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Policy Research

WORKING PAPERS

Water and Sanitation

Infrastructure and Urban Development
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Comprehensive Water Resources Management

A Concept Paper

Peter Rogers

Issues that should be covered in the formulation of comprehensive water resources management policies.

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Water and Sanitation

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This paper — a joint product of the Water and Sanitation Division, Infrastructure and Urban Development Department, and the Agricultural Policies Division, Agriculture and Rural Development Department — is part of a larger effort to define a Bank water resources management policy. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Danielle Ranger, room S11-043, extension 31296 (March 1992, 18 pages).

The world is entering a period of intense competition for limited supplies of water for alternative uses — in agriculture, in urban and industrial supplies, for recreation, by wildlife, for human consumption, and to maintain environmental quality.

Manifestations of this competition and our current ability to deal with it can be observed in many parts of the world. A large irrigation project in India does not operate because water has been diverted to the rapidly growing city of Pune. In China, industries are reducing their production because of water shortages, even though they are surrounded by paddy fields. In California, selenium salts leached by irrigation are killing wildlife. Bank irrigation projects in Algeria are now competing with Bank urban water supply projects for the same water — and many proposed irrigation projects and most hydro project proposals are on hold because of environmental concerns.

Until recently, the approaches taken to water planning management by planners in the developing countries and by analysts at the funding agencies were, by and large, appropriate and adequate to the task at hand. The increased competition for water, however, makes most of the project-by-project planning methods inadequate.

Rogers discusses new approaches that are needed to integrate water resource use among different users and across different economic sectors.

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1. Introduction

The world is entering a period of intense competition over limited supplies of water for alternative uses in agriculture, urban and industrial supply, recreation, wildlife, human consumption, and maintenance of environmental quality. Manifestations of this competition and our current inability to deal with it can be observed in many parts of the world. For example, a large irrigation project in India does not operate because water has been diverted to the rapidly growing city of Pune. In China industries are reducing their production due to water shortages even though they are surrounded by paddy fields. In California selenium salts leached by irrigation are killing wildlife. Bank irrigation projects in Algeria are now competing with Bank urban water supply projects for the same water, and many proposed irrigation projects and most hydro project proposals are on hold because of environmental concerns.

Until recently the approaches taken to water planning and management by planners in the developing countries and by the analysts at the funding agencies were, by and large, appropriate and adequate to the task at hand. The increased competition for water has, however, made most of the project-by-project planning methods inadequate. New approaches are needed that will integrate water resource use among different users and across different economic sectors. Realizing that the present approaches to dealing with these enormously complex and difficult issues are no longer sufficient, the Bank has initiated a Comprehensive Water Resources Management ~~Policy Study to~~ investigate how best to resolve them. This paper is an attempt to outline the issues which should be included in the Bank's Policy Paper.

1.1 The Water Sector at the World Bank

The World Bank helps to fund water projects that have broad impacts throughout the economies of developing countries. Water is used for domestic and industrial purposes. It is used extensively for irrigating crops, and is a major resource to electrical energy systems both for hydropower generation and for cooling thermal generators. It is essential to many transportation systems. Inland and estuarine fisheries depend upon adequate flows of high quality water in the rivers. Rivers, lakes, and groundwater are also extensively used for the disposal of treated or untreated wastewater, that itself has served to remove and transport chemical or other wastes. Fresh water is used to stop the penetration of salinity into surface or groundwater sources of supply. Increasingly water access is becoming a major component of both urban and rural recreation facilities. In many places large investments are required to minimize the consequences of naturally occurring floods and droughts. The maintenance of a locality's fauna and flora is critically dependent upon access to water. All of these uses have either been funded, or are potentially fundable, by Bank resources.

The water sector is also a substantial portion of the Bank's annual lending. For example, between 1984 and 1988, out of a total lending of $83 billion, water projects constituted $10.6 billion, or 12.8% of the total. Irrigation and drainage accounted for $4.6 billion, hydropower for $2.4 billion, and water supply and wastewater $3.5 billion. No data are available for flood control, water transport, and river and estuarine fisheries. A sum equivalent to 55% of the total expenditures for agricultural and rural development was spent on water projects. In many countries (for example Brazil) water sector expenditures are as high as 30% of total public expenditures.

Water is dealt with independently in each of the Bank's regional bureaus and in its central departments. This situation has sometimes led to inconsistencies in Bank policy between countries or between water uses. Under conditions of water surpluses such inconsistencies are not necessarily bad, given the wide diversity of the countries and range of uses for water. Indeed, this is what the Bank's own Operations Evaluation Department has found on the many projects for which it has carried out post-completion audits (more than 140 irrigation projects by 1989). Irrigation projects, for example, performed quite well in the arid regions in Europe, the Middle East and North Africa (EMENA) and Latin America, but less well in the humid tropics of South Asia, and quite poorly in sub-Saharan Africa. However, the current competition for water in regions such as EMENA is becoming so severe that the historical performance may not be expected to continue into the future without serious improvement of pre-planning, and the African projects need special care to ensure adequate future performance.

1.2 The Concept Paper

Under conditions of water scarcity and with increasing scrutiny from environmental interest groups outside the Bank and from the Bank's own internal auditors, the Bank staff has realized the increasing costs of the lack of a comprehensive view of the water sector and is looking forward to a Bank-wide policy with respect to actions in this sector.

This Concept Paper is an attempt by an outside observer to take a synoptic view of the water problems in a broad perspective encompassing water in all its important uses, and to indicate areas that should be emphasized in the Bank's Policy Paper. This paper has tried to achieve a balance between discussing broad conceptual issues and specific sectoral issues. Water resources is a very broad subject, hence it is not possible, nor advisable, to attempt to cover everything within such a short paper. The goal has been to provide discussion on the most important issues so that their inclusion in the Policy Paper can be justified. It is the author's opinion that there are a few *simple* concepts and methodological approaches that could, if understood and adopted, significantly influence the successful development of water resources around the world. This attempt at simplification should be taken in the spirit of Occam's Razor: exhaust the simplest explanations before requiring more complex ones.

Issues that are not discussed at length in this Concept Paper are the legal issues of water rights, development of water markets, privatization of facilities, development of new technology, and detailed sector-by-sector highlighting of problems and possibilities. To do justice to all of these issues a book-length treatment would be required. Since it is the author's contention that the major problems with successful development of water resources lie in the refinement of economic analysis, the other issues are not a major focus of this paper. Part 2 of the Concept Paper discusses some of the fundamental concepts underlying water management, and Part 3 addresses the economic issues stemming from the fundamental concepts that cause problems in pursuing Bank water policy. The emphasis throughout Part 4 of the Paper is a practical discussion of issues that are currently of widespread concern within the Bank and are likely to be of great importance into the next century.

2. Fundamental Concepts for Water Management

There are a few fundamental concepts that underlie the theory and practice of water management.

2.1 Water is a Unitary Resource

Rain, surface water in rivers and lakes, groundwater, and polluted fresh water are all part of the same resource base. They are all one and the same resource, although in different manifestations, occurring in different parts of the hydrologic cycle. Unused surface water can recharge the groundwater and, conversely, overpumped groundwater can reduce the flows in the surface streams. Contaminated water can be purified by constructing wastewater treatment processes or it can be recovered by the natural assimilative capacity of the surface and groundwater ecosystems. Thus, the entire hydrologic balance must be considered, not just parts of it. Actions taken in one part of the system often have significant impacts upon other parts of the system; these linkages must be taken into account when assessing the costs and benefits of specific actions.

Because water is a unitary resource there are often conflicts among users. The most common example is the conflict between surface and groundwater users in irrigated agriculture. Improvement of the efficiency of application of the surface water results in an immediate decline in the availability of groundwater. Allocation decisions are also frequently ambiguous. For instance, water is often allocated to irrigation projects at low cost to the users when nearby urban areas are suffering serious water shortages and are willing to pay high prices for water. As a result of these types of problems water use in all countries is proscribed by legal and institutional complexities. While it is evident that many of these institutional complexities can hinder economically efficient use of water, these controls first arose in the first place because of the genuine problems that water raises for any politico-economic system. As the costs of ignoring the unitary nature of the resource rise one would expect to see the gradual easing of institutional constraints on development in the direction of more rational integrated use of the resource.

