INTEGRATED WATER PROJECTS: BRIDGING THE GAP BETWEEN POLICY AND TECHNOLOGY

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Cost effective water resource planning and project implementation in developing countries is a challenging set of affairs. If the view that we take of water resources problems is broadened to address a wider variety of issues, we open up possibilities for solutions that are environmentally superior, more cost effective and more appropriate to the social setting. Moreover, the foregoing factors also happen to be the components of sustainable development.

BACKGROUND

Urban Growth

During the last two decades the urban populations in developing countries have significantly increased. Urban populations are expanding for two key reasons: higher birth rates and because poor rural residents are migrating to cities in search of a better way of life. This population increase and physical sprawl have outpaced the location and capacity of water systems in most cities.

Although grand plans and policies for municipal water systems are often made at the national level, in reality municipal water systems are usually very local in nature both in the source, distribution, and funding. In addition, the water infrastructure systems from source to distribution have suffered from general neglect due to underfunding. Most systems are operated in a reactive mode with the water utilities focused on trying to get through the calamities of each day, one day at a time rather than planning ahead. They have neither the funds, time, nor resources to move forward. The causes of this underfunding are the desire to keep tariffs low and the lack of incentives and/or discipline to collect the monies owed. The result is that the level of service deteriorates because the easiest way to continue operation is to neglect preventative maintenance and any orderly replacement of components before failures occur. Water is often sporadically delivered at varying pressures and likely is not potable (based on U.S. standards).

Many utilities have a concept of depreciation funding, but often this area is either not funded or it is funded with barter goods, debt notes, or other non-negotiable methods of funding. And in some cases, as a result of the utilities losing money on a per gallon basis because their rates are too low, the utilities purposely deliver less water in order to save money. There is a major disincentive to provide 24-hour service, expand systems, or hasten repairs.

Source Versus Distribution

It is hard to generalize about the relative importance of a system's source and the transmission/distribution network. However, without a good condition for the latter, much of the water produced at the source can be lost through leakage and can become contaminated while in the pipes. This negates efforts to increase the supply portion of the system. With distribution networks that have excessive leakage, the leakage will be proportional to the pressure and thus attempts to operate them at delivery pressures 24-hours a day can result in even higher losses. At the same time, operating the distribution networks with excessively low pressures can result in contamination due to the inflow of groundwater.

Cost of Water

Water may be considered by many as a free resource; but water collection, storage, treatment and distribution are not free. Water source development, treatment and distribution networks are highly capital intensive and require significant operation and maintenance expenses. Most of the components of water supply and distribution have universal costs (pipe, pumps, power, chemicals, etc.) which are affected neither by the country of origin nor the income levels of consumers. The cost of water in North America and Western Europe is indicative of the level of rates that must be charged to obtain equivalent service. The average cost of water service in these areas, where water is obtained by traditional means, often ranges between \$0.5 and \$1.5/m^3. It is this range of tariffs and successful collection processes that are needed to fund water systems which will be reliable, safe, and convenient. Without this income, the systems end up operating in an unsatisfactory condition.

FUNDING AND OWNERSHIP

Funding

Funding is usually the major problem in most systems. Almost all utilities levy a tariff on water users. There are a wide variety of tariff schemes ranging from flat rates to consumption-based billing with various weighted options. These rates are often combined with subsidies that may or may not be paid to the utility. In addition, utilities are often denied the enforcement power to obtain payments from customers; typically they are the domestic users and consume the majority of the water.

The result is that funding falls short of the amount needed for prudent operations and future capital investment. Operations conserve by not always paying their bills; reducing energy usage (by restricting hours of operation); minimizing routine preventative maintenance; and not making an orderly replacement of system components as might be called for under a depreciation schedule.

Capital Improvements

In many developing countries the funding for capital improvements frequently has come from and was controlled by the central governments. Although the control may still exist, there are few central governments able to allocate sufficient funds for an adequate capital investment program to make improvements in water service in urban areas outside of the capital cities. The local utilities are likewise financially unable to accumulate funds for meaningful replacement and orderly expansion of the systems, but at least they recognize the problem due to their daily operations.

Sources of Funding

Whereas utilities in developing countries have in the past looked to central governments for funding, many of them now are hoping that international financial institutions (IFIs) will provide funding for capital improvements. Unfortunately, funds available from IFIs are limited, and this means that only a select number of systems can be financed in this manner, and the amounts that can be provided are small relative to the problems.

Significant capital funding from IFIs, if any, will usually be in the form of loans; in which case the utility's repayment capabilities are going to be a consideration. Grant funding is limited in total funding and usually consists of studies, institutional restructuring, or minor demonstration capital projects. Normally, the basic technical problems of source and distribution network improvements are evident, but the institutional ability of a utility to devise a plan to improve finances is often limited.

