.

- **Two-part rate**

Two-part rate is one that combines the volumetric pricing and basic rate. Under a certain quantum of water usage, the charge is fixed and does not change with the consumption. Above this certain quantum, the charge is accounted according to the volume consumed. Two-part rate can ensure that water suppliers have fixed revenue.

- **Decreasing block-rate**

Decreasing block-rate is one where the unit charge decreases with the amount consumed. Decreasing block-rate is used to reflect the economies of scale present in serving larger users, and to reflect their higher load factors and the fact that they use less of the distribution system. Such a rate structure is an indirect way of charging rates to different customer classes whose unit cost of service differ. Decreasing block-rate make the added use of water less expensive on a per unit basis. Consequently, it does not encourage or promote water conservation.

- **Increasing block-rate**

Increasing block-rate is one where the unit charge increases with the amount consumed. The main objective is to encourage conservation since the price of water increases as consumption increases. Equity is accomplished since consumers who use lower amounts of water pay less, and those who put the most demand on the system pay a higher rate.

- **Seasonal rate**

In the water industry it is increasingly common to observe rates that vary by season; volume charges are higher during the peak season and lower during the off-peak season. It is referred to as

[28] Material concerned: Georgia water series, issue 5: rate design for small system, Jordan, J.L., 1998

seasonal rate. This pricing structure approximates marginal cost pricing. The economic theory behind surcharges is that prices during peak demand periods exceed prices during off-peak periods. It is peak use that strains the capacity of the system and triggers the need for expansion. Therefore, peak users should pay the extra costs associated with system expansion.

- **Life-line rate**

Life-line rate is set specially for the low-income consumers which can offer them some initial quantum of usage at a reduced price.

3.2.2 Trends of rate structures

In practice, a rate structure can be built by using a combination of the basic elements discussed above. The number of possible design permutation is almost endless. One finds rates that are uniform; uniform but adjusted seasonally; increasing-block; decreasing-block; increasing- or decreasing-block and seasonally adjusted; etc. It is interesting to review the trends of rate structures in some countries. This review is conducted in three sectors which are household, industry and agriculture respectively.

- **Household**

In the United States over the last 15 years (1982-97), the net effect of domestic rate structures is that about 25 per cent of that country's utilities appear to have switch out of decreasing-block schedules, and into increasing-block ones. In Organisation for Economic Co-operation and Development (OECD) countries, it is observed that there is a shift towards more use of volumetric pricing. It can be interpreted as a shift towards more equitable allocation of costs because it better reflects actual consumption by individual users. It is also observed that there is a shift towards more use of increasing-block pricing within the variable component. It can be interpreted as an effort to encourage and promote the conservation. [29]

- **Industry**

In OECD countries, the most common rate structures for industrial users involve two-part rates, including a fixed element and a variable element. Flat-rate rates are rare for industrial users. The use of decreasing-block rates used to be common in the US for industrial users, but now they are slowly disappearing (and have been banned entirely in Massachusetts). Increasing-block rates exist in Italy, Portugal, Spain and the US. In Spain, there is a large diversity of rate structures, but most involve increasing two-block rates. In the US, increasing-block rates are now more often favoured, especially in the West, where conservation objectives are more important due to repeated drought conditions. [30]

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[29] Household water pricing in OECD countries, OECD, 1999
[30] Industrial water pricing in OECD countries, OECD, 1999

- **Agriculture**

There are several types of rate structures for agricultural users that can be found in OECD countries, such as volumetric pricing, area-pricing, block-rate pricing, two-part rate pricing etc. Although interest in water metering increased significantly in the UK, metering is still an exception procedure in most irrigation districts in OECD countries. For one thing, the metering of water use in agriculture is costly, and occasionally inefficient. [31] Another study of water service to agriculture in Egypt has a similar conclusion about volumetric pricing, which states that volumetric charges are an unrealistic means of encouraging significant reductions in demand, because very high charges are required to have a significant impact.[32]

3.3 Principles of water pricing

Water is a "rival" and non-exclusive good. A "rival" good means that the supply of water is decreased or diminished in quality with every additional user. Non-exclusive good means water belongs to both everyone and no one at the same time. Non-exclusive nature means that the ownership right of water is not clearly defined.[33] Under this situation, price can not be used as a tool to allocate water among users. Non-exclusive good may result in over exploitation. Meanwhile, since a water utility operates as a natural monopoly, supply and demand forces do not determine prices as set in the market. In order to promote the efficiency of water allocation and provide reliable water supply, water pricing should comply with the principles outlined in subsequent sections.

3.3.1 Fair and equal principle

Water is a necessary factor for life and production. It is the basis of human beings' survival and development. Everyone has the right to access clean water to meet his basic needs. Therefore, water pricing must enable all people, regardless of whether they are low-income or high-income earners to afford the water for basic needs. Besides to ensure that everyone can use water, the fairness and equality should ensure that payments by users commensurate with the water services they received. In general, the costs vary with the quantity of water supply. Therefore, the prices for users with different amounts should be different. The fair and equal principle requires to consider the affordability and willingness-to-pay of users. Under some circumstances, it is required to consider making two-part rate or life-line rate.

3.3.2 Efficient allocation principle

Water is a scarce resource. Efficient allocation of water should be a priority when water price is set. Only when water price reflects its true economic cost, water could be allocated efficiently among different users. In the economic sense, efficiency occurs when each user pays a price that reflects the marginal cost of the water.[34]

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[31] Agricultural water pricing in OECD countries, OECD,1999
[32] Alternative approaches to cost sharing for water service to agriculture in Egypt, Perry, C., J., 1996
[33] Water as a public good: property rights, water issues in Wisconsin, Marcouiller, D., et al., 1999
[34] Urban water demand management and planning, Baumann, D., 1997

3.3.3 Revenue adequacy and stability principle

In order to keep the water utility operate sustainably, water pricing should do the job to produce the required revenues to meet the water needs of the community. The only way to achieve this goal is through the full supply cost pricing of water. In addition, revenue stability is also important. Stable revenues allow for more accurate budgeting, better planning, and lower long-term financing costs. To run a water utility, revenues must be predictable.[35]

3.3.4 Different priority among these principles

Since water is a special good, its pricing is very complicated. To summarize water pricing should not only consider the fairness and equality and water efficient allocation but also revenue adequacy as well. In practice, it is difficult to meet all of these goals at same time since some of these are directly conflict. It should also take the reality into consideration. Therefore, there may be different priority among these principles when water price is set in different sectors. For the household water, the prime priority of water pricing is fair and equal principle. Then efficient allocation and revenue adequacy principles could be considered. For industrial water, since water is production factor, it will be accounted into cost then passed to the consumers. The prime priority of water pricing is water efficient allocation and revenue adequacy. For the agricultural water, since the agricultural and rural development policies are the prime priorities compared with agricultural water pricing, the prime priority of agricultural water pricing is water efficient allocation, then the revenue adequacy. Fair and equal principle is generally not considered.

3.4 Effects of water price on water management

The consumers will determine their quantity of water consumption based on their income level if correct price signals are passed to consumers. Water has decreasing marginal utility. From the economists' view of points, financial incentive is one of important factors in determining the amount of water used. Therefore price is an important means to manage water resource.

In water supply management, price is a type of "soft" management. To manage water supply by pricing polices is one of the means in water management. The measures for water management could be divided into two types: regulation and market. Regulation measures could restrict the unnecessary water usage. Market measures could stimulate the conservation of water usage by the price. The effects of water price on water management are that using price instrument adjust water supply and demand thereby to reach the goal of water resource management, which is to promote water resource protection and conservation or promote water usage and bring sufficient revenue to water utility etc. The way to achieve this goal is to adjust rate structure and price level. The concept used to assess how users react to changes in the price of water is that of *price elasticity of demand*. Price elasticity of demand (here simplified as elasticity) is defined as the percentage change in use of water divided by the percentage change in price of water that brought it about. When the percentage change in consumption is less than the percentage change in price (elasticity greater than -1.0), the demand is said to be inelastic. When the percentage change in consumption is greater than

[35] Georgia water series, issue 4: issues in water pricing, Jordan, J.L., 1998

the percentage change in price (elasticity less than -1.0), the demand is said to be elastic.[36] It must be clarified that inelastic doesn't mean there is no reaction in consumption when water price is changed. It just means that the percentage change in consumption is less than the percentage change in price. In fact, as long as price elasticity is negative, consumption is reduced when price increases.

In figure 3.1, it can be found that there are some responses to water price changes, even though the price elasticity of demand presented vary in different types of usage.