2.2 Scarcity of Water

The discussion about scarcity is usually intimately bound up with the concepts of water as a renewable or non-renewable resource. If it is renewable, how can we ever run out of water? Certainly in many arid or semi-arid zones, people are currently experiencing shortages of water. Part of this problem has to do with the fact that under earlier historic conditions we were able to sustain the populations of cities and regions, even under relatively arid conditions. However, with the growth of population and income the demands for water seem to be overwhelming our technological capability to supply it. Under these conditions water scarcities and conflicts over water use begin to appear. The cost of supplying additional water to water-short areas is also increasing. As a result it becomes increasingly difficult to supply the same amounts of water to users at the old low prices. The Malthus-Ricardo theory of resource scarcity seems to be working exactly as predicted: scarcity of resources limits economic growth, and ultimately brings it to a halt. It is no surprise that this theory earned economics the sobriquet of "the dismal science."

Modern economists define water scarcity slightly differently, which allows for a way out of this dilemma: the need for water has to be expressed as a quantity and a price. This is called the "economic demand" for water and both quantity and price must be specified. In the current economic models resources do not "run out." As the quantity demanded increases new sources will be tapped, at the same or higher costs, and/or the price will rise, restraining what each user will desire to purchase. This is essentially a self limiting process. Clearly, if a resource base is fixed and the consuming population increases, something has to give. This will be either the price or the quantity of the resource used. However, even this system would ultimately be forced to a halt by population or economic growth. The magical ingredient that enables the economic system to continue to grow is the existence, at some reasonable cost, of substitutes for the scarce resource. Although there is *no* substitute for water in sustaining human and animal life, there is an almost infinite supply of sea water, which can be converted at a cost of energy into fresh water; then energy, or the capital to access the energy, becomes the limiting resource. Similarly, political boundaries, management skills, or human labor could limit the availability of water.

Part of the problem of dealing rationally with water scarcity is the different perceptions that various groups have about how close we are to reaching the resource limits. For example, in a study for the Bank, Falkenburg et al. (1990) claimed that some countries (Israel, Jordan, Saudi Arabia, Syria, and Yemen) were very close to being unable to supply their populations with the minimum needed amount of water (500 cubic meters per capita per year). However, others looking at the same data see many possible adjustment mechanisms, which include recycling, reduction in agricultural use, changes in population policy, and the reclaiming of additional brackish water. Has water been a significant limit on economic growth in any of these countries? How will each country address the future of this resource? Has water been priced out of the reach of significant portions of the populations? What accounts for the fact that in many other countries with much larger per capita quantities of available water the per capita water use is lower? On closer inspection the "water barrier" of 500 cubic meters per capita per year does not appear to be a real barrier in the Malthus-Ricardo sense. The idea that we are running out of water (Postel, 1990 and others) cannot be true globally, and even in specific water-short countries there is little doubt that water will always be available at some reasonable price, provided those countries follow sensible water policies. The definition of scarcity in non-economic terms is a distraction that can lead to major misallocations of the water resource. The rapid disappearance of the "oil crisis" once limited market responses were allowed to take place should be borne in mind by water planners.

2.3 Market Failure in the Economics of Water

The most useful economic literature on water is built on neo-classical economics. Much of it explains which assumptions and theoretical constructs deal best with aspects of "market failure," that is, when the classical model does not strictly apply. Eckstein (1958) mentions the following sources of market failure inherent in water resources as the most important:

1. Increasing returns-to-scale on the production side are prevalent in water projects. For example, inland waterways and municipal water and wastewater services are natural monopolies because of the large economies of scale in the provision of the infrastructure. Many water-related investments tend to be very large in order to take advantage of these economies of scale.

2. Externalities due to physical interdependence among production processes are inherent in many water activities. The externalities of both water quantity and water quality are experienced in the spatial sense between upstream and downstream users, and in a temporal sense between different seasonal releases of stored water, common pool effects on groundwater, and the export of pollution.

3. The classical model assumes that the income distribution in a given setting is optimal. However, in development work it is rarely accepted that the income distribution in a particular country is the best

one, and many water projects are specifically aimed at changing a mal-distribution of income.

4. When not all producers are small relative to the market, the marginality conditions for the existence of economically efficient solutions are violated. When government is involved it is often as the only producer in the market. In this case the water supplied will make large changes in the local price of water, thus undermining the assumption of marginality inherent in benefit measurements.

5. The resources are not necessarily mobile. Typically, capital resources are relatively mobile but labor resources are not. Pockets of poverty and unemployment exist and many water projects (like the Tennessee Valley Project, TVA) were originally designed to address this lack of resource mobility. In addition restricted water rights often impede the ease of transfer of water from one use to another.

The literature since Eckstein shows how each of these market failures can be compensated for in water resources planning. It is now the general opinion that careful application of neo-classical principles can deal with the market failures most likely to arise in water investment analysis. For example, increasing returns-to-scale and monopoly pricing can be dealt with by some form of Ramsey pricing. Externalities can be dealt with by expanding the definition of the system to "internalize the externalities." The lack of mobility of resources can be accounted for by suitable shadow pricing, and the income maldistribution can be dealt with by adding constraints on the distribution of benefits. The adjustments themselves lead to some loss in the overall "economic efficiency" implied by the classical model, but the loss is believed to be small relative to the broader improvement of solutions. Brown and Sibley (1986) discuss various techniques of improving utility pricing which come close to the economically efficient solution and which, at the same time, are closer to the practical methods useable by utilities.

2.4 Valuation of Water

Allocation of water among the myriad conflicting uses presents a major task to governments, all of which take responsibility in some degree for regulating access to water. It is difficult to assign unambiguous economic values to many uses, and hence these may be implicitly overvalued, undervalued or completely ignored in the decision-making process. Rogers (1986) gives many examples of the problems that arise from undervaluing water. Many of the problems of valuing water stem from the market failures mentioned above. In particular, the existence of externalities and the lack of mobility of resources make finding the market price quite difficult. In a perfectly functioning economy envisaged by the classical economic model "price equals value," and the cost of providing a good, after allowing for payments to all of its factors of production, will precisely equal its market price. As a result of this elegant solution one only has to establish "cost" to establish "value."

Unfortunately, many water resources planners forget that simply equating cost with value only holds true in a perfectly functioning market economy. In all other cases (that is almost all cases) care must be taken not to confuse cost with value. What then is the "value" of water? The answer appears to depend upon "to whom" and for "which use." Drinking water is obviously valuable and becomes increasingly so as the amount available decreases. A glass of water could be infinitely valuable to a person dying of thirst in the desert but not very valuable to a woman living alone on the banks of a pristine river. In the second case the woman would only be willing to pay the cost of somebody going to the river and fetching the water for her. She would be unwilling to pay more because she could go and take it herself. So the value in this case is the cost of obtaining the water. Now, if there was a farmer irrigating land alongside the river, how much would the water be worth to him? If there is enough water in the river so that the woman can have as much as she can drink just at the cost of obtaining the water from the river, then obviously the farmer can take as much as he wants at the cost of obtaining the water. Clearly, the farmer would also value the water at the cost of obtaining it. So far, so good; cost equals value.

However, such bucolic settings no longer exist in the modern world. Typically there are many users of the resource apart from the housewife and the farmer. At some point in time the use by one person will start to interfere with the use by another. At that point the water is said to have an "opportunity cost." Since the continued abstraction by one user reduces the amount available to another there is a loss of the opportunity to use the water by one user. This lost opportunity costs the affected user the amount he values these units of water. At this point the "value" of the water should reflect the willingness-to-pay of the user who is losing water. If for some institutional reason the housewife has to cut her consumption of drinking water, then the opportunity cost to society of this allocation of water away from her is her willingness-to-pay for water. If the allocation of the water shortage were the other way around, the relevant opportunity cost would be the farmer's willingness-to-pay for irrigation water.

If the question of how to allocate the water were left to an outside party, for instance, the World Bank, then that party might ask how society would best benefit from the allocation. One way of answering this question is to apply the logic of social choice theory embodied in modern economics, which allocates the water to the use with the highest value.

Establishing the willingness-to-pay for various consumers of water is a fairly well developed field in economics and can be easily adapted in many water conflict situations to establish estimates of the opportunity cost of water. Unfortunately, many economic studies of water use ignore the opportunity cost of water and only reflect the actual costs of obtaining the water itself. As mentioned above, if there were well-established markets for water then the market price would itself reflect the opportunity cost of water. However, in most countries such markets do not exist and one is left to estimate the opportunity cost in indirect ways.

The opportunity cost of water is only zero when there is no shortage of water. In evaluating water investments the value of water to a user is the cost of obtaining the water plus the opportunity cost. Ignoring the opportunity cost part of value will undervalue water, lead to failures to invest, and cause serious misallocations of the resource between users. The opportunity cost concept also applies to issues of water and environmental quality.

