Chapter 3

# Water Resources Management

Water supply does not exist in isolation. There are many factors that affect city water supplies, including social, environmental, and economic impacts. Water resources management is one of the most important environmental dimensions. A sustainable supply of water to a city will depend on the quantity and quality of the water available and its distance from that city. Other major factors are population growth and the wise use of the water resources available. This chapter deals with the latter by considering the supply aspects, the demand aspects, and policy and management.

## A. Supply Aspects

This section examines water supply by looking at sources, sustainability, and rights of users.

### Groundwater Sources

Cities are usually located near adequate or once adequate water supplies—mostly near groundwater, but sometimes near surface waters. Looking around Asia, many examples (Bangkok, Jakarta, and Manila) of groundwater overexploitation can be seen. These examples show that what could have been a finite but long-term sustainable resource has been destroyed through the depletion of aquifers, which has caused salinization and land subsidence. The excessive use of groundwater has been a short-term expediency that is becoming a long-term disaster (Figure 3.1 shows the extent of surface water use in major cities in Asia). Watersheds have been allowed to become denuded, which encourages flash runoff that erodes fertile soils and results in the loss of steady water flows in the dry season. Industrial wastewater and domestic sewage have been allowed to pass untreated into major waterways, thereby endangering water supplies of downstream users. Asian cities cannot continue to go to other water catchments without first ensuring that they have optimized water availability and use within the vicinity of urban demand.

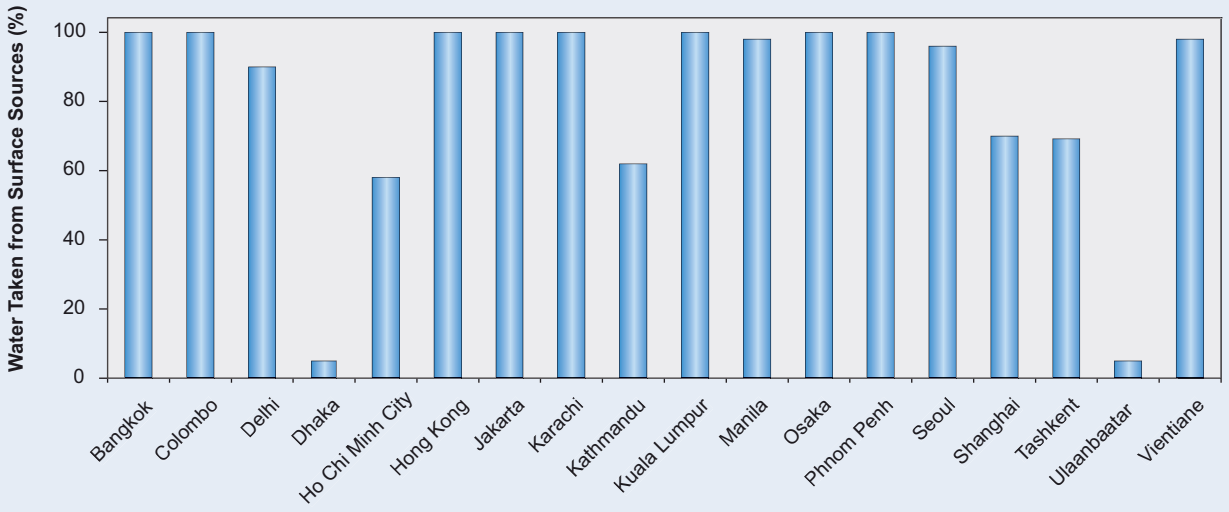
*Over the last hundred years there have been two major shifts in water management. First, the people have given over their role to governments. Second, people rely less on using rainwater and have instead exploited rivers and groundwater through the use of dams and tubewells. This second fact has led to a growing and in some places unbearable stress on water from these sources. In India, the exploitation of groundwater has been encouraged, but little has been done to recharge it. As a result, groundwater tables nationwide are falling. In years when rains are low, this problem becomes an emergency. The poor, who depend on dug wells (which dry off first), are the first to suffer.* (Agarwal, 2001)

**Many still rely on groundwater**

### Watershed Rehabilitation

One difference between developed and developing countries is that catchments for water supplies in developed countries are strongly protected. They have good vegetation cover, and human, animal, or agricultural uses of that land are prohibited. In developing countries, especially those with large populations, the governance associated with the use of watersheds for

**Figure 3.1 Surface Water Sources** (2001)
[piped supplies only]




other purposes is invariably quite weak. Furthermore, the rehabilitation of watersheds is a long-term undertaking that does not find much support when measured against the need for short-term political gains.