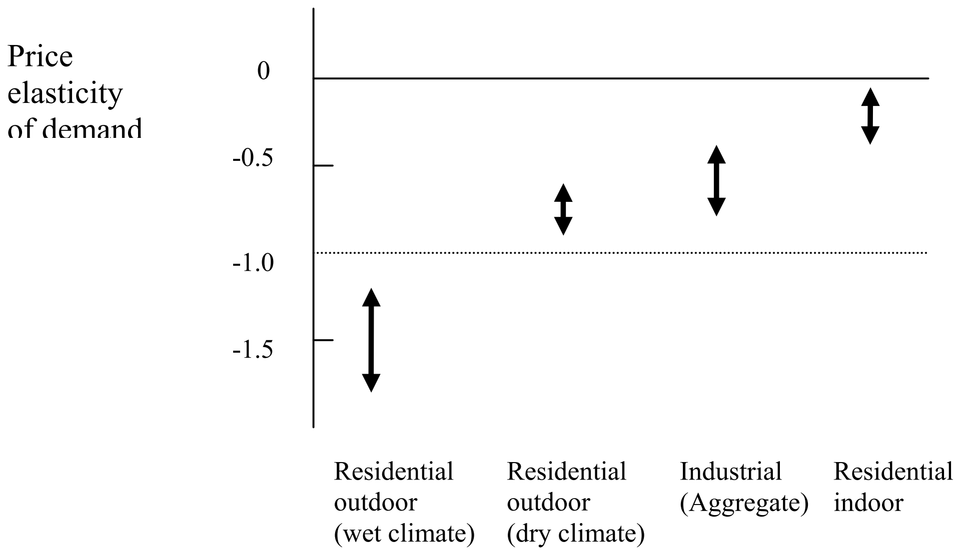

Figure 3.1 Range of price elasticity of demand for water in the United States[37]

The price elasticity varies in different seasons. A study shown that a summer residential demand of water is more price responsive than winter demand. Summer price elasticity can be as great as 30% more than winter price.[38]

For irrigation water, most available estimates seem to indicate some degree of price elasticity of demand. It means that farmers do seem to react moderately to water price. For example, in US Northwest, when groundwater price change, the ground water demand elasticity is -11.72.[39] However, there is also substantial evidence that water demand is usually inelastic only up to a given price level. For instance, in the western US the price elasticity of demand for irrigation water is low. The reason for this low elasticity is not that farmers do not respond to prices, but rather because user's reactions to price changes on the original price and because irrigation water price are held artificially low.[40]

For industry water use, a study has surveyed more than 2,000 industry firms in China, and gotten the conclusion that the price elasticity of water in industry use is -1.03.[41]

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[36] An introduction to positive economics, Lipsey, R. G., 1983
[37] The economic value of water, Gibbons, D.C., 1986
[38] Seasonality in community water demand, Griffin, R.C et al., 1991
[39] Agricultural water pricing in OECD countries, OECD, 1999
[40] The economic value of water, Gibbons, D.C., 1986
[41] Valuing water for Chinese industries: a marginal productivity assessment, Huang, H., et al, 1999

One study on the price elasticity of demand for residents water in Shanghai shows that when the water rate raise 10%, then the water consumption decrease 3.8%. [42] It means the price elasticity of demand for residents' water is about -0.38 and there is a potential to conserve water by using the incentive of water price. A considerable body of analysis for developed countries shows a central range of price elasticity of demand for household water of -0.3 to -0.7.[43]

The major point that emerges from many studies on the price elasticity of water demand is that the price elasticity is significantly negative which means that users react to price increase by reducing demand. The second important point is that the price elasticity is related to the price level - the higher the price, the greater the elasticity.[44] It illustrates that effects of water price on water management are obvious. Price should be as one of important means in water management. Water price plays a key role in sustainability of water resource.

3.5 Marginal cost pricing

At present, marginal cost pricing is a popular method that is recommended in literature. The economic argument for marginal cost pricing is that commodities (water in this case) should be produced and allocated to the point where their marginal benefit equals their marginal cost. At this point of time, there is full efficiency in the economy with respect to both total level of production and the allocation among individuals.[45] Marginal benefit is the extra benefit from producing and consuming one unit of water. Marginal cost is the extra cost from producing and consuming one more unit of water. The economist's rationale for marginal cost pricing is to set the water price be equal to the marginal cost. This could be illustrated graphically in figure 3.2. In figure 3.2, Q* is the optimal consumption of water.

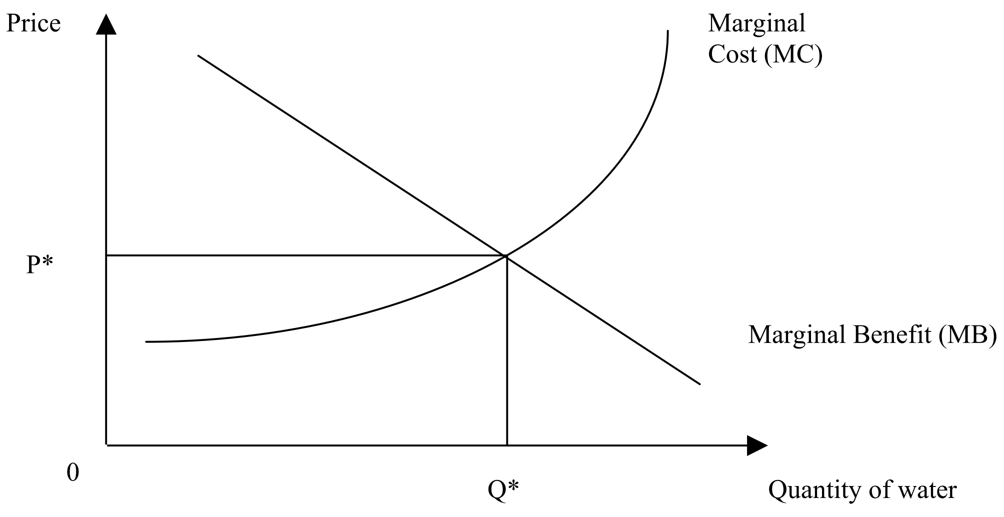

Figure 3.2 Marginal cost pricing[46]

[42] Interaction between water price and water environment, Fu, G.,W., et al, China Water, 1999
[43] Water allocation mechanisms - principles and examples, Dinar, A. et al., 1998
[44] Water as an economic good: the idea and what it means in practice, Briscoe, J., 1996
[45] Urban water demand management and planning, Baumann, D. et al., 1997
[46] Cost-based water prices, Barker, P., 1997

There are two types of marginal cost, which are short-run and long-run marginal costs. In the short-run, the capital stock is fixed and its cost is a fixed cost. In the long-run capital is variable and its cost constitutes variable cost. The fixed costs, which are associated with fixed inputs, are the costs that don't vary with the quantity of service provided. The variable costs, which are associated with variable inputs, are the costs that do vary with the quantity of service provided. By this definition, the marginal cost associated with the use of fixed inputs is zero -- the quantity of output changes, but there is no change in the quantity of these inputs, and so there is no change in this component of total cost. Only variable inputs generate non-zero marginal cost. In the short run, the capital stock is fixed, and the marginal cost arises mainly from O&M costs. In the long run, the capital stock can be replaced and expanded, and the marginal cost includes not only O&M costs but also capital costs. Thus, short-run marginal cost is always less than long-run marginal cost. If prices reflect short-run costs, this may encourage patterns of water use that are poorly suited to future circumstances when more expensive sources will be required. Since the water demand is increasing result from population, agriculture and industrilization growth, the capital stock is likely to expand in the foreseeable future. Long-run marginal cost pricing could be more close to reflect the true cost than short-run marginal cost pricing.[47]

In summary, water price based on marginal cost pricing precepts are intended to provide price signal that result in a more efficient allocation and use of a scare supply of water.[48] Efficient consumption requires that the benefit derived from consuming one more unit of a good equal the cost of supplying it. If the benefit is less than the cost, it is inefficient to produce additional units; the resources required to do so could be more productively employed elsewhere in the economy. By setting price equal to marginal cost, consumers are able to compare the benefit of additional consumption with its associated cost and make efficient choices. In this way, production may be guided towards more efficient levels.

However, if production does not take proper account of the full social and environmental costs, marginal cost will be too low and the price based on marginal cost can not promote effectively the efficiency of water uses and conservation. Thus it will result in the sustainability of water resources at stake.

