FUTURE DIRECTIONS FOR IMPLEMENTING WATER POLICY

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THE ASIA AND NEAR EAST BUREAU
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and

THE IRRIGATION SUPPORT PROJECT FOR ASIA AND THE NEAR EAST (ISPAN)

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May 27, 1994

Dr. Thomas Naff
Director, Associates for M.E. Research
847 Williams Hall
University of Pennsylvania
Philadelphia, PA 19104-6305

Dear Dr. Naff:

The enclosed notebook contains materials from the recent workshop on **"FUTURE DIRECTIONS FOR IMPLEMENTING WATER POLICY"**, sponsored by the Asia and Near East Bureau of the Agency for International Development (AID) and its Irrigation Support Project for Asia and the Near East (ISPAN). We regret that you were unable to attend the workshop, but wanted you to have the materials that were distributed to participants.

The workshop was designed to identify steps needed to promote improved water resource policies and to develop strategies to sustain water resources in Asia and the Near East now and in the future. A final report of the conference findings is being prepared and will be sent to you later this summer.

I hope you will find these materials informative and useful. Water quality and quantity issues remain critically important to policy makers, and to all humankind.

Sincerely,

[redacted]

Robert H. Thomas
Project Director
ISPAN

Enclosures

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Winter 1993, Issue 3

Water

A USAID Update on Water Resource Activities of Interest to Asia and the Near East

Mississippi Flood Experience Confirms Lessons Learned in Bangladesh

This past summer, record flooding inundated much of the upper Mississippi River Basin. Midwesterners suffered through the worst deluge in memory. In many areas, overflows were the highest on record. July rainfall in 10 basin cities ranged from 131 to 643 percent higher than the 30-year average, according to the U.S. Geological Survey. New record-high streamflows were set at 42 gauging stations on 33 streams in seven states.

Overpowering as the flood flow of the Mississippi was this summer, the combined flood flow of the Brahmaputra, Ganges, and Meghna rivers that meet in Bangladesh have an annual discharge five times the Mississippi's average.

Generally, each of these rivers peaks at different times in the monsoon season; however, in 1987 and 1988 local rainfall was higher than average and the peaks coincided, causing flood discharge through Bangladesh eight times that of the Mississippi's.

To see the Bangladesh floods in context, imagine nearly half the U.S. population squeezed into an area the size of Wisconsin with a river five times larger than the Mississippi flowing through it.

Despite the difference in scale, the 1987 and 1988 floods in Bangladesh resemble the 1993 flood in the United States. Ten-day and monthly mean rainfalls were reported to be between 100- and 150-year events, and damage to crops and property, which occurred on 39 percent of land area, affected 30 million people. In 1988, more than 60 percent of the area and 45 million people were affected by flooding.

In addition to floods, cyclones (hurricanes) periodically sweep up the Bay of Bengal, ravaging coastal areas. In 1970, over 500,000 people perished, and in 1991 about 139,000 were killed.

Against this background, the Government of Bangladesh, helped by the G-7 nations, is putting together a five-year (1990-95), $160 million Flood Action Plan (FAP) to guide investments in flood management. The FAP is composed of 26 studies, including strategic plans for regions and supporting studies that examine historic performance of existing flood control projects; environmental and social impact; land acquisition; new infrastructure; and nonstructural flood proofing measures. In addition, new floodplain mapping, upgraded flood modeling capability, and GIS are being implemented.

While many are already complete, the next two years will see the integration of all the studies into a strategic flood plan that many hope will be the realistic balance between full structural containment and environmental conservation.

It appears that one lesson to be drawn from the assessment of the 1993 Mississippi flood is that efforts to fully control the environment should be made very cautiously, or we must be prepared for massive costs in perpetuity to tame rivers and fight floods and potentially for irreversible damage to natural ecosystems. ■

Assessment of the Policy Reform Process: Case Studies of Tunisia and Sri Lanka

Recently, an ISPAN team reviewed two policy reform experiences in Tunisia and Sri Lanka to determine what guidance they might offer to USAID Missions and cooperating countries. This study attempted to isolate the key characteristics of successful policy formulation processes.

The National Strategy to Create and Monitor Water User Associations in Tunisia and the Irrigation Management Policy Support Activity (IMPSA) in Sri Lanka were designed as two-year activities involving expatriate and local experts.

They built on previous USAID-funded project experiences, were implemented with collaboration between USAID Missions and cooperating country governments, and produced a series of policy papers and implemented field studies.

The two policy processes demonstrate that, even within a given policy area such as water management, no generic approach to policy formulation can apply to all situations.

Key findings included:

Successful policy change tends to be evolutionary, not revolutionary.

(continued on page 2)

In this issue ...

Prepared for the Asia Bureau and Near East Bureau by the Irrigation Support Project for Asia and the Near East

(continued from page 1)

Attempts to bring about too much change over too short a time period usually fail to meet key objectives. Ideally, a policy change should build on an existing policy framework. When the focus is on one issue, the policy change process advances, even when complete success is not achieved.

Though this was generally the case in both Tunisia and Sri Lanka, the focus in Sri Lanka strayed from cost-effective and sustainable irrigation management to broader issues related to farmer participation and macro-policies affecting the irrigated agriculture sector.

When the process tries to do too much too fast, agreement can only be reached by diluting recommendations.

Successful policy change requires the support of a cadre of strongly committed senior government policymakers.

In Tunisia, the government had a clear directive to which they were committed, to create water user associations to operate and maintain rural potable water systems. In Sri Lanka, the Irrigation Management Division received a clear directive to create Farmer Organizations to help operate and maintain the major irrigation systems, but there was no commitment to this policy change outside of the organization.

When the necessary commitment is lacking, creating it must be part of the policy change activity's design.

The focus in Sri Lanka should have been on how to continue operation and maintenance of the country's major irrigation systems in the face of declining government budgets since this provided the initial impetus for the government's participatory management policy. Locating where budgets were constricted should have been a key part of the design and implementation of the IMPSA exercise.

Continuity of leadership is more important in bringing about policy reform than charismatic leadership.

A charismatic individual can generate strong interest and support for a policy change, sometimes providing the key to making it possible for policymakers to act. However, continuity of leadership is critical for effective policy change.

In Tunisia, while there was no charismatic leadership, strong and ongoing high-level support existed within the government and the regions. In Sri Lanka, a charismatic individual initially succeeded in generating widespread agreement and support for policy change, but, in the absence of continuity in leadership and support, the policy change has not occurred to date.

When attempting to change policy, minimizing the number of institutions affected by or implicated in the change is essential.

One important basis for the Tunisian activity's success was that only one institution was significantly affected by policy change. In Sri Lanka, on the other hand, at least five institutions, each with differing concerns and priorities, were involved. There is no question that greater success would have been achieved if the policy agenda in this case had been narrowed.

Principal Characteristics of Successful Policy Reform

From the policy approaches in Sri Lanka and Tunisia, the following process characteristics were isolated as good indicators of a high potential for success:

- **The process is supported by an appropriate macroeconomic and legal framework.**
- **Policy changes are based on replicable, field-tested models.**
- **Policy changes are seen as economically and socially desirable by all parties.**
- **The process is directed by a core group of well-trained, experienced, and motivated government officials.**
- **The process has a tightly focused policy agenda.**
- **The process is iterative, flexible, and consultative.**
- **The process tailors technical assistance and other inputs to address issues identified and agreed on by senior government officials.**
- **Process outputs are seen as having direct utility to senior government decision makers.**
- **The process tailors implementation activities to local funancial and personnel capacities.**
- **The process stresses and facilitates interministerial participation and collaboration at the national and regional levels.**
- **The process is actively supported by other major donors.**

Major policy change must be based on solid data and analysis rather than on policy change. The more complicated the policy change, the more important reliable data and high quality analysis become.

In Tunisia, since consultants based their recommendations on field trips that generated primary data, process implementors were able to document the basis for these recommendations and what would likely occur if they were not accepted.

In Sri Lanka, recommendations were often based on social science or organizational development principles and on whatever consensus could be reached in preparing policy papers. As a result, the documented case for IMPSA's recommendations was not strong enough to convince reluctant policy-level officials.

Successful policy change requires support and commitment at both the grassroots and senior policy levels.

When the government's participatory management policy was put into effect in Sri Lanka, there had not been enough consensus building. Consequently, the policy was not implemented effectively. The IMPSA exercise succeeded in building broad-based support for the policy change from the bottom up, but did not generate the requisite commitment at senior policy levels.

A specific policy change process should never be used as the occasion to address other peripheral or unrelated problems.

Both experiences clearly demonstrated that the policy change process must remain focused on its primary objective. In Tunisia, there were pressures to make water user associations responsible for a full range of community development needs. This would have weakened efforts to use them to provide cost-effective and sustainable management of rural water systems and fortunately was avoided.

In Sri Lanka, one reason the process became derailed was that management decided to add macro-irrigation policies to the policy agenda. This not only increased the complexity of the exercise, but also raised policy issues that could not be resolved. As a result of diverting attention away from the central issue of local irrigation management, the desired policy change failed to occur.

Although these lessons could relate to most change efforts, it is important to remember that project activities often take place within highly specific geographic, social, and sectoral contexts. Not all history is shared; not all experiences are equally valued. Thus, donors will need to approach each collaborative opportunity on policy reform as an individual case that calls for a unique design and implementation process. ■

Update

A SPECIAL REPORT

Winter 1993

ISPAN Brings GIS Technology to Bangladesh's Flood Action Plan

Bangladesh is a dynamic riverine delta, where islands can vanish in the night and river banks rearrange themselves with impunity. In such a setting, it is essential to have up-to-date geographic information.

In April 1991, USAID began funding a geographic information system (GIS) that would assist the Flood Action Plan (FAP) in its massive effort to mitigate flooding in Bangladesh. FAP environmental and water resources planning teams implemented GIS, a project run by ISPAN under the Eastern Waters Initiative, to use existing geographic information more effectively. GIS uses computer technology to record, manipulate, analyze, and display digital maps, satellite images, and other spatial information.

The Dhaka-based ISPAN project, known as FAP 19, has not only provided a GIS facility for the FAP but also has assisted the Bangladesh government's Flood Plan Coordination Organization (FPCO) in initiating a GIS network for the country. In doing so, it has provided on-the-job GIS training to the FPCO and other organizations connected with the FAP and has promoted access to water resources management and planning information.

The project's main image processing and GIS software packages, ERDAS and ARC/INFO, were purchased from U.S. commercial vendors, and Clark University's IDRISI program is also used. In addition to microcomputers and GIS peripherals, FAP 19 has made extensive use of hand-held global positioning system (GPS) receivers, which use U.S. Department of Defense satellite navigation technology for field mapping.

One of the most important aspects of the FAP 19 project is the selection and training of local personnel. Among the 13 professionals ISPAN now employs on the GIS project are specialists in engineering, geography, mathematics, and computer science. The resident team leader and several short-term consultants have provided staff training and technical expertise in global positioning systems, digital elevation modeling, hydrodynamic modeling, remote sensing, image processing, and spatial modeling.

The team leader and consultants have conducted initial training courses for FAP 19 staff and several specialized GIS and image processing workshops, attended by FAP 19 staff and scientists and engineers from the Bangladesh Space Research and Remote Sensing Organization (SPARRSO), FPCO, other FAP activities, CARE, and other Bangladesh development projects.

GIS PROJECTS

Below are descriptions of some of the GIS applications and pilot projects:

Dynamics of the Brahmaputra-Jamuna River

The Brahmaputra-Jamuna, a system of branching channels, sand bars, and vegetated islands which carries the country's highest discharges through its longest river reach, ranks as one of the world's largest rivers. Hundreds of thousands of people living along its erratically shifting banks are constantly threatened by erosion, and many more seek their livelihoods from the sandy, transitory river islands locally known as chars.

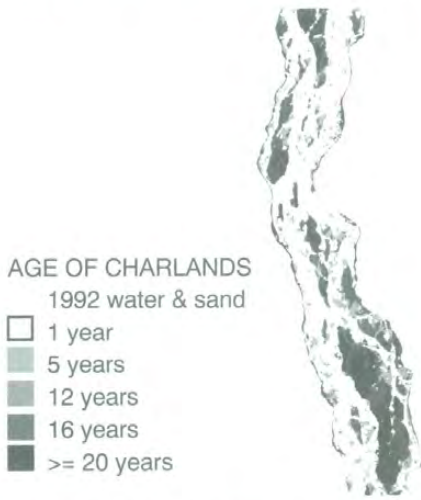


Figure 1: From an analysis of a time series of satellite images, those stable river islands (chars) most suitable for infrastructure development and government extension efforts can be identified.

This river morphology study was a collaborative effort with the Brahmaputra Right Embankment Strengthening Study (FAP 1), which used the results in planning embankment and river training works. Using GIS and image processing, an extensive series of current and historical satellite images and digital maps were analyzed, and detailed tables, graphs, and maps were produced that quantify and graphically portray bankline erosion and accretion, low-flow channel characteristics, and the evolution, movement, and lifetime of the numerous river chars. This information has been used to predict future bankline positions, assess and predict river bend behavior, describe relationships of bank erosion and island sediment storage, and identify stable chars that are more suitable for infrastructure development and government extension efforts.

Spatial Interface for Hydrologic/Hydraulic Models

A series of hydrodynamic models has been developed for Bangladesh, which compute water levels at specified stations or points along watercourses. Using these models, water levels and discharges can be simulated, and predictions can be made for a variety of future weather conditions and river management scenarios. Results of the mathematical models have traditionally been a tabular computer listing of water levels for the various river stations.

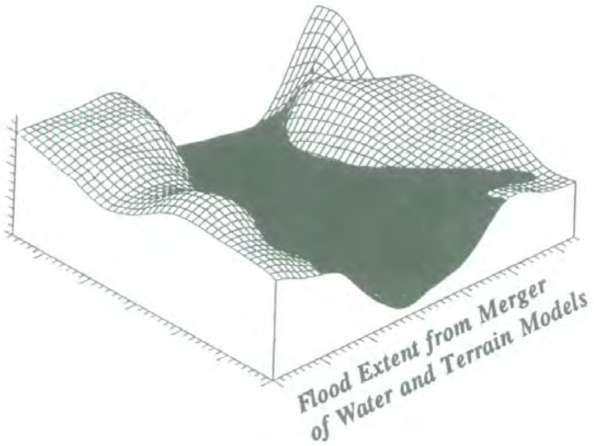


Figure 2: Flood modeling results can be visualized through GIS merging of water and terrain models.

Using GIS analysis, FAP 19 developed procedures for converting the water elevations into maps showing the depths of flooding rivers as well as the extent and depth on the floodplains. This is the first time that Bangladesh flood conditions have been directly mapped through linkage with mathematical flood models.

This project was performed with the collaboration of two FAP regional studies (FAPs 3 and 4), the Compartmentalization Pilot Project (FAP 20), and the Flood Management Model (FAP 25). The methods, along with extensive databases, have since been adapted by several other water resources projects in Bangladesh.

The GIS techniques developed under this project make extensive use of surface modeling through creation of digital elevation models for both the land and flood water surfaces. The intersection of the two surfaces defined the potentially flooded area and depth of flooding. The advantages of this technique are that flood model results can be portrayed graphically and flood depth maps can be integrated digitally with other GIS themes, such as land use and soil type, to comprise a GIS database.

Such a database has a wide variety of applications, among them: resource allocation and optimization modeling, flood forecasting and early warning, crop suitability studies, environmental impact assessment, and disaster preparedness studies.

National Database

The goal of the National Database project is to develop a GIS that can be used for planning and management on both national and regional scales. After surveying existing spatial and tabular databases, FAP 19 collected a number of data sets, which were then mosaiced and geo-corrected to form layers of national coverage. Subsets of the national data were then provided to those FAP regional projects with GIS capability for use in regional water resources planning. A benefit of this collaboration was that the regional projects edited and added new data, which are now being reincorporated into the national database.

Ten themes are now complete for the national database including information such as administration boundaries, soils, hydrology, a digital elevation model, and a digital satellite image mosaic. New data under development include flood regimes, a more detailed digital elevation model, and linkage with 1991 Bangladesh census results.

In addition, the national database has been requested by several other development programs in Bangladesh and the region and by the U.S. State Department. The data, currently applied to water and land management, will be used in other sectors such as disaster management and relief, population, and health.

Compartment Design and Environmental Impact Assessment

The Tangail Area Compartmentalization Pilot Project (FAP 20) and ISPAN's Environmental Study (FAP 16) collaborated on the compartment design and environmental impact assessment application of GIS, which was selected because of its broad range of data requirements, local scale of analysis, and interest exhibited by many other FAP activities. The "compartment" concept involves enclosing an area with embankments, then controlling water flow and drainage into and out of the area with intricate internal water management practices.

FAP 19 provided base maps derived from historical surveys and updated with interpretations of recent, high-resolution satellite images and ground surveys. Analyses were based on modeling flood extents under various water management scenarios and combining these with digital maps of soils, population density, crop patterns, and other parameters. The results were then used for compartment design and management and environmental impact assessments of various water management scenarios, both inside and outside compartment embankments.

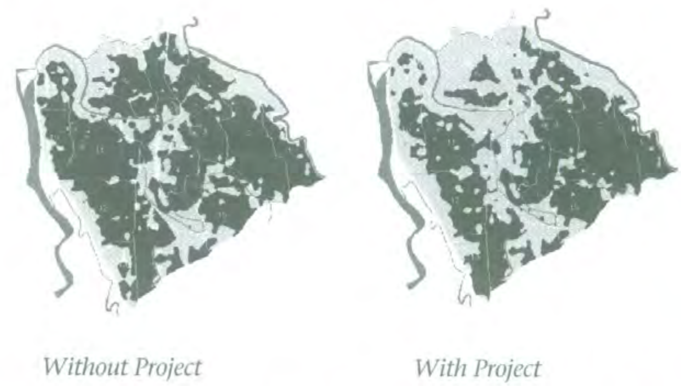


Figure 3: GIS simulates extent of compartmental flooding for "without" and "with" project scenarios, which can be used in environmental impact assessments.

Disaster Management and Relief Pilot Study

This FAP 19 pilot study is testing GIS as a tool for improving disaster preparedness and relief efforts in Bangladesh. The work is focusing on a section of the cyclone-prone Chittagong district that was badly damaged in April 1991 by a devastating cyclone. Disaster management is a multidisciplinary activity that requires broad expertise, and FAP 19 is collaborating with CARE

Bangladesh and with the Disaster Management Bureau of the government's Ministry of Relief.

It is clear from early results that GIS will prove useful for both cyclone and river flood management and relief. This pilot study prepared a digital elevation model from detailed maps and combined it with a digital representation of the April 1991 tidal surge, which was 6 meters high along the coastline. The result was a model of coastal flooding extent and depth.

Vulnerable populations, estimated on the basis of 1991 census data, were then linked to shelter "catchment" areas, which were determined from the location and capacity of cyclone shelters and other safe areas, as well as from the wind direction, road and embankment alignments, waterways, and other shelter access criteria. Outputs to date include maps and tables showing the extent and depth of flooding; shelter areas and protected population; flood-affected population by age and gender; and vulnerability based on access to drinking water, landlessness, and housing structure.

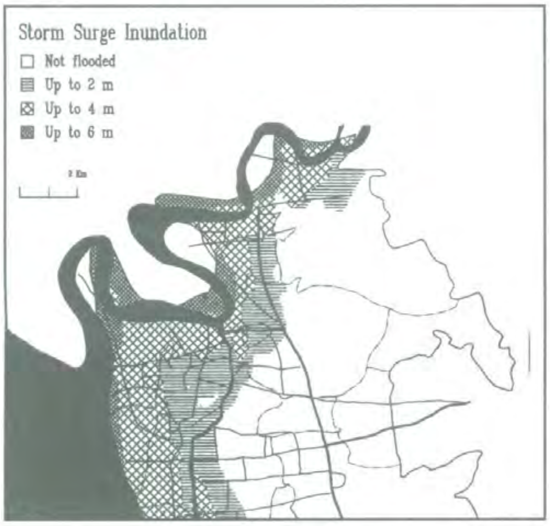


Figure 4: Simulated depth of flooding due to 1991 cyclone storm surge in Chittagong District.

Pilot Study on Applications of Digital Radar Imagery to FAP

While Landsat and SPOT have been used to gather important geographical information about Bangladesh, these satellite sensors cannot penetrate the clouds that normally cover the country during the monsoon season when it is endangered most by floods. The European Space Agency recently launched and is successfully operating a radar satellite, ERS-1, which can penetrate haze and clouds and provide imagery with a ground resolution of about 12 meters.

ERS-1 radar data could enable the FAP to map the flooding extent, estimated to cover about 35 percent of the country in a normal monsoon season and as much as 65 percent in a devastating flood year like 1988. Reliable maps of flood extent could assess damage from river floods and cyclone tidal surges and would be valuable for verifying and calibrating flood models, which in turn are useful to the FAP's modeling activities including regional and sub-regional planning, flood forecasting, fisheries studies, and wetland and environmental impact assessments.

FAP 19 designed the study, acquired four images, and carried out field verification in collaboration with the Fisheries Study (FAP 17), the Flood Management Model (FAP 25), SPARRSO, and three other FAP projects. Over the next several months, FAP 19 will process the digital imagery and analyze it in conjunction with mathematical flood models, digital elevation models, and conventional Landsat satellite imagery. The end result will be the documentation of the availability, quality, and utility of radar data and the design of a comprehensive program for using satellite radar technology for FAP.

BUILDING GIS CAPABILITY IN BANGLADESH

The activities of ISPAN's GIS and other projects have captured the technological interests of many in Bangladesh. To help maintain and support that interest, FAP 19 formed a GIS users' group in September 1991. The group, which grew from 10 participants to more than 100 in the first year, provides a forum for technical presentations, dialogue, and information exchange. Other FAP 19 activities are also aimed at developing a sustainable GIS capability in Bangladesh. For example, FAP 19 completed a survey of all Bangladesh GISs and spatial databases early in the project, and annual updates are distributed to foster cooperation and compatibility among the many new GISs being implemented by the Bangladesh government and donor programs.

In the future, project efforts will focus more on developing a sustainable institutional capability in Bangladesh for effective use of GIS, which will in turn facilitate more coherent water policy formulation and national resources planning.

ISPAN's Bangladesh Riverine Charlands Study

ISPAN surveys have established that there are 4.2 million people living in the active flood plains of the Jamuna, Ganges, Meghna, and the Padma rivers. People living on sand islands (called chars in Bangladesh) totaled 1.49 million in 1991-92, the period of the National Riverine Charlands Study. The residual 2.81 million people in the study area live either on newly accreted sand banks attached to river banks, or on unprotected mainland between the river and existing or planned flood control structures.

The unprotected mainland and char area, as defined above, comprise 8,444 km^2 of which 40 percent is island char, 28 percent attached char, and the balance unprotected mainland.

ISPAN has examined the Jamuna bridge's impact and various proposals for embanking the Jamuna's east side and the Padma's north side. The Ganges has very minor impacts (+6 cm in peak flood water levels), and the Meghna area's flood severity and risk will increase, but only by about 10 cm at its peak. In the Padma's upper reach, flood peaks are expected to increase by 20 to 30 cm, significantly raising the risk of flood damage.

While this increase does not seem very high, even a 20 cm increase in peak level will significantly increase flood damage. A similar difference in flood peak on the Padma in 1987 and 1988 accounted for an increase in the number of houses flooded to roof level from 2,300 to about 23,000, and in the number of houses destroyed from 9,200 to about 35,000. Average monthly household (6 persons) income in the chars is Tk.2,700 (US$66 at $1=Tk.40), and the weighted average house replacement cost is Tk.9,850, or roughly 30 percent of average annual income.

The input of the bridge and embankments on the Jamuna's east bank will increase severe flood peaks by about 80 cm. Calculations completed by ISPAN's GIS team show that during the worst floods (i.e., 1988) about 97,800 people living on island and attached charlands experience this 80-cm increase, and 316,200 experience a 50-cm increase. Of people who live on the unprotected mainland—the river side of the levee—88,400 are invaded by a 80-cm increase in flood peaks, and 242,500, a 50-cm increase. Thus, a total of 186,200 people live where 80-cm flood peak increases occur, and 558,700 where there are 50-cm increases.

At their worst, major floods in Bangladesh accounted for 2,168 deaths in 1988, the majority of which were in the Jamuna charlands (1,257, or 71 per 100,000 population for a 50+ year event).

If Bangladesh's rivers are fully confined by embankments, floods would tend to rise faster, possibly leading to an increase in mortality rates. In our studies, however, we found that deaths from disease—largely due to the charlands' negligible medical service provision and communication difficulties with mainland clinics and hospitals—were a larger problem over the long term.

Even without the proposed embankments and Jamuna Bridge Project, in the period 1983-92, the loss of land due to bankline erosion was 106,299 ha, and accretion was 19,305 ha, giving a net loss of 86,994 ha.