When watersheds are denuded of trees, through logging and cutting for firewood, rainfall rapidly becomes runoff, which causes the erosion of fertile land and reduces the time during which this water can be used, unless it is stored using dams. This situation is of course exacerbated by the wet and dry seasons that dominate the climates of many Asian countries. Watershed rehabilitation will facilitate the retention of rainwater, which will help river flows become perennial. The National Water Supply and Drainage Board (Sri Lanka) has been experimenting with watershed rehabilitation in different topographical and soil regions with a view to determining in each region the appropriate amount of integrated ground cover that would also give farmers the potential for revenue generation.

*It is possible to reforest more than 100 million hectares of degraded and unproductive land in India. Watershed development of 100 million hectares at the present norm would cost about $10 billion. At $1 billion per year, assuming a 10-year completion period, the cost is insignificant compared with the enormous benefits that would be derived. In terms of water storage, flood control, reduced soil erosion and loss of nutrients, and additional agricultural crops, fuel, timber, and other produce, the value of India's reforestation in monetary terms would be much more than the total value of all the country's current industrial assets.*[1] *If even a tiny fraction of the value of this great asset was spent on its upkeep, and if traditional (village) rainwater storage systems are revived, India's economy would improve more rapidly than by any other means.* (IEI News, 2000)

**Promotion of rainwater harvesting**

[1] This may be a matter of opinion, rather than fact, but it is worth careful consideration.

**Potential for rainwater harvesting**

## Rainwater Harvesting

Why is rainwater harvesting important? It is often said that water should be free, because it is a gift from nature. That is true if the user of that water collects it as it falls from the sky or draws it from a spring, before it has been treated or delivered, because it is the treatment and transport of water that have associated costs. Water tariffs must be raised to meet the costs of water supply, which continue to increase due to more advanced treatment, greater distances to be traveled, lower groundwater tables, and more costly distribution in densely populated areas. As tariffs rise, rainwater harvesting and other options become attractive.[2] To collect water off the roof of a home or office and store it for future use is efficient. While there are some constraints, such as the room for storage in very densely populated areas, there is tremendous potential not yet harnessed. What is required is for local authorities to amend the bylaws so that no new home is built that does not have rainwater collection from the full roof area and storage for that water on-site. In addition, for the owners of existing houses to also comply with these bylaws, time frames of 5–10 years can be given for the modification of the roofs and grounds of all existing homes. Chennai (India) is an example of a city making good progress in rainwater harvesting (see www.geocities.com on the Internet). Once again, governance is important.

*It does not matter how much rain you get, if it is not captured you can still be short of water. India receives most of its annual rainfall in just 100 hours. If this water is not captured, there will be shortages. When water harvesting and watershed development programs are handled well, it has been shown that rainwater harvesting is the starting point for meeting drinking water needs, eradicating rural poverty, generating massive rural employment, and reducing distress migration from rural areas to urban areas. Because smaller catchments give much more water than larger catchments, one state is planning to construct 10,000 check dams (one dam with a catchment of 10 hectares will collect much less water than 10 smaller dams, each with a catchment of 1 hectare). If the Government puts its mind to it, drought can be banished completely in a maximum of 10 years. The problem is one of mindsets. Rainwater harvesting demands a new approach to governance, a participatory form of governance instead of a top-down bureaucratic one.* (Agarwal, 2001)

## Check Dams and Wetlands

There is no doubt that one major frustration of water resources management in Asia is the failure to capture the wet season runoff so that it can be used throughout the dry season. In the past, too much attention was given to building large dams. Now, more attention is being turned to small (check) dams. Kathmandu Valley in Nepal is an example of a location where many check dams might be used to store water during the wet season. When urban water supply tariffs are raised to around $0.40–0.50/m³, it may become attractive for the private sector to build check dams that would divert wet season flows into Sri Lankan style "tanks," or even artificially constructed underground storage, so that the water collected can be sold to the utility for urban supply purposes in the dry season.

*The dams of the estimated 200 million beavers that once lived in the continental United States made meadows out of forests, as wetlands slowly captured silt.*

[2] I once had a conversation with a man from Frankfurt, Germany. The cost of water was discussed, and the man said water cost $2/m³ and sewerage cost $3/m³ in his home city. Then he said, "but I don't pay that—I collect rainwater off my roof." These days, Frankfurt is well known as a city that uses rainwater harvesting.