3.6 Water pricing towards sustainability of water resources

3.6.1 Definition of sustainable development

The concept of "sustainable development" can be traced back to the famous publication *Our Common Future*. In this publication, sustainable development was defined as: "to ensure that it [=development] meets the needs of the present without compromising the ability of future generations to meet their own needs."[49] Furthermore, it points out that "the concept of sustainable development does imply limits - not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities".[50] Sustainable development implicates that the carrying capacity of environment is limited. However, sustainable development is not a fixed state of

[47] Georgia water series, issue 4: issues in water pricing, Jordan, J.L., 1998
[48] Urban water demand management and planning, Baumann, D., et al., 1997
[49] Our common future, World Commission on Environment and Development, 1987
[50] ibid.

harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with future as well as present needs.

When the definition of sustainable development is adopted in water resources development and utilization, it could be said that sustainable water resources development and utilization is development and utilization that meet current needs without compromising the ability of future generations to meet their own needs -- both for water supplies and for a healthy aquatic environment.[51]

When the definition of sustainable development is converted into economic terms, as Panayotou defined, "sustainable development can be understood so that sustainable development is development that pays its *full* cost during the process of development. When it depletes resources it charges itself a user cost; when it despoils the environment it charges itself an environmental cost that fully covers the damage (at the margin); it receives no subsidies except in proportion to positive externalities that it generates. It is only by inextricably internalizing the conservation of resources, the protection of the environment and the provision of environmental and social infrastructure to the very economic activities and actions that place additional demands on these resources that genuine development can be attained and sustained."[52]

3.6.2 Water pricing and sustainability of water resources

Although water resource is renewable, it does not mean that water resource could be developed and used without limits. The renewal of water resource needs a certain environmental conditions. The periods of complete renewal of water resources are different. For example, periods of renewal of atmospheric water is 8 days, water in river channels is 16 days, soil moisture is 1 year, water in swamps is 5 years, water storage in lakes is 17 years and groundwater water is 1400 years, etc.[53]

Water resource is humankind's indispensable "partner-for-life", in a partnership in which humankind is not dominant. Humankind should realize that there is a limitation of development and usage of water resource. Sustainable development and usage of water resources means that the environmental conditions which is needed to ensure water resources being renewable should be guaranteed. The rate of development and usage should be lower than the renewable rate of water resources. The efficient water pricing should act as an incentive to reduce the pressure on water resources[*] and the environment, to protect the renewal of water resources, and to ensure that available resources are efficiently allocated between water uses.

Efficient water pricing should ensure water resources are developed and used sustainablly. The sustainable water resources development and usage means that water resources are developed and used harmoniously with the surrounding environment. Nature is a huge and complicated system and its sub-systems interact with each other. Water resource system as one important sub-system

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[51] Capacity building for water resource and aquatic environment, UNDP, 1998
[52] Financing mechanisms for environmental investments and sustainable development, Panayotou, T., 1994
[53] Human development report 1998, New York, UNDP

- Water stress occurs when the demand for water exceeds the available amount during a certain period or when poor quality restricts its use. (Environment in the European Union at the turn of the century, European Environment Agency (EEA), 1999) undertakes the task of flow of matter and energy transfer. All socio-economic and environmental activities on this planet are entirely dependent on this system, which distributes freshwater independent of human will. Water resource development and usage will certainly affect the inherent law of the system itself and further affect other related system. Thus, sustainable development and usage of water resource should emphasize that water resource is in harmony with the surrounding environment.

Efficient water pricing should have an impact on the water demand of different uses. As a result of the direct impact of pricing on water use, the pressure on water resources can be reduced. This can lead to the reduction of over-abstraction of groundwater resources and the recharge of aquifers, the increase of flows in rivers and the restoration of the ecological status of rivers.

Effective water pricing should mobilise financial resources to ensure the financial sustainability of water infrastructure and service suppliers. Because of the properties of water as economic good, water suppliers on one hand have to face the market and on the other hand have to be regulated by administrative department, both of these could result in insufficient revenue. Financial sustainability could make water suppliers develop and supply services more efficiency.

3.6.3 Full cost pricing--a way towards sustainability of water resources

While it is known that water pricing could improve use efficiency and conservation thereby enhance the sustainability of water resources, it is crucial to decide which types of cost need to be reflected in water price that can play an effective role in enhancing the sustainability of water resources.

The Commission of the European Communities (CEC) has proposed that water pricing needs to reflect different cost types: [54]

(1) Financial costs of water services or supply cost, that include the costs of providing and administering these services. They include all operation and maintenance costs, and capital costs;

(2) Resource costs or opportunity cost, that represent the cost of forgone opportunities which other uses suffer due to the depletion of the resource beyond its natural rate of recharge or recovery;

(3) Environmental costs or externalities, that represent the costs of damage that water supply and uses impose on the environment and ecosystem.

Based on this principle, it is proposed that full cost (including supply costs, opportunity costs and environmental costs) pricing is the means to achieve the sustainability of water resources.

Full cost pricing is thought to bridge the gap between private and social costs by internalizing all external costs (both depletion and pollution costs) to their sources: the producers and consumers of the resource depleting and polluting commodities (water in this case). Full cost pricing is going to charge not only the production cost but also full scarcity cost for resource depletion and full damage

[54] Pricing policies for enhancing the sustainability of water resources, Commission of the European Communities, 2000

cost for environmental degradation. [55] When we adopt the principle of full cost pricing to water price set, the Full cost pricing is given by the following formula:

$$P = MSC + MOC + MEC$$

Where P = price, MSC = marginal supply cost
MOC = marginal opportunity cost
MEC = marginal environmental cost

Marginal supply cost is the cost of producing one more unit of water or the added cost of incremental output of water. When we refer to the cost of water which is presented in last chapter, it is found what we called marginal supply cost here is the supply cost of water at level IV (refer to figure 2.2).

When we refer to figure 2.3 and figure 2.4, it could be found that what we here say full-cost pricing is exactly to price water on the true full cost which is presented in figure 2.3 and figure 2.4.

The principle of full cost pricing is graphically illustrated in figure 3.3 (overleaf).

In figure 3.3, USOC is the unaccounted social cost, $USOC = S+MOC_0 +MEC_0$. S is subsidies. The reason why consider the subsidies here is that water subsidies in water services are very common in many countries. MSC'_0 is the marginal supply cost with subsidies. P_0 is current water price and Q_0 is the corresponding production and consumption quantity of water. P* is water price under full-cost pricing. P* = MSC+MOC+MEC. Q* is optimal quantity of production and consumption. It is obvious that since P_0 does not include the opportunity cost and environmental externalities and even has the subsidies, P_0 is rather lower than P* which result in over production and consumption. MSC* is marginal production cost without subsidies. MOC* is MOC after internalized. MEC* is MEC after internalized. DD is demand curve.

[55] Economic instruments for environmental management and sustainable development, Panayotou, T., 1994

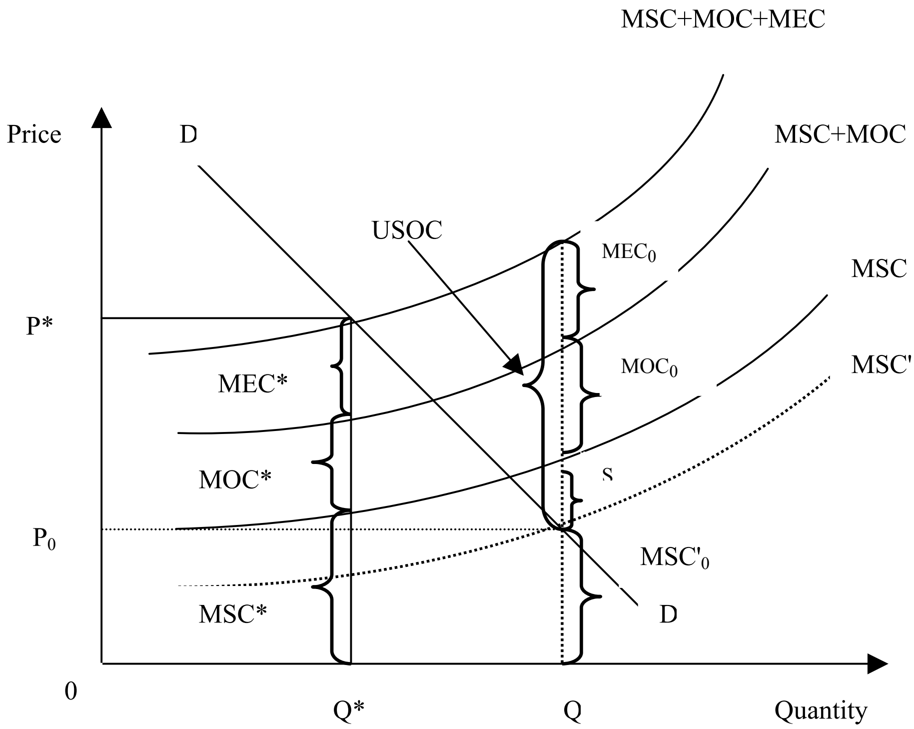

Figure 3.3 Full-cost pricing[56]