3. Planning for Water Resources

The management imperatives of water are embedded in its nature as a scarce resource that is often treated as a public good. External effects occasioned by water use also invoke important economic imperatives. Property rights and externalities raise political and financial imperatives which influence the choice of ways to price water to pay for the public supply of it. To appreciate fully water policy options and how they are evaluated, it is necessary to understand how economics is used and misused in the water area. Even though politics ultimately controls water resource planning, the discussion is usually framed in economic terms, and the ability to understand and manipulate the economic analysis may significantly improve the final outcome. Hence, a significant part of this Concept Paper explores the possibility of improving the economic aspects of planning. The attention devoted to economics should not be taken to mean that the institutional and technological dimensions are unimportant, but that in the judgment of the author the pay-offs from improving the economic dimensions are currently larger than those from other areas of concern.

3.1 Current Planning Approaches

Water resources planning has received a large amount of attention from economists and planning professionals for many decades. Based on the Flood Control Act of 1936, federal agencies in the United States, for example, were charged with devising economic criteria to ensure that only water projects for which the "benefits exceeded the costs" would be implemented by the federal government. This policy led to major research that culminated in the 1960s in fundamental works by Eckstein (1958) and Maass et al. (1962) at Harvard University, Hirshleifer, Milliman and DeHaven (1960) at the University of Chicago; and Kneese and Bower (1968) at Resources for the Future in Washington, D.C. The finishing touches with regard to dealing with environmental quality were in place by the end of the 1970s, with works by Dorfman and Dorfman (1972) and Baumol and Oates (1979). In addition to these books there are literally hundreds of other excellent texts explaining many of the practical aspects of the detailed analysis of benefits, costs, and technology choice for each possible use of water. While this was taking place in the water resources field, the Bank, UNDP, and many other funding agencies were developing reliable methods for economic appraisal of investment decisions in general. Outstanding examples of this literature are Little and Mirrlees (1974) and Squire and van der Tak (1975), sponsored by the World Bank, and Das Gupta, Marglin, and Sen (1972) and the Guide to Practical Project Appraisal (1978), sponsored by the United Nations Industrial Development Organization (UNIDO). These works are the basis for the current evaluation of investments in the water sector. B-C methods

The literature provides sound methods for planning water resources at a river basin level and at the level of individual projects. However, since most of the methodologies were developed in western industrialized nations, they pay little attention to planning for water resources in a macro or intersectoral way.

State-of-the-art economic project analyses are carried out routinely by the Bank staff. For example, benefit-cost analysis is carried out on irrigation assessments and the project is recommended only when a suitable internal rate of return (IRR), or another index such as a benefit-cost ratio is achieved. Recently the choices have also been conditioned upon not causing "too much" social or environmental harm. For projects such as urban water supply or sewerage, where benefit calculation is very difficult, the marginal costs of providing the services are computed and compared to other ways of providing the same services. For both of these types of project analysis, care is taken to correctly shadow-price the inputs and outputs. However, in order to decide whether to spend money on irrigation instead of on flood control, or on other investments outside the water sector, the rules for project analysis noted above need to be bolstered by additional assumptions and theory. In the theory, pricing of the resource is critical to the correct appraisal of the project and the correct implementation. Pricing has a threefold role in water policy. First, the price can be set to recover the cost of the investment from the beneficiaries. Second, increasing prices tends to ration water by cutting uneconomical consumption. Price increases cut the demand for water by moving up the demand curve, which is the effect most decision makers look for when pricing policy is advocated. The third aspect of pricing, and the one most frequently overlooked, is that of increasing the supply. When the price is higher, supplies of water from more expensive sources become available.

components of pricing

Price is also an integral part of the definition of "scarcity." The issues of pricing and cost recovery are a fundamental part of any approach to deal with the modern realities of water planning. The fact that pricing has not been rigorously applied in the past, and that the current prices of water are still generally quite low, is an indication that scarcity is a relatively new phenomenon. It also gives confidence that, at least for the next decade, moderate price increases will solve the water scarcity problem. Pricing and cost recovery are an integral part of the resolution to many of the water issues discussed below.

3.2 Where Does the Current Approach Break Down?

The Bank's Operations Evaluation Department has shown that current planning approaches worked fairly well when the competition for water was less acute. The same methods should also work under the new conditions. That they are not working is caused by a lack of attention to the correct implementation of the methods. For example, even if correct prices are computed in the appraisals, they are not used by the borrowing governments in implementing the projects once funded. This fact leads to overconsumption of water by some users and artificial shortages for others. There are two major areas where the current approach seems to be in trouble:

1) *Establishing and using the concept of opportunity cost of water in different sectors of water use.* Since the methods for evaluation are applied mainly to project-by-project appraisal, consideration of the intersectoral nature of water use is neglected. Therefore, perfectly well analyzed Bank irrigation projects in Algeria, for example, find themselves in direct conflict for the same water with other, equally well prepared Bank projects for urban water supply. In such cases the relative marginal benefits of additional investments in water must be carefully compared with those of other sectoral investments. Other resource sectors, such as energy, have well developed methodologies to relate sectoral and macro plans. Most of these were developed in response to the oil crisis of the early 1970s. It is now possible for energy planners to show the macroeconomic consequences of regulation of, and investments in, various energy sources, and, in the other direction, to estimate the consequences of shifts in macro policy on demands and supplies for energy by various sectors. This has not been done in the water sector.

The role of water investments as infrastructure services which serve as both intermediate goods and final goods is also often overlooked in water planning. So for instance, Ingram (1989) expresses concern that water infrastructure may suffer under-investment as a result of the Bank's structural adjustment programs for various countries.

A fundamental piece of information missing in most water plans is the opportunity cost of water. Adding the opportunity cost of water to its marginal cost of supply and comparing this with its current price indicates how efficient current water use is and how efficient it could be. In order to estimate these numbers it is necessary to have some form of intersectoral comparison of value or willingness-to-pay, hence the need for a strong policy directive in the Bank's Policy Paper to establish methods to evaluate water investments in an intersectoral context.

2) *Incorporating social and environmental concerns directly into planning.* Social and environmental impacts of Bank projects are increasingly a source of contention between the Bank and environmental interest groups in developed countries. It would be possible for the Bank to undertake economic analyses of the environmental impacts of water projects more diligently than has been done in the past. There is no doubt that this is a difficult task; nevertheless, there is now a large literature dealing with the economic impacts as lower bounds on the total impacts of a project.

> A society that allows waste dischargers to neglect off-site costs of waste disposal will not only devote too few resources to the treatment of wastes but will also produce too much waste in view of the damages it causes. (Kneese and Bower 1968).

As use increases, the public goods nature of water and the pervasiveness of externalities in water use lead inevitably to an increase of pollution. In the late 1960s and 1970s the public perception in the developed countries was that the environment was being "over-polluted." The externalities implied in water pollution were first extensively discussed by the Resources for the Future group in the early

1960s. The above-cited book by Kneese and Bower (1968) is still a leading text on the economics of water quality.

The concern of economists analyzing water pollution is with "market failure." In particular the issue of how to internalize the externalities has received most of the attention. At the most obvious level it would seem that if the effluent could be correctly priced, then industry and other polluters could be taxed by just this amount and problem would disappear – the correct amount of pollution would be obtained, and if this were considered too large then the effluent price could be raised until a satisfactory lower level of pollution was achieved.

Coase (1960) showed that externalities by themselves do not lead to economically inefficient solutions provided that the polluters and the people being affected can freely and inexpensively negotiate with each other. Coase claimed that the responsibility for damages is a reciprocal one, with the affected party taking steps to avoid them as much as the perpetrator takes steps to avoid producing them. Economic efficiency is achieved when external damages are borne by the party that can most cheaply repair them.

Hufschmidt and Dixon (1986) have extended environmental economics to the issues faced in developing countries, particularly with respect to water projects. Papers by Devousages and Smith (1983) and by Fisher and Raucher (1984) show how contingent valuation methods can be used to evaluate the benefits (and damages) associated with a wide range of environmental impacts that hitherto had been thought to be non-measurable. In the Policy Paper the Bank should pursue this line of thinking and lay out the appropriate methodologies for assessing the economic dimensions as well as the non-economic dimensions of environmental deterioration.

3.3 How the Problems Can Be Resolved

There are two possible, and not mutually exclusive, explanations of why problems arise in the way water resources are planned, appraised, and implemented.

1) The accepted economic principles are adequate but the application is inadequate.

The appraisal approaches used at the Bank and at other funding agencies are based upon the generally accepted principles outlined voluminously in the literature referred to above. The application of the principles is flawed because, when faced with economic scarcity, the water itself must be priced at its opportunity cost. This is typically not done and leads to serious misallocation of resources between different uses of water. For example, in the EMENA region the opportunity cost of water in the municipal sector is at least two to three times as high as the marginal value of irrigated agricultural production per cubic meter of water for all crops except some vegetables (tomatoes and cucumber). However, when the irrigation projects are evaluated by themselves, without consideration of the opportunity cost of water in other sectors, they appear to have acceptable Internal Rates of Return (IRR).