As a result of erosion, all the rivers have shown a tendency to widen to more braided forms, and the eroded sediment dumped in the channel has created an additional area of 23,568 ha of chars. The Jamuna, for example, widened from 6.2 km to 10.6 km in over 150 years, from 1830 to 1992, but from 1973 to 1992 alone, the river widened 2.5 km.

In addition to widening, the Jamuna, and to a lesser extent the Padma and Meghna, are migrating. GIS technology has shown that the Jamuna's center line has moved an average of 4.5 km west since 1830, with a maximum westward movement of 13 km at its northern end. Analysis of a time series of satellite images (taken from 1973 to 1992) shows that the river is migrating westward 50 m per year, primarily through bankline erosion.

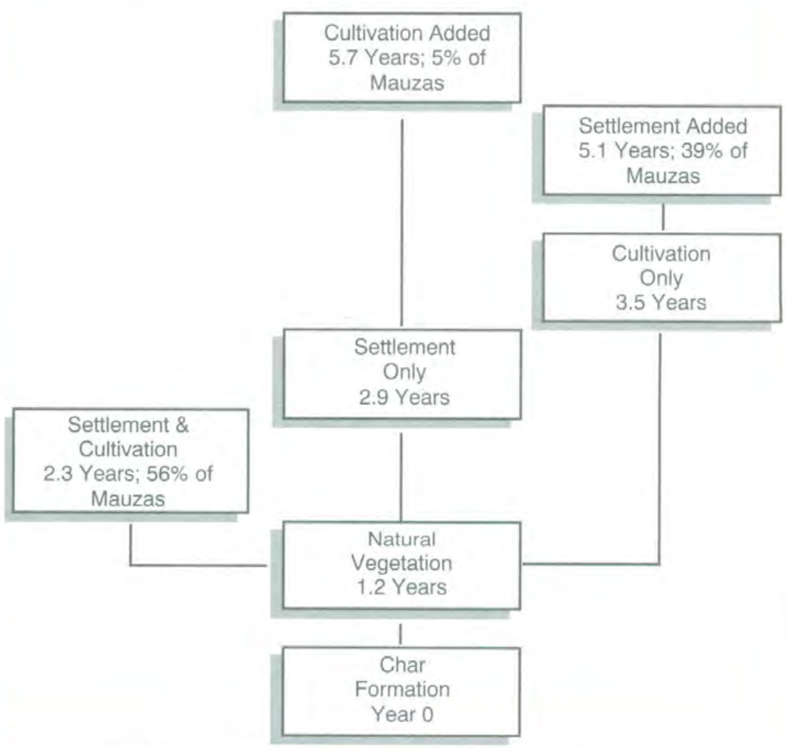
The effects of bankline erosion have been great. ISPAN data suggest that from 1981 to 1992 (the period measured in the 1991 census, minus our own field census undertaken 1992-93), erosion made 187,000 people permanently homeless in the Jamuna alone and permanently displaced 728,439 people in the four rivers studied.

Because of poor soil and flood hazards, the island chars can support only 48 percent of the national average population density (740 persons/km^2 or 1,917 persons/mile^2); attached chars can sustain 67 percent; while the unprotected mainland, where many erosion victims take refuge, has population densities 138 percent of the national average.

The majority of those affected by floods are thought to have left the area and migrated to the slum colonies that surround most larger towns and cities. It is for these and other reasons that Dhaka is believed to be the fastest growing city in Asia at present.

Our research shows that the newly formed charlands, if stable, take up to 20 years to become fully colonized and cultivated. The figure on this page shows a typical evolution of Jamuna River charland use, a process which differs significantly among the rivers studied.

Evolution of Jamuna River Charland Use



There is clearly a dilemma over the long-term management strategy of Bangladesh's mighty rivers. Confining them to their current active channels through bank protection works and river training would be risky and cost billions. On the other hand, with such an intervention, the chronic loss of homes and livelihoods caused by erosion of the unprotected mainland may be halted.

Over the typical 50-year economic life of new infrastructure, over 3 million people could benefit. Making an investment of new infrastructure would invariably lead to the permanent embankment of these rivers to the disbenefit of the current charland population of 4.2 million. Identifying the optimal solution and agreeing on a strategy will be difficult. ■

World Bank Water Resources Policy

The World Bank recently published two water resources management documents. *Managing Water Resources* takes a broad perspective that advocates support for the provision of potable water supply and sanitation, flood control, and the use of water for productive activities while sustaining the water environment, and *Strategy for Managing Water in the Middle East and North Africa* reiterates many of the same policies in the context of the Middle East and North Africa.

Comprehensive Water Policy

Managing Water Resources states that while water resources management has been one of the most important areas of the Bank's lending in the last 30 years, projects have often met implementation, environmental, and social problems. In the past, the World Bank and governments have taken insufficient account of environmental concerns in managing water resources.

Bank-funded programs have been troubled by lack of comprehensive planning, inadequate cost recovery and concern for poverty relief, neglect of project sustainability, delayed and poor-quality construction, failure to consider environmental assessments and needs for pollution control, and lack of watershed management measures.

In the past, the World Bank and governments have taken insufficient account of environmental concerns in managing water resources.

The proposed new approach uses comprehensive analytical frameworks to consider the interdependencies among sectors and to guide establishment of improved coordination among institutions, adherence to consistent regulations, and formation of coherent policies and targeted government actions. In addition, several institutional approaches to more efficient water management are proposed:

• appropriate pricing, increased decentralization, and privatization;

• user participation, enhanced accountability, and improved performance incentives; and

• systems for protecting and restoring water and environmental resources, including standards for pretreatment and effluent charges based on volume and pollution loads, improved land use management, and regional environmental assessments.

Water Management in the Middle East and North Africa

Strategy for Managing Water in the Middle East and North Africa focuses more specifically on the following points:

• Stakeholders involved in decision-making and selecting schemes should include disadvantaged groups.

• Service delivery, where possible, should be decentralized to financially autonomous utilities.

• Privatization—including full private ownership, contracting out of services, utility management, and build-operate-transfer arrangements—should be promoted.

• Particular attention should be given to managing critical ecosystems such as coastal lagoons and inland wetlands.

• Major emphasis should be placed on developing new sources of funds to supplement national budget allocations.

• Alternative industrial processes that use less water and cause less pollution should always be examined.

• Uses of reclaimed wastewater, such as agricultural irrigation, combatting sea water intrusion, and irrigation of urban green areas, should be considered.

• A strong water quality planning and regulatory framework is indispensable.

• Countries will be encouraged to prepare country water assessments, which would guide water sector lending by donors and may lead directly to Bank lending.

• The Bank will promote programs of complementary lending for coordinated development of water at the holistic level and at the subsector level.

A Global View of Water Resources

Key water resources development and protection issues worldwide include the increasing scarcity of water, resulting from rapid population growth and urbanization in developing countries. Human and industrial demands for water are competing with those for irrigated agriculture.

World population—which was 5.3 billion in 1990—will reach at least 6.2 billion by the year 2000 and 8 billion by 2025. Since approximately 90 percent of population growth will occur in urban areas, demand for potable and industrial water will increase. More water will also be needed to irrigate food supplies for urban areas.

Existing wastewater treatment and disposal systems are already inadequate, and costs continue to increase due to the need to go farther afield to locate new water supplies and the expense of dealing with higher levels of pollution.

The World Bank is preparing guidelines to operationalize a socially equitable, economically viable, and environmentally sustainable approach to water resources management.

Currently 22 countries have meager renewable water resources of less than 1,000 m^3/capita annually, a level of severe scarcity, and a further 18 have less than 2,000 m^3/capita on average.

Projected total renewable water supply for the Middle East and North Africa, the world's most water short regions, is 667 m^3/capita annually in 2025. Twelve countries in the region now have annual renewable water resources of less than 1,000 m^3/capita, and five have less than 100.

Strategy for Change

The World Bank is preparing guidelines to operationalize a socially equitable, economically viable, and enviromnentally sustainable approach to water resources management. Pricing and other incentive policies will help encourage water protective activities such as erosion control, and the Bank will seek to reverse groundwater depletion and encourage demand management and conservation. The Bank will explore ways in which it can assist in resolving disputes over water. Special attention is proposed to the provision of services to the poor.

Promoting the acquisition of knowledge about shared groundwater, monitoring International Law Commission efforts to formulate rules for the use of groundwater, and supporting the Global Environment Facility with UNDP and UNEP are other Bank priorities.

Contact the World Bank for more information on their water resources management policies or on these publications. ■

Publications Available

While supplies last, ISPAN has several publications available. To receive copies, please contact: ISPAN, 1611 North Kent Street, Room 1001, Arlington, VA 22209. Phone: (703) 243-7911. Fax: (703) 525-9137.

Contrasting Approaches for Water Policy Development in Tunisia and Sri Lanka—This document assesses the effectiveness of assisting cooperating countries in policy reform; identifies the most appropriate roles for USAID Missions to play; and determines whether these approaches can be adapted to other countries. (See page 1.)

Medium-Scale Irrigation Systems in Northeast Thailand—This study assesses the effectiveness and replicability of the Northeast Small-Scale Irrigation Project and irrigation rehabilitation scheme and provides recommendations for the next phase of medium-scale irrigation systems development in Northeast Thailand.

Providing detailed post-project analyses of social, economic, and technical factors, the study links improved water management practices to agricultural production practices, which in turn relate to expanding public and private market opportunities.

Irrigation Water Cost Recovery in Egypt—This report examines the problem of identifying incremental operation, maintenance, and rehabilitation expenditures needed to raise Egypt's water delivery system performance to an adequate level. The analysis, which is conducted for four policy scenarios, covers costs of Nile River structures and main and secondary canals and excludes "on-farm" portions of the water supply system.

Water Resources Action Plan for the Near East—Published in August 1993, A.I.D. Near East Bureau's water resources action plan identifies alternative means of addressing water resources problems in the region; summarizes actions currently underway to support the Bureau's water resources objectives; identifies areas where future programs may be desirable; and outlines strategic and analytic agendas for future programs in water resources.

Factors Determining Groundwater Use for Irrigation in Pakistan's Punjab—Unsustainable groundwater extractions by private wells and the degradation of soils from the use of marginal-quality groundwater threaten Pakistan's Punjab. This study illustrates how combinations of government energy pricing policies, technology promotion programs, and canal water allocation rules can dramatically affect the amount of groundwater farmers extract and the overall quality of irrigation water applied to farmers' fields.

Policy Alternatives for Pump Irrigation in Indonesia—This study assesses past and present experiences with pump irrigation and makes recommendations for future pump irrigation investment in Indonesia. The following policy issues are addressed: pump irrigation potential; environmental concerns; roles of public and private sectors in pump irrigation; institutional options for pump irrigation development; appropriateness of technologies for pump irrigation; economic viability of pump irrigation; legal framework and institutional support; and capacity of water users associations.

Privatization and Sustainability of Small-Scale Irrigation (Sederhana)—With emphasis on the situation five to ten years after completion of the Sederhana I, Sederhana II, and High Performance Sederhana Irrigation Systems projects, this report, which reassesses efforts by USAID and the Government of Indonesia to aid small-scale irrigation development, reviews the extent to which the systems have been sustained in organizational, technical, and agricultural terms and identifies factors that supported or impeded sustainability. ■

ISPAN

IRRIGATION SUPPORT PROJECT
FOR ASIA AND THE NEAR EAST

1611 N. Kent Street, Room 1001
Arlington, Virginia 22209 USA

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FUTURE DIRECTIONS FOR IMPLEMENTING WATER POLICY
AN OVERVIEW

Water is becoming more and more of a critical issue, both in the Near East and Asia. The success of the Middle East Peace process hinges to some extent on water agreements between the core parties. Growing populations in both regions are grappling with problems of scarcity, quality, and economic and equitable distribution. Each country will find it necessary to change the emphasis of its water management policies and strategies in the near future and into the next century. New, creative strategies and policies will be needed to ensure the sustainability of water resources for this and future generations.

The Asia and Near East Bureau, with the support of the ISPAN project, will hold a special workshop on "FUTURE DIRECTIONS FOR IMPLEMENTING WATER POLICY" on 28-29 April 1994 at the University of Maryland University College Conference Center in College Park, Maryland, near Washington, D.C.

The purpose of the workshop is to identify steps to promote improved water resource policies and strategies to sustain water resources in Asia and the Near East.

Invitations are limited to 50-60 individuals who have solid experience in water resources issues. The invitation list includes representatives from the World Bank and other multilateral donor agencies; NGOs and PVOs; water research organizations; U.S. governmental agencies; Congressional staffers; and University representatives. A.I.D. staff working in the environment and water sectors, and team members of A.I.D. centrally-funded environmental projects are also on the guest list.

The objectives of the workshop are to:

- present major water policy issues facing the world in the 21st century
- identify policy and strategy options in five areas
    - Tradable Water Rights
    - Water User Associations
    - Pricing and Cost Recovery
    - Wastewater Reuse
    - Industrial Wastewater Minimization
- identify constraints to implementing these policy and strategy options
- identify specific actions to move forward in these five areas

The two-day workshop will be facilitated to ensure that it is interactive and participatory. Following the official opening, Dr. Peter Rogers, Gordon McKay Professor of Environmental Engineering at Harvard University will give the Keynote Presentation.

Panel presenters will speak briefly on each of the five policy/strategy areas followed by discussion groups. The five panel presenters are Dr. Mark Rosegrant, Dr. Max Goldensohn, Dr. Ian Carruthers, Dr. Hillel Shuval, and Dr. William Lacy.

The outcome of the workshop will be suggestions for specific actions that can be supported by donors and countries to help resolve some of the major water policy issues facing Asia and the Near East.

FUTURE DIRECTIONS FOR IMPLEMENTING WATER POLICY

THE CHESAPEAKE ROOM
UNIVERSITY OF MARYLAND UNIVERSITY COLLEGE CONFERENCE CENTER
University Boulevard at Adelphi Road
College Park, MD
(301) 985-7303
28-29 April 1994

AGENDA

28 APRIL

8:30 Official Welcome from A.I.D.
Margaret Carpenter, Assistant Administrator, Asia & the Near East Bureau
Get Acquainted Activity
Workshop Objectives and Agenda

9:30 Keynote Speaker: "Future Directions for Implementing Water Policy"
Dr. Peter Rogers, Gordon McKay Professor of Environmental Engineering at Harvard University

10:30 Break

11:00 Panel presentation
- Tradable Water Rights:
  Dr. Mark Rosegrant, International Food Policy Research Institute (IFPRI)
- Water User Associations:
  Dr. Max Goldensohn, Development Alternatives, Inc. (DAI)
- Wastewater Reuse
  Dr. Hillel Shuval, Visiting Scholar, Harvard University and Hebrew University Professor

12:00 Lunch

1:00 Working groups on each of the three areas will address the goals for the future, major constraints, and specific actions that should be taken over the next two to three years. Resource persons joining these working groups include Dr. Atif Kubursi, Dr. Richard Reidinger and Dr. Dan Okun.

2:45 Break

3:15 Working groups report to plenary session

4:30 Closure

29 APRIL

8:30 Introductory activities for Day Two

8:45 Panel Presentation

- Pricing and Cost Recovery:
  Dr. Ian Carruthers, Wye College, University of London
- Industrial Wastewater Minimization:
  Dr. William Lacy, Lacy & Co., Environmental Consulting

9:30 Working groups will identify goals and major constraints for each of the two issues. Resource persons joining these discussions are: Dr. Les Small, Dr. Bill Easter and Dr. Jim Gallup.

10:30 Break

10:45 Plenary discussion on goals and constraints

12:00 Lunch

1:00 Working groups will identify specific actions that should be taken in each of the two areas over the next two to three years.

2:00 Plenary discussion on these actions

3:00 Break

3:15 Plenary discussion:
Summary and Conclusions:
Dr. Peter Rogers

4:30 Closure

FUTURE DIRECTIONS FOR IMPLEMENTING WATER POLICY
28-29 APRIL 1994

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2

KEYNOTE PRESENTATION

DR. PETER PHILIPS ROGERS, KEYNOTE PRESENTER

Dr. Peter Rogers was born in Liverpool, England, on 30 April 1937 and educated in England and the United States. He received his Ph.D. from Harvard University in 1966.

Since 1977, he has been Gordon McKay Professor of Environmental Engineering and Professor of City and Regional Planning at Harvard University. He is also a Member of the Center for Population Studies at Harvard University.

Other Appointments include: Guggenheim Fellowship, 1973; Visiting Professor, Technical University of Vienna, Austria, 1973; Member, Working Group on Water Resources Systems, The International Association of Hydrological Sciences, 1975; Member, Water Resources and Environmental Management Committee, American Geophysical Union, 1976; Member, Panel on Strengthening the Capabilities of Less Developed Countries in Systems Analysis, National Academy of Sciences, USA, 1976; Ford Foundation Advisor, New Delhi, 1978; Visiting Professor, Indian Institute of Technology, New Delhi, 1981; Chairman, Panel on Methodology for Assessing Water Resources and Environmental Impacts for Development Projects, American Association for the Advancement of Science, 1981-83; Senior Consultant to the Master Planning Organization, Government of Bangladesh, 1983-86; Member, Panel on the Role of Systems Analysis Models in Agricultural Planning, National Academy of Sciences, USA, 1985; Chairman, Panel on the Environmental Consequences of Large Dams, National Academy of Sciences, USA, 1986; Member, Review Panel on the Environmental Assessment of the Juba River Development, National Academy of Sciences, USA, 1986-89; Member, Study Group on the Interdependency of Population and Food, American Association for the Advancement of Science, 1986; Member, Panel on Climate Change and Water Resources, American Association for the Advancement of Science, 1987-89; Twentieth Century Fund Fellowship, 1988-91; Senior Consultant on Rural Electrification to the Ministry of Energy, Pakistan, 1988; Senior Consultant to the Center for Water Resources, Patna University, India, 1988; Team Leader, Study of the 1988 Bangladesh Floods for the US Congress, 1988-89; Senior Associate, Winrock International Institute for Agricultural Development, 1988-91; Senior Consultant on Strategic Energy Planning, Ministry of Energy, Ethiopia, 1991; Member, Organizing Committee, 1991 Global Change Institute, Aspen, Colorado; Member, World Conservation Union (IUCN) team to assess potential impacts of water developments in the Okavango Delta, Botswana, 1992.

Dr. Rogers' memberships include: Sigma Xi, 1965; Life Member, Indian Society for Agricultural Engineering, 1982; Cosmos Club, 1989; Associate Fellow, The Third World Academy of Sciences, 1990.

His research areas include: Improved methods for managing natural resources and the environment, with emphasis on the use of analytic optimizing methods to incorporate both the natural phenomena and engineering controls; and development of meso-scale models of resource management that relate directly to macro-economic parameters.

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FUTURE DIRECTIONS FOR IMPLEMENTING WATER POLICY

KEYNOTE PRESENTATION
by
Dr. Peter Rogers

Introduction

It is interesting to note that the title of this workshop is "Future Directions for Implementing Water Policy" not "Future Directions for Water Policy." By this, I assume that we already know what "water policy" is and merely have to focus upon the best way to implement it. For me this is a strong assumption. Do we really know the best water policy for the different countries around the world? There is a growing literature on water policy that should be helpful in answering this question.

The obvious blueprint for water policy around the world should be Chapter 18 of Agenda 21 adopted at the UN Conference on Environment and Development (UNCED, 1992). Starting from the clear position:

> Effectively integrated management of water resources is important to all socio-economic sectors relying on water. Rational allocation prevents conflict and enhances the social development of local communities, as well as economic planning and productivity. Efficient demand management allows water-using sectors to achieve long-term savings on water costs and stimulated resource-conscious production technologies. Health conditions and environmental quality should also improve, either a result of integrated development planning or as a beneficial consequence of improved environmental or social conditions. (Agenda 21, 1992, p. 174)

Agenda 21, unfortunately soon got bogged down in details of the solutions and it is hard to discern clear policy directions from it. It eventually consisted of "a long list of unreachable and unfundable targets, with no fewer than 184 activities advocated in this chapter alone" (Briscoe and Garn, 1994).

One of the preparatory conferences for the UNCED meeting in Rio which managed to stay relatively focussed was the International Conference on Water and Environment held in Dublin, 26-31 January, 1992. The post-conference started as follows:

> Scarcity and misuse of freshwater pose a serious and growing threat to sustainable development and protection of the environment. Human health and welfare, food security, industrial development and the ecosystems on which they depend, are all at risk, unless the water and land resources are managed more effectively in the present decade and beyond than they have been in the past. (Dublin Conference press release, 1992)

Starting from this problem statement the Conference came up with four guiding principles:

1. Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.

2. Water development and management should be based upon a participatory approach, involving user, planners and policymakers at all levels.

3. Women play a central role in the provision, management and safeguarding of water.

4. Water has an economic value in all of its competing uses and should be recognized as an economic good.

In essence, principles 2 and 4 were the relevant guiding principles for water policy enunciated by the Conference.

1993 saw the promulgation of the long-awaited World Bank's Water Policy paper. The Bank identified three major problems faced in the water area:

- fragmented public investment programming and sector management that have failed to take account of the interdependencies among agencies, jurisdiction, and sectors

- extended reliance on overextended government agencies that have neglected the need for economic pricing, financial accountability, and user participation and have not provided services effectively to the poor

- public health investments and regulations that have neglected water quality, health, and environmental concerns.

These problems were to be overcome in reaching the Bank's overarching policy objective "to reduce poverty by supporting the efforts of countries to promote equitable, efficient, and sustainable development," by adopting water policies that stress the following:

- comprehensive analytic frameworks
- institutional and regulatory systems
- incentives for providers and users
- water-conserving technology
- poverty alleviation
- decentralization
- participation by stakeholders
- environmental protection
- upgrading professional skills of providers
- design of country programs
- management of international watercourses, and
- implementation capacity

Last year also saw a flurry of water policy studies by USAID: a study of water resources and environmental sustainability (Thomas, et all, 1993), a **Strategic Framework for Water in Asia** (Bureau for Asia and the Near East, 1993), and an **Action Plan for Water Resources in the Near East** (Bureau for Asia and the Near East, 1993). The study on sustainability claimed three significant global trends in water resources:

- widespread shortages
- increasing competition among and within different sectors for limited resources
- growing degradation of the quality of water resources.

The Action Plan for Water in the Near East stated USAID's goal to achieve "sustainable economic growth, high levels of employment, widespread recognition of basic human rights, and peaceful relations with neighbors, the benefits of which are shared by a broad spectrum of the population." It is claimed that five strategic objectives support this goal: private sector activity, governance, contraceptive methods, maternal and child health services, and water resources. For water resources, the following objectives were stressed:

- Increase the efficient use of water
- Enhance water quality
- Improve water management.

The Strategic Framework for Asia saw the key problems faced as:

- Policy failures and institutional weaknesses (including cost recovery issues)
- Competition for water
- Health and environmental needs and effects.

Another paper done for USAID by Eriksen and Poulin (1993) compared and contrasted lessons learned from examining water policy development in Tunisia and Sri Lanka. They drew some lessons from this comparison which I believe are of general interest:

- Successful policy change is evolutionary, not revolutionary.
- Successful policy change required involvement and support of a cadre of strongly committed senior government policymakers, who see the process as one that will be useful to them.
- More helpful to policy change than charismatic leadership is leadership continuity.
- When attempting to change policy, it is vital to minimize the number of institutions affected.
- Major policy change must be based not on generalities but on solid field data and analyses. The more complicated the policy change, the more important reliable data and high-quality analysis become in the process.
- The distinction between top-down and bottom-up approaches to policy formulation is an artificial one; successful policy change requires support and commitment at both grassroots and senior policy levels.
- A specific policy-change process should never be used as an occasion to address peripheral or unrelated problems.

- A policy-change process generally needs support from more than one major donor.

Not to be outdone by other events in 1993, I also published a book entitled **America's Water: Federal Roles and Responsibilities** in which I identified the problems as the lack of coherent policies on the part of the federal government which lacks a unifying vision of the whole water picture. I suggested 7 areas of pressing concern to address the problems:

- Financing infrastructure
- Privatization
- Information
- Water research
- Meaningful regionalism
- Intergovernmental relations
- Institutional reform

For the urban water resources sector, three other recent studies are relevant. The paper by Serageldin (1994) and Briscoe and Garn (1994) reflect the new thinking on financing of water supply and sanitation, and the paper by Rogers (1993) takes a broad view of the entire urban water resources sector and comes out heavily in favor of economic and institutional mechanisms that would lead to cost recovery for the urban utilities. The papers by Serageldin (1994) and Briscoe and Garn (1994) reflect what they call the gap between the "old agenda" which stressed backlogs in service provision, slow pace of increasing coverage, the size of the resource gap, and the need for governments and external support agencies to increase resources so that the targets can be met, and the "new agenda" which is based upon two of the principles endorsed by the Dublin Conference; that water has an economic value in all its competing uses and should be recognized as an economic good; and water development and management should be based upon a participatory approach, involving users, planners and policymakers at all levels, with decisions taken at the lowest appropriate level.