3.6.4 Discussion

When water is full-cost pricing, it can send a right signal to users for using water in a sustainable manner. It obviates the need for construction of additional reservoirs, water treatment facilities, and waste water disposal plants to meet growing demand; financial resources necessary for mitigation of environmental impacts of dam construction are also saved. When water is full-cost pricing, that reduces the burden on the state budget from the deficits of public utilities that do not fully recover their costs. With increasing supply costs, marginal cost pricing results in financial surplus that can be used to finance environmental improvements, to provide basic services to poor people at subsidized rates. [57]

In addition, the report of World Water Commission states that since the arithmetic of water in coming decades does not add up, there are must be a redoubled effort at technological, financial, and institutional innovation to ensure that environmental quality is improved and people's needs are met. The Commission emphasizes that unless full-cost pricing for water services becomes accepted practice, none of these will succeed.[58]

However, since full-cost pricing internalize all external costs (both opportunity and environmental costs), it is true that full cost pricing implies higher prices for the consumers and producers in the

[56]Economic instruments for environmental management and sustainable development, Panayotou, T., 1994
[57] Financing mechanisms for environmental investments and sustainable development, Panayotou, T., 1994
[58] For a water secure world: vision of water, life and the environment, World Water Concil, 2000

short-term, but the long-term benefits in terms of sustainable economic growth often outweigh these costs. Just as Mr. Abaza, Chief of Environment and Economics Unit at United Nations Environment Program (UNEP), said, " Without full internalisation of those costs, a country could not achieve sustainable development ".[59]

So far full cost pricing could be though as an effective means to achieve sustainability of water resources. However, it should be point out that water has been traditionally subsidized to achieve very specific socio-political objectives of food security, provision of clean drinking water, and increasing the income and health of the rural poor. If full cost pricing is to be introduced, other policy instruments have to be developed to achieve the same objectives.

[59] The use and application of economic instruments for environmental management and sustainable development, Abaza, H., 1994

4. A case study in Beijing

4.1 General introduction of Beijing

Beijing is the capital of China. It is the political and economic center of China with an area of 16800 km^2. In 1998, the population was12.46 million. During the past several years, Beijing has achieved its success in economic modernization and development. The dramatic rates of economic growth that is averaging nearly 10 percent annually have substantially improved standards of living for the people.[60]

However, this economic growth hinges on the wide-scale and unremitting exploitation of natural resources. On the one hand, the water demand is increasing because of the population growth and the development of industry and agriculture. On the other hand, the degradation and depletion of water resources, often by industrial or agricultural waste or emissions, reduces its overall availability. Both growing demand and declining supply are contributing to the situation of serious water shortages that Beijing has faced. During the past several years, however, the situation has steadily deteriorated, with little evidence that scarcities will be alleviated in the future.

4.2 Water resources in Beijing

4.2.1 Water resources description

Water resources in Beijing comprise of surface water and ground water. The surface water resources in Beijing are mainly from two sources: one is precipitation, with the annual average rainfall being about 606 mm; another one is inflow water. The annual average surface water resources with different reliability are shown in table 4.1.

Table 4.1 Composition of water resources in Beijing at different reliability[61]

Item	Annual average	Reliability		
		50%	75%	95%
Rain-off	2.3	1.8	1.2	0.9
Inflow water	2.1	1.8	1.3	0.8
Ground water	2.9	2.9	2.9	2.9
Total	7.3	6.5	5.4	4.6

Note: unit in the table is billion cubic meters (BCM).

Due to the restriction of the natural, technical and economic conditions and the ecological environment to the availability of water resources, a certain limit really exists in developing and utilizing the water resources. Therefore, it is neither possible nor reasonable to use completely all the water resources. Table 4.2 shows the available water supply in Beijing at different reliability.

[60] Data extracted from: China statistical yearbook, 1999
[61] Bulletin of water resources in China, Ministry of Water Resources of China, 1999

Table 4.2 Available water supply in Beijing at different reliability[62]

Item	Reliability		
	50%	75%	95%
Surface water	2.1	1.3	0.7
Ground water	2.3	2.3	2.3
Total	4.4	3.6	3.0

Note: unit in the table is billion cubic meters (BCM)

Using the data in table 4.2, we can calculate that available water resources per capita in Beijing is 353 cubic meters, 289 cubic meters, and 241 cubic meters at reliability of 50%, 75% and 90% respectively.

Now it is interesting to see the actual water supply and consumption in Beijing. Figure 4.1 and figure 4.2 (overleaf) show water supply and consumption in 1998.[63]

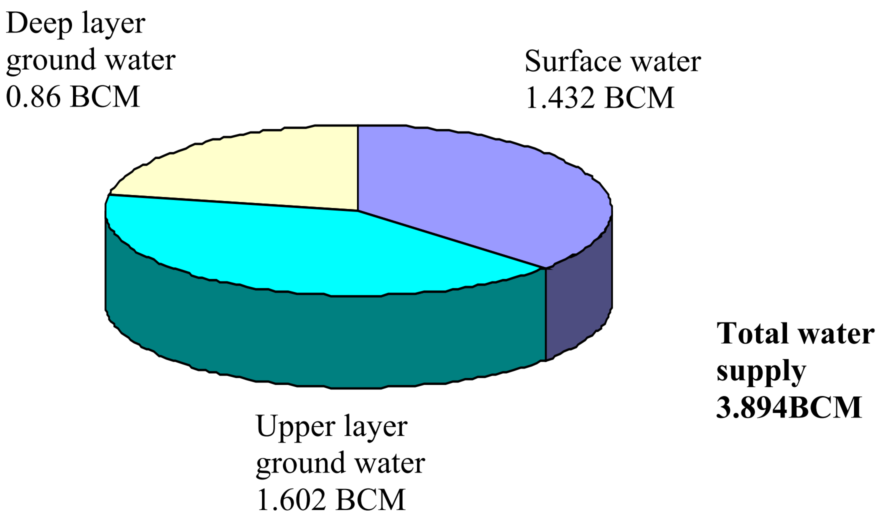

Figure 4.1 Water supply in Beijing in 1998

[62] Bulletin of water resources in China, Ministry of Water Resources of China, 1999
[63] Data extracted from: Beijing and Tianjing sustainable development with water resources, Guo, H., Y., 2000

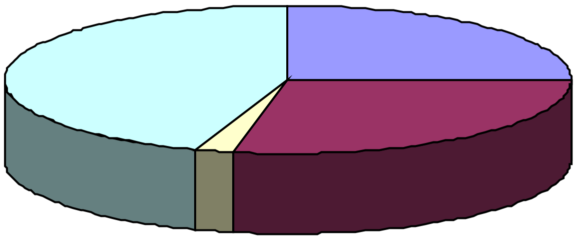

Figure 4.2 Water consumption in Beijing in 1998

From the table 4.2 and figure 4.2, we can find that total water consumption 3.894 BCM is lower than available water supply 4.684 BCM and 3.966 BCM at reliability of 50% and 75% respectively, but is higher than available water supply 3.292 BCM at reliability of 95%. It means that conflict between supply and demand is serious. Irrigation, industry and domestic are the main water users.

The present situation of water supply and demand is like this, how about the future? One prediction has been made by Beijing Water Resources Bureau, and the result is shown in table 4.3.

Table 4.3 Prediction of water shortage in Beijing[64]

Year	2000			2020		
Reliability	50%	75%	90%	50%	75%	90%
Water demand	4.538	4.813	4.813	6.075	6.37	6.37
Water supply	4.094	3.721	3.454	3.854	3.521	3.196
Water shortage	0.444	1.092	1.377	2.221	2.849	3.174

Note: unit in the table is BCM

From table 4.3, it can be found that there is a big gap between water demand and supply, water scarcity is even worse with the time going.

4.2.2 Water crisis

Along with the development of society and economy, the conflict between water demand and water supply is getting sharper and more serious, water resources scarcity is serious challenge that Beijing is facing. The water crisis, which Beijing is facing, may be considered to be the result of following phenomena.

[64]Water resources present situation and future situation prediction in Beijing, Beijing water resources bureau, 1997

First, population and economy are keeping growing, water shortage situation will get more serious and unavoidable. From 1991 to 1998, the population in Beijing increased 7% per year[65], and it is estimated that population will grow at this rate in near future. Meanwhile, the economic growth rate that was averaging nearly 10 percent annually during last several years will keep this growth speed in near future. Both of these will place serious stress on already scarce water resources.