Similarly, the externalities due to environmental damages are not integrated into the appraisal of projects. The economic principles are clear, but little attention has been devoted in the past to evaluating the damages and therefore they tend to be overlooked in the analysis.

2) The theory needs refining.

No theory is perfect, and so it is with the theoretical approaches to water resources management. The relevant question is how the imperfections in the theoretical underpinnings lead to unacceptable outcomes from the point of view of the Bank, other funding agencies, and governments. There are several assumptions about the theory that cause difficulty in water planning, but there are also approaches to softening or eliminating these market failures from the conceptual model. Three areas stand out as causing more trouble than others and, hence, may need more refinement of the theory.

A. *The difficulties associated with making macroeconomic allocations between investments in water resources and other economic sectors*. The pervasiveness of water use throughout the economy may partially explain the first problem, but other sectors, including energy, radiate similar pervasive connections throughout the economy and society. Water planning has been an integral part of governmental planning for much longer than other resource sectors. Hence, large and powerful interest groups are fully cognizant of their stakes in planning. In most countries it is not of particular concern that the water planning and investments be balanced with other sectoral activities; indeed, the idea of such balancing is threatening to groups with a vested interest in water investments and management. The development of reliable planning methodology to relate water sector plans to the overall macro development of a country is a generic problem that should guide investments and other Bank water activities.

B. *Dealing with externalities directly in the analysis (internalizing the externalities)*. Dealing with externalities directly in the appraisal methodology is another important requirement. The theory and methods for doing this have been developed and many environmental consequences can be adequately treated within the existing benefit-cost methodology. These methods have only received sporadic application in actual project evaluation. Fisher and Raucher (1984) report on several such studies but additional work is needed to develop this methodology for the types of projects supported by the Bank.

C. *The political economy of tariff setting in the water sector*. The political economy of tariff setting is extremely important and has to a large extent been neglected by water experts. This is particularly true in the cases often encountered when there are economies of scale associated with the investments. The canon of price theory is marginal cost pricing. In other words, set the price at that point where the demand and the supply curves intersect. Unfortunately, establishing the marginal price for many water uses is difficult because of the characteristics of water that make its supply a natural monopoly. The existence of economies of scale ensures that those who first entered the market will always be able to underprice and drive out any potential newcomers. They can decide on their desired profit level and set the prices accordingly. This fact has been recognized for a long time in the area of municipal water and wastewater treatment and the suppliers have been regulated, typically by public utility commissions. Meier (1983) showed that there are at least five different ways of measuring marginal cost under these conditions, each resulting in a different estimate of the marginal cost. In practice good estimates can be obtained for most water investment projects with either of the approaches currently used in Bank appraisals: long run marginal cost (LRMC), and average incremental costs (AIC).

Unfortunately most regulatory commissions have tended to take a "backwards" accounting stance and allow pricing based only upon average costs and the revenue needs to meet them:

> Traditional rate-setting methods, employed by state regulatory commissions as well as local government agencies, appear to have produced a situation of rapidly deteriorating water systems, both rural and urban, characterized by aging capital facilities and under-maintained water systems. (Mann, 1981)

This stance is not appropriate in situations where the utilities are facing increasing marginal costs (all the best projects have been built and now it becomes increasingly difficult to supply the same amounts of water at the historical costs). Under these conditions a "forward" looking accounting stance is appropriate. If this policy were pursued, the emphasis on revenue requirements of utilities would be replaced by establishing adequate future investment funds.

Economic theory provides "second best" pricing algorithms for such circumstances. However, according to Hanke and Davis (1973) even these lead to problems for utility managers. Therefore they suggested the need to develop "third best" pricing methods, which would be more responsive to the political dimensions of water resource pricing. In a study of water conservation in Perth, Australia, Hanke (1982) outlines how to estimate economically efficient choices considering the resource cost to the utility, the resource cost to the consumers, and the useful consumption foregone as a result of a particular conservation policy. Interestingly, when he compared two pricing policies (marginal cost pricing, and seasonal marginal cost pricing) with three non-price policies (leakage control, metering, and mandated water restrictions) he found that the most economically efficient was leakage control, followed by metering and annual marginal cost pricing. All of the other policies had negative benefits. This is an eloquent reminder that rationing by pricing is not always the most efficient approach. In order to find out, however, it is imperative to carry out analysis at the level of economic sophistication applied by Hanke.

3.4 Distinguishing between Generic and Region-Specific Issues

The Bank has operations in 152 countries, aggregating them into four major regions. To formulate Bank policy with respect to water it is essential to distinguish between issues that are generic to the management of water as a resource, and others that are specific to individual regions. For example, the difficulty of making "correct" allocation decisions between different uses or users is generic to water around the globe, but the relative importance of irrigation varies by climatic zone and water availability. The generic issues are the ones for which the Bank needs to evolve institution-wide policy; the remaining issues can be left to the regional departments.

Fourteen generic issues are briefly described and discussed below; nine as broad sector-wide issues (section 4.1), and five as sub-sector issues.

4. Generic Issues of Concern for the World Bank

In the water planning community there are several connections of "water and . . ." which are taken by many as paramount relationships that brook no questioning. As argued below, the Bank's Comprehensive Water Resources Management Policy Paper should take a close look at such sanctified linkages as water and health, water and food, water and equity, water scarcity, irrigation efficiency, and so forth, leaving no assumption unexamined.

4.1 Broad Sectorwide Issues

4.1.1 International Conflicts over Water

Worldwide there are hundreds of rivers shared by different nations (54 just between India and Bangladesh). In many cases serious bilateral or multilateral conflicts over water have arisen. The current dispute between Turkey, Syria, and Iraq over the Euphrates is a good example of such situations. International law on transnational rivers is weak; it is essentially left up to the goodwill of the upstream riparian to settle problems amicably. Several decades ago, the World Bank was a major player in one of the most successful conflict resolutions; the Indus Basin settlement between India and Pakistan.

The Bank should maintain its rule of not making loans for a project that is not acceptable to a country's neighbors, but it should also consider establishing a negotiating unit to help countries deal with these issues. In many cases the provision of a neutral corner and unbiased international expertise could make it politically easier for countries to explore their water conflicts with neighbors in a non-threatening situation, relatively free of inhibiting political limelight and implicit threats to national sovereignty. Although regrettably not fruitful to date, the Bank's work over many years on hydro-electricity conflicts between Nepal and India is an example of such an approach, and a credit to the Bank. Easing some of these disputes would open up many new investment possibilities for constructive multi-purpose use of internationally shared river basins.

4.1.2 Linking the Water Sector to the National Economy

It is a paradox that although water resources have probably received more analytic attention than any other kind of public investment, there has been little attention paid to relating the water sector to intersectoral or macro allocation decisions. This lack of analysis should be of great concern in countries such as Brazil where 30% of public investment is in the water sector.

Other resource sectors such as energy have well developed methodologies to relate sectoral and macro plans. The development of reliable planning methodology to relate water sector plans to the overall macro development of a country is a generic problem that is of major significance to guiding investments and other Bank water activities. In a paper with Hurst (Hurst and Rogers, 1985) the author found in the literature only a few attempts to do this. Hurst and Rogers built an economy-wide model for Bangladesh which incorporated a detailed water sector and its macro economic linkages. When the model was run, the optimal solution was radically different from the optimal solution predicted when the components were run separately. In the overall model there was a strong bias against producing an export crop because:

> The reason for this is that the growth of the non-agricultural sectors depend upon the import of raw materials and intermediate goods. If the food requirements of the rapidly growing population must be met with food-grain imports (for a given level of imports) less raw materials and intermediate materials can be imported. Consequently, non-agricultural sectors must grow at a slower rate, and in order to meet a reasonable level of national growth, the agricultural sector must grow rapidly.

While this particular model was never used in making a plan, it does indicate that quite different policy implications arise when the macro linkages are explicitly considered. Additional research in this area would help improve the quality of water investments in all sectors.

4.1.3 Water Sector Planning Methodology and Data Requirements

At the next level down, within the water sector there are a plethora of water planning tools. One of these has come to be called "multi-objective planning." Although conceptually satisfying, planning theoreticians have made the approach unnecessarily complicated with its own nomenclature and dedicated computer software. In reality multi-objective planning is based upon the concept of constrained optimization. One merely optimizes one objective, for example, national economic growth, while setting other objectives, such as environmental quality, as constraints upon the system. The Bank itself has already been a major contributor to the development of "multi-objective planning" through its modelling work in Mexico and Pakistan. The issues of equity, food self-sufficiency, and health discussed below are typical of the issues whose opportunity costs can be established by such methods. There is no doubt that this approach should be taken in any planning study. Whether specialized software or more general purpose models such as linear and non-linear programming or simulation models are used, the different versions of this tool yield essentially the same results, and like all analytic approaches should be employed with a great deal of caution.