*These dams resulted in a remarkable and uniform buildup of organic material in valleys, a checkerboard of meadows throughout the woodlands, and a great deal of edge (the fruitful zone where natural communities meet). Beavers are a keystone species. Their dams create wetlands that provide homes and food for dozens of other species, including ducks, moose, fish, frogs, and great blue herons. Wetlands clarify water and prevent soil from washing downstream. When beavers make a series of dams and ponds within a drainage basin, the water cycle in an entire watershed is affected. Wetlands are like sponges. They soak up water during storms and release it slowly in drier times. Water detained in wetlands behind beaver dams is more likely to percolate down to groundwater, raising the water table and creating springs and small streams throughout a watershed. A tenth of the total land of the United States was once beaver built wetland. Now the beavers and these wetlands are gone.* (Outwater, 1996)

## Pollution Control

Water availability can drive economic growth. And, along with a ready source of labor and ready markets or transport to markets, water availability has encouraged industries to spring up in cities. Industries, however, damage waterways through pollution, discharge of raw sewage, and disposal of garbage. Incentives must be created for the relocation of industries to industrial estates, preferably downstream of cities, where their effluents can be treated before they are discharged. Town planning rules must be transparent to the public and implemented. Industries that are water intensive should be closely monitored, like they are in Singapore, not only for pollution but also for their conservation measures. In line with this, relatively high tariffs can encourage conservation. The "polluter pays" principle can be applied in urban areas, and this can be regarded as trading for the right to restrict other uses. This more than anything is a question of governance. Others may argue that one could also consider a "beneficiary pays" principle. Perhaps there is room for both. As noted at the Third World Water Forum, which was held in Japan in March 2003, national actions should be more focused on pollution control at the source instead of simply building more and more advanced water treatment plants at high cost.

## Trading Water Rights

While there have been many advocates of trading water rights (mostly on economic grounds), the expected advantages of allowing the market to determine water resources management have not always resulted. The following learning experience from Australia is a timely warning that theory is not always manifested in practice.

*The legislative basis for water markets in Australia is almost complete, and water trading for irrigation is now possible in 87% of its river systems. It was expected that managing water demand, including environmental needs, would lead to a reduction in water usage and increase efficiency as water moved (via trade) from low value to high value users. Contrary to expectations, increased prices have increased water usage overall. And most of the water sold interstate was not originally used by the sellers. Moreover, this water is being transferred to land that was not previously irrigated (leading to increased risks of salinity). One outcome of the operation of water markets is that rice and cotton crops, those that have the greatest impact on Australian rivers, are showing no signs of decline. Instead, rice is on track to break production levels, and the top nine private water holders are in the cotton trade.* (Isaac, 2002)

Current conflicts among water users are governed mostly by ad hoc political decisions. If, however, they were governed by the free market value of water, and if customary and legal water rights were freely traded, then such conflicts could result in win-win situations freely chosen by all parties. What we need to precipitate this is a paradigm shift in urban water supply tariffs. The options for the farmers are then considerable. They can sell the whole of their customary water rights. They can improve irrigation efficiency or plant crops that are less water intensive and sell the water saved. Or, they can sell their water rights only for the dry season. While it is important to secure economic gains for farmers, the question of job losses cannot be ignored, so alternative employment should be secured as part of the solution.

Subsidies and having the money trail run through governments are impeding the trading of water rights. More effort must be made to recognize the customary water rights of farmers and others. More awareness of this matter needs to be developed through the Internet and other media outlets. Records and documentation related to trading water rights should be more transparent for the public. We must explore, through surveys, the willingness of farmers to trade water rights. It is quite possible that more private sector development and management of water would result from freely trading these rights.

It is an unreasonable situation that Asia is now facing, one in which new water sources to satisfy increased demands—resulting from rapid urbanization—are now often secured on the basis of a 10-year design horizon, instead of design horizons of 50 or 100 years, which would be acceptable to secure water for basic human needs. The problems must be sorted out now, before they become even more acute and civil conflicts and wars emerge over water use. Two keys to resolving these issues are recognizing water as an economic good and trading water rights. For example, Angat Dam in the Philippines represents the next major source of water for Manila, but only if the water rights can be traded (see Box 3.1). When water supply tariffs rise to approximate the real cost of water, that is to say in the \$0.30–0.40/m³ range for many Asian utilities, other options for water security present themselves, such as trading water rights.