Second, water quantity descending and water quality deterioration in main water supply reservoirs are becoming serious. Guanting reservoir and Miyun reservoir are main surface water resources of Beijing, and supply 2/3 water usage of Beijing. Because of drought, irrigation and industry increasing in the upstream areas, water amount that enters the reservoirs are lessening recently. For example, average annual water amount entering Guanting reservoir was 1.93 billion m^3 in 1950s, but it had decreased to 0.4 billion m^3 in 1990s; for Miyun reservoir, it has lessened 0.4 billion m^3 since 1950s.[66] In the meantime, water pollution has become more serious. Since 1997, water in Guanting reservoir has been polluted and was unsuitable for drinking water source, now it is only used for industry, irrigation and urban rivers and lakes water charging.

Third, the local water is seriously polluted. There is 1.2 billion m^3 waste water discharged annually in Beijing, about 0.9 billion m^3 of which from urban area, only 12% of which was treated through waste water treatment plants.[67] Untreated waste water discharged to the seeping wells, rivers and waste water ponds, in addition to fertilizers and pesticides from farmland, is getting into ground water through seepage, which causes ground water pollution. Water pollution not only directly affects health of people, but also enhances water shortage crisis, especially in dry years, which causes serious water resources deterioration.

Fourth, the groundwater is over extracted. Large amount of groundwater extracted leads to land subsidence, sea water intrusion, waste water seeping into groundwater and ecosystem deterioration. There is 4.0 billion m^3 of groundwater has been over extracted in all, 1.8 billion m^3 of which is in urban area. This has caused the 800 km^2 ground subsided with the deepest subsidence of 850 mm. Originally, the water table under Beijing was 5 to 10 meters underground; now it is over 40 meters below the surface. On average, the water table decreases by 0.5 to 1 meter annually.[68]

Based on the analysis above, it is known that the present situation of water resources in Beijing is severe. If nothing will be done, the sustainability of water resources in Beijing will face serious challenge, and more and more people will suffer water scarcity in the near future.

4.3 Water price in Beijing

4.3.1 Review of history of water price

The history of tap water price is simple, since it kept unchanged for a long time. Table 4.4 (overleaf) shows the history of tap water price in Beijing.

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[65] China statistical yearbook, 1999

[66] Water resources present situation and future situation prediction in Beijing, Beijing water resources bureau, 1997

[67] 1998 report on the state of environment in Beijing, Beijing Environment Protection Bureau, 1999

[68] Beijing and Tianjing sustainable development with water resources, Guo, H., Y., 2000

Table 4.4 History of tap water price in Beijing [69]

	Commercial		Industry		Community		Residents	
1952 - 1966	0.21	*0.21*	0.10	*0.10*	0.18	*0.18*	0.18	*0.18*
1967	0.12	*0.12*	0.12	*0.12*	0.12	*0.12*	0.12	*0.12*
1983	0.21	*0.18*	0.10	*0.09*	0.18	*0.16*	0.12	*0.10*
1988	0.25	*0.14*	0.25	*0.14*	0.25	*0.14*	0.12	*0.07*
1993	0.45	*0.18*	0.45	*0.18*	0.45	*0.18*	0.30	*0.12*
1997	1.0	*0.26*	1.0	*0.26*	1.0	*0.26*	0.7	*0.18*
1998	1.3	*0.35*	1.3	*0.35*	1.3	*0.35*	1.0	*0.27*
2000	1.6		1.6		1.6		1.3	

Note: unit in the table is RMB yuan per cubic meter (note: 1 US$ ≈ 8.3 RMB yuan).

In order to make the data of water price be comparable, all these data are converted to the equivalent price on 1978 which are shown in the right side of each corresponding column in italic. From table 4.4, it is found that there are several changes on tap water price during last several decades. The price level was fluctuating with increasing and decreasing in turn before 1997. After 1997, the trends of water price was increasing.

In regarding surface water and ground water, they were free in a long time. Before 1980, there were 3641 wells in Beijing, and the amount of water extraction was 0.35 BCM per year. All of this water was free to be used. After 1980, Beijing water economizing office began to administrate these wells, and charged extraction fee of 0.02 yuan per cubic meter.[70] At present, the use of surface water and ground water are both charged on different rate. For the surface water, it is charged 0.36 yuan per cubic meter for industry and 0.02 yuan per cubic meter for irrigation, the average price in terms of all kinds of users for surface water is 0.29 yuan per cubic meter. For ground water, the charging criteria are same as the surface water.[71]

The rate structure for all kinds of water in Beijing is uniform rate.

4.3.2 Analysis the problems existed in water pricing

There are several problems existed in the water pricing in Beijing: mainly the low water price, unitary water rate structure and confused water pricing system.

4.3.2.1 Low water price

Water prices have been justified several times during this decade, but they are usually lower than the cost of production. For example, the surface water for irrigation is only charged 0.02 yuan per cubic meter, which is almost free. Even the average price of surface water is 0.29 yuan per cubic meter but is still lower than the cost of production.[72] For tap water, the average tap water price was

[69] Data extracted from:
A. Theory of water resource value, Jiang, W.L., 1998
B. China statistical yearbook, 1999
[70] Theory of water resource value, Jiang, W.L., 1998
[71] Suggestions on set rational price system of water supply in Beijing, Shun, F.H., 2000
[72] ibid.

0.22 yuan per cubic meter, but the cost of water supply was 0.587 yuan per cubic meter in 1988, the water price was much lower than the cost. Although there was a raise in 1993, water price was still lower than the cost of supply. In 1994, the cost of tap water supply was 0.469 yuan per cubic meter, the average price was 0.42 yuan per cubic meter, it was obvious that water price was lower than the cost, this resulted in the total profit of water industry being negative 24.16 million yuan.[73] At present, the tap water price for residents is 1.3 yuan per cubic meter which is still lower than the cost of supply of 1.32 yuan per cubic meter.[74] Since the water price is lower than the production cost, Beijing municipality has to subsidize the water utility every year.

Such low water price could not promote the consumer to conserve water and use efficiently. It is estimated that the current end-use efficiency of fresh water is around 10%. In agriculture, almost half of water for irrigation either evaporates or leaks. The water use for producing one unit of food is 2-2.5 times that in developed countries. In industry, the water efficiency is 75% lower than the developed countries; the water use for producing each unit of GDP is 0.005 cubic meter, which is 5-10 times that in the developed countries.[75] The low water price also leads the agriculture and industry have no incentive to invest in water saving technology. The awareness of citizens to conserve water is also low because of the low water price.

There are many reasons which result in the low water price. But the main reason is that water price was not calculated according to the regulation issued by the state (Note: the regulation issue will be explained in chapter 4.3.3). For the water supply, since water is not treated as commodity, when the local government check and ratify water price criteria, it usually put undue emphasis on taking the interests of various users into consideration rather than consider feasibly the costs and expenditures incurred by the water suppliers. As a result, water price is restricted at a low level.

4.3.2.2 Unitary water rate structure

The current water rate structure that is carried out in Beijing is uniform rate. This kind of rate structure seems flat and inflexible. The rate can not reflect the situation that the costs vary with the water consumption, and send consumers the accurate signal of cost variation. Meanwhile, uniform rate can not give the feedback that the utility needs. It thereby can not function as adjustment of water supply and demand. In addition, since the uniform rate results in cross-subsidizes, there is unfairness existed among the consumer due to the rate un-responding to the water services. Under such kind of rate structure, the utility can not justify the production so as to suit the variation in the market thereby result in the normal operation of utility is difficult.

4.3.2.3 Confused water pricing system

The present water pricing system in Beijing could be described as the interaction of Beijing Water Resources Bureau, Beijing Construction Bureau and Beijing Price Bureau, which are administrated under the Ministry of Water Resources (MOWR), Ministry of Construction (MOC) and Beijing municipal government respectively, are the primary forces determining water pricing.

[73] Urban water supply statistical yearbook 1995, China City and Town Water Supply Association, 1995
[74] Suggestions on set rational price system of water supply in Beijing, Shun, F.H., 2000
[75] Two threatening factors for China's water resources, http://www.enviroinfo.org.cn/Water_Pollution/b061409_en.htm

The MOWR administrates water projects of water resources, i.e., ecosystems such as rivers, as well as reservoirs and major irrigation engineering projects. These projects have been mainly financed by the government and suffer from the fact that the cost of project construction, maintenance and operation have never been linked to the price charged to users for the water supplied by the projects. It should noted that the State Development and Planning Commission (SDPC) remains in charge of all infrastructure project approvals and through its Price Bureau in charge of giving final approval to any price changes.