The literature on water resources is also heavily influenced by the ideas of comprehensive multi-purpose river basin planning. This has historically been the approach taken in Western Europe and the United States. Although intellectually satisfying, it is not clear whether it is the best approach to practical problems. It is helpful for the physical aspects of rainfall and run-off but much less helpful from the point of view of political jurisdictions and economic markets. In the United States it has since been abandoned by all major agencies involved in national water planning. Today agencies allow the specific problem to dictate the unit of analysis. With increasing concern for broader problems such as environmental quality, the idea of analyzing "problem-sheds" rather than river basins is gaining ground. A recent book by Major and Schwarz shows how river basins can be building blocks in larger problem-sheds. The Bank will have to examine closely the types of issues faced by its clients before recommending a particular planning approach.

At the practical level, however, little planning of any kind seems to have been applied consistently across water uses in the economy. For example, in many places the uses of water are still examined separately on a project by project basis. Thus, in Algeria it is possible to find examples of carefully planned irrigation projects alongside carefully planned urban water supply projects, with no way of reconciling the conflicting demands that both have for the same water supply. In Brazil there was surprise when the introduction of a tariff on wastewater discharges led to large decreases in revenue to the water supply utility, almost leading to its bankruptcy. In these cases the unit of analysis was not large enough to capture the external effects of policies dealing with individual components.

There is a need to ensure that appropriate models of the water sector be included in any project appraisal. The unit of analysis must be large enough to ensure that most of the relevant externalities are captured in the analysis. In irrigation projects, ground and surface water as well as drainage must be analyzed as one unit. Urban water supply cannot be divorced from wastewater disposal and its downstream impacts. Water diversions from rivers must consider alternative in-stream uses of the same water for navigation, fisheries, downstream users, and the maintenance of stream ecosystems. Well established methods using mathematical programming and simulation models should be required as a prerequisite for project appraisal in such cases.

In any policy study the quality of the data used determines to a large extent what conclusions can be reliably reached. However, there is a mind-set, that always looks for more and more data and more and more complete coverage of a region or basin. Geographical information systems (GIS) are currently very popular. Some of the practical problems encountered in the use of such systems should be examined. For instance, many of the current systems have been devised with little or no idea about how the information is to be used. This results in over-collection of some types of data and under-collection of others. The experiences of GIS users to date have not been uniformly happy. Most systems concentrate solely upon physical and scientific data, and there is little or no coverage of important economic facts. Although many of the economic data do not need to be collected according to detailed geographic distributions, the economic realities may be as important as the physical data that do, and may be critical to understanding the meaning of the physical givens. More attention should also be paid to the statistical variability of the data. Currently available methods to establish statistical reliability should be insisted upon in all data analyses and be carried over into the analyses of particular investment decisions.

One issue that ties the methodology and the data together is the issue of "uncertainty." Not only is it important to develop and use reliable data but it is also imperative that the planning methods used elucidate the uncertainty regarding the planning decisions. All too often in the water resources area the bulk of the analysis is aimed at the consequences of hydrological uncertainty when, as demonstrated by James, Bower, and Matalas (1969), the largest part of the uncertainty in the implied decisions stems from the economic parameters which typically receive little stochastic evaluation.

In its Policy Paper the Bank should make a serious effort to show what are realistic expectations about the data that may reasonably be gathered, and the levels of reliability that can be achieved by the use of these data.

4.1.4 The Political Economy of Pricing

Apart from certain aspects of religious and health significance, most people in every day use do not regard water as an end in itself. It is a commodity like "ships and shoes and sealing wax," consumed directly or used as an input to other processes. Empirical observation shows that in Boston as well as in Beijing, if the price of water is increased, consumers will use less of it. In other words, there is a "willingness-to-pay" for water that is not an abstract economic concept depending on elaborate theories of private property, but rather is a reliable behavioral trait of consumers of the products. The same behavior can be expected in Kansas and Kathmandu -- and is a good basis for assessing the economic demand for water. (Water has a downward sloping demand curve.) We can expect human actions to meet demand to be similar in widely different locations. The most accessible water for human use is the cheapest to develop, the next most accessible costs a little more, the next yet a little bit more, and so forth. Very soon one observes an upwardly sloping "marginal cost" curve that depends upon nature, not upon theory. Based upon these two observed phenomena of willingness-to-pay and increasing marginal cost curves, a good set of practical rules can be derived for helping to decide upon how much to invest in developing a particular water supply.

Although most people perceive water in this way at an individual level, the same individuals treat water differently when they gather collectively to make decisions about future uses of water. This contradiction may be due to the common social misperception of water as a "pure public good" which belongs to "everyone" at the same time, with a right of access for all. As a result it is

> customary to treat water as a free good when it is in fact anything but free. People come to expect that it is their right to take (and to waste) as much water as they want. (Baumol and Oates, 1979).

There is clearly a paradox here, since it is obvious that for many uses (for example, irrigation and municipal supply) water has all the properties of an exclusive economic good--just the opposite of a "public good." Adam Smith was one of the first to define a "pure public good": once the good is provided, it is not possible to exclude anyone who wants to take advantage of a public good from using it, and the consumption of the public good by any one consumer does not impede the consumption by any other potential consumer. At the other extreme, a "pure private good", such as food purchased from a market, can be and usually is the exclusive property of the owning individual; his or her consumption of the food absolutely prevents anyone else from consuming it. Water, like many other goods, falls somewhere between these two extremes. It has "pure public good" aspects when it is left in a scenic river, but even then too many people using the scenic river will destroy some of its value for other participants. It has "exclusive economic good" features when it is evaporated by farmers irrigating their crops for profit in a market setting.

It is the in-between cases which tend to predominate in the academic works on water and which confuse the issue. The question as to who has access to water becomes very important in determining how water is defined, and this definition in turn hinges upon the different doctrines governing water rights. In order to use water more efficiently it may be necessary to codify the water rights. Markets are based upon a system of property rights to scarce goods and the right to exclude other users of the resource. A private water market can only exist if property rights are secure and can be transferred. However, water law and water rights differ radically from country to country, and sometimes even within countries and between different water uses. It is hard to draw from the gamut of individual cases to provide a general theory, other than to say that, for many modern market-incentive systems to work, there is the need for a much clearer demarcation of property rights to water use than often exists. At any level, the definition of property rights to water is very difficult in the face of water's sacral quality in many societies, its essentiality to life, and its pervasive externalities. As a result, a large body of law has grown up around water in almost every country.

Water pricing, therefore, is not a task to be left solely to economists. The political, legal, and social dimensions are extremely important and emphasize the need for a "political economy" of water pricing.

1. Pricing

Three important concepts tend to get confused in the discussion of water pricing. These are, 1) the opportunity cost of water discussed at length above, 2) marginal cost pricing, and 3) cost recovery. Marginal cost pricing is the pricing of water at the cost of supplying an additional unit of water. In a perfectly functioning market economy the most efficient solution occurs when commodities are priced at their marginal cost. The market is said to clear when the marginal cost is equal to the marginal benefit. The marginal cost must include the opportunity cost of the water. Cost recovery refers to pricing of water to recover the costs of providing it. Typically, cost recovery is based upon accounting procedures that are based upon historical costs. Cost recovery pricing can be close to marginal cost pricing when the costs of new projects are similar to the costs of past projects. Unfortunately, in water resources development historical costs are typically much lower than current or projected costs of projects.

Many water planners confuse cost recovery with marginal cost pricing, the economist's "golden rule." Most water utility officials consider marginal cost pricing as leading to unrealistically high tariffs. Unfortunately, economists often try to mandate strict marginal cost pricing, ignoring practical problems faced by utility managers. In fact, there are many different tariff structures that would allow full cost recovery without marginal cost pricing. Brown and Sibley (1986) showed for the telecommunications industry that the Ramsey prices necessary to cover costs and profit were only in the range of 3% more efficient than tariffs based upon traditional cost recovery methods. (Remember that telecommunications industry, however, has declining costs not increasing costs like the water industry.) While tariffs have financial, economic, and political dimensions, it should be remembered that marginal cost pricing relies only on the economic dimension.

The best approach probably lies somewhere between the two extremes. The tension between regulation and efficient pricing will always remain a source of contention between the planners and the political process, however, as Brown and Sibley (1986) stated:

> When regulation violates efficiency criteria seriously enough, not only economists become concerned. Peak load pricing in electricity. for example, was taken seriously in the U.S. when it became clear that excessive use of electricity was contributing to an energy crisis that alarmed many people. Hence, normative economics plays an important, though not preeminent, role in the regulatory process.