## B. Demand Aspects

This section examines demand by looking at water use and access to this resource.

### Irrigation

About 90% of all water use in Asia is for irrigation. Yet, when we talk of a "water crisis," it seems that the gains that can be made from this sector in terms of efficiencies and recognizing water as an economic good have to a large extent been ignored. Low efficiencies result from water losses in canals through evaporation, leakage, and pilferage. They come from irrigation methods that waste water. They come from growing crops that are heavy water users, such as paddy crops, when

### Box 3.1 Trading Water Rights—Angat Dam Irrigation versus Manila Water Supply

**Economic Justification**

- Five million of the 12 million people in Manila are not connected to piped water, 5 years after PSP in water supply.
- Two reasons for the high number of people not connected are given. First, the tariff is too low to allow concessionaires to invest. Second, there is an inadequate water source.
- The farming population of 22,000 also relies on water from Angat Dam to irrigate (mostly paddy) crops. Yet, in times of drought, they can lose all water to Manila.
- Most of the land being irrigated from Angat Dam will in all likelihood become urbanized within the next 20 years.
- There can be a win-win situation for the urban poor in Manila not connected to piped water and the farmers, if the whole of the water rights of the farmers are traded to the urban dwellers over time (say, for example, 10 years).
- If a price of \$0.03/m³ is paid to farmers, they have the potential to triple their current income, as long as they also plant new crops (like potatoes) that do not need irrigated water.
- When compared with developing a new source, payment of \$0.03/m³ by the water utility for a guaranteed source of 21 m³ per second represents a much cheaper and faster solution to providing piped water to the 5 million people in Manila without access to piped supplies. This should translate into an increase in the water tariff of no more than \$0.06/m³.
- An average domestic tariff of \$0.40/m³ in Manila is clearly feasible and affordable and should ensure that all the urban poor not connected to piped water get connected as quickly as possible.

**Political Reality**

- Water rights are held by the National Irrigation Administration. And this organization, in response to rapid urbanization, encourages irrigation of more land.
- Owners of the land have no water rights.
- Tillers of the land (farmers) have no water rights.

**Government Options**

- Produce a transparent policy or plan for land and water use in the future.
- Buy the land or require private developers to buy the land for controlled urban development and lease back to farmers in the interim.

for the purpose of generating income other crops will do just as well on much less water. They come from the salinization of soils caused by the use of too much water. They come from the lack of mechanisms to trade customary water rights in a free market. And they come from national policies on subsidies and food security that are often in conflict.

*Continuous irrigation, without proper drainage, gradually destroys land and nearby streams and rivers through salinization. The sun's heat evaporates irrigation water, leaving salts behind. This water also flushes salts out of mineral rich soil, leaving these to dry on the surface or dissolve in groundwater and poison plant roots. Furthermore, where rainfall is limited, crops must be carefully chosen. Sugarcane is just about the worst crop choice in terms of water needed—whereas potatoes would be much more beneficial.* (Time International, 1990)

*Subsidized irrigation is one reason for waste. Farmers rarely pay more than one fifth of the cost of operating public irrigation schemes, let alone capital costs. In most cases, farmers can cut their water use by 10–50%. It has been shown that an investment in irrigation efficiency is usually an investment in crop and soil productivity. Better water management often leads to increased yields, a reduction in erosion, and a reduction in the amount of fertile cropland that becomes water logged, salted, or sapped of nutrients.* (Postel, 1997)

## Demand Management and Water Conservation

Although average domestic water consumption in European cities is only 130 liters per capita, many cities in Asia use around 200 liters per capita (for those connected to piped water). This can be traced primarily to low tariffs and a lack of public awareness concerning the importance of conserving water as a scarce resource. When tariffs are raised in many Asian cities (Chennai, Colombo, and Manila are examples) there is no drop in demand, indicating that there is no price elasticity of demand at these levels. Standpipe water is in many cases free to users, and it is common to see water being wasted at standpipes in South Asian countries. Water is also wasted through poor plumbing in homes, leaks in distribution systems, and overstorage on a 24-hour basis, which is related to users' attempts to adjust to intermittent water supplies. In Asia, unlike Europe, there is little attempt to conserve water through toilet or shower retrofitting. Singapore is an exception, and the PRC offers some good examples of industrial and domestic water conservation. The block tariff systems employed by Asian utilities invariably have large volumes at lifeline rates, thereby providing subsidies to all, including the rich.