Given the plethora of policy statements and documents, it is really surprising to find a consensus emerging from them. Most studies find the lack of coherent integrated government policies regarding all phases of water as a major cause of current problems. All see improved efficiency in water use using pricing as part of the incentive structure, all see the need for more attention to water quality, public health, and sustainability issues. The question posed in the first paragraph above has been answered. It is now time for the water resources community to move forward to the issues involved in implementing water policy.

This Workshop

We are now indeed at the stage of suggesting concrete steps to move toward implementing these policy initiatives. This leads to the charge faced by our Workshop over the next two days. The areas that we are expected to discuss are:

Major water policy issues facing the world in the 21st century

Identify policy and strategies in five areas
- Tradable water rights
- Water user associations
- Wastewater reuse
- Pricing and cost recovery
- Industrial wastewater minimization

Identify constraints to implementing these policy and strategy options

Identify specific actions to move forward in these five areas.

Other topics that might be added to this list, without overloading it, are the need for resolving international conflicts, particularly in the arid Near East, and the role of pricing in improving utility management.

TABLE 1
PROBLEM STATEMENTS

Agenda 21

Effectively integrated management of water resources is important to all socio-economic sectors relying on water. Rational allocation prevents conflict and enhances the social development of local communities, as well as economic planning and productivity. Efficient demand management allows water-using sectors to achieve long-term savings on water costs and stimulates resource-conscious production technologies. Health conditions and environmental quality should also improve, either as a result of integrated development planning or as a beneficial consequence of improved environmental or social conditions.

Dublin Conference

Scarcity and misuse of freshwater pose a serious and growing threat to sustainable development and protection of the environment. Human health and welfare, food security, industrial development and the ecosystems on which they depend, are all at risk, unless the water and land resources are managed more effectively in the present decade and beyond than they have been in the past.

World Bank

Fragmented public investment programming and sector management that have failed to take account of the interdependencies among agencies, jurisdictions, and sectors.

Extended reliance on overextended government agencies that have neglected the need for economic pricing, financial accountability, and user participation and have not provided services effectively to the poor.

Public health investments and regulations that have neglected water quality, health, and environmental concerns.

Sustainability Study

Widespread shortages

Increasing competition among and within different sectors for limited resources

Growing degradation of the quality of water resources.

Strategic Framework for Asia

Policy failures and institutional weaknesses (including cost recovery issues)

Competition for water

Health and environmental needs and effects

TABLE 2
WATER POLICY IMPLEMENTATION

Dublin Statement

* Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.

* Water development and management should be based upon a participatory approach, involving users, planners and policymakers at all levels.

* Women play a central role in the provision, management and safeguarding of water.

* Water has an economic value in all of its competing uses and should be recognized as an economic good.

Action Plan for Water in the Near East

Increase the efficient use of water

* Reallocate water resources
* Manage demand
* Conserve water
* Improve technology
* Resolve transboundary disputes
* Enhance water quality
* Upgrade monitoring and regulation enforcement
* Introduce pollution prevention techniques
* Foster local capacity for water protection
* Improve water management
* Strengthen public sector services
* Expand financial responsibility
* Divest management responsibilities
* Encourage private sector services

World Bank

* Comprehensive analytic frameworks
* Institutional and regulatory systems
* Incentives for providers and users
* Water-conserving technology
* Poverty alleviation
* Decentralization
* Participation by stakeholders
* Environmental protection
* Upgrading professional skills of providers
* Design of country programs
* Management of international watercourses
* Implementation capacity

America's Water

* Financing infrastructure
* Privatization
* Information
* Water research
* Meaningful regionalism
* Intergovernmental relations
* Institutional reform

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[illegible] Water Policy [illegible] Washington, D.C. [illegible]
[illegible]

[illegible] Water [illegible]

[illegible] Management [illegible]

[illegible]

[illegible] Policy [illegible]

[illegible] Water [illegible] Development [illegible] Water [illegible]

[illegible] Policy and Planning [illegible]

[illegible] National Water [illegible] Washington, D.C. [illegible]

[illegible] Development [illegible]

[illegible] World Bank [illegible] Paper [illegible] World [illegible] D.C. [illegible]

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Figure 7: Sources of financing in World Bank-assisted Water and Sanitation Projects

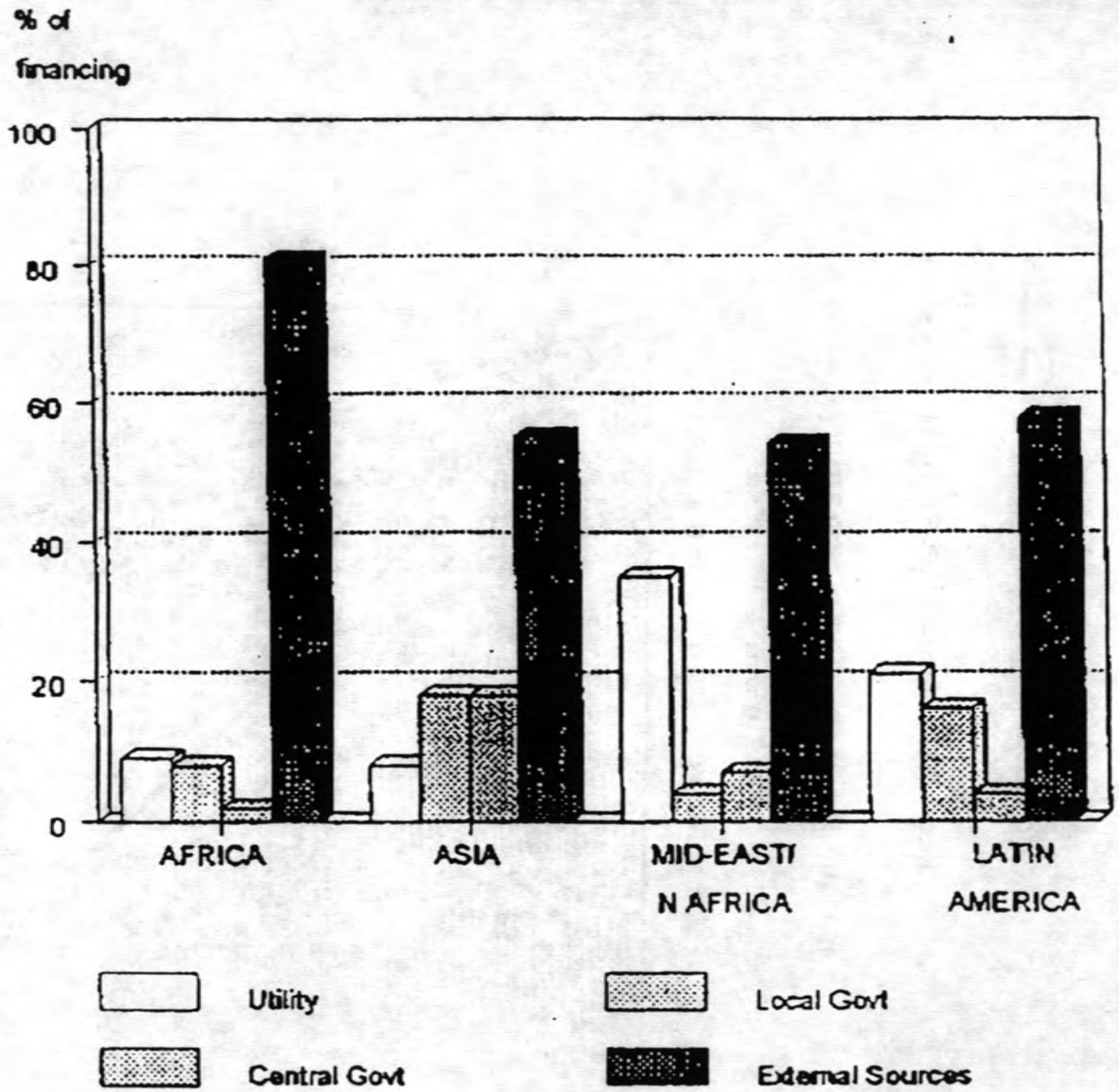
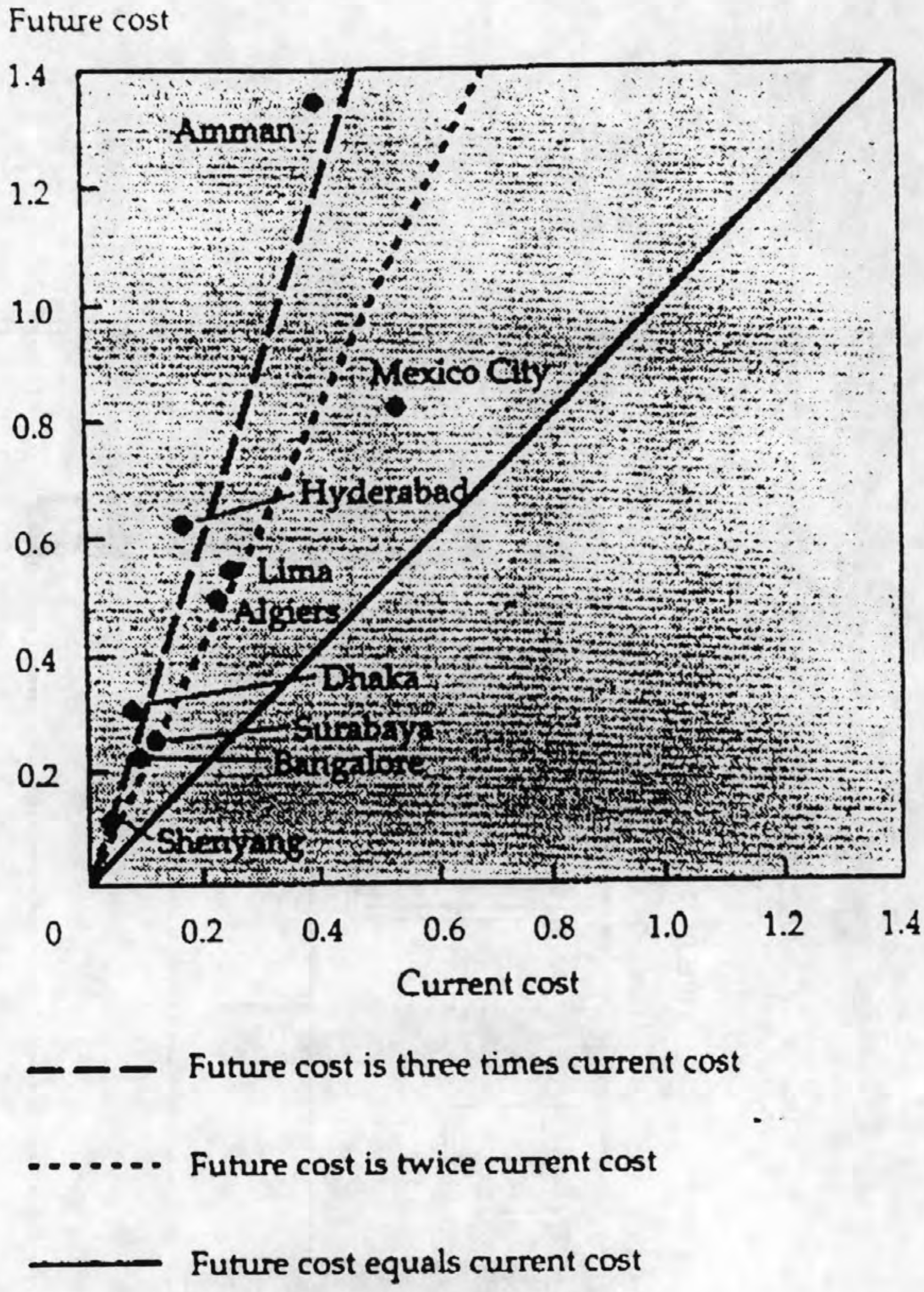


Figure 4.1 Supplying water to urban are as: current cost and projected future cost
(1988 dollars per cubic meter of water)



Source: World Bank 1992(a).

Figure 5: The costs of sewage treatment

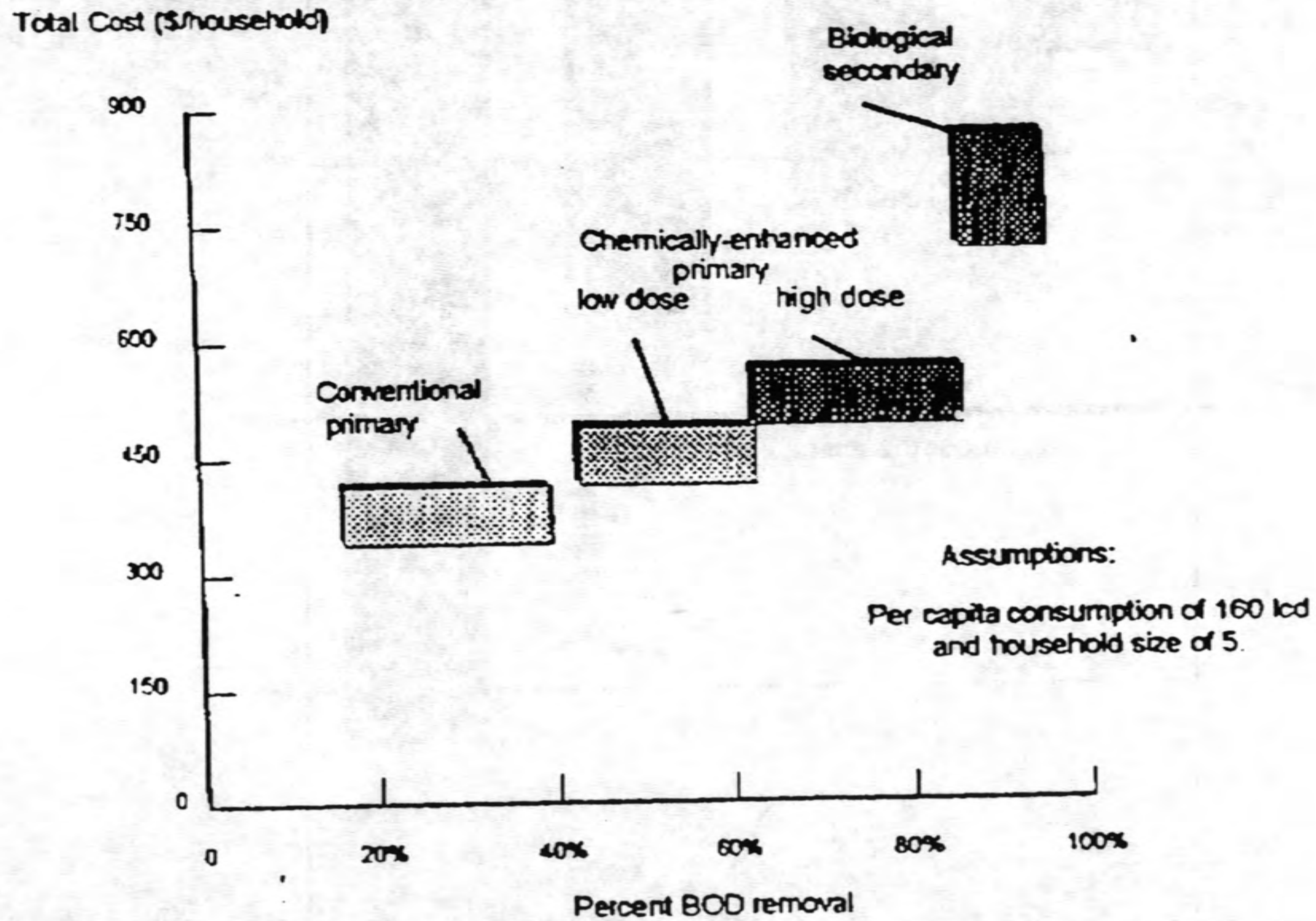
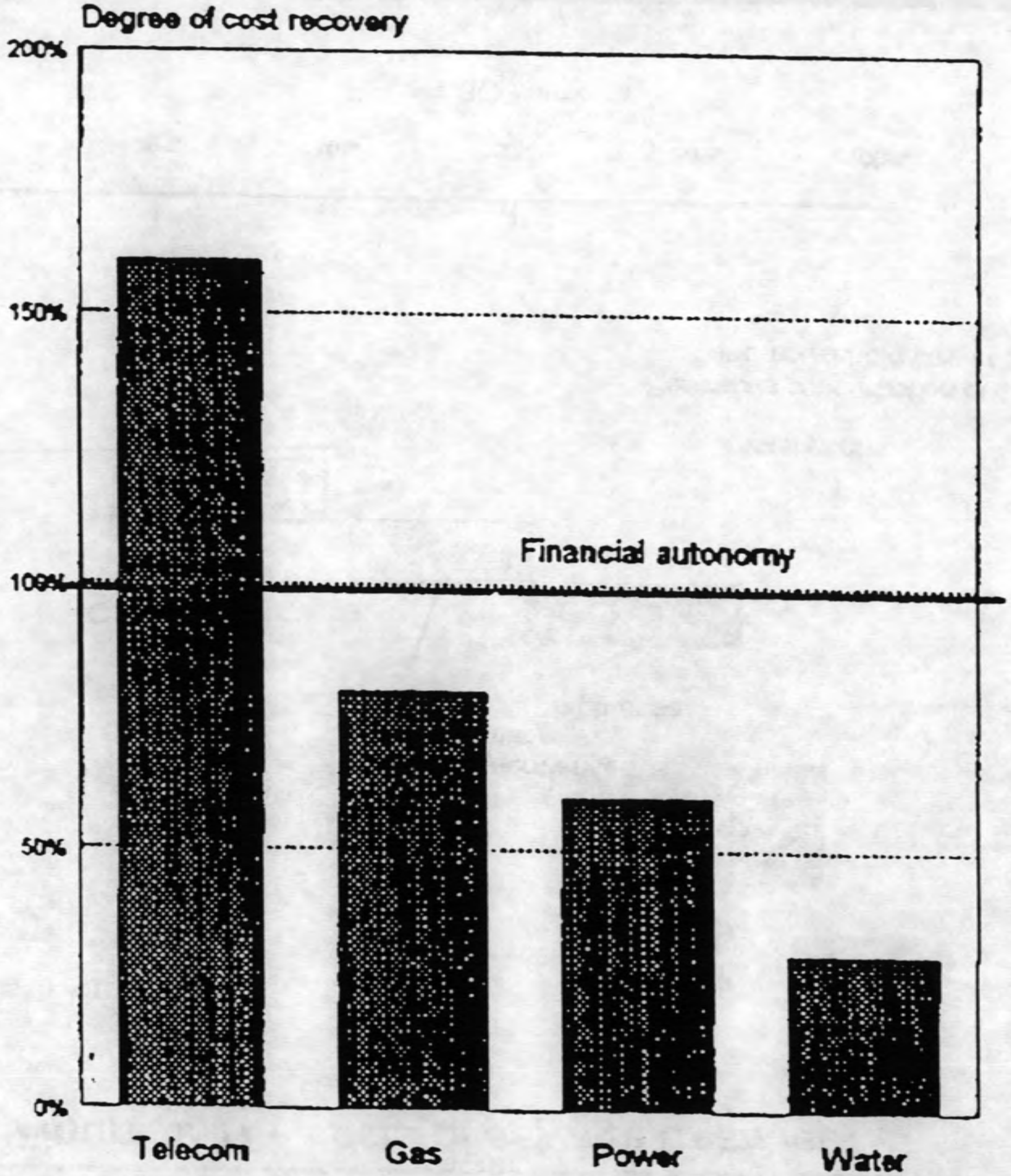
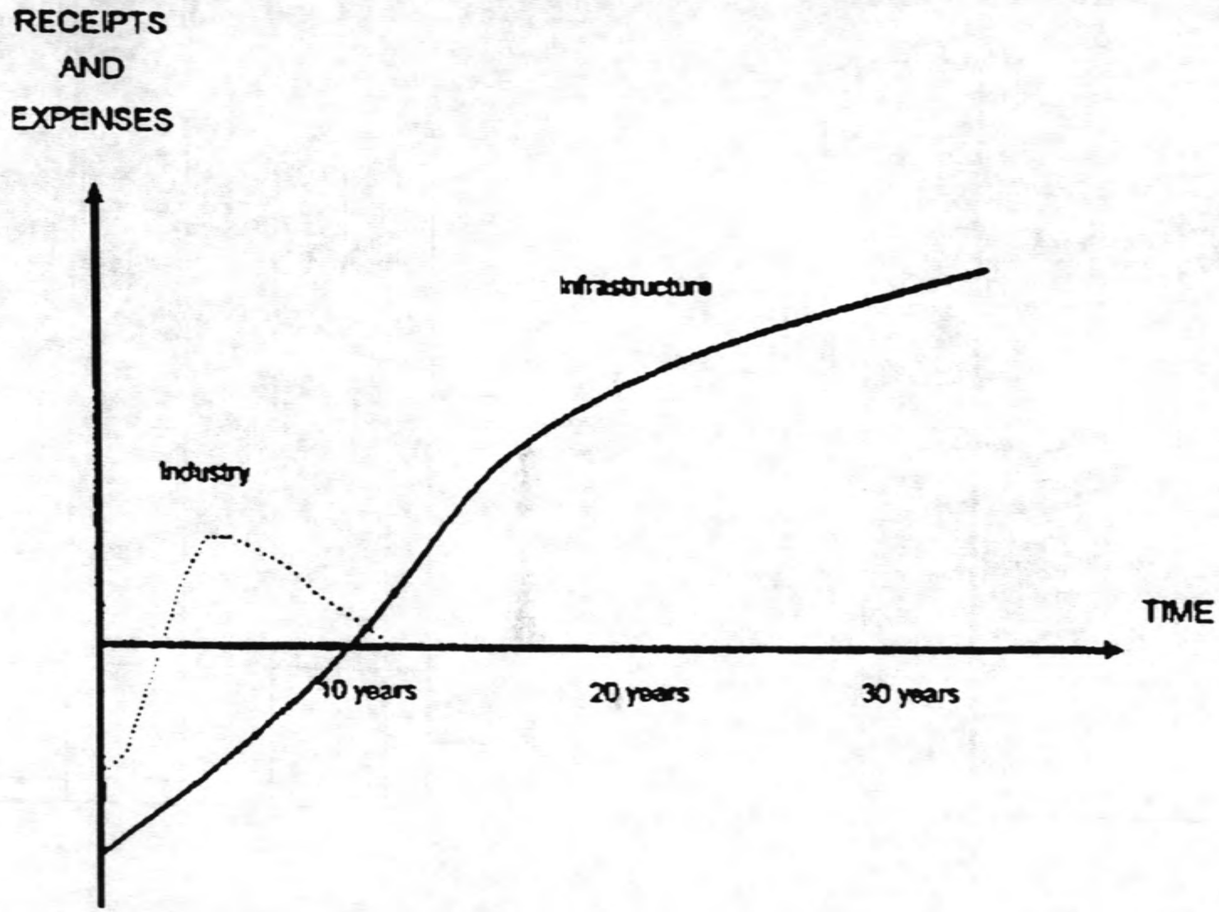


Figure 4: Degree of cost recovery in infrastructure sectors



Source: WDR 94

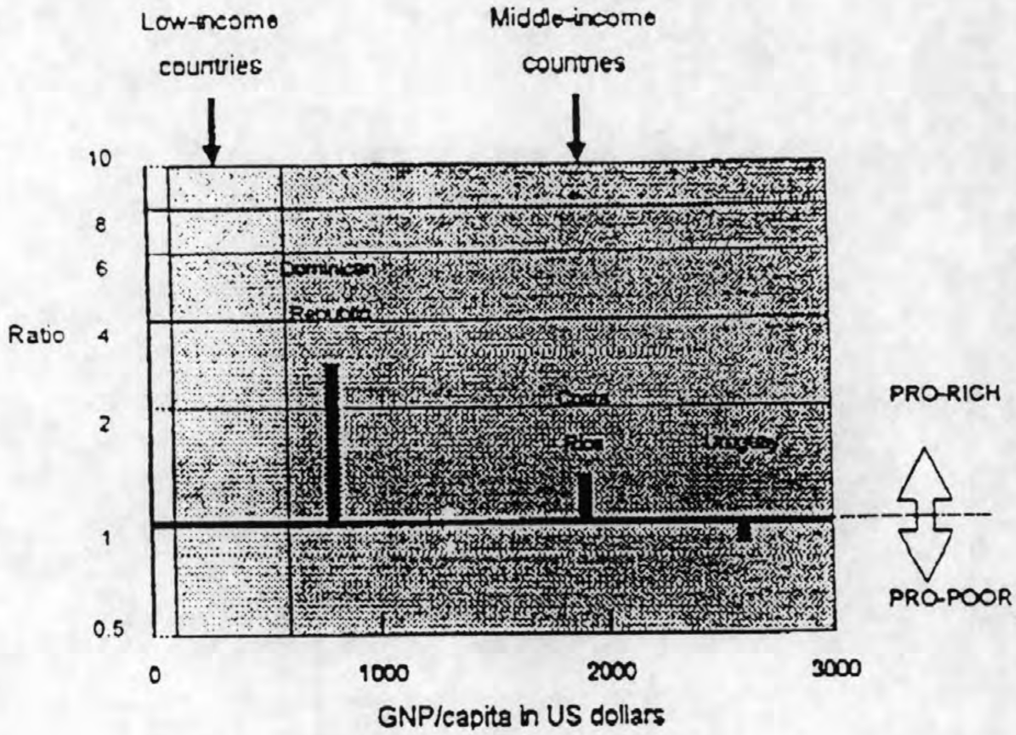
Figure 12: The time profile of expenses and receipts for typical Infrastructure investments