Pricing is the major tool by which economists attempt to bring about efficient resource use. Pricing is more than cost recovery; it also aims at leading society to correct allocation decisions. Unfortunately, when many of the prices in an economy are artificially set, it is hard to induce rational resource allocation by "correctly" pricing just a few of the resources. This is a major problem in all countries and regions. For example, it is estimated that in the EMENA region alone the subsidy to agriculture due to incorrect water pricing is of the order of $40 billion per year.

The Bank must develop strategies that will enable countries to bring their resource pricing progressively closer to market pricing, economywide, than is currently the case. The Bank's Policy Paper will have to lay out the issues and consequences of price policy so that price policy will become an integral part of the Bank's own operations as well as of those of the borrowing countries.

2. Cost Recovery

In the Indian state of Bihar, the charges for Irrigation Department water from river diversions and dams are so low and the attempts to collect the fees so feeble, that in 1979 the cost incurred in collecting the fees for water was 117 percent of the actual amount collected. Owing to its serious financial difficulties, the Irrigation Department has had to defer maintenance, and the water system has deteriorated. Farmers have less incentive to pay for poor service, and a vicious cycle has developed. Moreover, the low water charges have led farmers to use water inefficiently. By contrast, in both the Punjab region in India and in areas of the United States that rely on water from private wells, farmers are far more conservative in how much water they use since they pay higher prices. (Well water costs more because it is not subsidized.) Yet these farmers' crops are not doomed to economic failure: when the cost of pumping in the Punjab increased in the 1960s, farmers began growing more water-efficient crops such as high-yielding wheat, and cash crops such as cotton, tobacco, and oilseeds.

Outside observers are surprised by the disparities among cost recovery rules for Bank loans in different sectors. In the electric energy and telecommunications sectors the Bank insists on full cost recovery for the capital as well as O&M expenses. The goal is to create viable public utilities, able to set tariffs that will efficiently finance the future development of the sector. In contrast, water sector projects typically require only repayment of the O&M and of some "reasonable" part of the capital costs. Many would argue that this policy leads to sloppy performance on the part of both the suppliers and consumers of water. Since we do know that water use is directly related to the prices charged; the higher the prices, the lower the usage.

The Bank should carefully study the implications of moving toward full cost recovery for water sector investments, and alternative methods of doing so.

4.1.5 Environmental Impacts of Water Development

There are increasing pressures on international institutions to take the lead in responding to concerns about environmental deterioration. The Bank should take the initiative in dealing with these problems, instead of its being seen as merely reacting to specific challenges as they arise. As the industrialized nations have discovered, assuring water quality entails more than the regulation of industrial and municipal wastewater discharges. Nonpoint sources such as agricultural runoff, are now recognized as major contributors to environmental problems that cannot be ignored. More importantly, at the level of questions of sustainability of ecosystems as a whole, water use and water contamination play major roles. They cannot be easily separated into water quality and water quantity issues; both are critical.

From the environmental point of view much of the concern with water projects stems from the casual way in which environmental consequences are handled as a last minute consideration, rather than being integrated into project design from the beginning. Big offenders include irrigation projects in which drainage issues are neglected in the initial planning, navigation projects in which the disposal of dredged materials is haphazard, and flood control projects which ignore flood-plain fisheries. In all of these cases adequate pre-planning guidelines could substantially reduce the environmental impacts. There are other projects, for example large dams, which have major environmental impacts that cannot be mitigated, such as loss of habitat, loss of fertile bottom lands, destruction of forests, and sediment trapping, in addition to the social impacts of moving large numbers of people from their homes and farms. These consequences can only be addressed on a political level by providing the right kinds of institutions that will allow for dialogue, negotiation, and compensation to the affected groups. However, guidelines that force a thorough search for alternatives could, in the case of large dams, suggest attractive alternate solutions such as modifications of the scale of the project or other storage options such as underground storage or a larger number of small storages closer to the users. The World Bank Operational Memorandum 4.00, Annexes A and B, could provide a good starting point for the development of appropriate guidelines.

4.1.6 Social Impacts of Water Development

In a perfect world, water development projects would have only positive impacts on societies. However, because of the externalities inherent in many water investment projects, there are almost always some winners and some losers. Local people lose their lands so that urban populations can have electric power and lowland farmers can have irrigation. Upstream users pollute rivers with wastes or choke them with sediment, causing severe damages to downstream users. Attention must be paid in planning projects to minimize disruption outside of the project area and to provide compensation to the affected parties.

As in the case of environmental consequences, many negative social impacts could be avoided by careful preplanning. Some of the most egregious social impacts follow from involuntary movement of populations out of areas that are flooded by dams and embankments. The move itself may be unavoidable, but social disintegration and destitution are not, and the needs of the affected populations should be integrated early into the planning process, with adequate resources and communication channels provided to meet those needs. Other cases, such as equity in water access in irrigation projects, are less obvious and are therefore often ignored by project developers and funding agencies. Particular impacts on women and children are also often overlooked until it is too late to mitigate their damage. Human health issues are often neglected in evaluating water sector investments. For example, the introduction of schistosomiasis into a region by irrigation projects is a serious matter and can be avoided or controlled to a significant extent by changes in system design and operation. Access to water for bathing, for religious purposes, for watering animals, and for recreation are all important social uses of water often inadvertently left out of project plans.

There is also the option of actively using water investments to achieve poverty reduction or other equity goals. The irrigation literature is replete with discussions of how to define equity, how to measure it and its effects on productivity and other values, and how to plan for it. Some options are more equitable than others and should be pursued in the design and implementation of water resources works. Nevertheless, if one were looking for investments in the economy to achieve equitable distributions of benefits, water projects are not the most likely candidates. Even within irrigation projects themselves it is important, for example, that the economic costs of skewing water allocations in favor of equity that are imposed upon society be defined in terms of the number of farmers, rather than farm sizes, and that they be carefully estimated and politically assessed as to whether they exceed the accrued social benefits. In some situations farms are too small to be economically efficient and the water might be better used on slightly larger farms.

Equity is an emotionally charged issue which the Bank can help borrowing governments weigh properly by providing a dispassionate discussion of it in its Policy Paper. There is a large role for the Bank in helping countries deal with these types of impacts in a straightforward way by giving them due weight in their own indigenous planning methods and organizations. Some of these resources are already covered by the Bank's own environmental assessment guidelines. They should be made explicit in the Policy Paper.

4.1.7 Conservation and Recycling of Water

One of the most obvious ways of extending the water resources base is by conserving water or by recycling it after use. Unfortunately, by themselves these measures are not the panaceas that they are often thought to be. In most cases people and industries "waste" water only because it is the cheapest thing to do. Unless water prices are raised significantly there is no incentive to do otherwise. The experience in the industrialized countries is that people can be motivated to conserve water on the basis of altruism only in times of shortage. Typically, after the stress is removed consumption rises to the previous levels.

There is much discussion of the recycling of sewage for use in agriculture. Many cities have been doing this more or less successfully for some time. The practice is widespread in Asia, with, however, some problems in protecting the public from pathogens. With care such use can be made of sewage, and should be made wherever appropriate. However, much of the discussion implies that large amounts of irrigation can be accomplished with such recycled water. One needs to be reminded of the tremendous asymmetry in volume between agricultural and domestic water uses: one large irrigated farm in the U.S.

consumes as much water as a town of 15,000 people produces wastewater. It takes the wastewater of 50 people to irrigate the land required for growing the food for one person. Although water recycling for industrial and domestic uses appears attractive and a worthwhile investment for vegetable gardening, it is not likely to make a major contribution to irrigating field crops.

Direct recycling of municipal wastewater has also been practiced without the use of irrigation as an intermediary. For example, Windhoek, Namibia, has been successfully recycling large quantities of municipal water for more that 20 years without apparent problems. In some parts of the world such recycling is practiced in an unobtrusive way. For example, in Holland polluted water from the Rhine is filtered through the river banks before being abstracted for urban water supplies.

A lot has also been written about conserving water by improving the efficiency of use in irrigation and reducing the losses in urban water systems. As discussed below, increasing water use efficiencies in agriculture is a difficult concept and the practice may not really provide great savings of water in many cases, particularly where conjunctive use of groundwater is practiced. Nor is it necessarily wise to reduce losses in urban water systems, since the cost of reducing the losses may exceed the benefits as perceived by the water utility. This is clearly an area where the appropriate pricing and valuation of the water itself is the major issue. Conservation for its own sake is not a realistic or advisable goal; it only makes sense within a correct pricing policy for water. The Bank's Policy Paper should clarify the potential role of conservation and recycling.