It has become increasingly evident that even with sovereign guarantees from the central governments, repayment of loans and most other expenses of operating a system will need to come from the local utility and the actual users of the water.

Ownership and Operation Options

Based on widespread experience, water systems can be successfully owned and operated using a variety of management methods. The key is that in any form of ownership and management, public or private, the system should be operated as a business. Income (from any source, including paid subsidies) should equal or exceed expenditures, and investments should be made with some reasonable consideration of return.

Forms of ownership include: completely public (by central or local governments); semi-independent authorities or public ownership, but operated by privately owned companies; and utilities that are completely privately owned. There are also variations of these with selected tasks being done by the private sector.

Private sector operations can offer advantages in raising capital funds, procuring materials and technology, providing for efficient use of labor and materials, and reducing bureaucracy. However, private operators require that all costs be recovered. This will usually lead to increased rates and/or more aggressive collections.

One argument for public-sector ownership is the implied stewardship for water, its resource base, its delivery, and the previously invested capital. In many instances, however, good stewardship has not proven to be the case. Artificially low rates and inefficient collection practices have led to deteriorated systems and, in the end, service to the poor usually suffers the most. The rich can always obtain water by other means.

Done well, any type of ownership can work. To be successful, all costs must be matched with actual income, including the costs of operation, orderly replacement, and future expansion. In almost every case this income will have to be derived from the users.

NATIONAL AND LOCAL POLICY

Reliable funding for water system capital costs and operations basically will be obtained from users; therefore, they must be involved in the planning and operation. Except in rare cases the supply and distribution of water for urban areas should be directed and controlled from the local level. There is a sound place for national policy and planning but this should be limited to standards or overall planning efforts. The setting of national policies as it affects utilities should be done with the utmost care. Since the central government will generally be unable to fund capital or operating costs of water systems, it should be prudent regarding its level of involvement.

National policy should be to encourage good decisions and practices (technically, financially, and managerially) at the local level. Practices should be in keeping with the funding that is reasonably available to the utilities. Therefore, fiats for mandatory implementation of plans, like universal metering and certain levels of water quality, may not be within the financial reach of the local utilities and could be a counterproductive exercise in power.

If national standards are imposed, national policymakers should recognize the conditions in the field. Requirements should be sensible and realistic. They should not be unattainable, forcing utilities to cheat in order to meet the requirements.

PROJECT IMPLEMENTATION

Planning

A plan should be the basis for any significant investment in the improvement of a water system. This should include measurable intermediate and ultimate goals. Generally, the ultimate goal in an urban system would be the supply of in-house potable water 24-hours a day at a steady pressure. This service goal may take many years or even decades to achieve. Therefore, realistic intermediate goals should be set.

The situation that urban utilities face in developing countries is usually of such great significance that caution should be taken in deriving a solution. Intermediate solutions and goals that are applicable to the local situation (technical and financial) and social setting should be considered rather than using only ideas and approaches from North America and Western Europe. Although the technical method of operation and engineering will generally end up being the same in the end, the pathway, methods and goals of operation found in North America and Western Europe may not be relevant in the early stages.

Planning should begin with a realistic system evaluation—the level of detail should match the problem and potential for solution. Based on this evaluation and input from stakeholders and users, a strategic plan for the future should be made. It is crucial that the plan is realistic in its costs, priorities, time, and funding.

The costs to upgrade a water system to the ultimate goal of a 24-hour water system can involve a significant investment of capital funds. Therefore, the involvement of users and other stakeholders in the early part of the planning process is important, as the financial commitment for the future is large. Further discussion of this is contained in Section VI Public Involvement.

A plan for moving a deteriorated system toward efficient operation should be take into account the phases of stabilization, rehabilitation, and modernization.

Stabilization

Stabilization is the process of halting or slowing the degradation of the system. It includes making selective repairs and modifications. This is not the stage to build new structures such as treatment plants or dams for the sake of bringing in modern technology. This stage usually consists of replacing the most troublesome parts of the distribution and transmission network, reducing energy usage by pump and piping changes, and repairing intake and treatment systems.

Serious health threats should be eliminated, but the goal of always having potable water available for the users may not be achievable during this early stage if it didn't previously exist. As important as the physical plan is, there is a need to stabilize finances so that they are at least at a breakeven point. Without the accumulation of excess funds to make present and future capital investments, meaningful improvements are basically impossible.

Stabilizing finances will usually involve institutional and possible management changes to enable the utility to set suitable tariffs and the ability to enforce collections. This will require support from the users and the politicians.

Realizing that local utility financing must be manageable, IFIs will insist on a solid stabilization plan. Commonly, much of what an IFI can initially loan a utility will be needed to accomplish the stabilization phase.