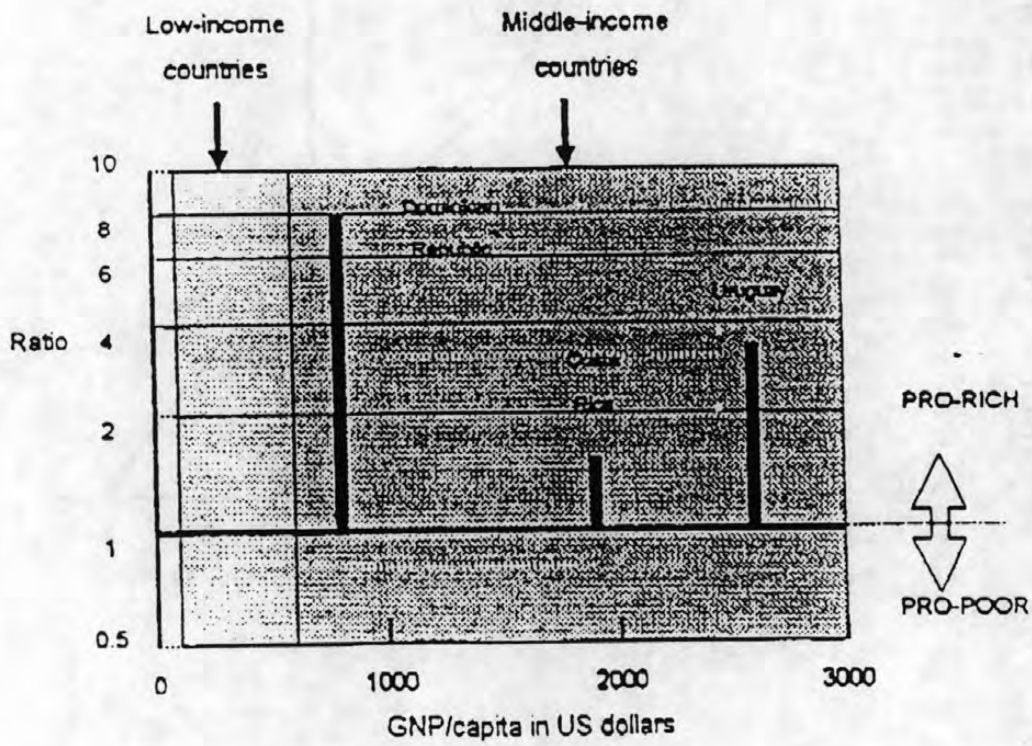
After Davezies and Prud'homme, 1993

Figure 10: Who benefits from subsidized water and sanitation services in Latin America:

"Ratio" = subsidies to the richest 20%/subsidies to the poorest 20%

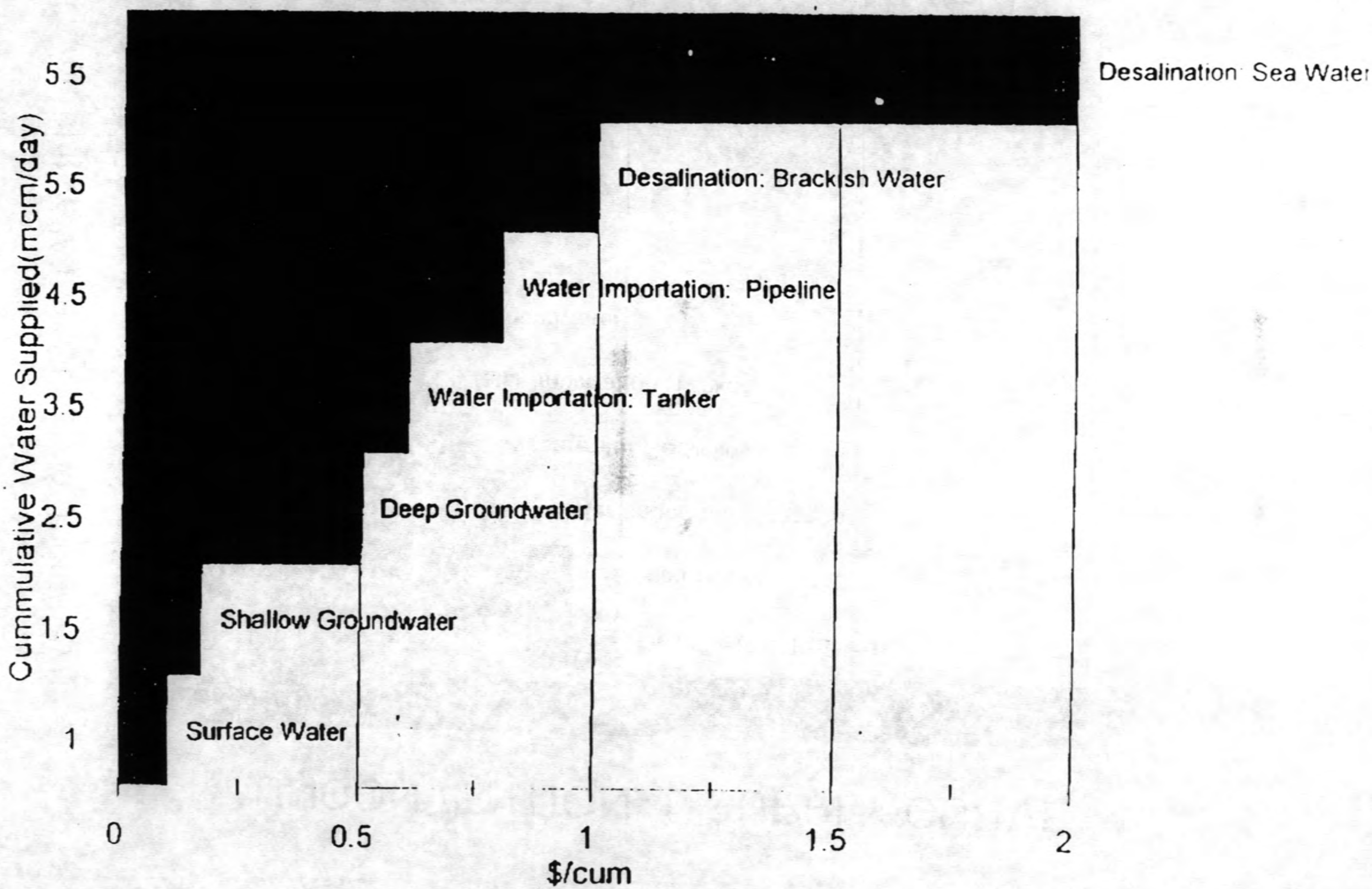


WATER SUPPLY

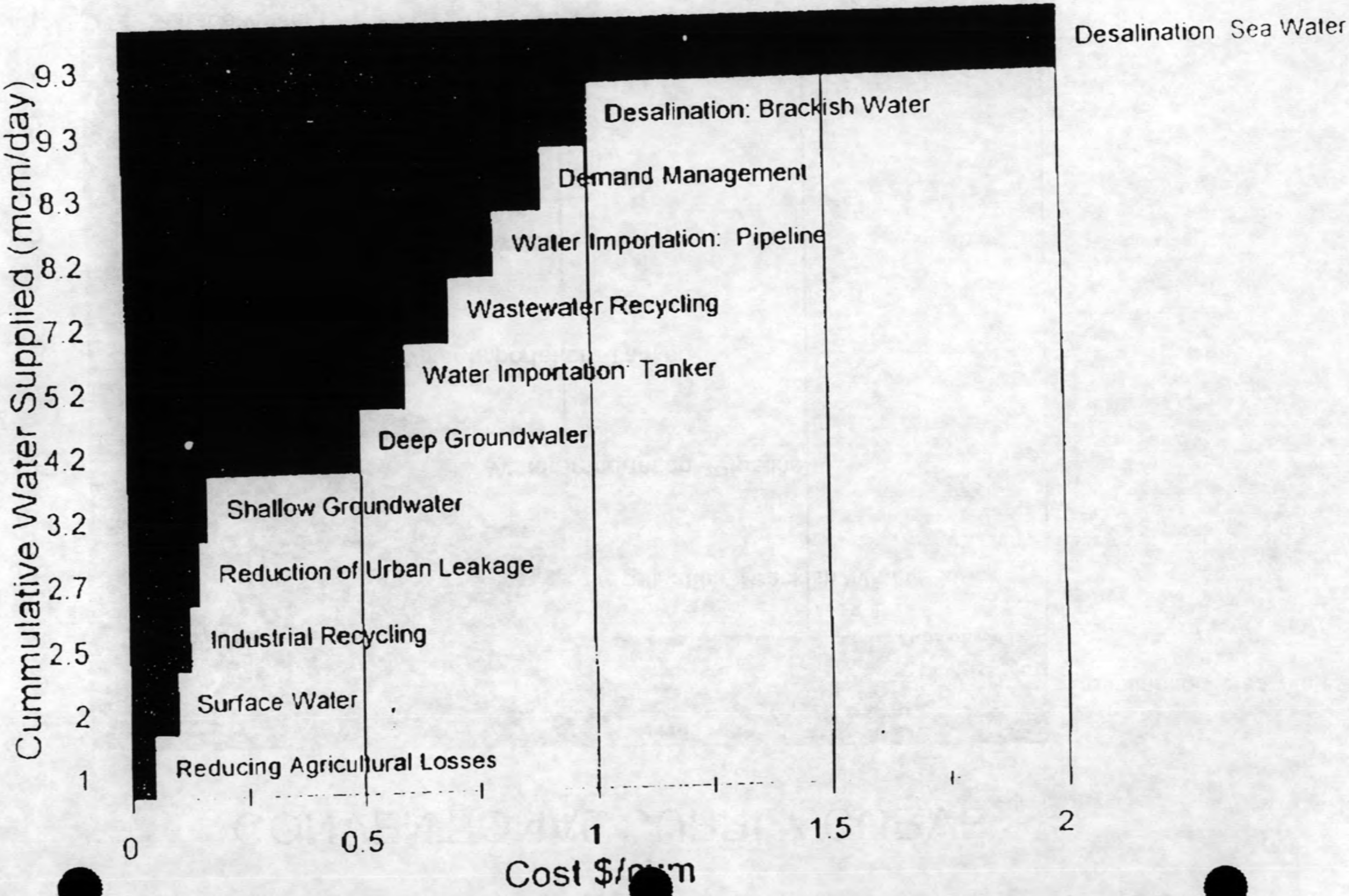


SEWERAGE

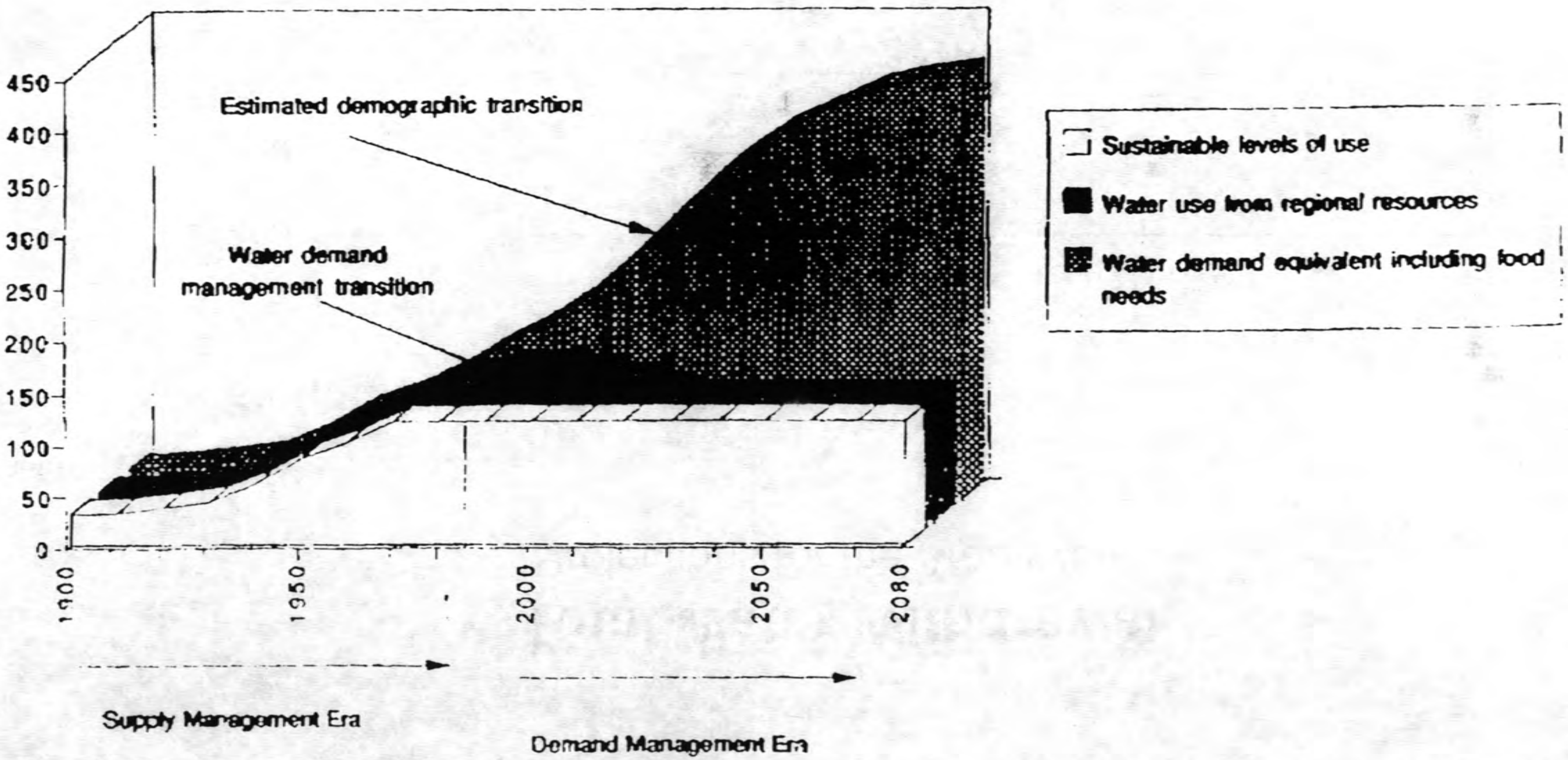
CONVENTIONAL SUPPLY CURVE



UNCONVENTIONAL SUPPLY CURVE



Estimated levels of water demand and use in the Arab Middle East including the water equivalent in food needs 1900-2080. Showing the effect of the demographic transition and the water demand management transition.



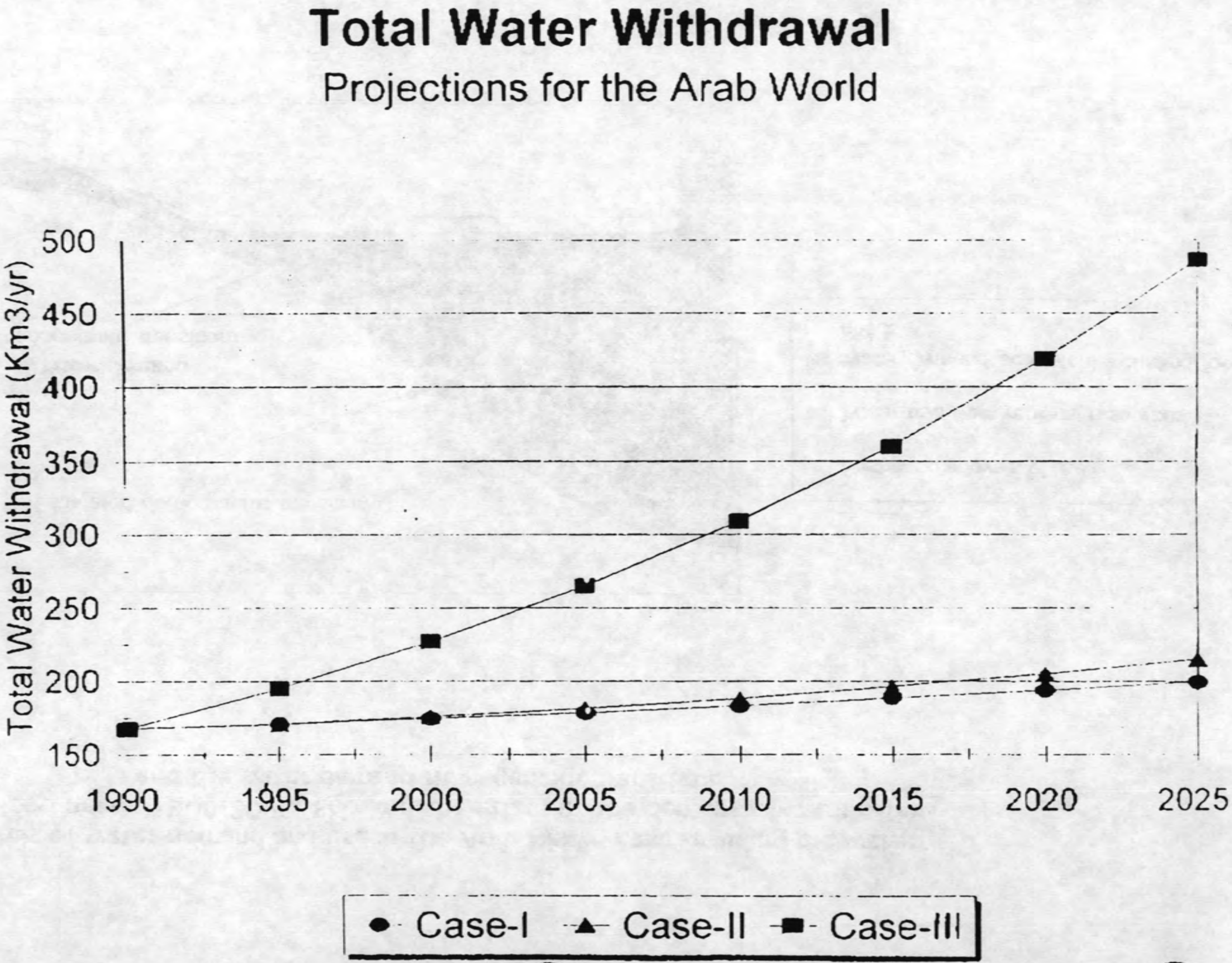

Total Water Withdrawal
Projections for the Arab World
Total Water Withdrawal (Km3/yr)
500
450
400
350
300
250
200
150
1990
1995
2000
2005
2010
2015
2020
2025
Case-I
Case-II
Case-III

Figure 4.3

Number in Low Income Countries Without Access to Safe Water

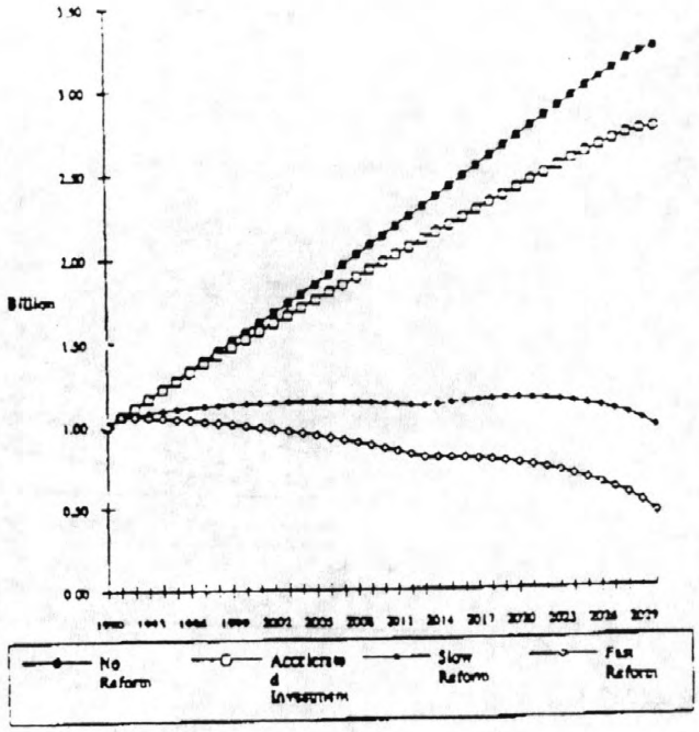


Figure 4.4

Number in Low Income Countries Without Access to Adequate Sanitation

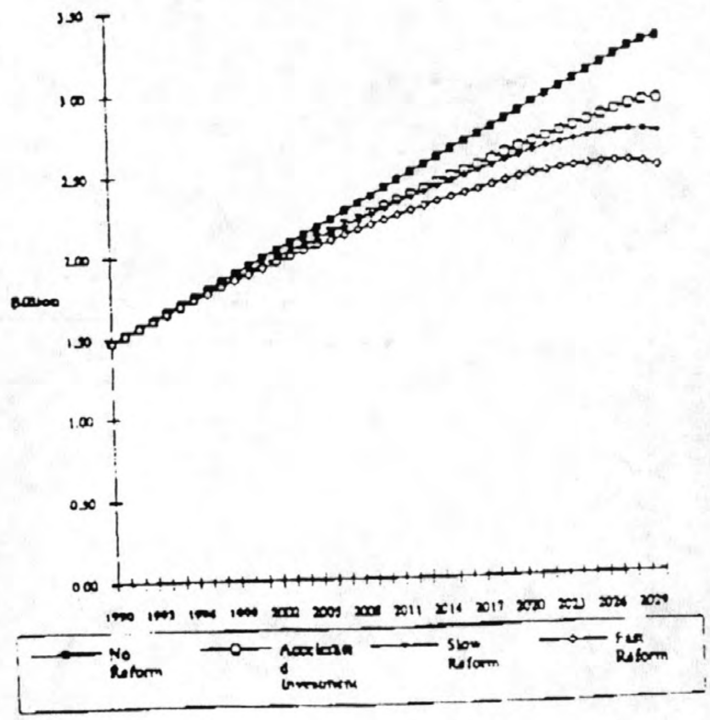


Figure 4.5

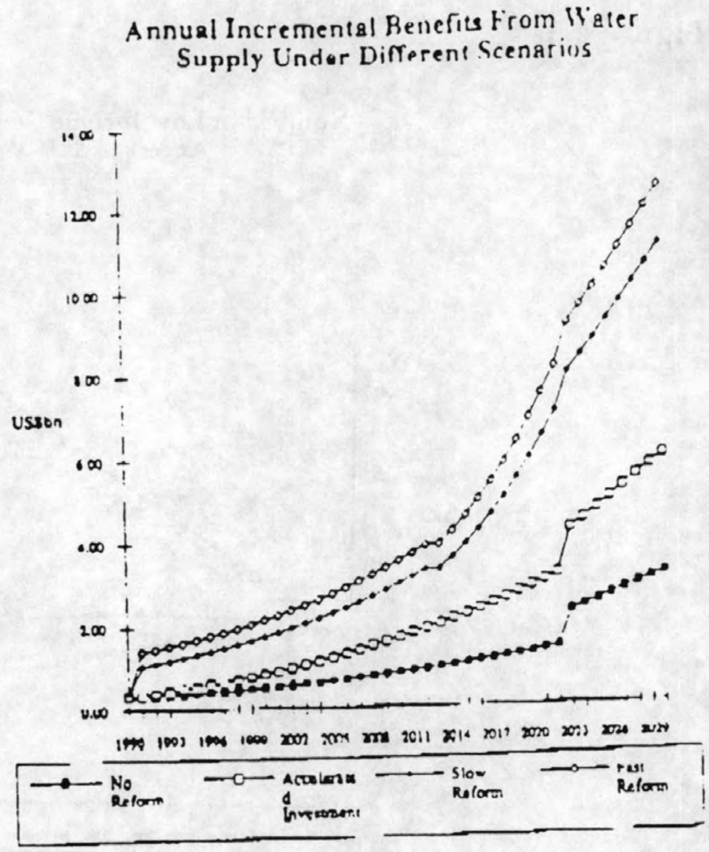
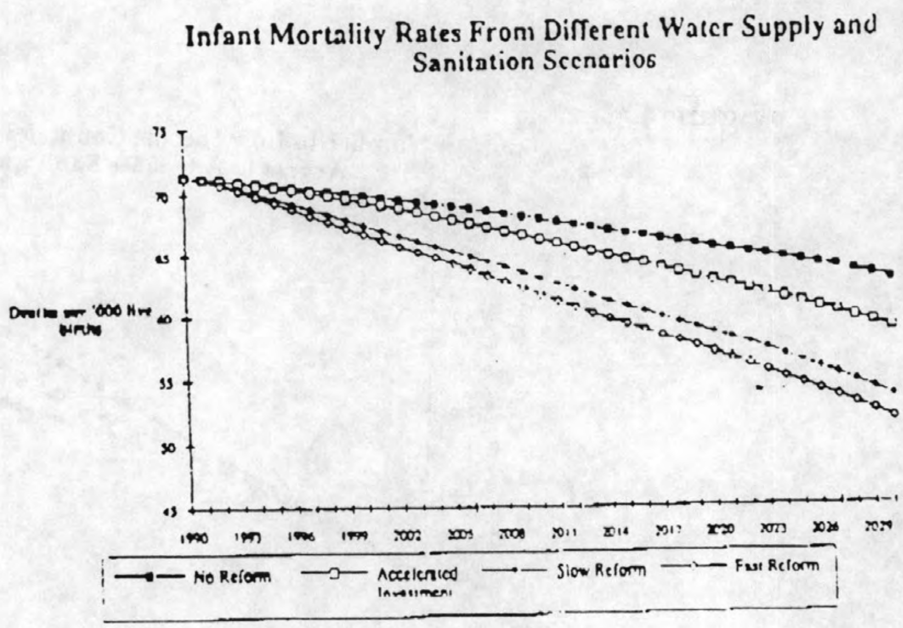


Figure 4.6



3

TRADABLE WATER RIGHTS

DR. MARK ROSEGRANT, PANEL PRESENTER

DR. ROSEGRANT, a U.S. citizen, received a B.A. in government from Beloit College and his Ph.D. in public policy studies at the University of Michigan in 1978. He worked as a policy analyst with the Ministry of Agriculture of the Philippines until he joined the International Food Policy Research Institute (IFPRI) as a research fellow in 1980. While in the Philippines, he was also a visiting lecturer at the University of the Philippines. Rosegrant has published extensively in his areas of research interest, including agricultural productivity growth, government investment behavior, food pricing policy, irrigation investment policy, and water resource allocation policy.