4.1.8 Host Country Institutional Reform

In most countries there is a great need to upgrade the institutions dealing with the various aspects of water. Most importantly, in every country there should be one institution with the responsibility to coordinate water policy across uses and across government agencies. Even advanced industrial countries such as the United States, suffer from lack of coherence in water policy across uses. There is often a tremendous inertial asymmetry between the staffing of agencies with traditional concerns and those with more modern ones. For instance, in Thailand the Irrigation Department is the single largest government agency. In India, the use of surface water is administered by the Central Water Commission, whereas the Central Groundwater Board oversees groundwater use. There is little practical integration of these agencies' plans, despite a formal agreement to cooperate. Each of India's 22 states also has its own department of irrigation, which usually deals only with surface-water supplies, while other departments focus on groundwater. In cities around the world, municipal water is a local responsibility, but many individuals also sell water in small quantities to households. Rural households are almost always in charge of obtaining their own supplies. The result of such compartmentalization is that agriculture, industry, and municipalities use water inefficiently.

While institutions are likely to be highly regional and culturally specific, the need to strengthen them is one of the major generic problems facing development activities around the world. The need is not for large new institutions but, rather, for small policy councils composed of cabinet rank officials who will be able to coordinate the work of the existing water institutions. The Bank's Policy Paper should emphasize structure, organization, management, and the role of adequate cost recovery, to enable individual countries' institutions to carry out necessary maintenance tasks and build for future demands.

4.1.9 Role of the Bank in Education, Training, and Information Exchange

As the world's leading institution for supporting investments in the water sector the Bank is ideally positioned to use its prestige and influence to further education, training, and information exchange. Through its Economic Development Institute (EDI) the Bank is already heavily engaged in the formal training of Third World government servants. This role could be further enlarged by requiring more on-the-job training for host government employees. As mentioned above, the appraisal process itself could be used as a useful teaching mechanism. In particular, the environmental and social impact assessment requirements stressed above can be used as a public education tool. If government agencies actually develop and use environmental and social impact assessments, they will discover, as will the impacted groups if they are integrated into the process, how water investments really function in their own societies. This has been one of the most important outcomes in those developed countries which have implemented such an approach. Their citizens are now much more aware of the environmental and social consequences of government action and have begun to make their views felt through political action. Green parties are springing up throughout the industrialized countries. Since funds are limited, the Bank might consider a role for itself in educating other public and private financing agencies in this field.

4.2 Subsector Issues

4.2.1 Irrigation

"Water and food" carries many assumptions about development policy which need to be carefully and separately examined. Food security is a major concern of every government throughout the world but how to achieve a satisfactory level of security is not obvious. National self-sufficiency in food grains is not the imperative that it is often assumed to be. In the modern world oil is essential for survival, but nowhere do we find the belief that every country should be self-sufficient in oil. There is no reason why every country should grow grain, which requires 2,000 to 3,000 tons of water per ton. In an arid country water can have much higher value for other uses. International trade can redistribute water – in the form of grain – to nations that decide not to grow it. Israel subscribes to this practice, emphasizing valuable cash crops such as fruits, vegetables, and flowers for the European market. Countries that take this approach could maintain stockpiles of the basic grains; even though stockpiles are costly and can deteriorate, replacing spoilage is less expensive than growing grain. Such countries could grow a diversity of cash crops so that fluctuating international prices could not devastate their economies.

Even the definition of self-sufficiency is not clear. Does it mean that a country should be self-sufficient on the average, or for drought years, or only 75% of the time? The choice of the definition has a large impact on planning for water use in agriculture. It is imperative that the Bank address this issue head-on in its Policy Paper.

Increasing "water use efficiencies" in agriculture is a widely suggested solution to water shortages. However, in many parts of the world one farmer's inefficient use provides the water for another farmer downstream or recharges the groundwater for many other farmers. It has been argued that the irrigation efficiency in California's San Joaquin Basin approaches 100% despite the fact that on any one farm the efficiency may only be 60-70%. Individual cases must be closely considered before much can be made of the advisability of improving "irrigation efficiency." Many commentators looking only at farm level efficiencies have advocated improvement of efficiency of water application as the best way to conserve water. Although this may be true in some cases, it is not universally true and should be subjected to careful analysis.

It is more appropriate to start from the larger perspective of the overall regional efficiency of the use of water for irrigation. But even this is a difficult concept, and agricultural and irrigation professionals will be on still stronger ground if they orient themselves to the further-reaching concept of the "economic efficiency" of all water use rather than of "irrigation efficiency." "Irrigation efficiency" is a seductive notion because it simplifies the problem to water alone by focusing it on engineering and management variables. But it can become a form of tunnel vision; it can throw the larger benefit-cost picture seriously out of balance, and lead to misplaced investment on a significant scale.

In its Policy Paper the Bank will have to devote a major effort to analyzing irrigation since this is one of its major lending activities. However, there are many other issues involving choice of technology and cropping policies that have not been featured here, which are also of major concern in this part of the water sector. Many of the sector-wide issues apply in the irrigation area. For example, a recent paper by Johnson (1990) indicates that the problems with irrigation in South and Southeast Asia are becoming particularly acute because of the funding of the operations and maintenance (O&M) of the systems. As indicated above, pricing and cost-recovery are fundamental to achieving proper operation and maintenance of systems.

4.2.2 Water and Health

A relationship between water and health has been accepted since at least the time of Frontinus, the Water Commissioner of Rome in 97 A.D., but the exact relationship is not well understood even now. A World Bank position paper on domestic water supply (World Bank, 1976) cautiously limited itself to saying that "other things being equal, a safe and adequate water supply is generally associated with a healthier population." Many of the benefits observed during the "sanitary revolution" in the industrialized world were achieved when protected water supplies were provided to societies with rising income levels, which induced other positive behaviors with respect to personal hygiene and nutrition. At low levels of development, investments in improved domestic water supplies are often necessary but generally not sufficient to realize the potential health benefits. For middle-level developing countries, where the population is generally better educated, the health benefits of investments in water supply and sanitation are generally substantial. At higher levels of development one typically observes small additional health benefits from further investments in such facilities.

But apart from drinking water and sanitation, serious human health problems can be introduced into an area through the development of water resources. The classic case is the spread of schistosomiasis in Africa and Asia after the introduction of irrigation. Debilitating rather than fatal in most cases, schistosomiasis now infects more than 200 million people. Malaria, filariasis, yellow fever, onchocerciasis (river blindness), dracunculiasis (Guinea worm disease), and sleeping sickness can be spread by irrigation projects. Many water-soluble chemicals used in agriculture, particularly chlorinated hydrocarbons, accumulate in animal and plant tissues and thus enter or become concentrated in the food chain. High concentrations of nitrogen fertilizer in water supplies cause blood diseases in infants. In many countries unregulated and indiscriminate production and disposal of chemicals and their wastes have led to serious contamination of surface and groundwaters by toxic and carcinogenic substances. Some of the worst cases are observed in developing countries which have few resources to deal with them. A careful review of all of these components of "water and health" is in order, not just of drinking water and sanitation.

4.2.3 *Urban Water Supply and Wastewater Disposal*

With continuing rapid population growth, the number of cities of over one million people is expected to increase rapidly. It is in these burgeoning metropolises of the Third World that the most pressing needs for water supply and wastewater disposal investments will be felt. In all cities the costs of providing new water supplies and wastewater facilities are rapidly increasing. Careful assessment of new approaches to the whole problem are needed. For example, Akhter Hameed Khan, the former head of the Comilla Academy for Rural Development, has successfully applied the approaches of rural organization to the densely packed parts of the city of Karachi, mobilizing the local population to plan, construct, and finance a sewer and drainage system at a fraction of the cost of similar systems provided by the city government.

We must look harder for innovative ways of dealing with urban water and sewer issues. Technical and managerial performance needs scrutiny to ensure that excessively costly systems are not built merely to copy the industrialized countries. This is particularly true now in Eastern Europe, where the tendency is to proceed immediately with the same approaches as those used in Western Europe. As is well known, the general rule is that removing the first 50% of pollution is quite cheap, with the incremental improvements being increasingly costly. This consideration often supports developing a system in stages, moving to the expensive higher levels of performance as general economic growth generates increased ability to pay for them.