Rehabilitation

Rehabilitation is a long-term process of restoring the system through an orderly replacement of pipes, structures, tanks, etc. This phase can be expected to continue for the life of the utility; to restore the system to a high quality of operation entails a massive expenditure. In making long-term capital investments in infrastructure, use of quality materials (especially for buried infrastructure) is the best long-term strategy. This enhances the service life, reduces waste and repairs, minimizes service interruptions, and results in a lower long-term cost. During this phase, the work is focused on making the system reliable and safe.

Modernization

Modernization is the stage that includes increasing the amount of available water, dramatically improving the delivery systems, and improving water treatment. These facilities can be expected to be quite expensive and should not be undertaken until basic institutional and financial structures are in place.

As with any complex endeavor, more than one of these stages can be simultaneously implemented.

NEW TECHNOLOGIES

The rehabilitation and upgrade of most urban systems in developing counties will be done largely with pipes, pumps, and related controls. The quality and availability of these commodities has improved over the years and are widely available worldwide at competitive prices.

In addition, there are a variety of new technologies that can be applied during the various stages of system improvements.

Source Augmentation

A number of new ways have been developed and entered into more common practice to augment water sources. The source of supply for large urban areas is often inadequate and/or contaminated. Due to the sprawl and creation of new urban areas and the increased use of water for agriculture, the quantity and quality of source water is often restricted. Any significant increase in source water for urban areas generally requires a large capital investment and considerable time for planning, funding, and permitting. There are some new technologies to consider to help deal with the problem of source augmentation.

Desalination—The technology for desalinating brackish water and seawater has rapidly developed into a commercially successful treatment process. For coastal arid areas this has opened up new sources for fresh water. This can be especially useful where heretofore long distance transmission lines were needed to bring fresh water from distant sources.

Desalination by using both thermal and membrane processes is widely accepted and used. In North America membrane processes (electrodialysis and reverse osmosis) have been used the most. In the Middle East thermal processes, usually multi-stage flash distillation is employed. In Middle East countries such as Saudi Arabia and Kuwait, thermal processes are often used as part of dual purpose plants where steam is produced and successively used in steam turbines to produce electricity and in distillation plants to desalt sea water. This reduces the overall energy needed and thus reduces the production cost for both processes (Buros, 1999).

The cost of desalted water, especially from seawater, has been reduced considerably in the past 5 to 10 years. To fairly evaluate desalting one must look at all costs, environmental and social factors involved in both desalted water, and alternate methods of source augmentation.

Water Reuse—The reuse of treated wastewater for nonpotable purposes has become increasingly common as a way to both extend water supplies and to properly dispose of treated effluent. The use of this technology is rather site specific, as it requires that the source of wastewater and a useful application for treated effluent need to be relatively close together. It also requires that wastewater be consistently treated to a standard that will not be a threat to public health.

Water reuse applications include ground water recharge, landscape, and some agricultural irrigation, industrial cooling water, etc.

Aquifer Storage Recovery—In areas where there is a seasonally high supply or demand, the best answer has been storage in order to balance supply and demand. Dams are an example of storing seasonal water. Dams are becoming more controversial to build and conventional tank storage is expensive. The use of aquifers to temporarily store surplus water through various means of artificial recharge has become popular in recent years. Aquifers can provide natural, low-cost storage space if the right conditions exist. A special variation of artificial recharge called Aquifer Storage Recovery (ASR) has proved quite effective and has been used in a number of applications in the United States over the past 20 years. ASR is a form of artificial recharge in which water is stored in a confined aquifer using the same bore hole for both recharge and water recovery. It has been used to store fresh water in aquifers containing fresh, brackish and seawater (Pyne, 1995).

Water Distribution

The condition of the distribution network is usually crucial to the entire water system. Large losses or contamination in the distribution network forces artificial demands on the water source and then can negate any of the benefits and expense of treatment. The improvements in this area are mostly the result of steady improvements in older technologies.

Analytical Tools—Analytical tools can be advantageously used for distribution system evaluations. These tools include software programs and portable meters to make measurements. Although mathematical methods to calculate projected flows and head losses in pipe networks have been around for many years, the improvements in personal computers and related software have made the use of these methods considerably faster and less tedious. There are a variety of software programs with a variety of technical features available in the marketplace. One public domain software program is EPANet; it was developed by the U.S. Environmental Protection Agency.

Portable recording ultrasonic flow meters have a tremendous value in being able to obtain flow data in many parts of a system. Using the flow meters in combination with portable pressure gauges allows considerable data to be gathered. Additional equipment exists for leak detection and for determining the physical condition of pipes in the system (Makar and Chagnon, 1999). However, in substantially deteriorated systems extensive leak detection can be avoided as the rate and location of current pipe failures are often at such a high frequency that candidates for replacement soon overwhelm and exhaust appropriated funds.