TRADABLE WATER RIGHTS

Abstract of Panel Presentation
by
Dr. Mark W. Rosegrant

BACKGROUND

Developing countries in Asia and the Near East face rapidly growing demand pressure on water resources from agricultural, household, industrial, and environmental uses. This pressure is accompanied by accelerating degradation of the watersheds supporting the water resource, the agricultural land base supporting the main consumer of water - irrigated agriculture, and the declining quality of the delivered water itself.

New sources of water are increasingly expensive to exploit. The main source of incremental water supplies to meet growing demand will thus have to come from saving water through more efficient use of existing water supplies. The only source of water savings of the necessary magnitude to meet growing demand is irrigated agriculture, which generally accounts for at least 80 percent of consumptive use of water in developing countries in Asia and the Near East.

The paramount objective for water resource policy is thus to sustain production growth from irrigated areas while saving water through more efficient allocation of irrigation water, and reversing the degradation of land and water.

However, technological and management approaches to saving water through more efficient irrigation have not worked as well as hoped because they have not been linked to the basic mechanisms and incentives by which water is allocated. A promising approach beginning to receive the attention of developing country policy makers is the reform of laws and institutions to establish well-defined, transferable water rights for water users or groups of water users.

CRITICAL ISSUES

What are the potential benefits of establishing markets in tradable water rights, and what are the main obstacles to effective implementation of this water allocation mechanism?

Devolution of water rights from centralized bureaucratic agencies to farmers and other water users has a number of potential advantages.

> The first is empowerment of the water users by requiring their consent to any reallocation of water and compensation for any water transferred.
>
> The second is to provide security of water rights tenure to the water users. If well-defined rights are established, the water users can invest in water-saving technology knowing that they will benefit from the investment.

Third, a system of marketable rights to water would induce water users to consider the full opportunity cost of water, including its value in alternative uses, thus providing incentives to efficiently use water and to gain additional income through the sale of saved water.

Fourth, a properly managed system of tradable water rights will provide incentives for water users to take account of the external costs imposed by their water use, reducing the pressure to degrade resources.

Fifth, compared to the often-recommended volumetric pricing of irrigation water, the rights-based approach would be more acceptable to farmers. Imposition of volumetric pricing would be seen by farmers as expropriation of traditional water rights, which would create capital losses in established irrigated farms. Establishment of transferable water rights would instead formalize existing rights to water.

Finally, allocation of water through tradable rights provides maximum flexibility in responding to changes in crop prices and water values as demand patterns and comparative advantage change and diversification of cropping proceeds. The market-based system is more responsive than centralized allocation of water.

The key potential constraints to implementation of water allocation by markets in transferable water rights are institutional and technological in nature. Establishment of markets in tradable property rights does not imply free markets in water. Rather, the system would be one of managed trade, with institutions in place to protect against negative effects on third parties and against negative environmental effects that are not eliminated by the change in incentives.

A number of important issues arise in the process of establishing markets in tradable water rights. Laws, institutions, and contracts must be reformed or developed to equitably assign initial rights, to deal with variability of water supply, and to protect against third-party impairment from water transfers.

Development of markets cannot be isolated from the real-world institutional and technological context of developing-country irrigation. Effective development of markets in tradable property rights will likely require continued improvement in irrigation technology for conveyance, diversion, and metering; institutional improvement in management of the irrigation systems; and in many cases, development of water user associations to manage water allocation. (For a more comprehensive treatment of these issues, see Rosegrant and Binswanger, forthcoming, 1994.)

SOME ACTIONS BEING TAKEN

Interest among policy makers in the concept of water allocation through tradable property rights is growing rapidly in Asia/Near East countries, including Egypt, India, Jordan, Malaysia, and Thailand. The developing countries with the most comprehensive water laws establishing a system of tradable water rights are Chile and Mexico. Brief highlights of these laws are summarized here. (For more detail, see Gazmuri, 1994; and Rosegrant and Gazmuri, 1994.)

The Chilean water law, passed in 1976, secures tradable water rights, expressed in terms of water volume per unit of time, permits trades within and between agricultural and non-agricultural sectors, establishes protection for third party rights, institutes water users associations and a National Water Authority to solve most conflicts, and provides for judiciary solutions to conflicts not solved by users organization or the water authority (Gazmuri, 1992).

In Chile, any transfer of rights of use requires prior authorization, with trades monitored at two levels, the local water user association, and the National Water Authority. Issues of third-party impairment and conflicts over water trades can be resolved at either level. If agreement is not reached at these levels, conflicts are moved to the court system. Evidence indicates that the establishment of the system of transferable water rights in Chile has greatly reduced the number of water conflicts reaching courts, with a large share of conflicts being resolved at the level of the water user associations.

The new water law establishing tradable water rights in Mexico was passed in December 1992, and the regulations implementing the law were published in January 1994, so it is still in the early stages of implementation. The law establishes concessions of volumetric transferable water rights of 5-50 years duration, assigns initial rights based mainly on historical use, and establishes strong third-party and environmental protection overseen by the Comision Nacional del Agua (CNA).

Fundamental to the establishment of water rights in Mexico is the turnover of irrigation districts to newly organized water user associations. Under law, water rights can be provided to individuals or groups, but there appears to be a strong preference within CNA for concessions to be made to groups, with the groups then able to grant subsidiary water rights to their members through internal processes initially authorized by CNA.

Since CNA approves all trades other than exact transfer of original consumptive use, it by definition monitors and has approval over any trade potentially involving third party effects. Protection of third-parties through prohibition of damaging transfers or setting of compensation also receives separate emphasis in the water law as a responsibility of CNA. The water law establishes strong explicit protection of the environment for the first time in Mexican water law, using a regulatory, rather than a market approach. The quality of discharge for non-agricultural uses must be specified in the granting of the water right, and the CNA can invoke restrictions over water use in the event of severe water shortages, damage to ecosystems, overexploitation of aquifers, and other environmental impacts.

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MARKETS IN TRADABLE WATER RIGHTS: POTENTIAL FOR EFFICIENCY GAINS IN DEVELOPING-COUNTRY IRRIGATION

Mark W. Rosegrant and Hans P. Binswanger

May 1993

Summary.--*Establishment of tradable water rights could play an important role in programs to increase the productivity and sustainability of water use in developing countries. The growing scarcity of water as economic growth proceeds will be conducive to water market development. Well-defined tradable rights formalize and secure the existing water rights held by farmers; may economize on transactions costs; induce irrigators to consider the full opportunity cost of water; and provide incentives for irrigators to internalize and reduce many of the negative externalities inherent in irrigation. Questions about the potential and feasibility of markets in water rights are fundamentally empirical, and should receive increased attention from researchers and policy makers.*

Introduction

Over the past decade, the cost of new irrigation investment has been rapidly increasing, and existing systems have performed poorly and have degraded through waterlogging, salinization, and mining of groundwater aquifers. Growth in crop productivity in irrigated areas has slowed, and competition for water for non-agricultural uses has increased. These developments have raised serious questions whether irrigation can continue to raise agricultural productivity without serious environmental effects. What are those policies which can lead to efficient increases in productivity while reducing resource degradation in the irrigated areas in developing countries? Four broad categories of policy prescriptions have been employed: technological solutions, reform of public management of irrigation systems, communal irrigation management, and the establishment of tradable property rights in water and development of markets in these rights. The first three broad prescriptions have been widely utilized by international lenders and national governments. However, the design and implementation of policies to encourage the establishment of tradable property rights and markets in water have not been pursued vigorously.

This paper will explore the reasons why allocation of water rights through markets has not been a prominent solution in developing countries. We will argue that, with the rapid economic growth and increasing competition for water in many developing countries, policies to encourage most of development of markets in tradable water rights should receive increasing emphasis from policy makers and researchers. In the remainder of this paper, recent trends in technological solutions, reform of public management, and communal irrigation management will be briefly reviewed, a more detailed presentation of issues related to water market development will then be provided, and conclusions will be summarized.

Policy Options for Arresting Degradation and Improving Productivity in Irrigated Areas

Technological solutions

Technological approaches to expanded irrigation production and reduced degradation include construction of new irrigation systems, rehabilitation and modernization of existing systems, canal lining and drainage, and field drainage. Investment in new construction and rehabilitation, while still substantial, has declined dramatically over the past decade. Rosegrant and Svendsen (1993) conclude that the substantial cutback in public investment for irrigation during the 1980s was an appropriate response to declining world prices of rice and wheat and to the rapidly increasing capital costs of irrigation. However, the world prices are endogenously related to irrigation investment and a slowdown in investment will eventually lead to higher prices. Furthermore, covariance of prices and output will make it more likely that a country will have to import when prices are high, rather than low. These two considerations imply that, a moderately higher shadow price for rice and wheat should be utilized in evaluating irrigation (and other) investments, moderately boosting future expenditures on new irrigation, rehabilitation, and other irrigation improvement options. Nevertheless, a return to the investment levels of the 1970s does not appear likely.

Review of the record of rehabilitation projects shows highly variable net benefits. Perhaps the only straightforward conclusion is the importance of selectivity. Many rehabilitations have been large-scale, capital intensive projects which aim at a thorough remake of the system. These investments are subject to the same type of rent-seeking, delays, and cost overruns that characterize much construction of new systems. Rosegrant and Svendsen (1993) note that selective investment in irrigation rehabilitation, management reforms, and other interventions to improve the efficiency and performance of irrigation systems have an important role in future development in Asian irrigation. High cost rehabilitation to reconstruct and modernize systems from the dam to the farmers' fields should, however, be avoided. Careful identification of systems to be rehabilitated and selection of high-payoff points of intervention within the systems will improve the cost-effectiveness of these interventions. Improved impact assessment could yield large benefits by better identifying cost-effective intervention. However, overall, the rates of return, and aggregate production and income payoffs of rehabilitation investments do not appear to be as high as many observers have estimated.

Reform of public management of irrigation systems

Policies undertaken in this area (often in conjunction with technological interventions) include modification of water distribution methods (such as shifting from continuous flow to rotational flow water allocation); implementation of water pricing policies; and institutional reform of public irrigation bureaucracies. Similar to the case for rehabilitation, reform of water management methods within existing systems has shown mixed results, with some interventions showing high rates of return (Aluwihare and Kikuchi, 1990) while others have been much less effective (Rosegrant, 1990; Rosegrant and Svendsen, 1993).

Attempts to implement efficiency pricing of water, where all users are charged the social opportunity cost of water, have been relatively rare (Sampath, 1992). However, various forms of marginal cost pricing of water under centralized management have been proposed, supplemented by taxes and/or subsidies to account for externalities. For surface water, they include direct pricing based on volume of water; quasi-direct pricing based on delivery "turns" or duration of delivery; and indirect pricing through productivity-based taxes on land. For groundwater, they include direct pricing through charges on water pumped; quasi-direct pricing through charges on the time the pump is in operation; and indirect pricing, through taxes or subsidies on electricity or fuel used by pumps. Efficiency pricing of water will be discussed in more detail below in conjunction with water markets.

Institutional reform of public irrigation agencies has received increasing attention in recent years, and holds considerable promise for long-term progress in improving system performance. Just as changes in available technology alone are insufficient to generate significant improvements in irrigation performance, it is likewise becoming increasingly clear that management innovations, by themselves, will not suffice for the task. Attention is shifting to the sectoral policies and institutional forms which shape the operation of irrigation agencies. Examination of the personal and institutional rewards and incentives which operate within public irrigation bureaucracies suggest that more fundamental changes in policies and institutions are needed to permit "the will to manage" to emerge (Uphoff, Ramamurthy, and Steiner 1991; Small and Carruthers 1991; Svendsen, Adriano, and Martin 1990). Tools and mechanisms suggested for use in this area include shifting from a line department to a semi-independent or public utility mode, applying financial viability criteria to irrigation agencies, profit-sharing plans for employees, franchising rights to operate publicly-constructed irrigation facilities, and strengthened accountability mechanisms such as providing for farmer oversight of operating agencies. Many of these reforms can be seen as introducing quasi-market incentives into the management of public irrigation systems.

Communal irrigation management

The practice of involving farmers more directly in both the processes of system management and system improvement has received increasing prominence over the past two decades. "Farmer participation" has by now become virtually its own discipline, and spawned a large volume of conceptual papers and case studies. It is applied both as a means of directly improving tertiary level water management and maintenance of system facilities. It is also used in conjunction with activities aimed at main system managers, as a way of building a grass-roots structure which can link with the irrigation bureaucracy to facilitate improved management of whole systems (Rosegrant and Svendsen, 1993). The most celebrated examples of this approach come from the Philippines (Korten and Siy, 1988; de los Reyes and Jopillo, 1986), but experience now exists in a number of countries in Asia, Africa, and Latin America. Uphoff (1986) reviewed 50 case studies of farmer participation in irrigation management in Asia, the Middle East, Africa, and Latin America and found farmers to be willing and able to discharge greater responsibility in irrigation management than is traditionally believed and their involvement to be highly beneficial. Although a difficult process to initiate and sustain, farmer participation and communal management have shown promise in a variety of settings and will continue to be an important tool in performance improvement efforts in the years to come.

A challenge here is to insure that the methods of increasing farmer involvement in system operation remain firmly connected to the objective of improving the quality of irrigation service and increasing the system's agricultural outputs. Although there is benefit in simply having farmers involved in decisions affecting them, the case for farmer participation becomes substantially less compelling if the linkage with productivity cannot be firmly established. A key constraint in many instances where communal management has been ineffective appears to be the lack of reliable water supplies to the water user group; i.e., the rights of the group to water from the publicly managed system have not been well-defined.

Establishment of tradable property rights in water and development of markets in water rights

For most commodities and inputs, allocation by means of markets has been the favored solution of economists. Coase (1960) formalized this contention, showing that market allocation will be efficient, given well-defined -and nonattenuated initial property rights and zero transactions costs. Well-defined and nonattenuated property rights are completely specified, exclusive, transferable, and enforceable.

Obviously, the assumption of zero transactions costs does not hold true in real markets. However, even in a world of transactions costs, markets are usually superior to other allocative mechanisms. Markets in water would economize on transactions costs, because the information costs of a centralized managing institution would be reduced, with the market generating the necessary information and market users bearing the information costs. In addition, a system of marketable rights to water would induce irrigators to consider the full opportunity cost of water, including its value in alternative uses, thus tending to correct allocative deficiencies which may be inherent under alternative mechanisms.

Given that markets may have significant advantages over alternative allocative mechanisms, why has centralized allocation of irrigation water been most commonly used? Why has relatively little attention been given to tradable property rights and markets in irrigation water? Is there a potential for gains in productivity and reduced resource degradation through development of markets in transferable water rights? Much of the basic research to understand these issues in a developing country context has yet to be done, but a critical review of issues and evidence can provide some insights.

Water Markets: Concepts and Issues

First, it must be stressed that usufructuary rights to water already exist in most developing countries, either implicitly (through custom) or explicitly (through bodies of law and regulations). Establishment of transferable property rights is a matter of reforming or modifying existing water rights systems. Water rights are generally based on one of three systems: riparian rights, public allocation, and prior (appropriative) rights (Sampath, 1992): (a) **riparian rights** link ownership of or reasonable use of water to ownership of the adjacent or overlying lands; (b) **public allocation** involves administered distribution of water; and (c) **prior rights** are based on the appropriation doctrine, under which the water right is acquired by actual use over time.

None of these systems of rights fulfill the conditions for well-defined property rights to water. Riparian rights are the most restrictive of transfers, because they limit use of water to adjacent or overlying lands, but even appropriative rights can be highly restrictive, building in a bias toward maintaining existing, possibly inefficient uses of water. Under many appropriative rights systems, selling of water is risky because the transfer may be evidence of non-beneficial use and therefore be grounds for revocation of water rights (Frederick, 1986).

The basic case against establishing markets in tradable water rights is that the transaction and equity costs exceed the social benefits. The transactions costs include not only the charges in physical hardware to convey the traded water, but also the analytical, legal, and institutional framework to (a) assure both buyer and seller the exact quantities transferred and (b) to confirm the absence of externalities imposed on third parties due to the trade. Equity could worsen within the irrigated sector or across sectors. The social benefits include the net income gains generated through trade, taking account of positive and negative externalities incurred through the trade. For developing countries, Sampath (1992), OECD (1987), and Young (1986) further elaborated this basic criticism:

1. Transactions costs are particularly high in developing-country irrigation, which is characterized by large systems serving numerous small farmers. The variable nature of water flow makes it especially difficult and costly to achieve the necessary certainty in transferable rights, which must be well-defined in terms of quantity, quality, location, and time of use. The establishment of tradable property rights in water therefore would require high investment costs in technology and management to implement improved conveyance for on-demand delivery of water, water metering and enforcement of contracts.

2. The high costs of investment needed to develop water markets are exacerbated by the relatively low value of water due to the low value of the principal irrigated crops in developing countries, rice and wheat.

3. The presence of significant externalities imposed on third-parties, i.e. spillover effects on other people's property from water trades, makes it difficult to enforce and regulate trade in water. For example, if tradable rights are defined in terms of the full diversion of water a trade of full diversion rights by one farmer is likely to deprive downstream farmers of the use of the flows.

4. Tradability of water to non-agricultural uses will lead to an excessive transfer of water out of agriculture, reducing food production and farm income.

5. The process of allocating water rights and of operating water markets will favor the rich over the poor and be characterized by monopoly rents, leading to worsening of the income or wealth distribution.

We will discuss these criticisms and other issues within the following framework: (1) As a consequence of increasing scarcity of water, the benefits from reallocating it to the highest valued uses increase. In several instances this has led to water trading; (2) Three alternative processes for reallocating water exist: (a) allocation by water management authorities through administrative and/or negotiation processes; (b) opportunity cost pricing of water; and (c) water markets. Each of these processes has its own transactions costs, which will be discussed. But more striking than the differences are the similarities in institutional requirements; (3) The key difference between tradable water rights and opportunity cost pricing is in who obtains the scarcity rents of water, and this influences the political feasibility of the two options; (4) Tradable property rights may reduce, rather than increase externalities; (5) If farms are very small, property rights to water may be allocated to associations or communities of beneficiaries rather than to individuals, and communities may be given the right for internal water allocation and external trading; (6) Tradable water rights will lead to greater involvement of users in investment decisions than the other approaches, increasing the efficiency of investment; (7) Variability in water supply does not preclude clear definition of rights or constrain the usefulness of water markets; (8) If the response of water users to increased water prices is high, tradable water rights may not lead to large reductions in agricultural production due to diversions of water from agriculture to nonagricultural uses; (9) Studies of existing groundwater markets find a great deal of competition among sellers, rather than monopolistic power.

1. *Increasing benefits of reallocating water.* There is evidence that, as economies grow, and competition for water and the value of water increase, the benefits from reallocating water will increase significantly. Water can be reallocated by administrative decisions or through the responses of users to higher administered or market prices. Randall (1983) argues that, as "water economies" move from the expansionary phase to the mature phase, conditions for establishment of property rights emerge: the long run supply of impounded or diverted water becomes inelastic; the demand for delivered water increases rapidly; competition for water among agricultural, industrial, and urban, and instream uses increases; externality problems, including rising water tables, land salinization, and groundwater salinization and depletion become increasingly important. All of these factors increase the value of water and therefore the benefits from efficient allocation of water.

Does the increasing value and scarcity of water induce water trading and establishment of water markets? The evidence from the western United States is clear that this process is occurring, despite water laws (see above) that often discourage formation of water markets. Young (1986), Fisher and Fisher (1984), Gardner and Miller (1983), Martin (1986), and Saliba, Martin, and Bush (1985) document the rapid increase in water trading and market development in several western states.

The dynamic process of water development described above also appears to be underway in many developing countries, particularly in Asia and Latin America, where unexploited potentially irrigable areas are declining, construction of new irrigation is increasingly costly, and competition for water for non-agricultural uses is growing. In addition to increasing scarcity of water, technological innovations in water delivery and metering will reduce transactions cost and encourage market-oriented reform in allocative mechanisms (Young, 1986). Thus, as development proceeds, conditions are becoming more favorable to establishment of water markets.

The only country with a comprehensive water law that establishes a system of tradable property rights is Chile. The Chilean water law secures tradable water rights, expressed in terms of water volume per unit of time, permits trades within and between agricultural and non-agricultural sectors, establishes protection for third party rights, institutes compulsory water users associations and a National Water Authority to solve most conflicts, and provides for judiciary solutions to conflicts not solved by users organization or the water authority (Gazmuri, 1992).

Characteristics and outcomes of the Chilean water rights system will be described as relevant in the discussion below.

In other developing countries, formal tradable rights have not been established. Nevertheless there appears to be considerable expansion in water trading and water markets. Market development appears to be highest in groundwater: Shah (1991) estimates that as much as one-half of the gross area irrigated by tubewells in India belongs to buyers of water; Meinzen-Dick (1992) and Chaudhry (1990) document the rapid development of markets for groundwater in Pakistan. Water trading within surface water systems is also expanding. A recent survey in Pakistan found active water markets (trading or purchasing of water) in 70% of watercourses studied (Pakistan Water and Power Development Authority, 1990). In addition, there appears to be synergy in market development when conjunctive use of ground and surface water is possible. The availability of supplemental water supply from groundwater reduces the uncertainty of trade in surface water, encouraging development of markets in surface water (Renfro and Sparling, 1986).

2. *Transactions costs and institutional requirements of alternative mechanisms for reallocating water.* Water can potentially be reallocated via three processes. Under administrative allocation, a public or quasi-public water authority (e.g., a river basin commission, or a national or regional water authority) would identify water demands or alternative uses and simply reallocate existing water allocations or rights to higher-valued uses. Since the losers will undoubtedly protest, the authority will have to negotiate with the users and find some way of compensating

the losers. Opportunity cost pricing of water and tradable water rights, on the other hand, use the price response of users to reallocate water. With rising prices all users have an incentive to increase their water use efficiency, and low-valued uses will give up water to higher valued uses in a decentralized decision process involving the individual users.

Transaction costs arise whatever the process by which water is reallocated. These transaction costs include (a) the cost of identifying profitable opportunities for transferring water, (b) the costs of negotiating or administratively deciding on the water transfer, (c) the cost of monitoring possible third party effects and other externalities, (d) the infrastructure cost of actually conveying the water and monitoring the transfers, and (e) the infrastructure and institutional cost of monitoring, mitigating, or eliminating possible third party effects and externalities.

No empirical research exists comparing these cost elements under alternative systems. However, it is possible to discuss the initial incidence of these costs, i.e. who will bear the costs, as done in the table below.

Under administrative allocations, all processes are carried out by the authority or the utilities which operate within the jurisdiction of an authority. Other actors get involved in some of the components. For example, the users would share in the cost of negotiation and conflict resolution, and the courts would likely play a role in conflict resolution. With tradable rights users would bear the costs of identifying opportunities and negotiating the transfers. The costs of conveyance of water and of mitigating third party effects would fall on the buyers.

Incidence of Transaction Costs by Type of Water Allocation Process

	Allocation Process		
Cost of	Administrative	Opportunity Cost Pricing	Tradable Rights
Identifying Opportunities	Authority	Users	Users
Negotiating transfers	Authority & Users	None	Users
Monitoring Third Party Effects	Authority	?	Authority
Conveyance	Authority	Authority	Buyer
Mitigation of Third Party Effects	Authority	?	Buyer
Resolving Conflict	Authority, Courts, Users	Authority, Courts Users	Authority, Courts, Users

The authority would bear the cost of monitoring third party effects and would be involved in conflict resolution, perhaps along with the courts.