Little effort is going into rehabilitating watersheds to secure future supplies. It is a waste of funds to treat and distribute water if it is lost or wasted. As urban populations continue to expand, there is sometimes a need to go farther afield (more than 100 kilometers) to harness new water sources, and this is becoming very costly, not only in capital costs but also in operating (pumping) costs. Unfortunately, this fact is seldom reflected in tariffs. Much can be done to have more efficient use of water in the urban context. In some cities, including Bangkok, Jakarta, Kathmandu, and Manila, NRW is around 40% of production or more. The tariffs for piped water are so low that there is little demand management.

## Water Scarcity

Water scarcity is a relative term. It depends on location, climate, season, and potential use by humans. The scarcity value of water is determined by the quality of water, the quantity of water, and the number and type of water users. It is greatly influenced, therefore, by the integrity of watersheds, overexploitation of groundwater, cost of water transport and distribution, density of populations, and water pollution levels. What is being seen (and is clearly demonstrated by the rapid rise of bottled water use) is that the urban issue is one of scarcity of clean and potable water, which is also a reason behind rainwater harvesting becoming more and more relevant for cities. But water scarcity in Asia is not manifested across the board. It is characterized more by unequal access to water. For example, half the population in a city might get piped water and half might rely on vended water. Another example, involving irrigation, is where farmers at the head of a system might get plenty of water and farmers at the bottom of a system might miss out altogether on water for their crops. The challenge, then, is to overcome this lack of equality.

*Grossly underpricing water perpetuates the illusion that it is plentiful and nothing is lost when it is wasted. Many of the world's water shortages stem from failing to value water at anything close to its true worth.* (Postel, 1997)

*Most of the world does not treat water as a scarce resource. The foremost challenge related to water scarcity in developing countries involves inefficient water use in agriculture and urban areas and by industry. Inefficient use is linked to subsidized rural and urban water use. In line with this, irrigation water is essentially*

*not priced. The price of water in cities does not cover the cost of delivery. And capital investment decisions in all sectors are divorced from the management of this resource. It is not uncommon for water subsidies to go disproportionately to the better off (irrigation farmers and urban water users connected to public systems).* (Rosegrant, 1995)

### Industrial Water Use

Water utilities in cities often rely heavily on revenue from industrial users to stay financially viable. In Greater Colombo, for example, the average industrial tariff is six times the average domestic tariff. Yet industry is invariably not controlled in terms of location and type, so polluting industries, like carpet factories, are located upstream from domestic water users. There are very few industrial estates (where some collective treatment of effluents can be made). There are almost no incentives for industries to relocate to areas where they will have less effect on residential zones. There is heavy exploitation of groundwater (normally without charge) by industry, and there is little knowledge of or control over water use by industry in terms of water needs and conservation measures. In addition, it has been noted that some major industrial users of public piped water are using armed personnel to guard illegal connections. Moreover, in Sri Lanka, the sand mining of rivers—a livelihood for many and a cheap resource for construction—is allowing seawater to move far inland, which is upsetting the water supply intakes for several towns. In short, governance is a real issue in the industrial use of water in Asian cities.

### Water for the Environment

The need for minimal "environmental flows" for water left in rivers during the dry season is now beginning to be recognized. These flows are still very low and probably inadequate, but recognition is at least a start. There is a need to consider the whole ecological regime of rivers, including fishing as a livelihood; fishing as a sport; recreational needs, such as swimming, sailing, and white-water rafting; flood and fertility regimes; artificial lakes with tourism potential; garbage control; and storage of wet season flows.

## C. Policy and Management

This section examines policy and management by looking at different approaches and challenges.

### ADB'S Water Policy

ADB's water policy (see Box 3.2) addresses approaches to water management and development. It seeks to promote the concept of water as a socially vital economic good that needs increasingly careful management to sustain equitable economic growth and reduce poverty. The conservation and protection of water resources in the region through a participatory approach are at the heart of the policy. References are made to specifics of the water policy throughout this book.

### Management Principles

The following ideas reflect some of the latest thinking from South Asia.