Pipe Lining—In many countries large quantities of unlined and often uncoated pipe have been used, both cast iron and steel for distribution networks. These pipes tend to have a short service life, but by using one of the various types of lining practices the service life can be extended. These lining practices include slip-lining using plastic pipes, cement lining, and the application of some types of epoxy lining. All of these practices require entry to the pipelines at reasonably close intervals and hence the costs can be significant. The choice of lining or replacement is one that needs to be done carefully; for large systems needing a lot of rehabilitation it is usually a combination of the two.

PUBLIC INVOLVEMENT

Bridging the Gap

Although evaluation and planning within an overall policy are mandatory, the key to moving ahead with system improvements is funding. Funding must ultimately come from local users. Bridging the funding gap between policy and implementation is public involvement. Public support in paying increased water charges is essential for long-term success. This involvement should start at the planning stage and continue through implementation.

Input should be sought on the level of service, water quality, implementation schedules, etc. This involvement must include a comprehensive public education program on the current situation, various options for the future, and methods of funding. Since a long-term commitment by the ratepayers is required, a measure of trust must be built between the users, citizens, and the utility. This in turn means a considerable amount of transparency in decisionmaking, which can be difficult for any entity — especially for one that previously has had no transparency.

Long Term Commitment Needed

Involvement is needed as the obstacles are great and the effort to "fix" the system will take a long time. High expenditures will be needed to "make up" for past neglect and the demands of rapid urban growth. This usually means water rates will be high, especially relative to the income of the poor. In addition, significant time will pass (when high rates must be paid) before improvements are seen. Since the users must pay for the system, they need to help make decisions on major capital investment and methods of financing.

Historically, collections for water service have been poor and politically unpopular. Enforcement has also been technically difficult to enforce due to the lack of means to effectively shut off service to low-income consumers.

ENVIRONMENTAL FACTORS

Environmental factors may positively or negatively impact the optimal development of water resources, usually in both ways. A small selection of potential environmental factors for a water-supply project is shown in the following table.

Positive Environmental Impacts	Negative Environmental Impacts
Enhanced health of human and other biota	Decreased upstream biological diversity (through impoundments)
Improved receiving water quality for variety of uses	Decreased riverine habitat
Improved city and village streetscape	Temporary construction disruption Archaeological damage

Such factors ideally should be addressed as part of a comprehensive, integrated approach. This approach should identify potential problems (and hidden benefits) so as to enhance the opportunities for incorporating into the solution any mitigating measures for adverse impacts. Successful implementation of environmental mitigations or enhancements depends on early identification, which is a prerequisite of an integrated approach that aims to involve the local community, since local interests are well suited to the identification of environmental factors. However, regional, national, and sometimes even international environmental resources can be affected by water system development. The integrated approach, if properly carried out, will expose all of these factors if the various levels of government have been appropriately involved.

SUSTAINABLE DEVELOPMENT

There is an additional cluster of benefits stemming from the broadened approach to water system development: sustainability. Sustainable development is defined as development which "meets the needs of the present without compromising the ability of future generations to meet their own needs." (Brundtland Commission, 1987).

Sustainable development is commonly referred to as having three dimensions:

- environmental protection and enhancement (as described in the previous section)
- economic development, in which prices are in reasonable relationship to the cost of resources utilized and developed
- social accountability, in which all elements of civil society are properly involved in decisions affecting the lives of its members

As shown above, a broadened approach to water system planning and implementation will provide solutions that are environmentally superior, cost-effective, and socially sensitive. These match very well the three dimensions of the sustainable development definition: (1) The integrated approach allows for the early identification of environmental factors and the mitigation of adverse environmental impacts; (2) Cost-effective water system development is encouraged in which the users ability and willingness to pay are fully utilized in the selection of project technology and design (such development will not disappear when the initial investment stage is completed and/or the grant-making institution moves on); (3) All elements of civil society must be involved, which further enhances the stakeholder commitment and the long-term sustainability of projects.

CONCLUSION

If the broadened, integrated approach to water system improvement is taken, then bridging the gap between policy and technology is possible. Projects will be planned taking all factors into account, and appropriate technology will be identified. Full costs will be accounted for over the entire life of a project, including environmental, economic, and social factors. These costs, where possible, must be included in the rate structure.

To make this all possible, it is essential that policymakers, water planners, engineers, economists, and environmental scientists work hand in hand with the affected publics. This must focus on the users of the water system as they are the ones who will need to pay for the improvements and level of service. It is crucial to have them as part of the team.

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