The MOC is in charge of municipal water supply as well as construction of municipal wastewater treatment facilities. Beijing Municipal Public Utility Companies (water supply enterprises), financed by Beijing government but nominally under the administration of the MOC, control all such urban water issues with the exception of natural water bodies controlled by the MOWR. It is in charge of collecting all fees.

Beijing Price Bureau is in charge of giving final approval to any price changes relating to municipal water supply and wastewater treatment. It means that without the support of Beijing government, no change of water rate can take place.

The above reveals a complicated management structure exists in Beijing, and as a result of which revenues, investment and pricing policy are fragmented and subject to often competing interests.

4.3.3 Review of the present water pricing precept and policies

The present water pricing precept adopted in Beijing is average cost pricing.[76] This kind of pricing precept could be usually found in monopoly firms.[77] The cost that the price is based on is historical cost rather than replacement cost. It is historical cost pricing.

The present water pricing for water projects is based on the *Regulations of price checking and ratifying, counting and collecting, and management of water supplied by water projects*, which was issued by the State Council in 1985, and which is also the main legal basis for the central and local government to regulate and administrate paid supply for water projects. It clearly points out that checking and ratifying the water price should base on water supply costs.[78] The promulgation of this regulation marks that water price of water projects starts to change from low price or almost free to price based on cost and quantity consumed. Water pricing provisions are also stipulated in other two regulations: *Water Law* and *Industrial Policy of Water Industry*. The *Water Law* issued in 1988, which governs water resources development and use as well as the protection and management of water resources, clearly defines that, "the water supplied by water projects should be paid to the supplier according to concerned regulatory requirements."[79] The *Industrial Policy of Water Industry*, issued by the State Council in 1997, further specifies that, " water pricing for newly constructed water projects should cover the project's operational costs and expenses, taxes, loans

[76] Suggestions on set rational price system of water supply in Beijing, Shun, F.H., 2000
[77] Economics, Samuelson, P.A. et al., 1985, p525
[78] Regulations of price checking and ratifying, counting and collecting, and management of water supplied by water projects, the State Council, 1985
[79] Water Law, National people's congress, 1988

and a reasonable profit."[80] However, it should be noted that incorporation of these provisions into industrial policy has not yet been fully implemented.

In regard to urban water pricing, the MOC, joint with SDPC, issued the *Management Regulation for Urban Supplied Water Price* in 1998. The Regulation aims to provide a structured criteria for water pricing and to standardize and improve what has in the past been subject to varying degrees of local government decision making capabilities. The water price structure criteria outlined in the Regulation is expected to assist urban Public Utility Companies to become self-sustaining and profitable in market economy when the existing subsidies do not exist any more. This Regulation defines the water as a commodity provided by urban Public Utility Companies after treating surface and groundwater to meet relevant quality standards. Water prices are defined according to intended use into five categories: residential, industrial, office, business services, and special use. Price in each category should be decided by each local municipality based on the local situation and the following breakdown:[81]

1) Water supply cost (i.e., cost for purchasing raw water, electricity, raw materials, assets depreciation, maintenance, salary costs, water quality monitoring, and other direct fees)
2) Administration cost (i.e., sales, management and finance costs incurred while managing water supply generation and handling)
3) Tax (on the Public Utility Company)
4) Profit (a reasonable allowable amount for supply company)
5) Cost associated with any loss during water transportation.

However, since this Regulation was promulgated in September 1998, no major progress has been made in its implementation.[82] The reason of unwillingness to implement is that the local government is more concerned about the social unrest. As a result, water price is still too low to recover the costs of production.

4.3.4 Discussion

The present low water price has impeded the sustainable water resources development and usage. Since the water price is too low, the revenue from water charge can not cover the costs of production. As a result, water suppliers can not maintain the normal operation and development, water projects is aging because of the lack of money to repair and manage, and water services suppliers can not supply reliable services. On the other hand, the low water price can not pass on a right signal to water users for water conservation and use efficiency. Large amount water is wasted and over used which result in large quantity of wastewater. In addition, the low water price results in the low water recycle because of the cost of reprocessing water is more expensive than the subsidized fresh water. Both of the over consumption of water and discharge of large quantity of wastewater put a high pressure on the water environment which threats the sustainability of water resources. It leads to water scarcity and environment pollution even more severe. Therefore, it is the time that the low water price has to be justified without other choices.

[80] Industrial Policy of Water Industry, the State Council, 1997
[81] Management Regulation for Urban Supplied Water Price, the Ministry of Construction, 1998
[82] Suggestions on set rational price system of water supply in Beijing, Shun, F.H., 2000

4.4 Proposed water pricing justified

In the process of transition from planning economy to market economy, the water pricing in Beijing is transferring from pricing based on planning to the pricing based on cost of production. The present situation of water pricing in Beijing can be illustrated in figure 4.3. (Note: the definitation of A, B, C, D and I, II, III, IV is as same as that in figure 2.2, and the externalities is assumed being negative.)

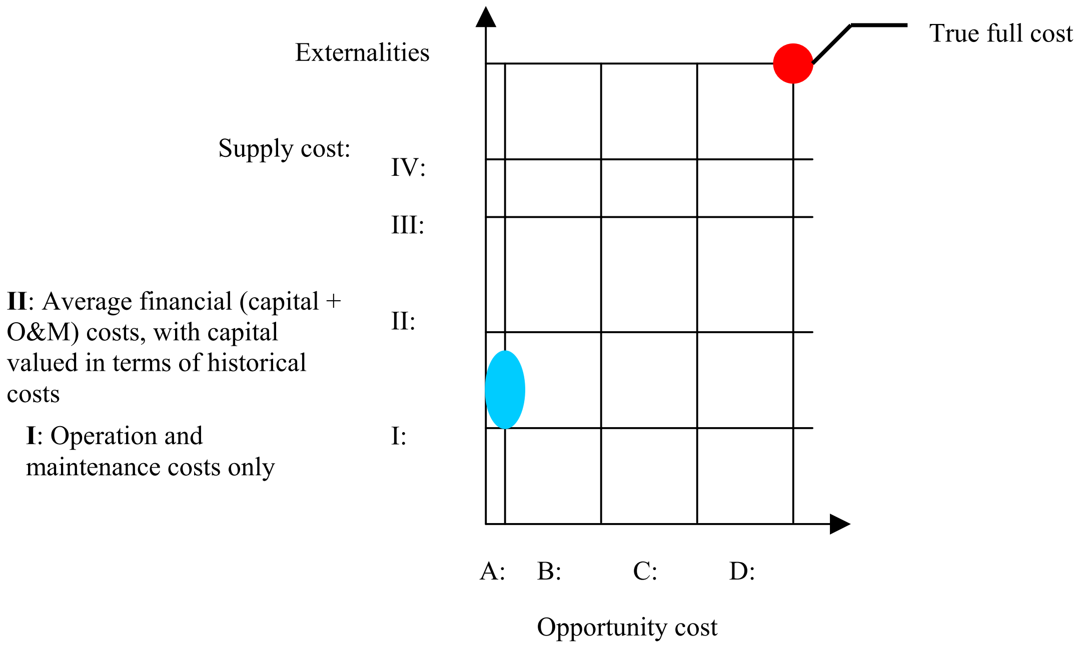

Figure 4.3 Present situation of water pricing in Beijing

However, regarding the sustainable water development and usage, even the water pricing based fully on cost of production is still not enough. Because water pricing based on the cost of production do not include the opportunity cost and environmental externalities. According to the discussion in chapter 3, water pricing which could enhance the sustainability of water resources should be full cost pricing, in which the opportunity cost and environmental externalities are included. It is proposed that water pricing could be justified in a phased manner to ensure acceptability and stability. Phased implementation gives users time to adjust to new conditions and thereby minimise the burden on any affected group. It also increases the predictability of that system for both users and suppliers. Thus phased implementation of full cost pricing can be schemed in which first step could be average supply cost pricing with capital valued in terms of historical costs and the second step could be average supply cost pricing with capital costs computed in replacement terms. These two steps are schematically shown in figure 4.4 (overleaf). The third step could be long-run marginal supply cost pricing, which is schematically shown in figure 4.5 (overleaf). The final goal is full cost pricing, in which opportunity cost and environmental externalities are included. It is schematically shown in figure 4.6 (overleaf).

In regard to water rate structure, it is proposed to implement increasing block rate and seasonal rate. One advantage of implementation of increasing block rate and seasonal rate is to promote consumer conservation. In summer time, the average temperature in June, July and August is over 20°C in

Beijing, and the water consumption at this period of time is higher than other period of time. Thus, the implementation of seasonal rate should be effective to promote conservation. Another advantage of implementation of increasing block rate and seasonal rate is to make the variation of rate reflect the variation of costs of water resources development and usage therefore make water price reflect the real cost.