Under opportunity cost pricing, transfers are not negotiated. Therefore it is not clear how third party effects would be handled. Suppose a farmer decides to stop buying water whose price increases. Who would compensate the downstream user for reduced return flows is not clear. On the other hand, conveyance costs would in the first instance be borne by the authority or the utilities, who would recover the costs through the water charges.

Based on a priori reasoning some remarks about the costs can be made. Since buyers will bear the costs of conveyance and mitigation, they will attempt to find those trades which minimize the total of purchase price, conveyance, and mitigation costs. Administrative allocation, on the other hand, may be subject to political pressures, and authorities may not have the same incentive to minimize the total cost of the transfer as a buyer would. On the other hand an authority may face lower conveyance costs than a buyer if conveyance requires large-scale construction and the authority has the right of eminent domain to acquire the right of way for the structures.

It should also be stressed that, when comparing the transactions costs of water markets with alternative allocation mechanisms, the "hidden" transactions costs of the latter must also be taken into account. Wade (1982) shows the very high costs of private rent seeking by the managers of publicly administered irrigation systems in India. Allocation of water through markets in well-defined property rights in water will economize on rent-seeking costs.

We have seen that establishment of a system of tradable rights requires an organizational structure to convey and deliver irrigation water; and a regulatory structure to enforce contracts, protect third-party interests, and resolve conflicts. Whether traditional quantity allocations or water markets are used to allocate water, high levels of efficiency in management of the irrigation system are desirable. However, allocation of water through markets in tradable water rights is likely to place a premium on efficiency in management of the system. Appropriate reforms of public irrigation institutions such as discussed above may therefore be even more important in the context of an allocation system consisting of markets in tradable water rights.

Public institutions must also protect the poor against the development of market power, protect against third-party impairment from water trades, and resolve conflicts arising from water trades. In Chile, any transfer of rights of use requires prior authorization, with trades monitored at two levels, the local water user association, and the National Water Authority. Issues of third-party impairment and conflicts over water trades can be resolved at either level. If agreement is not reached at these levels, conflicts are moved to the court system (Gazmuri, 1992).

Are institutional failures in developing countries a prohibitive barrier to enforcement of tradable property rights in water? As illustrated in the table above, any water allocation regime requires an institutional support system to handle transaction costs, and it is not clear that resolution of equity issues and conflicts is more difficult to achieve under a tradable property rights regime. Existing water allocation regimes in developing countries have in many cases been ineffective at protecting the rights of poor farmers or protecting against third-party impairment (Byrnes, 1992; Maas and Anderson, 1978). In fact, establishment of well-defined tradable property rights may ease the institutional burden of conflict resolution by reducing uncertainty in rights. Gazmuri (1992) reports that the establishment of the system of transferable water rights in Chile has greatly reduced the number of water conflicts reaching courts, with a large share of conflicts being resolved at the level of the water user associations.

3. *Markets in water rights vs. water pricing.* The establishment of administered efficiency-based pricing of water is often advocated as an intermediate policy between managed quantity allocation and water markets. Efficient allocation of resources usually requires that marginal units of water are priced at their marginal cost. Although complications arise due to economies of scale and lumpiness of investment in irrigation, it is theoretically possible to design and implement a system of administered prices which would lead to efficient allocation of water (Chakravorty and Roumasset, 1991). However, the information requirements for an efficient system of administered prices are demanding and much of this information would necessarily be gathered by trial-and-error experimentation (Phelps, Moore and Graubard, 1978). Information is expensive and mistakes made in the trial-and-error process may be costly. If prices are set too low, demand for water would be excessive, and if prices are set too high, water would be wasted to drainage.

Perhaps even more important, in existing irrigation systems, the value of prevailing usufructuary water rights (formal or informal) has already been capitalized into the value of irrigated land. Imposition of administered pricing is correctly perceived by rights holders as expropriation of those rights, which would create capital losses in established irrigation farms. Attempts to establish administered efficiency prices are thus met with strong opposition from established irrigators, which makes it difficult to institute and maintain an efficiency-oriented system of administered prices (Randall, 1983).

Markets in tradable water rights thus have two major advantages compared to administered efficiency pricing. First, as noted above, information costs would be reduced, because the market, composed of irrigators with expert knowledge of the value of water as an input in the production process, would bear the costs and generate the necessary information on the value of marginal product and opportunity costs of water. Second, establishment of transferable property rights would formalize existing rights to water, rather than being seen as an expropriation of these rights, and is therefore politically more feasible.

4. *Property rights and externalities.* As noted above, a key argument against the property rights approach is the existence of externalities in the use of water, which may undermine the theoretical argument that markets are efficient. But both opportunity cost pricing and appropriately defined property rights will in most instances cause farmers to internalize and thereby eliminate externalities. For example, one of the primary externalities arising from the use of surface water is the overuse of unpriced or underpriced irrigation water by farmers near the head of the system, which leads to waterlogging and salinization, and to deprivation of downstream farmers. This externality will be mitigated by establishment of tradable property rights in water, which will induce the "overuser" to consider the opportunity cost of water to other irrigators when determining his own use of water. The upstream farmer can increase his income by economizing on his use of water and trading the excess (low-productivity) water to downstream farmers,

who will be willing to pay a price higher than the marginal value of additional water application at the head of the system.

Another classic externality in irrigation occurs with exploitation of groundwater. Individual pump irrigators have no incentive to optimize long run extraction rates, because the value of water left in the ground can be captured by other irrigators or potential future irrigators. The resulting tendency for overdraft or mining of groundwater at a rate higher than recharge can cause several externalities, including increased pumping lifts and costs for other irrigators due to the lowered water table, land subsidence, degradation of water quality, and exclusion of other potential irrigators from access to water.

However, well-defined tradable property rights in stocks and flows of groundwater would promote efficiency, because users would have an incentive to compare the opportunity costs of both different types of water use and current vs. future uses of water. A holder of a title to a stock of water could still face increasing extraction costs imposed by the usage rates of other pumpers, but these effects could be reduced with unitization, a contractual arrangement that evolved in oil recovery to mitigate common-pool problems. With unitization, all pumpers contract to use agreed-upon methods of extraction and delivery and to share the costs. Each pumper's share of the lift costs would be based on his usage rate, so unitization might entail higher delivery costs, but it would also provide incentives for increased water conservation and thus lower lift costs (Anderson and Leal, 1991).

In other instances, it is not tradable property rights per se, but inappropriately defined tradable rights which may create problems, by imposing third-party costs. Thus, if tradable rights are defined in terms of the full diversion of water, for example, a trade of full diversion rights by one farmer can result in reduced availability of return flows to other farmers by affecting return flows. However, properly defined proρerty rights will again reduce or eliminate this type of externality. Johnson, Gisser, and Werner (1981) show that a property rights system based on consumptive use rather than diversion, combined with monitoring of third-party effects, will maintain efficiency in water trading and eliminate third-party impairment.

Furthermore, under such a system of water rights, third-party effects will generally occur only when irrigation flow constraints are binding, and when rights to water are traded upstream. Because of the limited domain within which third-party effects can take place, the costs of enforcement are not likely to be excessive. The practicality of defining water rights in terms of consumptive use combined with third-party protection is shown in New Mexico's administration of an appropriative rights system, which closely resembles the system described above (Johnson, Gisser, and Werner, 1981).

5. *Individual vs. communal property rights.* It has been argued that establishment of tradable property rights in water is somehow antithetical to traditional community values, and inimical to communal management of water (Young, 1986; Mumme and Ingram, 1985). However, tradable property rights can be assigned to communal groups or water user associations as well as to

individuals. Assignment of tradable property rights to communal groups should in fact enhance the control of these groups over water resources, better insuring access to water than is often the case with existing water user groups. Assignment of tradable property rights in water to communal groups may be more cost-effective than assigning rights to individuals in instances when internalizing bargaining within the group reduces the information, contractual, and enforcement costs relative to pair-wise bargaining by individuals. To prevent domination of groups by powerful individuals would require the establishment of transparent decision-making mechanisms within the community. It is essential in either case that the assignment of property rights is congruent with the structure of decision-making with respect to allocation of water.

6. *User involvement in investment decisions.* The public goods nature of a large-scale irrigation system implies that the organization of financing and construction of large-scale systems will likely remain the responsibility of governments in developing countries. The principles for efficient and equitable financing and recovery of the capital cost of irrigation systems extend beyond the issue of tradable property rights to include identification of direct and indirect beneficiaries and the efficiency of taxation and resource mobilization (Small and Carruthers, 1991; Sampath, 1992, 1983).

However, Small and Carruthers (1991) point out the importance of involving potential water users in the new irrigation system investment decision and financing process, in order to promote financial discipline and realistic economic appraisals. Establishment of tradable property rights to water is conducive to farmer input into the investment process: creation of water rights prior to construction of an irrigation system, and requirement of consultation and approval for construction plans, together with participation in the capital cost by prospective rights holders, establishes strong incentives for cost-effective investments in irrigation. The water law in Chile mandates this type of participation by prospective water rights holders. Publicly funded irrigation construction requires active participation by potential users, commitment of at least one-third of prospective users for project development, and commitment by one-half of prospective users to acquire the infrastructure prior to the start of construction (Gazmuri, 1992).

For the case of existing irrigation systems, Randall (1981) suggests that fixed costs should be written off, with no attempt to capture fixed costs through increases in charges to irrigators upon establishment of tradable water rights. Attempts to capture sunk costs through increased water conveyance charges would likely lead to the same type of political opposition which has met the attempts to implement full cost recovery or efficiency pricing. However, it is clear, that if a properly administered system of tradable property rights is established that ensures that farmers will receive the full opportunity cost of their water, then the variable costs of operations and maintenance, including full conveyance cost, should be paid by the irrigators. To preserve the marginal rules for efficiency, the final user of the water should pay the full conveyance charges to his farm, so that when a trade of water is made, the purchaser of the water will be responsible to the water authority for conveyance charges to his farm.

7. *Variability in water supply and the design of property rights.* While it is true that water supply is variable in surface irrigation systems, high variability in supply is also characteristic of many agricultural commodities. In developing countries where marketing systems are poorly developed, agricultural input supplies (such as fertilizer) are also often highly variable. Under these conditions, a wide range of institutional and household decision-making mechanisms have evolved to cope with risk in input and output markets. These mechanisms would undoubtedly develop also in conjunction with markets for rights to water. Among the possible mechanisms are contingency contracts; specification of different classes of rights, each with a different probability of delivery and price; development of insurance markets which would compensate for non-delivery of contracted water; and assignment of tradable property rights in terms of proportions of streamflow, rather than absolute amounts of water. The latter may be the most straightforward method of sharing the risk arising from variable streamflow.

The commonly practiced prior rights systems in developing countries are wholly dependent on variable streamflow, offer no mechanisms for sharing risk through trades, and typically impose greater risk on farmers farther from the source of water, since nearby farmers often increase their share of water flow during periods of low streamflow. Assigning tradable property rights in terms of proportions of flows should therefore be at least as secure as existing formal and informal prior rights systems in surface irrigation in developing countries.

8. *Competition between agricultural and non-agricultural demand for water.* A further critique of tradable property rights in water is that this allocation system

will lead to an excessive transfer of water out of agriculture and into industrial, power, and municipal uses. Burness and Quirk (1979) point out that this critique is implicitly embedded in water laws of the western U.S., as limitations on transfers of a water right from irrigation to industrial or power use tend to be much stricter than limitations on transfers within the agricultural sector.

It is not clear in what sense transfers out of agriculture are expected to be excessive: there appears to be an almost Jeffersonian argument that water used in agriculture is morally superior to water used elsewhere, combined with a concern that wealth and social power differences between large private firms or public utilities in the non-agricultural sector and widely dispersed small farmers will allow the former to take advantage of the latter. There is essentially no evidence on the extent to which this could be a problem in the developing country context, but the system of tradable property rights should certainly incorporate legal protection against inappropriate trades.

The actual impact on the overall availability and productivity of water in agriculture if trades to non-agriculture are permitted is not well known, particularly in developing countries. However, there is considerable evidence of price responsiveness of both municipal and industrial demand for water. Higher water prices induce conservation and recycling of water in industry and conservation in domestic demand (El-Ashry and Gibbons, 1986). In developing countries, wastage from industrial and municipal uses of cheap water appears to be very high (Keller, 1992), indicating the potential for considerable reductions in losses if users must pay the full opportunity cost of tradable water. With significant savings possible in both non-agricultural uses, and in agriculture through the use of more efficient irrigation methods, and through shifts to higher valued, less water-intensive crops as the true scarcity value of water is internalized, there may be no net reduction in effective availability of irrigation water and no decline in the value of irrigated production or farmer income as a result of establishment of tradable water rights.

Vaux and Howitt (1984) simulate a liberalization of interregional water trading in California, and find a sharp increase in the value of agricultural water, a reduction in total water use, and large increases in net welfare in both agriculture and non-agriculture due to gains from trade of water from the agricultural sector to municipal and industrial sectors. Dinar and Letey (1991), using a micro-level production model applied to conditions in the San Joaquin Valley of California, show that establishment of a water market would induce the farmer to invest in improved irrigation technology and would increase farm income while transferring a portion of agricultural water to urban uses. In Chile, it appears that the establishment of tradable property rights in water has facilitated the shift from water-intensive crops such as corn and oilseeds, to higher-valued, less water-intensive crops such as fruits and vegetables (Gazmuri, 1992).

9. *Tradable property rights and market power.* There has been considerable criticism that the development of private groundwater irrigation will subject small farmers to monopolistic prices for the use of water due to lumpiness and relatively high cost of tubewell investment will preclude investment by small farmers. However, Chaudhry (1990) shows that, in Pakistan, this has not happened. Instead, the development of a hire market in tubewell services has stimulated the

emergence of a new entrepreneurial class in the rural areas. Inequalities in rural income in areas of high tubewell penetration are dwindling and benefits emanating from new technology are widely shared with small and medium farmers.

Similarly, Shah (1991) details the development of highly competitive water markets in India. Intense competition among sellers contains arbitrary or collusive behavior and ensures access to groundwater by land-poor farmers who cannot afford to invest in their own wells. Groundwater prices are responsive to changes in energy costs and to the availability of canal water. On equity as well as efficiency grounds, these highly developed groundwater markets have attractive and socially desirable properties.

As would be expected, the evidence indicates that greater numbers of pumps and availability of alternative water sources lead to increased competition and lower water prices. The clear implication is that policies that encourage development of markets in tradable water rights would improve access of the poor to water, not discourage it.

Conclusions

Technological solutions, reform of public management of irrigation systems, and communal irrigation management by users associations are major components of programs to increase the productivity, allocation efficiency, and sustainability of water use in developing countries. Tradable water rights may be another major component in such programs. Far from being competititive with the other reform components, successful introduction of water markets in fact requires many of the other reforms as an initial step.

While a relatively low value of water and high transactions costs have slowed development of markets in tradable rights to water in developing countries in the past, the growing scarcity of water as economic growth proceeds will be conducive to market development. Existing property rights systems are restrictive of water transfers, because they limit the use of water to adjacent or overlying lands, or build in a bias toward maintaining existing, possibly inefficient uses of water. -As water becomes scarcer, markets in tradable water rights could have several major advantages over alternative allocation mechanisms: establishment of well-defined tradable rights formalizes and secures the existing water rights held by farmers; markets may economize on transactions costs, reducing the information costs of a centralized managing institution, with the market generating the necessary information and market users bearing the information costs; and markets in tradable rights induce irrigators to consider the full opportunity cost of water, including its value in alternative uses; and provide incentives for irrigators to internalize many of the externalities inherent in irrigation.

A number of serious issues arise in the process of establishing markets in tradable water rights. Laws, institutions, and contracts must be reformed or developed to deal with variability of water delivery, to protect the poor against the development of market power, and to protect against third-party impairment from water trades. Development of markets cannot proceed in an isolated fashion from the real-world institutional and technological context of developing-country irrigation. Effective development of markets in tradable property rights will require continued improvement in irrigation technology for conveyance, diversion, and metering; institutional improvement in management of the irrigation systems; and in many cases, development of community organizations to manage water allocation.

The discussion above demonstrates that the questions about the potentials and constraints of markets in tradable property rights to water in developing countries are fundamentally empirical in nature. It is time to move beyond debate over principles to active empirical research in developing countries into the costs and benefits of including well-defined tradable property rights to water. The benefits of water market development will not be uniform across regions. The costs and benefits from alternative institutions, and policies to remove constraints on water transfers are likely to vary across underlying conditions and regions, in terms of agroclimatic zones, relative water supply, level of agricultural intensification, and degree of intersectoral competition for water.

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4

WATER USER ASSOCIATIONS

DR. MAX GOLDENSOHN, PANEL PRESENTER

Dr. Max Goldensohn, Senior Vice President of Development Alternatives, Inc. (DAI), has 26 years of experience in managing, designing, and evaluating development projects in Asia, Africa, and the Caribbean. Dr. Goldensohn specializes in institutional and policy analysis related to agricultural and agribusiness development, the adaptation of modern private and public sector organizations to the demands of changing economic and social conditions, and project start-up and implementation. He has paid particular attention to the linkages between remote agricultural producing areas and urban agro-industrial processing and marketing centers. Dr. Goldensohn is experienced in all aspects of field office operations, having served as Chief of Party of three large, long-term USAID projects in Mauritania, Zaire, and Sri Lanka.

WATER USER ASSOCIATIONS

Abstract of Panel Presentation
by
Dr. Max D. Goldensohn

BACKGROUND

When many countries in Asia and the Near East became independent, donors and host governments began large investment programs designed to improve irrigated agriculture. Most of these investments paid for the construction of new irrigation infrastructure or the rehabilitation of old works which had fallen apart following World War II. The objective of these investments was to increase the area devoted to irrigated agriculture and thus to expand food production and employment opportunities. By the late 1960s, donors found that host governments were already beginning to request funds to rehabilitate infrastructure built only a few years before. There seemed to have been a general failure to operate the new infrastructure properly and to maintain the canals and drainage systems. This failure seemed particularly acute at the downstream end of the new systems. Farmers were doing little to maintain their new infrastructure.

In the early 1970s, the National Irrigation Administration of the Philippines began to create water user associations (WUAs). Farmers were to contribute to paying the growing cost of new and rehabilitated infrastructure and take over the operation and maintenance of the downstream (tertiary and quaternary) infrastructure. The Participatory Method very successfully mobilized farmer resources to contribute to construction planning, design and implementation in the Philippines. The methodology spread quickly to other countries in Asia and has since been adopted in most countries where irrigation is a significant contributor to agricultural production by small-holder farmers.

Now, after 20 years of implementation, host governments and donors have begun to see problems with the results of the participatory method. While very successful at mobilizing farmer resources and at getting construction and rehabilitation work done quickly and well, the WUAs have in general disappeared at the end of the construction phase and in many areas, farmers' contribution to O&M is no greater than before the elaboration and implementation of the Participatory Method.

The USAID Asia/Technical Resources office has commissioned the ISPAN Project to carry out an applied study of WUAs in six countries of Asia (Philippines, Indonesia, Pakistan, Nepal, Sri Lanka and India) and one country in the Near East region (Egypt). The objective of the study is to see under what circumstances WUAs seem to contribute to the improved performance of irrigation systems and under what conditions they seem to become permanent, sustainable parts of the agricultural economy. The study is also designed to look at the effect of WUAs on rural participation in democratic processes and at the process of turning over irrigation systems or parts of systems to farmers.

CRITICAL ISSUES

A. **Question: Should WUAs be sustainable?** WUAs have worked very well to mobilize farmer resources for construction and to generate participation in the planning, design and construction of appropriate irrigation systems. Why bother to try to change them into sustainable organizations?

Answer: Yes. Small-holding farmers cannot effectively defend their interests as individuals. In the modern world, where irrigated agriculture is embedded in multi-tired economic and administrative structures, farmers need to organize to survive. In irrigation systems, water is a very appropriate basis for that organization.

B. **Question: Should WUAs concentrate exclusively on water?** Until very recently, all those involved in creating and strengthening WUAs felt that farmers should organize around the issue of water exclusively: O&M of infrastructure, resolution of allocation conflicts, payment of irrigation service fees, etc. They felt that permitting WUAs to get involved in other activities would distract them from water and lead to the failure of the organizations.

Answer: No. Effective rural organizations have to represent all the interests of their members and especially their most fundamental interests: increasing their incomes and increasing their control over decisions which affect their lives. Or put another way, if the organizations do not help the farmers obtain more money and more power, they are unlikely to last.

C. **Question: Is water an end in itself or a means to an end?** Are conveyance systems more important than the farms to which the water is conveyed? WUAs are formed to improve water conveyance systems. Once they have done this, those agencies which work with WUAs are satisfied.

Answer: Water is clearly a means to an end. The end is making a living from irrigated agriculture. A rural organization which worries only about water delivery and not about water use and the economic returns to water use is likely to prove non-sustainable.

D. **Question: Is there a difference between national agricultural interests and individual farmer interests?** Most irrigation programs assume that what nations want is good for their citizens: increased agricultural production, low cost food for cities and armies, saving of water for use in other sectors, etc.

Answer: Yes, there is a dramatic difference. Farmers want to earn money from their farms at minimal risk to their investments, while maximizing the control they have over decisions which affect them. Farmers care little for food-self-sufficiency. They are interested in getting a good price for their outputs. Scarcity suits them well. Farmers do not care about saving water for municipal use or for use on other people's farms. They care about optimal water availability for their own irrigation system and farm. To understand what makes rural organizations sustainable, governments will have to reconcile national interests and farmer interests.

E. **Question: Will turnover programs, which give farmers control over their own downstream infrastructure, lead to better irrigation system performance and more sustainable WUAs?** Many countries have launched intensive programs to delivery tertiary and quaternary infrastructure to WUAs. The stated reasons for these programs are to have farmers take over the O&M of those parts of the irrigation systems which they use directly and which governments can no longer afford to operate or maintain, and to give farmers a sense of ownership of the infrastructure which will lead to better O&M.

Answer: Probably not. That government officials and donors refer to these programs as turn-overs is significant. They should talk, rather, about the take-over of the systems by the WUAs. Turn-over programs will not create better WUAs. You need a good, strong WUA **before** the WUA takes over the system. Particularly in areas where governments have historically paid for all O&M themselves, turnover is an undesirable step for most WUAs.

IMPLICATIONS

Asian agriculture cannot survive without irrigation. Most Asian people live from agriculture and most Asian farmers are poor. They are among the most disenfranchised people on the earth. As donors and host governments pay more attention to participation, empowerment and democratic initiatives, they should keep in mind that **Asian democracy has to begin with the empowerment of rural people**. Most democratic initiatives to date deal with urban phenomena: media, political processes, rule of law, labor unions and business associations. These initiatives should start to emphasize the empowerment of the rural poor as well. The rural poor are overwhelmingly agricultural and depend on irrigation systems for their livelihood. **Water distribution systems are a natural starting place for rural organizations that can contribute quickly and materially to empowering their members.**

Donors have begun to show signs of discouragement with the irrigation sector and investment in irrigation projects has declined in recent years. USAID has few, if any, irrigation projects in the works. But irrigation is critical to the economic and social survival of many of our Asian allies. If irrigation projects have not lived up to expectations so far, it is perhaps not because the sector is hopeless, but rather that we have gone about things in the wrong way. Irrigation is a critical input for agriculture, not a domain in itself. By systematically separating irrigation from agriculture, donors and host governments have warped the nature of our participation in financing agricultural development. WUAs are but one example. We need to adopt a new paradigm for the development of WUAs: The Opportunity-Oriented Farmer Organization (OOFO) should replace the WUA. The OOFO should become a rural organization that represents farmers' interests in both empowerment and enrichment. An OOFO should take care of irrigation O&M to the extent that farmers need irrigation water to grow their crops to make their living. In this context, O&M makes sense and OOFOs, if they succeed in contributing to the enrichment and empowerment of their members, have a good chance to become permanent parts of the agro-economic landscape of Asia.

BACKGROUND MATERIAL FOR THE WATER USER ASSOCIATION SESSION, PROVIDED BY DR. MAX GOLDENSOHN, PANEL PRESENTER

WATER USER ASSOCIATION COMPARATIVE DATA

(This material was prepared during the collection and analysis of data for an upcoming ISPAN Lessons Learned Report on Water User Associations. The team is led by Dr. Goldensohn)

The Comparative Matrix: Six Countries by Fifteen Dimensions

To ensure that comparable information was collected about the WUAs in five of the countries visited plus India, the ISPAN team prepared a comparative matrix. (Data from Egypt is not included in this information, even though it is part of the study). The team tried to represent a **general** reality as faithfully as possible. The team recognizes, however, that attempts to assign a *national character* to WUA organizing and strengthening programs will necessarily distort the true picture in any given region of the country in question.