- *Three sets of stakeholders—managers, users, and social auditors—need to interact.*
- *Society's ability to respond to local water management needs is primarily an issue concerning information, governance processes, and the structure of civil society.*
- *Watershed management has to do with afforestation and check dams as much as with livelihood issues concerned with irrigated agriculture.*
- *History suggests that an effective approach to water management may be to allocate equitable shares among stakeholders.*
- *Absence of clear water rights results in inequitable access to water resources, and the establishment of water markets and rights will create incentives for users to make efficient use of their water entitlements.*
- *The most effective instruments to reduce water demand may be agricultural price policies and subsidies.*
- *Management issues are rooted in interactions between complex and interdependent water resources and economic, environmental, cultural, institutional, and social systems.* (Moench et al, 1999)

### Box 3.2 The Water Policy of the Asian Development Bank (in a Nutshell)

**Promote a national focus on water sector reform.** Developing member countries (DMCs) will be supported to adopt effective national water policies, water laws, and sector coordination arrangements; improve institutional capacities and information management; and develop a national action agenda for the water sector. Throughout, the needs of the poor will be specifically factored into legal, institutional, and administrative frameworks.

**Foster the integrated management of water resources.** Integrated management will be based on conducting comprehensive water resources assessments and concentrating interlinked water investments in river basins.

**Improve and expand the delivery of water services.** Focusing on water supply and sanitation (rural and urban), irrigation and drainage, and other subsectors, support will be provided for autonomous and accountable service providers, PSP, and public-private partnerships emphasizing equity in access to water for the poor and underserved.

**Foster the conservation of water and increase system efficiencies.** Packages that combine water use and resources management charges to recover costs, improved regulation and increased public awareness, and provisions to ensure that the poor are not excluded will be supported.

**Promote regional cooperation and increase the mutually beneficial use of shared water resources within and between countries.** The primary focus will be on the exchange of information and experiences in water sector reform. Support will be provided to enhance awareness of the benefits of shared water resources, create sound hydrologic and socio-environmental databases relevant to the management of transboundary water resources, and implement joint projects between riparian countries.

**Facilitate the exchange of water sector information and experiences.** Socially inclusive development principles will be supported to promote stakeholder consultation and participation at all levels, increase the access of poor consumers to basic water services, and enhance water investments in DMCs through public-private and community-nongovernment organization (NGO) partnerships.

**Improve governance.** This will be accomplished by promoting decentralization; strengthening monitoring, evaluation, research, and learning at all levels, particularly in public sector institutions; and building capacity. (ADB, 2001a)

## River Basin versus Local Management

On the one hand we learned at Dublin[3] that water should be managed at its lowest practicable level, but on the other hand we are now told that comprehensive water resources management on a river basin basis[4] is best. There is potential for conflict. This has to do as much with local versus national politics as with anything. We are seeing (in Sri Lanka) how it is very difficult to get various water users to agree on development and management on a more comprehensive basis. Allocation of water rights is still an issue. In many countries, irrigation authorities do not willingly share information with water supply authorities. In default of the desired trading of water rights, however, we see other mechanisms, such as compensation and water levy payments, that mimic this type of trading. The Melamchi Water Supply Project in Nepal provides such an example (see Appendix 2, Kathmandu case study).

## Managing Water Resources to Meet Megacity Needs

Some findings of a regional study and consultation on this subject—in the cities of Bangkok, Beijing, Delhi, Dhaka, Jakarta, Karachi, London, Manila, Seoul, Singapore, and Tokyo (ADB,1993)—are presented. Ten years later the findings are still valid.

[3] International Conference on Water and Environment held in Dublin, Ireland, in January 1992.

[4] Management on a river basin basis is the management of water from the top to the bottom of its catchment of rainfall in an integrated manner, rather than the management of water within the confines of local authorities.

**Problems**

- Growth rates are explosive.
- The use of resources causes conflicts.
- Rivers and the living environment are polluted.
- The urban poor are marginalized.

**Main Findings**

- Controlling pollution is the top priority.
- Demand management by pricing is needed.
- Water must be treated as an economic as well as social good.
- Scope for recycling and reuse in industry and agriculture must be identified.
- Water is a priority need of the poor, and they are willing to pay.

**Urban Planning**

- Development strategies should have a horizon of 15–25 years.
- Urban zoning with industrial estates is needed.
- Development in flood plains should be avoided.
- Urban planning should integrate water planning with land use, housing, drainage, and environmental protection.
- Equitable sharing of water resources can be based on a basin development plan addressing social, political, and economic aspects of various options.
- Water resources planning and management should include monitoring the quantity and quality of sources.
- Investment cost analyses should include public and private expenditures, as the latter can be very high if the supply is intermittent.