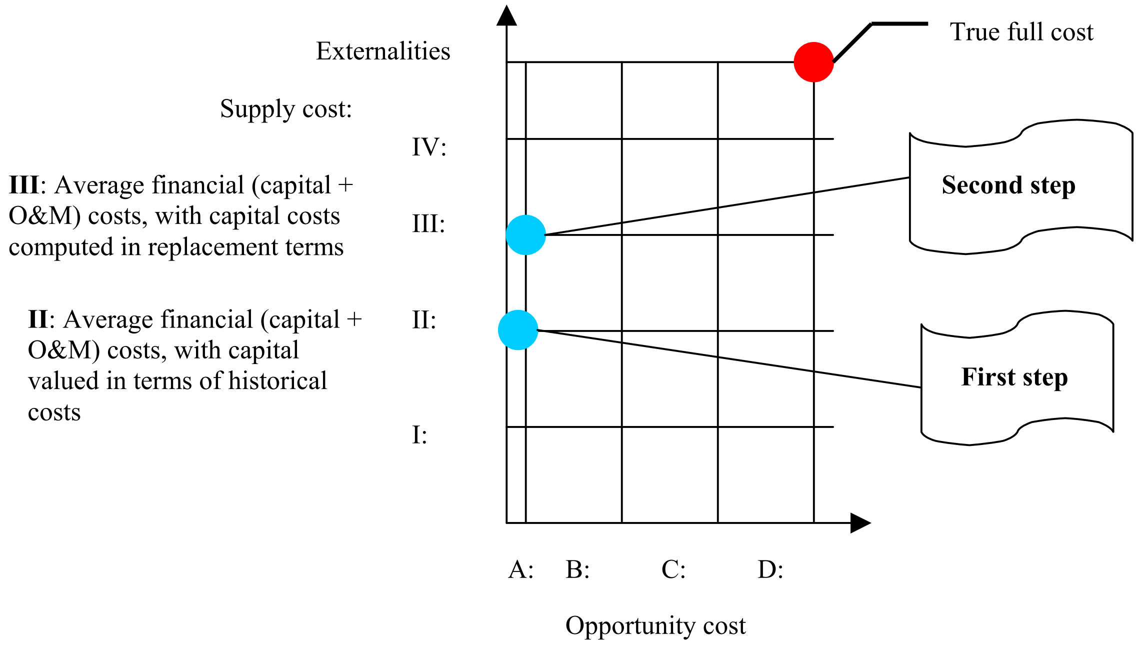

Figure 4.4 First and second step for water pricing justified

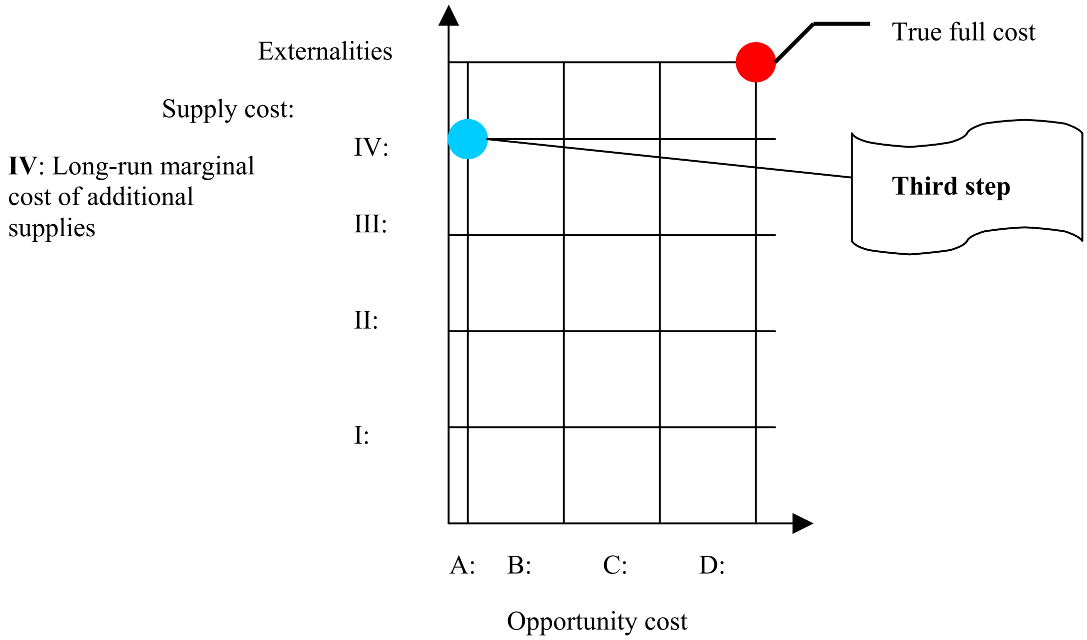

Figure 4.5 Third step for water pricing justified

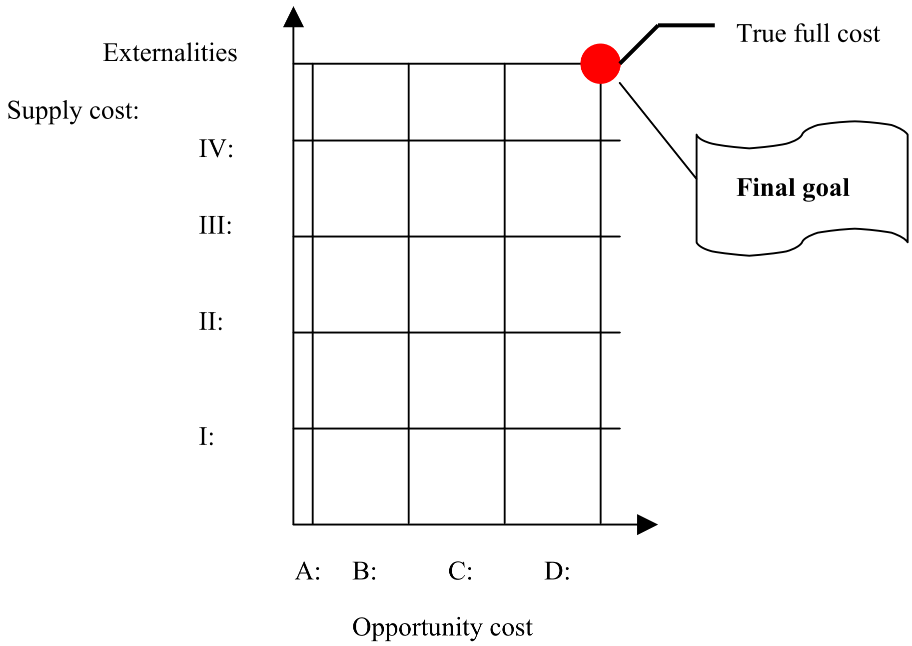

Figure 4.6 The final goal for water pricing justified

4.5 Affordability of residential water use

Affordability is one of the most important issue in water pricing. Although water is priced extremely low compared with most other goods, it is an essential good, it is the humans' basic needs. People have little choice but to use water and pay it.

A critical distinction when considering affordability is the difference *between ability-to-pay* and *willingness-to pay*. Willingness-to-pay reflects consumer preference about purchasing a quantity of goods or services relative to prices. Ability-to-pay focuses not on whether consumers will pay for water service, but whether consumers can pay for water service.

Affordability is a function both of the price of water service and the ability of water users to pay for this service. High prices alone do not necessarily indicate an affordability problem; similarly, low ability-to-pay may not present an affordability problem if water prices are very low. The combination of low prices and high ability-to-pay is the best case scenario; the combination of high prices and low ability-to-pay is the worst case scenario.[83]

In order to make the concept of affordability be quantitative, one formula can be adopted as follows:

Affordability coefficient = expenses for water consumption / income[84]

[83] EPA information for States on developing affordability criteria for drinking water, U.S. Environmental Protection Agency, 1997

[84] Theory of water resource value, Jiang, W.L., 1998

One study has conducted the affordability coefficient for residential water use in the north of China to show that this coefficient could be in the range of 0.025 - 0.03.[85]

It is known that the annual income of urban household in Beijing is RMB8520 per capita, annual income of rural household was RMB3952 per capita in 1998.[86] Per capital daily consumption of tap water for residential use was 116.96 liter in 1998.[87] We can use above formula to make a rough calculation. The coefficient of affordability is set to be 0.025 - 0.03. Thus, it is calculated that at this coefficient of affordability the water rate can be 4.99 - 5.99 in urban area and 2.31 - 2.77 yuan in rural area. Comparing with the present tap water rate of 1.30 yuan, this result means that there is a big potential room to raise the water rate within the affordability of both people in urban and rural area.