1. THE OFFICIAL TYPOLOGY OF IRRIGATION SYSTEMS

The ISPAN Team observed that the countries in the study paid too little attention to the type of irrigation system in which they applied their WUA methodology and approach. The team began by trying to find out how the countries themselves defined their own gamut of irrigation systems.

Philippines: National Systems - >500 hectares
Communal Systems - <500 hectares
Pump Systems
Private Systems

The NIA deals with irrigation systems by size and type of water delivery system. Gravity flow systems are treated as big or small. All lift-irrigation systems are treated alike. Private systems are those owned by one individual or family. The NIA does not generally intervene in these systems.

Indonesia: Technical Systems: require engineers for O&M
Semi Technical: requires technicians for O&M
Simple: Farmers can do O&M

Large - >500 hectares
Turnover systems - any size, but generally small, part of the turnover program
Village - <500 hectares

Indonesia uses two classifications simultaneously. WUA organizing goes on in the same way in all of the systems. Technical and semi technical systems are not yet part of the turnover program, which specifically calls on villages to take over the burden of paying for O&M on their irrigation infrastructure.

Pakistan: Indus Basin
Civil Canals
Farmer Managed Irrigation Systems (FMIS)

Most of Pakistan's agriculture takes place on one big irrigation system, using the waters of the Indus basin. Civil canals are privately owned systems based on pumps or on small capture areas. FMIS are generally in the parts of PaKistan outside of the Indus Basin, such as the Northern Areas. They tend to be small and to use inexpensive, simple technology. Throughout the Indus Basin, Pakistan employs the same WUA methodology and approach. Some FMIS receive support from the Aga Khan Rural Support Program (AKRSP).

Nepal: FMIS
AMIS - Agency Managed Irrigation Systems
JMIS - Jointly Managed Irrigation Systems
Turnover systems
Private Systems

Nepal categorizes its systems officially by type of management, but employs a single approach to WUA organizing and strengthening. Jointly managed systems (JMIS) have yet to be implemented but are officially recognized in national policy. Private systems belong to one individual or family. Turnover is an officially approved goal, but the program is just starting.

Sri Lanka: Major - >10,000 hectares
Medium 500 - 10,000 hectares
Minor - <500 hectares
Interprovincial

Sri Lanka uses size as its major criterion for distinguishing among types of irrigation systems. However, unlike other countries, a separate agency, the Agrarian Services Department, deals with minor schemes. Organizing techniques are slightly different in different schemes. Schemes which cross provincial boundaries because of hydrological limits which cross political lines or because of basin-to-basin transfers by canals, tunnels or aqueducts are declared o be in the national interest and are dealt with by special authorities, like the Mahaweli Authority of Sri Lanka.

India: Major - >10,000 hectares
Medium - 2,000 - 10,000 hectares
Minor - <2,000 hectares

India uses size as the major differentiator of types of irrigation systems. All irrigation systems are controlled by state governments and no official WUA program exists. WUA interventions are project and donor-driven.

2. INVENTORY OF IRRIGATION SYSTEMS

The ISPAN Team felt that the size and type of irrigation system had a major effect on the type of WUA program which would have the best chance of success in each area. The team wanted to get an idea of the extent of irrigated area under each type of system in the countries in the study to see whether WUA programs seemed adapted to the conditions in the country studied.

Philippines: NIS: 621,000 hectares 42%
CIS: 695,000 hectares 47%
pump: 152,000 hectares 10%

The NIA WUA program has had its best success in the Communal Irrigation Systems (CIS), where systems are small and are usually managed by a community group with broad-based links and structures. The pump systems are also generally small. Applying the WUA approach developed for CIS to the National Irrigation System (NIS) segments has not worked well to date. Since the small systems provide 57% of the irrigated area in the Philippines, the approach based on the CIS model was appropriate.

Indonesia:	Big systems: 2,800,000 hectares	58%
	Turnover systems: 900,000 hectares	19%
	Village systems: 1,100,000 hectares	23%

One reason the transfer of the Philippine methodology to Indonesia has not worked well is the dominance of big systems in Indonesian irrigation. Indonesia has tended in general to leave village systems alone, while concentrating their efforts on big systems where O&M costs are extremely high.

Pakistan:	Indus basin: 14,000,000 hectares	88%
	Civil and FMIS: 2,000,000 hectares	12%

Pakistan's irrigated agricultural sector depends almost entirely on water from the Indus and its tributaries. This is really just one big irrigation system. The Civil and FMI systems are small and scattered and get almost no government or donor support outside of the AKRSP. The OFWM Model, based on the NIA approach, is non-sustainable in Pakistan. But it gets the construction done and is thus valuable and useful.

Nepal:	FMIS: 824,000 ha	76%
	AMIS: 267,000 hectares	24%
	JMIS - NA	
	Turnover - NA	

Of the countries in the study, Nepal has the highest proportion of FMIS. However, Nepal is also the only country with large FMIS (up to 15,000 or more hectares in some systems). The WUA approach has so far not worked at all well in AMIS, including small gravity or pumped AMIS. In FMIS, traditional management works well in many areas. Nepal has wisely avoided manipulating traditional forms for state reasons, such as increasing irrigated surface area or asserting control over cropping and marketing practices. But the conditions which fostered successful FMIS are disappearing in many areas and Nepal needs to adapt WUA approaches to its own particular conditions and requirements.

Sri Lanka:	Major/Medium: 335,000 hectares	67%
	Minor/Village: 163,000 hectares	33%

Sri Lanka is the only country in the study which has explicitly adopted different approaches to large and small irrigation systems. Both approaches are based on an agricultural, not an engineering model, though both give absolute primacy to water management and system O&M. The major schemes, including interprovincial projects, are not only more widespread, they are also more productive than are minor and village schemes.

India:	Major/Medium: 33,000,000 hectares	49%
	Minor: 34,800,000 hectares	51%

Major and minor schemes seem equally important in India. To date, donor-funded projects have concentrated on large systems, although the ISPAN Project in Tamil Nadu includes some relatively small systems as well.

3. GOVERNMENT INSTITUTIONS OVERSEEING WUAs

Nearly all WUA programs are funded by donors or by host governments. Exceptions such as the AKRSP are few and far between. The agency named by the government to oversee the WUA activities has a marked influence on the nature and content of the program. The ISPAN Team contacted decision makers in all these agencies and inquired into the management and administration of their programs to form and strengthen WUAs.

Philippines: National Irrigation Administration (NIA)

The NIA's mandate is to design, build, operate and maintain irrigation systems while establishing financial autonomy. NIA is managed at most levels by engineers, though the current Administrator is a businessman. Other Philippine government agencies administer their own rural organizational programs, many of which are water-based. But they generally follow the NIA model. These include the Department of Agriculture, the Department of Cooperatives, and others.

Indonesia: Department of Public Works (DPU)

The DPU, like the NIA, has as its mission to design, construct, operate and maintain irrigation systems. It is managed by engineers at all levels. Unlike the NIA, the GOI does not expect the DPU to become financially self-sufficient. Many other agencies have rural organizations in parallel with those of the DPU: Department of Agriculture, Ministry of Home Affairs, Department of Cooperatives, etc.

Pakistan: Department of On-Farm Water management (D/OFWM) in the Ministry of Agriculture (DOA)

The D/OFWM operates on a provincial basis in Pakistan, where its mission is to organize farmers into WUAs to support the improvement of the systems for delivery of water to the fields. Other DOA agencies do the on-farm agricultural work. The D/OFWM works exclusively on downstream infrastructure (D-canals and tertiary systems) and is staffed almost entirely by engineers. The ISPAN Team could find no other agencies doing organizational work among farmers of the irrigated areas.

Nepal: Department of Irrigation (DOI)

The DOI in Nepal is headed by a Lawyer who has specialized in water rights. His staff is made up of engineers. Their mission is to build, operate and maintain irrigation systems and to turn them over to farmer groups (WUAs) as quickly as possible. To date, there has been a lot of construction and rehabilitation, but very little turnover. Other agencies in nepal have parallel rural organizations among irrigated farmers: the Department of Agriculture, the Agricultural Development Bank of Nepal, the Department of Cooperatives, the Forestry Department, etc. Project-specific agencies also work with WUAs in certain areas.

Sri Lanka: Irrigation Management Department (IMD)
Mahaweli Economic Agency (MEA)
Department of Agrarian Services (DAS)

The IMD works within the Ministry of Irrigation; the MEA within the Mahaweli Authority of Sri Lanka, an autonomous public corporation; and the DAS within the Ministry of Agriculture. Sri Lanka is the only country where construction and rehabilitation are not part of the mandate of the agencies which deal with WUAs. The IMD's only job is to organize farmers to take over the O&M of the downstream portions of major irrigation systems. MEA's job is to provide all post-construction and settlement support for those who move into the newly-irrigated areas watered by the Mahaweli River system. The DAS works to organize farmers in minor schemes to do their own O&M. The DAS also tries to run an input supply network and to help farmer groups with agricultural planning.

The post-construction, agricultural orientation of Sri Lanka's program shows in the charter of their Farmer Organizations: the Agrarian Services Act calls for multi-purpose, income oriented organizations throughout the country, not just in irrigated zones.

India: None

The Department of Irrigation does not officially recognize WUAs, though donor-funded projects may form them, if they want to. Outlet level WUAs were formed under the Command Area Development program, but have all disappeared now.

4. OFFICIAL NAME FOR WUAs

What's in a name? An attitude. The ISPAN team felt that the way governments name their rural organizations directly reflects their approaches to rural organization in general.

Philippines: Irrigators' Associations (IA)

The NIA clearly marks its program by the name IA:The association is for irrigation purposes only.

Indonesia: P3A or Water Users' Associations

Indonesia also limits its DPU organizations to water management and O&M. The name fits.

Pakistan: Water User Associations

Nepal: Water User Associations

The DOI in Nepal is emphatic in its limiting WUAs to water management and O&M. Other roles would complicate life for the DOI and for the farmers, they say.

Sri Lanka: Farmers' Organizations (FO)

The agencies dealing with FOs in Sri Lanka are not primarily engineering agencies, although both MEA and IMD have engineering sections. The name reflects the GSL's orientation toward multi-purpose rural organizations which meet farmers' need to increase their income.

India: No official name, because they have no official status.

Informal organizations are called Pani Panchayats, water cooperatives, FOs, Chak Committees, etc.

5. FORMAL ROLE OF WUAs and 6. LEGAL STATUS OF WUAs

All of the countries in the ISPAN study have established a formal, legal status for WUAs. The texts state clearly what the government sees as the role of WUAs.

Philippines: IAs are defined as single-purpose organizations to carry out O&M, collect irrigation service fees (ISF), and manage the irrigation systems (CIS) or parts of systems (NIS) which their members use. Ias are registered with the Securities and Exchange Commission and have full legal personality.

Indonesia: P3As are defined as single purpose organizations to carry out O&M on tertiary segments of big systems and on complete small systems. They also collect ISF, keep a small portion and turn the rest over to their local DOI office for use in improving their system and maintaining main system infrastructure. Since 1992, P3As can theoretically register with the local office it is, it will provide full legal personality to P3As. Now, P3As register with the local government, through the Ministry of Home Affairs (MHA) and have limited legal status. They cannot take out normal bank loans and cannot sue or be sued, for example, but a\have access to certain special credit programs.

Pakistan: Each Province of Pakistan has separate legislation for WUAs. They all allow for multi-purpose organizations, starting from water management but then moving to other activities (the CWM model). In practice, the WUAs are all single purpose and time-bound. They only do system rehabilitation and disappear after the construction phase. The WUAs register with the Provincial D/OFWM offices, under the provincial WUA Ordinances of 1981/1982. They have limited legal personality - just enough to enter into agreements with the D/OFWM to provide labor and other contributions to the rehabilitation of their systems. The AKRSP associations have no legal status.

Nepal: Nepal's WUAs are formally single-purpose. Their roles include O&M of their irrigation systems or segments thereof, resource mobilization for rehabilitation or expansion of systems, and system water management. But many of these organizations quickly assume a multi-purpose character and the legislation allows local flexibility in determining the nature and functions of WUAs.

Sri Lanka: FOs are defined as multi-purpose organizations whose attributions depend on farmers' preferences and priorities. These can include O&M, water management, input supply, marketing, outgrowing, credit, etc. FOs can register and assume limited legal personality under the Agrarian Services Act Amendment No. 4 of 1991. The DAS can delegate authority to other agencies, such as the MASL, to register FOs. FOs, for example, cannot sue or be sued, but they can borrow from commercial banks and enter into binding contracts.

India: As WUAs are not formally recognized, they have no formal role or legal status. Their activities depend on donor and local government decisions. Most do only O&M and water management, as well as ISF collections. They have no formal status under the irrigation acts, though Command Area Development Acts did recognize them in the CAD areas. Traditional FOs are recognized by the Irrigation Acts and in some cases, traditional FOs can get assistance for system rehabilitation or expansion.

7. LEVELS OF WUA ORGANIZATION

The ISPAN team noted that resource control is a critical element in motivating farmers to form and strengthen their WUAs in into permanent, sustainable entities. Almost all WUA programs establish informal groups at the turnout level where small groups (10 - 100 farmers) take water from a distributary. These turn-out groups elect the officers of the Distributary Canal WUA, which is the legal, formal organization with which governments deal for programs of turnover or rehabilitation. In small systems such as the CIS or the Philippines or the Minor Tank systems of Sri Lanka, this Distributary or Watercourse level organization has control of the source of water for irrigation. No higher levels of organization are required for resource control.

In large systems, the WUA or Distributary level/watercourse level organization does not have control of the resource which the irrigation system delivers. The main canals and head-works infrastructure usually remains in the hands of an engineering agency such as NIA in the Philippines or DPU in Indonesia. Water arrives at the part of the system controlled by the WUA at the time and in the quantity decided by the engineering agency. This lack of control vitiates the importance of a water-management based organization for its members. They do not have a voice in the decisions which effect their ability to use all their reo\sources to best advantage.

Some of the countries in the study have agreed to encourage WUAs to federate within systems and to generate sub-system or system-level organizations with which the government agencies will consult about the O&M of the main system and headworks infrastructure. While these federated or 'nested' organizations do not give farmers complete control over their water, they do afford them a voice in its management from the source. These federated organizations have proven difficult to organize and make effective but they are clearly a positive step toward increased farmer participation and control of critical decisions about resource allocation and use.

Philippines: Federated WUAs are not needed in CIS and pump systems, but are authorized in NIS.

Very few NIS in the Philippines have moved to generate federated or nested WUAs. Although NIA policy allows this, field personnel have not begun encouraging a movement which could compromise their control of the irrigation systems and which is not directly related to system construction, expansion or rehabilitation.

Indonesia: Regulations do not allow federation of village and turnover systems into larger units. They are not specifically forbidden, but would not be recognized. In ISF systems, the rules encourage federations at the tertiary level. The GOI is considering authorized federations of ISF WUAs at the secondary or sub-project level.

Pakistan: WUAs are allowed to federate at the distributary level (sub-system) in all provinces except the Punjab. The ISPAN team found no evidence of working federations anywhere.

Nepal: Nepal's irrigation policy allows the recognition of federated WUAs at all levels of irrigation systems. Many of the large, traditional FMIS are made up of nests of smaller organizations down to the turn-out level.

Sri Lanka: The implementing agencies in Sri Lanka recognize federated FOs or WUAs up to system level. Systems are limited to canals running off of one main canal. Sri Lankan legislation poses no obstacles to recognizing federated FOs up to that level. Many systems have sub-project and project level organizations which consult with implementing agencies about water management issues. In several Mahaweli systems, the federated FOs also have a voice in general administrative and economic development decision making.

India: As WUAs have no legal status, there is neith encouragement, nor objection to federations. One USAID Project has attempted to start from a federation and to organize at the tertiary level through the large, higher level organization.

8. RELATIONSHIP TO TRADITIONAL RURAL ORGANIZATIONS AND LEADERS

Farmers using irrigation systems for agriculture in all of the countries in the ISPAN study have developed indigenous forms of organization to deal with their O&M needs as well as with other economic and social issues. These traditional organizations take many forms. Some are very formal, others completely informal. Some are grounded in religion, others in economics. Some have been around for hundreds of years, others have sprung up recently. (see box).

> In the 1960's in Sri Lanka, in the Moneragala area, groups of farmers identified ancient minor tanks which had fallen into disrepair. The organized themselves to repair the tanks and the water distribution systems which served small command areas below the tanks. They established varying but highly rigorous,almost draconian rules for collective work and contributions to O&M and to other collective activities. Dozens of these systems grew and prospered until a well-meaning Government Agent tried to impose a uniform constitution and set of rules on these organizations in return for help with system improvement. Within five years all the systems had disappeared back into the jungle.

The countries in the ISPAN study and their donor partners have taken differing approaches to traditional organizations. Some have tried to turn them into modern WUAs, others have ignored them and tried to set up parallel organizations, competing with traditional ones. Few have attempted seriously to work with local, indigenous groups; although Nepal has tried to replicate traditional forms in non-traditional settings.

The importance of government and donor attitudes toward traditional organizations and authorities is critical to the implementation of WUA Programs. Governments may see the traditional authorities as feudal and non-representative. They may see them as undesirable sources of interference in governments' ability to plan and manage projects in their own way. Local government agents may see traditional organizations as rivals for the affections, loyalty and resources of the villagers and farmers. Or governments may see traditional organizations as imperfect entities which need to become more like standard national models. In rare cases, like Nepal or Bali, they make take traditional forms as models.

Philippines: On NIS and pump irrigation systems, the GOP ignores all traditional leaders and structures. On CIS, they begin with traditional organizations, but push hard to get them to conform to national IA standards of organizational form and content. In general the GOP and the NIA are mistrustful of traditional leaders and of traditional organizations and avoid building on them.

Indonesia: Like the Philippines, the GOI and the DPU prefer to avoid traditional organizations and leaders. They want their own organizations in the field, set up according to a national standard and answering to the DPU in return for a set of pre-established 'treats'. However, in many areas of Indonesia, strong indigenous organizations take over the WUAs and integrate them with other rural organizations.

Pakistan: The D/OFWM does not seek to graft WUAs onto traditional structures or use traditional leaders. But the feudal elite in most agricultural areas is so strong that they nearly always become WUA leaders. The D/OFWM and the GOP seem to have no objection this.

Nepal: The DOI in Nepal tries to begin its WUA programs on the basis of traditional organizations, if they exist. They try to push these traditional organizations to evolve into modern organizations, as defined in national policy documents.

Sri Lanka: The GSL and its implementing agencies (MEA, IMD) ignore the possible existence of traditional rural organizations in planning and executing FO programs in medium and large irrigation schemes. In small schemes, the DAS works with traditional village leaders and irrigation officials.

India: In India, as there is no formal recognition of WUAs, there is no national or even State-specific attitude to traditional structures and leaders. Different projects work in different ways with indigenous organizations and elites.

9. THE NATURE OF ORGANIZING EFFORTS: CONCEPT AND REALITY

WUA programs are meant to be participatory. They involve farmers in planning, designing, building their own irrigation systems and then in managing those systems. The host governments and the donors all subscribe to a participatory ideology about forming and strengthening WUAs. The ISPAN Team found a number of tendencies in the countries in the study that compromise the participatory nature of the organizing and strengthening efforts. As most countries in the study use a national standard model for WUAs and insist on its application, farmers ability to participate in the creation of appropriate organizations to meet their own needs is limited.

Philippines: The NIA approach espouses participation as the cornerstone of the IA program. In CIS systems, the bottom-up approach works well as long as the farmers agree to the rules: set up a WUA according to NIA regulations and forms. In NIS, where discipline is harder to enforce and common interests are harder to identify, the approach is quite top-down. NIA staff tell the farmers how to participate.

Indonesia: The DPU and its staff stick so closely to the national WUA model that the participatory system becomes quite non-participatory. The exceptions occur when strong local leaders manipulate the WUA program in their own interest and that of the members (see box).

In Bantul district of Jogjakarta, Mr. Sutedja, the head of the WUA (P3A) in Catu Hayo village in the Pijenan Irrigation System, is also the head of the Farmer organizations (Kolompo Tani) and of the Village Committee of the MHA. His WUA conforms to DPU rules about books and meetings, but also helps farmers with marketing their products and with access to inputs and credit. They organize religious ceremonies and social action as well.

Near Hyderabad, in Sindh Province, most irrigation systems rehabilitated by the D/OFWM are owned by one individual or one family. Mohammed Ismael, one such land-owner, told us clearly that he instructed his tenants to contribute the labor the D/OFWM required as counterpart contribution for the lining of his canals. He also said that he had accepted everything the D/OFWM told him to do in order to get his 'treat': an improved irrigation system.

Pakistan: The D/OFWM uses the local elites in most parts of the country to form WUAs for canal and structure rehabilitation and expansion programs. These elites participate in decision making about the construction programs, as they see clearly the interest of these programs for the community. For the majority of farmers, the approach is top-down (see box).

Nepal: Nepal endorses the participatory concept and in the large FMIS follows it well. In small FMIS and in most AMIS, the approach has been, to date, top-down. Even today, Nepal is building new irrigation infrastructure with World Bank (WB) financing without WUA programs in advance of construction. There are a number of pump irrigation projects where the DOI has installed infrastructure which is far too large and expensive to maintain. WUA members accepted this infrastructure but have so far refused to enter into the management turnover process. They know they cannot afford to keep up and fuel the pumps (Kapilvastu and Ramgunj Pump Irrigation Projects, for example).

Sri Lanka: Sri Lanka allows more flexibility in creating and structuring FOs than do the countries which prefer the WUA or water-based approach. Approach to farmers is generally participatory. This tendency is reinforced by Sri Lanka's tradition of strong rural participation in democratic elections.

India: Most WUA organizing goes forward under the auspices of Projects and NGOs. Approaches vary dramatically from State to State and project to project. India has experimented with explicit top-down methods and with very participatory approaches in some areas. India shares with Pakistan the concern with the role of local elites who often dominate local organizing efforts and reproduce feudal relationships in the WUAs.

10. NATIONAL STANDARD ORGANIZATIONS OR LOCAL OPTION

The ISPAN team was surprised during this study to find how consistently government agencies throughout the study area applied a national standard model conceived at the central government level to all WUAs throughout their countries. The justification offered everywhere for this approach was the same: irrigation systems are irrigation systems. Organization for O&M requires certain specific actions and a formal, standard structure for generating these actions is the approach easiest for field level civil servants to use. In the opinion of the study team, this 'one size fits all' approach (see box) cannot begin to meet the needs of the types of irrigators and farmers within any one of the countries in the study, much less across international boundaries.

> Imagine a shoe-store which only sells one size of one model of shoes. The chances are good that their goods will please no one's eye and hurt everyone's feet.

History, topography, scale, ethnography, economics, politics and a thousand other factors militate in favor of locally adapted models for

In Indonesia, a very dedicated and energetic NGO, LP3ES, administers WUA programs for USAID and the GOI, as well as for other donors in a wide range of settings. The ISPAN Team met them on the USAID-funded Small Scale Irrigation Management Project (SSIMP) in South Sulawesi. The LP3ES supervisor stated emphatically that they applied the GOI DPU model to the creation of WUAs in the SSIMP area and further specified that their training of field agents does not take into account the experience of LP3ES agents and programs elsewhere. All the same, interviews with farmer-leaders seemed to show that they intended to merge their WUAs with their Kolompotanis and cooperatives to help meet farmers needs for service snot directly related to irrigation systems O&M.

WUA or FO organizational approaches. Farmers who belong to successful WUAs have, throughout the study area, modified the national approach on their own. All too often this goes on behind the back of or in face of opposition from government agencies (see box).

Philippines: National Standard form and content

Indonesia: National Standard form and content

Pakistan: Provincial standards, but very small differences among provinces. Local bye-laws to accommodate local conditions are specifically authorized but little used.

Nepal: National standard but policy and laws allow local modification of the standard.

Sri Lanka: Each implementing agency (IMD, MEA, DAS) has its own standard form, but applies it quite rigorously. However, Sri Lanka's more flexible overall FO approach allows farmers full choice of the sets of activities they can undertake. This is particularly true in the Mahaweli, slightly less so in IMD systems and hardly true at all in the DAS minor systems where a standard organization form and set of activities is generally the rule.

India: No standards at all. Everything is left to the projects, NGOs and local or state governments to decide.

11. SOURCES OF FUNDING; COST RECOVERY POLICY; AND INVESTMENT LEVELS

The information in this category measures the importance of the irrigation sector to the host governments, as well as the extent to which they expect farmers to pay a share of the costs of their systems: both O&M costs and capital costs. This should help indicate the commitment of the governments to WUA-type programs.

Philippines: Funding comes from a combination of multilateral donors (WB, ADB), some bilaterals, local foundations, farmer fees and amortization costs, and GOP budgets: NIA, DA, BSWM, etc.

GOP policy, implemented principally by the NIA, calls for full O&M and capital cost recovery in CIS and pump systems. To date, there is no plan for capital cost recovery in NIS, though they do expect full O&M cost recovery in NIS.

The NIA pegs normal O&M costs at 10% of capital costs/year.