**Wastewater Disposal**

- In dense areas of megacities, the long-term solution to wastewater disposal is piped sewerage and treatment with separate sewage and drainage pipes.
- Effluent discharges should be downstream from water supply intakes. Discharge standards should be consistent with water uses in catchments.
- Sanitation schemes that achieve local improvements in one area at the expense of others are not appropriate in megacities.
- Wastewater should be regarded as potentially having value for reuse in agriculture, maintaining surface water flows, and groundwater recharge.

**Institutions**

- Roles of agencies should be carefully defined.
- Water and sanitation utilities in megacities should be able to act as bulk suppliers to urban poor areas. Utilities and local governments should adopt flexible approaches to the provision of water to unauthorized settlements and base their decisions on commitments to pay for services.

**Economic and Financial Aspects**

- Demand side should receive more attention, and increased efforts need to be made to estimate demand and understand its determinants in an economic sense. Financial revenue estimation should increasingly be made on demand information, rather than simply estimating required revenues based on future financial costs.
- Subsidies, when used, should be explicit and transparent and target the urban poor. They should be directed at the demand side rather than the supply side.

## Conflict of Water Users

The main users of freshwater in Asia are farmers (through irrigation), next come the urban water utilities that serve domestic, commercial, industrial, and some gardening and stock raising needs. Hydropower facilities are, strictly speaking, not consumptive users, but their activities do influence others. The environment needs a certain amount of water to be reasonably well maintained. And recreation and tourism also rely on freshwater.

By far the greatest potential for conflict among users involves irrigators and urban water utilities, as urbanization continues to grow at rates of around 5% per annum. First comes the desire to take over the water used by the irrigators, as it is the next nearest source of water to develop. Next comes the sale of farmland for subdivision and estate construction. But there is also great conflict between farmers for water. Those at the bottom end of the irrigation network invariably miss out in times of drought. Then there is the conflict that arises when water is taken from one locality or river basin and transferred to another for irrigation or water supply. Certainly the environment is greatly altered. Livelihoods (water wheels, irrigation, and fishing) are affected, and

aesthetics are impaired. Hydropower often involves dams for storage of potential energy, and these dams severely alter the regime of rivers for other users. When industrial and domestic water users mine groundwater, they are in conflict with future users, because access will be deeper and more costly, and the risk of saline intrusion will often be ignored until the damage has been done. Pollution of waters, especially by industrial users, affects other users of the water downstream as well as groundwater users. Religious use of water is greatly impaired by such activity. Finally, there is the potential conflict of use that results from local management of water versus comprehensive water resources management on a river basin scale. Watersheds involve the conflict between urban water users and inhabitants who live in or near watersheds and cut down trees for much needed fuel for cooking. When it comes to interbasin transfer, governments often state that water belongs to the nation, but more and more now the customary rights of the settled people are being observed. In line with this, their past and future use of water must be considered.

Unfortunately, where these uses conflict, it is not easy to compare apples with apples. The nearest we can come to that is (sadly) to put a monetary value on such uses and allow market forces to determine proper rewards and penalties. This means that we must recognize customary use now and in the future and allow current and future beneficiaries to participate in determining equitable sharing. Once trading water rights becomes a reality, conflict resolution by politics can be eliminated. But the impetus for trading water rights must come from domestic urban water users. When they pay tariffs of around $0.40/m$^3$, instead of roughly $0.05/m$^3$, there will be something with a realistic value to trade. But as long as domestic tariffs remain low, there will be little incentive to transfer water rights.

The case of water transfer from Melamchi Valley to Kathmandu Valley for domestic water supply is interesting, as the water levy is to be charged to consumers in Kathmandu Valley and paid to the people living in Melamchi Valley. In essence this is trading water rights, but it does not go under that name because legally the people of Melamchi Valley do not own the rights to that water, the nation holds the rights.