However, since the data of income is average, there are still some poor people who will have the problem of affordability if water rate is raised. In order to address this issue, the rate design could be thought as a way to solve this problem since rate design by utilities can affect the ability of individual households to pay for basic services. Some rate structures, such as lifeline rates, are specifically designed to keep a basic block of usage affordable. Nevertheless, it could be contradictory to require the utility to be both commercial entity and welfare enterprise. The experience of Chile can be used for reference in Beijing. In Santiago, Chile, the government realized that it was inherently contradictory to require that an urban water utility function as a commercial entity and provide subsidized services to the poor, since each subsidized person served would represent a loss of revenue to the utility. Accordingly, the government decided to institute a targeted, means-tested, government-administered “water stamps” program, whereby poor people get “stamps” to cover part of their water bill. The utility then not only strengthened its focus (getting out of the welfare business and focusing on becoming the most efficient utility it could), but now had a clear incentive to serve the poor, who became revenue-generating customers like all others. The system works well.[88]

4.6 Assessment of impacts on water resources by raising water price

In section 4.4 it is proposed that phased implementation of full cost pricing can be schemed in which first step could be average supply cost pricing with capital valued in terms of historical costs, second step could be average supply cost pricing with capital costs computed in replacement terms, third step could be long-run marginal supply cost pricing, and eventually towards the full cost pricing, in which the opportunity cost and environmental externalities are included. It is interesting to see the impacts on the water resources even if only the first step is achieved which means water price is set based on average supply cost pricing with capital valued in terms of historical costs.

When water is treated as an commodity, it is available to adopt the following formula to calculate the quantity of water demand under different water price.[89]

$$Q_2 = Q_1 \times (P_1 / P_2)^{E}$$

[85] Theory of water resource value, Jiang, W.L., 1998
[86] Data extracted from: China statistical yearbook, 1999
[87] Calculation and analysis of function of residential demand for water in China, Shen, D.J., et al, 2000
[88] For a water secure world, World Water Commission, 2000
[89] Economics of water resources planning, James, L., D., et al, 1984

Where Q_2 is the quantity of water consumption at raised water price P_2, Q_1 is the quantity of water consumption at original water price P_1. E is the price elasticity of demand.

In a Beijing municipal report, it has calculated that water price based on average supply cost with capital valued in terms of historical costs is 0.68 yuan for surface water and 2.08 yuan for tap water.[90] (Note: this price is within the affordability which is discussed in section 4.5). Because of the limitation of data, here only industry water use and residential water use are calculated.

- **Residential water use**

In 1998, the quantity of residential water use was 1.084 BCM in Beijing (refers to figure 4.2). The water price was 1.0 yuan. The price elasticity of demand is -0.24.[91] By using these data, the quantity of water consumption (demand) at raised water price 2.08 yuan can be calculated as follows:

$$\begin{aligned} Q_2 &= Q_1 \text{ x } (P_1 / P_2)^{E} \\ &= 1.084 \text{ x } (1.0 / 2.08)^{0.24} \\ &= 0.909 \text{ BCM} \end{aligned}$$

It means that when water price is raised to be 2.08 yuan, 1.084 - 0.909 = 0.175 BCM water can be saved.

- **Industry water use**

In 1998, the quantity of industry water use was 0.986 BCM in Beijing (refers to figure 4.2). Among this, tap water occupied 0.295 BCM.[92] The remaining was surface water and ground water. The tap water price for industry use was 1.3 yuan. The price of surface water and ground water for industry use was 0.36 yuan. It is assumed that water price raised for ground water is same as for surface water. It is reasonable because if there is a difference between the water price of ground water and surface water, the water demand will shift to the water resources with lower price. The price elasticity of water in industry use is -1.03 (it is average number in China and it should be available to Beijing). By using these data, the quantity of water consumption (demand) at raised water price 2.08 yuan for tap water and 0.68 yuan for surface water and ground water can be calculated as follows:

For tap water:

$$\begin{aligned} Q_2 &= Q_1 \text{ x } (P_1 / P_2)^{E} \\ &= 0.295 \text{ x } (1.3 / 2.08)^{1.03} \\ &= 0.181 \text{ BCM} \end{aligned}$$

It means that when tap water price is raised to be 2.08 yuan, 0.295 - 0.181 = 0.114 BCM water can be saved.

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[90] General planning of capital's sustainable utilization of water resources in early 21st century, Beijing water resources bureau, 1999

[91] Calculation and analysis of function of residential demand for water in China, Shen, D.J., et al, 2000

[92] China statistical yearbook 1999, National Bureau of Statistics, PRC, 1999

For surface water and ground water:

$$\begin{aligned} Q_2 &= Q_1 \text{ x } (P_1 / P_2)^{E} \\ &= (0.986 - 0.295) \text{ x } (0.36 / 0.68)^{1.03} \\ &= 0.691 \text{ x } (0.36 / 0.68)^{1.03} \\ &= 0.359 \text{ BCM} \end{aligned}$$

It means that when water price of surface water and ground water is raised to be 0.68 yuan, 0.691 - 0.359 = 0.332 BCM water can be saved.

The sum of the tap water, surface water and ground water saved for industry use is 0.446 BCM.

To summarize above calculation, when tap water price is raised to be 2.08 yuan, and price of surface water and ground water is raised to be 0.68 yuan, the total water saved for both residential water use and industry use is 0.621 BCM. This amount of water saved is more than the predicted water shortage of 0.444 BCM at reliability of 50% in 2000 (refers to table 4.3). Therefore, using water price as a tool to mitigate the conflict between water demand and water supply is effective.

The achievement of 0.621 BCM water saved is only the result of first step of water pricing justified which is based on production cost pricing in the domestic and industrial water use sectors. As we have discussed before that the eventual aim of water pricing towards the sustainability of water resources is full cost pricing, i.e. to include not only the production cost, but also the opportunity cost and externalities as well. Only when the water pricing complies with this principle, the water price could have a substantial impact on the water demand of different uses. As a result of changes in water demand, which means the less consumption and less discharge, efficient water pricing reduces the pressure on the water resources. Furthermore, to enhance the sustainability of water resources.

5. Conclusions

Water is a scarce commodity. In the 21st Century, water scarcity and conflict over supply will become a serious issue because of the population growth, food needs and industrialization. The scarcity and utility of water makes it has the money value in the market instead of the common sense that water is free.

The role of water pricing for managing water resources is widely recognized in many areas of the world. This recognition relates to the increasing scarcity of water resources, a high competition between water uses, and problems of environmental degradation. Water pricing can contribute to higher water use efficiency thus a lower pressure on water resources and on the environment thereby more sustainable consumption of water. It can provide financial resources that can be directly used in investing in new water resources infrastructure for the protection of the environment or for sustaining the operation and maintenance of the existing water infrastructure. Water pricing can make the water users recognize the true value of water that is an important element in the context of the increasing participation of water users and stakeholders in the management of water resources.

When water is treated as an economic good, the cost of water constitutes not only the supply cost but also the opportunity cost and environmental externalities as well. It is crucial to take the opportunity cost and environmental externalities into consideration since they are invisible financial cost comparing with the supply cost.

Marginal supply cost pricing is popular method in water pricing recommended by economists since it is intended to provide price signal that result in a more efficient allocation and use of a scare supply of water. However, under the conditions of sustainable development and utilization of water resources, the inadequateness of marginal supply cost pricing is that it does not take the opportunity cost and negative environmental externalities into account. Therefore, full cost pricing is proposed as a sustainable way in water pricing since it take all costs including supply cost, opportunity cost and environmental externalities incurred during water supply into account.

Artificially low water price in Beijing leads to water over consumption and large quantity of wastewater discharge, which result in high pressure on the water environment. In order to develop and utilize water resources sustainablly, justifying water pricing in Beijing is necessary and pressing. It is proposed that water pricing could be justified in a phased manner in which first step could be average production cost pricing with capital valued in terms of historical costs, second step could be average production cost pricing with capital costs computed in replacement terms, and third step could be marginal supply cost pricing and eventually towards the full cost pricing. Regarding water rate structure, it is proposed to adopt increasing block rate and seasonal rate since they can promote conservation and reflect the real cost of water supply. It is also the trend in many countries in rate structure design.

The analysis of affordability of residential water use shows that there is a potentially large room to raise the water price while does not affluence the welfare of people. The assessment of impacts on water resources by raising water price shows that water pricing could be an effective tool for more sustainable water consumption. Treating water as an economic good and adopting full cost pricing, water pricing can play an effective role in enhancing the sustainability of water resources in Beijing.

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