The costs of alternative approaches to urban water supply and waste disposal should be carefully examined. Local agencies should be made aware of these costs and encouraged to set their tariffs to reflect real costs and projected trends of costs. The issue of cost recovery, discussed in more detail above, is critical here. The Bank should also initiate studies to elucidate the economic benefits of the provision of these urban services. Such studies should be based upon assessments of the willingness-to-pay for these services by different socioeconomic groups. Such studies are conceptually difficult as well as time-consuming, but they should be carried out in a sufficiently large number of cases that the basic magnitudes of the expected benefits can be demonstrated. This is particularly important in this sector since most of the literature focuses upon the cost of the services and on complaints that they are becoming too expensive. "Too expensive" compared to what? The only meaningful comparison is with the benefits received from consuming these goods and services.

For urban water and wastewater disposal, consideration of the role of industry in the management of the ambient quality of the water resources is vital. Industry uses only 5 to 10 percent of all water supplied but still represents an important segment of demand. This results in part from the fact that industrial processes pollute a disproportionate amount of water. For example, in Sao Paulo and Seoul, industrial pollution has turned many streams and rivers into open sewers. Developing countries should learn from the experience of industrialized nations: it is much more expensive to clean up polluted water than it is to avoid polluting in the first place. Economic incentives against industrial pollution, such as effluent fees, should be established so that companies will have an incentive to control their effluents at the source. In addition to the usual regulatory methods, innovative approaches such as tradeable permits and privatization of facilities should be explored. The failure of some of these approaches in the industrialized world does not mean that they may not be appropriate in Third World settings.

Regulating environmental quality by pricing the effluents that individuals, municipalities, and corporations emit is one of the standard recommendations of economic theory. The economic literature is full of conceptual schemes for pricing and taxing effluents that would lead to internalizing the externalities of pollution. Once this is done, environmental quality can be left entirely to the usual market forces. The Washington-based research institute, Resources for the Future, has led the campaign for fees on effluent discharge into waterways for over 20 years with little success; it has mainly been opposed by those who think it improper to sell the right to pollute the environment.

Nevertheless a substantial amount of effluent pricing has been used in the U.S. and in Europe. Hudson (1981) reports on the extent and mode of implementation of water pollution pricing through sewer charges. He claims that by 1970 more than 90% of the municipalities with populations over 50,000 levied some form of sewer charge on residences and industry and that 40% of local expenditure on sewage was derived from these charges. Industry can choose to pretreat its waste, decrease its water use, improve housekeeping, change either the production process or products, or it can choose to pay the effluent fee. The industrial charges are typically related to the quantity of water used and the "strength" of the effluent measured in terms of the oxygen-demanding organic waste load (BOD) and total suspended solids. These charges can give an incentive to industries to change the amounts and strength of their sewage effluents. Hudson's study of five large cities (Atlanta, Chicago, Dallas, Salem (Oregon),and South San Francisco) and 101 industries found that effluent charges were overwhelmingly preferred by the industrialists to discharge limitations. There was a universal attempt by the industries in the sample to respond to the effluent fees despite their relatively small costs to the industries. Hudson concluded that; "...we are confident that economic incentives work well and can be effectively administered." In its Policy Paper the Bank should stress the application of well established economic principles and innovative technical approaches in this area.

4.2.4 Rural Water Supply and Sanitation

This one problem area could easily consume the entire Bank lending portfolio and still not be completely resolved. 1990 is the end of the United Nations Water and Sanitation Decade, but in percentage terms the population covered remains similar to that at the beginning of the Decade. More effort is needed on the social and economic side of this issue, and Bank-sponsored research on assessing willingness-to-pay for rural water supply should be extended to sanitation. As in the issue discussed in section 4.2.3., too much of the discussion focuses upon the costs and too little on the benefits. In addition, there is a need for research on appropriate incentive schemes to encourage individual or private sector undertakings to provide goods and services in rural water supply and sanitation.

The Bank has played a major role in the Water and Sanitation Decade and it would be appropriate to include in its Policy Paper a critical review of the accomplishments and problems with respect to this entire set of activities.

4.2.5 Hydropower

Hydropower is a major area of Bank funding and one that until recently was considered well defined and not contentious. Recently, however, hydro projects have received a lot of criticism based upon their environmental impacts. The Bank's environmental guidelines have already begun to address these issues and should make sure that governments receiving the funds are equally as careful in the development of hydro projects. Some economic issues that need clarification in the hydro area relate to the intersectoral nature of electricity and the conflicts over the potential uses of the water between users. In addition, the pricing of the output from multipurpose water resources projects that include hydropower needs careful reappraisal. The temptation is to load a disproportionate amount of the cost recovery on the electricity consumers and not on the agricultural and other users of the joint output of the project.

The Bank's Policy Paper should help develop explicit guidelines for dealing with these issues, particularly the environmental and social impacts discussed above, in its own operations and to encourage the governments receiving funds to recognize them as potential problems.

REFERENCES

Baumol, W. J. and W. E. Oates. *Economics, Environmental Policy, and the Quality of Life*. Prentice-Hall, 1979.

Brown, S. J. and D. S. Sibley. *The Theory of Public Utility Pricing*. Cambridge University Press, 1986.

Dasgupta, P., S. A. Marglin, and A. Sen. *Guidelines for Project Evaluation*. United Nations Industrial Development Organization, 1972.

Desvouges, W. H. and V. Kerry Smith. *Benefit-Cost Assessment for Water Programs*, Volume I. Prepared for the U.S. Environmental Protection Agency, Research Triangle Institute, North Carolina, 1983.

Dorfman, R., and N. Dorfman. *Economics of the Environment*. W.W. Norton, 1972.

Coase, R. "The Problem of Social Cost." *The Journal of Law and Economics*, October, 1960.

Eckstein, O. *Water Resource Development and the Economics of Project Evaluation*. Harvard University, 1958.

Falkenburg, M., M. Garn, and R. Cestti. "Water Resources: A Call for New Ways of Thinking." World Bank, INUWS Working Paper, March, 1990.

Fisher, A. and R. Raucher. "Intrinsic Benefits of Improved Water Quality," in V. Kerry Smith, editor, *Advances in Applied Micro-Economics*, Volume 3. JAI Press Inc., 1984.

Hanke, S. H. "Economic Aspects of Urban Water Supply: Some Reflections on Water Conservation Possibilities." International Institute for Applied Systems Analysis, Laxenburg, Austria, December, 1982. Mimeo.

Hanke, S. H. and R. Davis. "Potential for Marginal Cost Pricing in Water Resources Management," *Water Resources Research* 9, 4, August 1973.

Hirschleifer, J., J. W. Milliman, and J. C. De Haven. *Water Supply: Economics and Policy*. University of Chicago Press, 1960.

Hudson, J. F. Pollution Pricing: *Industrial Responses to Wastewater Charges*. Lexington Books, 1981.

Hufschmidt, M. M. and J. A. Dixon. *Economic Evaluation Techniques for the Environment*. Johns Hopkins Press, 1986.

Hurst, C. and P. Rogers. "A Tale of Two Simulations: Integrating Water Sector Planning into Economy Wide Planning Models." Paper presented at the 12th International Symposium on Mathematical Programming, Massachusetts Institute of Technology, August 1985.

Ingram, G. K. "Note on the Macroeconomic Linkages of Infrastructure." World Bank, October, 1989. Mimeo.

James, I. C., B. T. Bower, and N. C. Matalas. "Relative Importance of Variables in Water Resources Planning." *Water Resources Research*. 5, 6, December 1969.

Johnson, S. H. "Progress and Problems of Irrigation Investment in South and Southeast Asia." *Water International* 15(1990):15-26.

Kneese, A. V. and B. T. Bower. *Managing Water Quality: Economics, Technology, Institutions*. Johns Hopkins Press, 1968.

Little, I. M. D. and J. A. Mirrlees. *Project Appraisal and Planning for Developing Countries*. Basic Books, 1974.

Maass, A. et al. *Design of Water Resource Systems*. Harvard University Press, 1962.

Major, D. C. and H. E. Schwarz. *Large-Scale Regional Water Resources Planning*. Kluwer Academic Publishers, 1990.

Mann, P. C. *Water Service: Regulation and Rate Reform*. National Regulatory Research Institute, Columbus, Ohio, 1981.

Meier, G. M., editor. *Pricing Policy for Development Management*. EDI Series in Economic Development, Johns Hopkins Press, 1983.

Postel, S. "Saving Water for Agriculture," in L. R. Brown et al. *State of the World: 1990*. W.W. Norton, 1990.

Rogers, P. "Water: Not As Cheap As You Think." *Technology Review* 89, 8, Nov/Dec 1986.

Squire, L. and H. G. van der Tak. *Economic Analysis of Projects*. Johns Hopkins Press, 1975.

United Nations Industrial Development Organization. *Guide to Practical Project Appraisal*. UNIDO, 1978.

World Bank. *Village Water Supply*. World Bank, 1976.

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