Chile has been a pioneer in introducing tradable water rights. In 1981, Chile's water code allocated (without charge) property rights to existing users of water. Property rights for new users were sold by auction. Property rights can be used for loan collateral and are assigned for consumptive and nonconsumptive uses. Agriculture was and remains the largest consumptive use. The city of La Serena initially planned to construct the Puclara Dam to satisfy its rapidly growing water requirements. With the introduction of a water code, many farmers in the region recognized that the water rights they held had a higher value than their water's current agricultural use. Farmers put in place more efficient irrigation systems requiring lower water volumes and sold all or part of their water rights to the city at good prices. The transfer of the agricultural water rights to La Serena has led to the indefinite postponement of the dam's construction. The reduction in water use in the agriculture sector has helped control salinity, which was primarily caused by excessive use of water. Introducing an economic value for water rights has also had positive impacts on water utilities. For example, Chile's main water company chose to invest in the reduction of NRW rather than pay for additional water rights to meet its customers' growing demand.

Groundwater use by industries should first be examined to decide whether it is in the best interest of cities and their environments to relocate these industries. However, if it is found that these industries provide essential services, like the services provided by tourist hotels, their use of groundwater should be monitored in an effort to control extraction, and they should pay for the water used, as the water belongs to the nation and industrial use prevents or restricts other uses.

## D. Conclusion

In most cases, but especially in South Asia, water is treated as a social rather than an economic good. The most pressing need is to get entire populations in urban areas connected to 24-hour supplies of potable piped water. Without tariff levels being appreciably raised, however, this is unlikely to happen. Yet affordability is not preventing such increases, as there are very few cases in which those connected to piped water pay more than 3% of their household income for the service.

Just as the past 20 years has shown that NRW cannot be reduced by dealing with this problem in isolation, it can be seen that water conservation and demand management cannot be introduced in the same way. They are part of the bigger picture of governance, policy, regulation, accountability, and transparency (see Figure 2.2). Conflict between water users is as much about governance as anything else. In the absence of clearly defined and transparent policies, ad hoc interventions or prevention by elected officials will continue to promote this kind of conflict. We need transparent

government policies covering watershed rehabilitation and protection; reduction of NRW; the increase of tariff levels, so that these curtail excessive demand; and regulatory bodies to see that policies are implemented. Such policies should include measures designed to educate schoolchildren on the need for and the ways and means of water conservation. And they should include provisions stating that utilities and regulators must create, through media, public awareness on these matters so that to some extent positive peer pressure can come into play.

Computerization will help everyone involved analyze the effects of tariff increases on demand and fine-tune this relationship over time. Carefully structured block tariff systems can ensure that the poor are not penalized and that demand is controlled. Gradual tariff increases matching service improvements are best.

In the end, it will be relatively high urban water supply tariffs that put pressure on nearby irrigation systems to either greatly improve efficiencies in water use or trade their water rights to cities.

The recent modeling of water demand and supply in Kathmandu Valley shows the value of comprehensive water resources management, which is not an exact science. Balancing economic, social, and environmental concerns is very much time dependent and influenced by outside considerations. Creating the Kathmandu Valley Water Authority, however, will give local governments some control over their environment and at the same time facilitate comprehensive water resources management at arm's length from these considerations. This study has highlighted the need for constructing good databases and maintaining them over many years.

More recently, the concept of managing water where it falls is being emphasized around the world, especially in regard to rainwater harvesting, control of storm-water runoff, and wastewater management. There are good lessons to learn from the beavers who gave America their wetlands by creating millions of small dams. We should think about floods and fertility. We need to think more about the morality of transferring water from one river basin to another. We should share good case studies through the Internet. We should learn from history. And we should learn to be proactive and not reactive in managing water.

*In the years ahead we may come to judge our success at water management by our ability to share water equitably, to do more with less of it, and to restore life and integrity to the earth's rivers.* (Postel, 1997)

## Water Resources Management (Problems) in a Nutshell

- Watersheds are degraded—the trees have been felled and wet season rains are lost.
- Groundwater is overexploited because it is free.
- Irrigation is often a wasteful use of water—both in terms of crop types chosen and poor water delivery mechanisms.
- Urban water supplies have high rates of NRW.
- Underpricing water does not help conservation.
- There is conflict between urban and rural water users.
- Water pollution results from ineffective governance.

## Water Resources Management (Solutions) in a Nutshell

- Water policies and social auditing are needed.
- Have long-term planning horizons.
- Introduce demand management through awareness and pricing.
- Plant more trees to rehabilitate watersheds.
- Plant crops that use much less water than do rice, cotton, and sugarcane.
- Do not subsidize water management.
- Remember the triple bottom line: environmental, social, and economic development.
- Develop rainwater harvesting in cities.
- Remember the beavers—build check dams.
- Trade customary water rights.