Indonesia: Funding comes largely from donor funding and from the DPU. Farmer fees cover small parts of O&M costs.

GOI policy calls for partial O&M cost recovery in ISF systems. No capital costs are recovered in any systems.

O&M levels are pegged at Rs. 30,000/year[1].

Pakistan: Funding is almost entirely from donors. D/OFWM budget is very limited and covers only personnel.

GOP policy calls for farmer contributions to system improvement or expansion up to the watercourse level: about 20-30% of the cost of civil works plus the unskilled labor required to do the work. There is no recovery of capital costs above the watercourse level. Traditional water duties exist, but are rarely paid.

O&M levels are pegged at 2.8% of capital costs each year, plus the cost of a watchman - about Rs. 1,000/mo[2].

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[1]. $1 = +/-2,000 rupees.

[2] $1 = 30 Pakistani rupees

Nepal: Funding is almost entirely from donor sources.

GON policy calls for partial capital cost recovery in participatory projects. In AMIS, policy calls for recovery of a variable but low proportion of O&M costs. In JMIS, they call for a higher proportion of recovery of O&M costs. In FMIS, farmers pay for all O&M but the government collects no ISF.

O&M levels are pegged at 700-800 Rs/ha for groundwater projects; 300-400 Rs/ha in the Terai; and 500 Rs/ha in the hills[3].

Sri Lanka: Funding is largely covered by donor projects and loans. ID, IMD and MASL budgets are significant but declining.

GSL policy includes a low water rate which would cover a small proportion of O&M costs. But this tax is not collected at present throughout the country. There is no capital cost recovery planned anywhere. If WUAs take over the D-canals, they can collect and keep ISF, but no contribution to main system O&M is anticipated at present.

O&M levels are pegged at Rs. 2,000/ha in the Mahaweli areas. This includes real costs for tertiary and main system/headworks O&M.

India: Funding is largely from State budgets but is thought inadequate. There is donor funding but in a smaller proportion than in other countries in the study.

O&M levels are pegged at $5/hectare.

[3]. $1 = 50 Nepali Rupees.

12. CROPPING ISSUES

The ISPAN team started from a hypothesis, formed from our collective experience and subsequently confirmed in the field, that farmers are primarily interested in agriculture and that they see water as part of a general system of agricultural production for profit. Their interest in and commitment to WUAs or other rural organizations should increase if those organizations contribute to their success at agricultural enterprise. The contribution of rural organizations to rural income and empowerment of rural people depends to a certain extent on the agricultural context in which farmers and groups of farmers work. This section and the one immediately following describe the agricultural conditions in the countries of the study and the policies which affect those conditions.

Philippines: Major crop: rice
Secondary crops: corn, legumes, vegetables

cropping intensities: 100-240%

returns on investment (ROI):
- rice: 40 - 80%
- corn: 30- 260%
- vegetables: 200 - 700%[4]

Terms of trade for farmers have declined at about 3%/year for the last ten years.

Philippine farmers have generally become worse off over the past decade, if they have grown low value crops, such as rice or legumes. Cropping intensities have remained stable, as have yields, while agricultural prices have declined relative to industrial and service sector prices.

Indonesia: Major crop: rice
Secondary crops: legumes, vegetables

cropping intensities: 200-300%

ROI:
- rice: 163%
- corn: 200%
- legumes: 421%
- vegetables: 373%

Terms of trade for farmers have declined at about 6%/year in 1992 and 1993.

The high returns to investment in staple crops in Indonesia reflect low costs of production, not high incomes. Farmers tend to have very small plots of land. Those who have grown staple crops have

[4]. These ROI figures, and those for the other countries in the study, assume that farmers earn a positive return on what they grow. All too often, crops fail and farmers lose money.

become worse off over the past few years. Yields and intensities have remained stable while agricultural prices have declined relative to prices in other sectors.

Pakistan: Major crops: wheat, cotton, rice
Secondary crops: sugarcane, fruit, truck crops

cropping intensities: 80-150%

ROI: very low for wheat. Higher but variable for cotton and rice.

Terms of trade for farmers have declined steadily over the past decade.

Much of Pakistan is arid and cannot grow rain-fed crops. Irrigation water is limited and many systems cultivate less than half their acreage in any given season. Like in Indonesia and the Philippines, farmers growing staple crops - wheat in this case - have become poorer over the years, while agricultural prices in general have risen far less rapidly than prices in other sectors. Yields in many areas are falling, while cropping intensities decline rapidly when system O&M fails.

Nepal: Major crop: rice
Secondary crops: wheat, maize, legumes, vegetables

cropping intensities: 153% - 191%

EIRR:[5] New large projects: 8%
DOI groundwater projects: 8-46%
Other DOI Projects: 4-16%
ADB/N: 46%[6]

Terms of trade for farmers have declined for the past several years.

Nepal suffers from the same agricultural conundrum as do the other countries in the study: those who grow the crops the country needs most become poorer in both absolute and relative terms if they grow those crops for the market. Those near good markets who grow high value crops do better.

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[5] The ISPAN team could not obtain ROIs on crops in Nepal. The Economic Internal rates of Return on projects reflect return to agricultural crops relative to the cost of the infrastructure.

[6] Agricultural Development Bank/Nepal

Sri Lanka: Major crop: rice
Secondary crops: legumes, vegetables, fruits

cropping intensities: 100-300%

ROI: rice - 130-150%
corn - 100-110%
legumes - 120%
vegetables 200-300%

Terms of trade for farmers have declined as much as 10%/year for the past 6 years.

In Sri Lanka, rice yields have reached a plateau and even declined, while cropping intensities have also declined in systems where O&M has proven inadequate. High ROI for rice and other low value crops reflect low costs of production. On small farms,these crops do not permit farmers to make an acceptable level of income (see box).

> The MARD project in Sri Lanka, funded by USAID, has worked since 1988 to improve farmers incomes in Mahaweli System B, using crop diversification as its major tool. MARD has collected field data about prices and returns in this isolated area since its inception. Returns to rice have remained within a narrow band since the project began (SL Rs. 14-18,000/ha) while annual inflation has run between 8% and 14%/year according to official statistics. Real rates are assumed to be higher.

India: Crops: great variation by agro-climatic zone

Cropping Intensities: 100-300%

ROI: Rice/wheat - 100-150%
oilseeds - 150-200%
sugarcane - 200 -300%
vegetables: very high but very variable

Terms of trade for farmers have declined steadily for several years.

India is the largest and most varied country in the study. It is very difficult to generalize about agricultural conditions here, but the same trends are observable as in the other countries in the study: farmers are becoming poorer, relative to the rest of the population.

All six Asian countries reflect the same lesson: farmers in traditional crops are getting poorer, no matter how well they farm. In theory, rural organizations which represent their economic and political interests should arouse their enthusiasm and support. If WUAs have not done so, then farmers do not find WUAs appropriate vehicles for their aspirations and the WUAs will die, as they have done so far, at the end of their utility. This period of usefulness is limited to the construction or rehabilitation phase of irrigation systems improvement projects.

13. GOVERNMENT POLICIES WHICH EFFECT WUAs AND THE AGRICULTURAL ECONOMY

If attempts to carry out agricultural development in Asia over the past 30 years have taught us anything, it is that government policies play a critical role in determining the development of the agricultural sector. The range of policy decisions which directly effect agricultural production goes beyond the sectoral issues which have direct effects on agricultural prices, production or profit margins. Agriculture is embedded in the national economy in the same way that irrigation infrastructure is embedded in the agricultural economy.

The ISPAN team tried to identify a small number of macro-economic and agriculture sector-specific policies which have a noticeable impact on production, prices and profits in agriculture. As WUAs are essentially associations of farmers trying to maximize returns to their investments, the set of policies implemented by the government should effect their sustainability and their performance.

The policies chosen for identification include:

1. Macro-Economic Policies:
   Food policy - Is food self-sufficiency a high priority goal?
   Investment in Infrastructure - Is the country putting growing amounts of resources into irrigation infrastructure
   Devolution/Decentralization - Is the government allowing real power, including financial authority to local governments and farmer groups
   Exchange rates - Is the government trying artificially to control international exchanges and consumer preferences through manipulation of the exchange rate?
   Trade policy - sectoral orientation - Does the government impose hidden taxes on agricultural exports or on domestic sales by its trade policy?

2. Agriculture Sector Policies
   Output prices - Does the government support or control prices of farm produce?
   Input prices - does the government subsidize or over-tax agricultural inputs, including credit?
   Water Resource Use Priorities - Is irrigation high on the priority list for sectoral allocations?
   Membership in WUAs - can only land-owners join?
   cropping choices - can farmers choose what they want to plant and when?
   Land markets - is land a commodity or are sales and other transactions controlled?
   Incentive channels - how does the government get 'treats' to the farmers and WUAs? Is there a preferred channel?

Philippines: In the Philippines, the effect of macro and sectoral policies on WUAs seems mixed. On the whole, policies do not encourage WUAs to become sustainable as the immediate effect of most policies is to keep returns to irrigated agriculture low. Chances for WUAs to take advantage of economic opportunities is limited by emphasis on food self-sufficiency and an over-valued exchange rate.

MACRO-ECONOMIC POLICIES

Food Policy: The GOP puts a high priority on rice self-sufficiency. This has two contradictory effects. First, the GOP tries to get farmers to grow rice, even if returns to rice are inadequate to let farmers make a decent living. Second, the GOP tries to restrict rice imports to keep domestic prices relatively high, compared to international market standards.

Investment in Infrastructure: GOP and donor funds for the construction and rehabilitation of irrigation infrastructure in the Philippines are shrinking. Levels have declined significantly over the past decade. Remaining investments are largely demand driven. The GOP responds to the requests of farmers and farmer groups for the improvement and expansion of irrigation systems.

Devolution: The GOP has effectively devolved much power, including financial power to local government units throughout the country. However, the NIA has remained a centrally directed and funded activity. NIA local offices can collect ISF and use the money for local works. But they submit all receipts to the central NIA treasury before spending them.

Exchange rate: The Philippine Peso seems overvalued by about 25%. This works against agriculture by making exports relatively expensive on the world market. It should help keep imported good cheap, promoting competition from other agricultural countries. A most agricultural inputs in the Philippines are produced domestically, cheap imports do not help farmers or WUAs.

Trade policy:	In general, trade policy seems biased against agriculture and in favor of the promotion of industry.

SECTORAL POLICIES

Output prices:	The GOP legislates support prices for major commodities, such as rice and maize. But budget allocations to the National Food Authority are insufficient, so these support prices are totally ineffective.
Input prices:	Farmers buy all inputs at market prices. Farmers can receive a slight subsidy on interest rates for loans via an ADB program administered through the cooperative system.
Water Resource priorities:	The GOP does not have set priorities. Sectoral assignments of quotas are needs-based and subject to constant negotiation. This effects NIS, where water may be diverted for urban, industrial or hydro-electrical uses. CIS most often control their own water sources.
Cropping choice:	Free but cultivation of staples is encouraged to the extent possible.
Land market:	Free. Land can be sold, mortgaged, leased at the will of the owner. Laws to protect tenants exist but seem ineffective.
Incentive channels:	The GOP under the Aquino government channeled most incentives to farmers through the cooperatives. The only exception has been funds for irrigation system rehabilitation, the distribution of which depends on the establishment of WUAs on the NIA model.

Indonesia: GOI policies, both macro-economic and sectoral, generally favor agriculture. In many areas, WUAs have taken advantage of this environment to take advantage of economic opportunities of different kinds. However, GOI WUA formation and strengthening methods, as well as sectoral egoism, have tried to limit WUAs to water-related activities only.

MACRO-ECONOMIC POLICIES

Food Policy:	The GOI places great importance on rice self-sufficiency. Many local government agencies work to restrict farmers' cropping choices in order to promote rice production. This restricts the income generating possibilities of irrigated agriculture and thus of WUA members.
Investment in Infrastructure:	GOI and donor resources devoted to irrigated agriculture remain quite high and are growing. The GOI continues to make many supply driven investments, putting new or expanded infrastructure where the government thinks it will do the most good.
Devolution:	The GOI has very effectively decentralized many functions, including collection and use of revenues. This helps WUAs develop partnerships with local institutions which make decisions effecting WUA members' activities.
Exchange rate:	Market level. The GOI avoids economic and price distortions based on artificially over- or under-valued exchange rates.
Trade Policy:	The GOI is moving quickly to free trade in all commodities, including agricultural products and inputs. It is less restrictive than the Government of the Philippines and lets farmers and groups of farmers make cropping and investment decisions based on real economic factors.

SECTORAL POLICIES

Output prices:	The GOI legislates support prices for most staple commodities and assigns enough resources to the program to make the support prices generally effective.
Input prices:	While credit is generally available at market rates only, other inputs are subsidized: fertilizer, seed, etc. Under donor pressure, these subsidies have declined in recent years.
Water Resource Use Priorities:	Until recently, irrigated agriculture was the first priority for the allocation of scarce water resources. This is no longer the case. Agriculture must now compete with the urban, industrial, and hydro-electric sectors for its share of the water.
Cropping choice:	In theory, farmers are free to plant what they want. In fact, local authorities often impose cropping patterns which emphasize crops useful to the nation but which give farmers poor returns.
Land Market:	All transactions involving agricultural land are allowed under national law.
Incentive channels:	The GOI promotes sectoral egoism among its agencies by giving each one a set of 'treats' to offer to farmers and groups of farmers such as WUAs.

Pakistan: The GOP macro-economic and sectoral policies generally favor industrial development over agriculture. WUAs and their members do not find that the GOP overtly favors the development of income generating opportunities for farmers.

MACRO-ECONOMIC POLICIES

Food Policy:	The GOP has no overt food policy but generally works to try to ensure self-sufficiency in wheat. For other crops, self-reliance is the objective: to earn enough from exports to cover the costs of food imports.
Investment in Infrastructure:	The trend in investments in irrigation system improvement and construction has declined in recent years. Most expenditures are supply-driven.
Devolution:	The GOP has decentralized irrigation and agricultural operations to the provinces. quite effectively. But the provincial government have not yet effectively transferred any real power to local governments. For most WUAs, this means that devolution has no real meaning.
Exchange rate:	Market level. No distortions are introduced through the manipulation of access to foreign exchange.
Trade policy:	GOP commercial policy works against agriculture and in favor of industry. In effect, the GOP taxes agriculture to generate the resources to protect industry.

SECTORAL POLICIES

Output prices:	Support prices exist but are generally below the free market price. Most crops are effectively sold at a market rate, but at one which is held down by the GOP floor price.
Input Prices:	Only credit and potash fertilizer receive subsidies. Other inputs sell at market rates.
Water Resource Use Priorities:	In Pakistan, 93% of all water is used for

	agriculture. Nonetheless, allocation is needs-based and each sector negotiates with the government for its allocation.
Cropping choice:	Free
Land Market:	Free
Incentive channel:	Every government department has its own set of 'treats' to offer the farmers. No single channel dominates.

Nepal: The GON has established a policy environment which generally favors agricultural development. This should also favor WUA performance and sustainability.

MACRO-ECONOMIC POLICIES

Food Policy:	The GON seeks food self-sufficiency and thus encourages the expansion of irrigated hectarage for basic, staple crops. The country also promotes the export of agricultural commodities to the extent its difficult geography permits.
Investment in Infrastructure:	GON and donor funds for irrigation infrastructure have declined in the past several years. Much of current investment is demand driven, especially in FMIS.
Devolution:	Nepal has begun an extensive program of decentralization of all government functions. To date, however, the technical ministries, such as irrigation, have retained complete managerial and financial controls at the center. Administration, on the other hand, is quite effectively decentralized. FMIS exercise almost complete control over their resources, including ISF collection and use.
Exchange rate:	Market levels.

Trade policy:	Nepal's trade policy is very dependent on the country's relationship with India. Trade is generally quite free, though tariff and subsidy levels depend to a large extent on those of India. There seems to be no sectoral bias against agricultural trade.

SECTORAL POLICIES

Support prices:	The GON has them, but they are generally ineffective. Most crops sell at market rates below price support levels.
Input prices:	The ADB/N offers subsidized credit to farmer cooperatives and to individuals. The GON subsidized urea, but not other fertilizers. Agro-chemicals are sold at market rates. Seed production is subsidized though imported seeds are sold at market prices.
Water Resource Use Priorities:	Nepal has an official policy on sectoral water use priorities: Domestic use is first, irrigation second.
Cropping choice:	Free
Land market:	
Incentive channel:	Each government agency has its own 'treats' to hand out. There is no preferred channel.

Sri Lanka: The GSL has enacted a series of policies which favor agricultural development and at the same time open opportunities for FOs to increase their income and those of their members.

MACRO-ECONOMIC POLICIES

Food Policy:	In recent years, the GSL has moved from an absolute priority on rice-self-sufficiency to an overall policy of food self-reliance. This has opened the way for crop diversification for a number of farmers and FOs and for new income opportunities.

Investment in Infrastructure:	GSL budget allocations for irrigation systems construction and rehabilitation have dropped dramatically in recent years. Donor support has also waned. Most investment is supply driven, based on GSL priorities.
Devolution:	The Provincial Councils have taken over much of the administrative work associated with government, as well as the field staff of many technical ministries. The Irrigation Department and the IMD continue to report to their central agencies, however, while the Mahaweli systems, as interprovincial systems, are entirely outside the decentralization program..
Exchange rate:	The SL Rupee floats in relation to a basket of currencies, led by the dollar. Most analysts feel that the float reflects the real value of the currency and that no distortions come into the economy via the exchange rate or via foreign currency controls.
Trade Policy:	The GSL trade policy promotes export a exports of fresh or processed food products. Import licenses for selected crops provide protection for domestic production at certain times of the year (e.g. rice, onions), in spite of occasional speculation and abuse of these licenses.

SECTORAL POLICIES

Output prices:	The GSL sets a floor price for paddy but is unable to provide the resources to back up this price. Most paddy and all other crops sell at market prices. The GSL occasionally uses import controls to control agricultural prices.
Input prices:	The only subsidy remaining on agricultural inputs is in the field of credit. The state-owned banks (Bank of Ceylon, People's Bank) on-lend Central Bank funds at below-market rates to eligible farmers. All other inputs are sold at market prices.

Water Resource Use Priorities:	The GSL has not set official priorities for water use, but electrical power generation and irrigation are the primary competing sectors. In times of drought, the GSL has cut power in order to keep water flowing to the irrigated areas during rice production seasons.
Cropping choice:	Officially, farmers can grow what they like, but the extension service, input supplies, and marketing/processing infrastructure supports paddy cultivation. Combined with GSL emphasis on the importance of paddy, especially outside of Colombo, there is a good deal of pressure on farmers to grow rice for the nation.
Land Market:	In Major Schemes the agricultural land market is very limited. In the Mahaweli, for example, allottees may not sell, lease, rent or otherwise alienate their land. They also may not subdivide or give away their land. Banks do not generally accept agricultural land as collateral for loans, as taking it over would prove impossible, both literally and politically.
Incentive channel:	In the past, most agencies in the field had their own advantages to offer to cooperating farmers, the GSL now tries to channel all its programs through FOs.

India: The ISPAN team did not cover Indian policies in the same way as they did in the countries they visited. India has a national water policy which stresses farmer participation in irrigation and better use of water resources. The GOI has committed itself to export agriculture and to the privatization and commercialization of agriculture in general. India has support prices for most major crops and allocates the resources needed to avoid price crashes at the time of post-harvest glut. Most inputs are subsidized, as India has set itself the goal of complete food self-sufficiency.

14. THE NATURE AND SOURCE OF SUPPORT SERVICES

The self-sufficient farmer cannot be found on irrigation systems in Asia. Farmers borrow money. They buy fertilizer, seeds and chemicals. They keep abreast of new crops, new varieties, new techniques and new markets. They collect information on the investment of surplus capital and on adding value to their harvest. In different places farmers get these support services from different sources: government agencies and parastatals, NGOs, private firms, associations, or their fellow farmers.

The ISPAN team noted that in most cases where government supplies support services to farmers, the farmers have to accept what is on offer or do without. This is a classic sellers market for services. Farmers pay in obedience, respect, hospitality, gifts, even bribes. When farmers organize, they can transform the market for services into a buyers market. A farmer group in the Philippines (Cavite) purchased O&M services from the NIA in such a way that farmers set the schedules and nature of the work done. Other examples show the same phenomenon in the markets for agricultural inputs, even extension services.

In general, the ISPAN team felt that the more available sources for support services, the more power farmers could exercise in buyers' markets. In consequence, getting services from private sources tends to promote the need for negotiation among alternate suppliers. This promotes the need for WUAs or FOs and thus contributes to the sustainability and performance of the organizations.

> In Mahaweli System 'B', the USAID-funded MARD Project helped start the islands first relationship between a gherkin grower and exporter and small-farmer outgrowers. When another private grower in System 'B' saw how well the outgrower relationship worked, he tried to capture the first grower's farmers by offering a better deal. The first grower kept his farmers by a combination of good extension work, timely supply of inputs and fair pricing. The outgrowers worked together, under MEA and MARD auspices to negotiate their fidelity to the first grower.

Philippines: Technical assistance, such as O&M, comes almost entirely from the GOP, but other support services come from a wide variety of private and parastatal sources. Credit is difficult to obtain outside the cooperative movement, but most other inputs come from the private sector. Some agro-chemical and fertilizer companies have begun to carry out their own extension work. Projects like the USAID-funded ASAP (Agribusiness Support) help farmer groups get together to negotiate with buyers for their common production and to hire processing services. Nearly all output sales go to the private sector.

Indonesia: The GOI provides almost all support to farmers. Sectoral egoism keeps some sense of competition alive, but farmers are very much in a sellers market for services. They take what they can get and seem to expect relatively little. The private sector supplies certain inputs such as agro-chemicals and vegetable seed and purchases a good part of the harvest of most crops.

Pakistan: The GOP provides all support services except pesticides, fertilizer, and agricultural; machinery. All TA except that related to agro-chemicals comes from the GOP. Output purchasing is through the private sector, except for about 25% of the annual wheat crop.

Nepal: The GON provides most support services in most areas. This support is erratic and unpredictable. The private sector has begun selling agro-chemicals and one or two companies do extension and demonstration work related to their company's products. Agricultural credit comes large;y through the state-owned ADB/N, but some private banks have recently begun making some loans for agricultural production and marketing. DAP fertilizer supply is also in private hands.

Sri Lanka: In most areas of Sri Lanka, farmers get their support services, with the exception of credit, from the private sector. With the exception of the Mahaweli areas, the only farmers in Sri Lanka who receive regular extension visits and training are those who produce as out-growers for private firms of growers, packers or exporters. These include growers of gherkins, melons, tobacco, and other vegetables. Credit for crop production comes mainly from the state-owned banks, but private banks (Hatton National, Ceylon) have begun lending programs to individuals and to FOs. The GSL encourages the private sector to take over the provision of support services it can no longer afford to provide.

India: The government and the private sector provide support services of almost all types in all States. Only credit remains dominated by state lending institutions. But even these loans are often distributed through private channels.

Overall, the countries in the ISPAN study seem to be moving toward private sector provision of essential support services to the agricultural economy. Certain essential support services remain in the hands of government: sectoral water allocations, main system O&M, transport and communications networks. But the tendency toward private provision of support services should promote the healthy development of WUAs and FOs in the future.

15. INDICATORS OF SUCCESSFUL WUA PROGRAMS

The final set of comparative dimensions which the ISPAN Team collected during our field visits had to do with how the countries in the study measure the progress of their WUA programs. As nearly all the agencies we visited felt their programs had achieved a good deal of success, these indicators take on a good deal of importance. We hoped to find methods to measure the impact of the WUA programs on the performance and sustainability of the organizations themselves and the irrigation systems they grow up to serve.

This was not often the case. Mostly, we found indicators of conformity to rules and regulations (meetings held, books kept, etc.), measures of inputs and outputs (meters of canal lined, ISF paid, etc.), or no indicators at all. Only the Philippines had attempted to develop impact indicators.

Philippines: The NIA uses three indicators of the impact of WUA programs. These indicators are original and thought-provoking. But the ISPAN team felt that they did not measure the impact of WUAs. A system such as Friar Lands NIS, which has no WUA, ranks very high on these indicators. Another, like a distributary organization in Upper Pampanga, a large NIS, would rank very low but seemed to have a dynamic, rather effective WUA.

1. cropping intensity - higher is better. Cropping intensity depends on accumulation of individual decisions about resource availability, investment choices, potential markets, as well as on collective water system O&M. Increasing cropping intensity is a good thing, but it does not measure the strength (or weakness) of a WUA. If there is little water, even the best maintained system, managed by the best run WUA will not help increase the cropping intensity.

2. ISF Collection Efficiency - higher is better. The WUA-less Friar Lands NIS collected over 100% of the ISF it owed, but had no WUA. NIA staff go from farmer to farmer to collect the money, which all pay willingly in return for O&M services rendered. On the other hand, some CIS with very useful WUAs (e.g. Cusa Rica, in Central Luzon, near Munoz) do not collect much ISF. They prefer to do the work themselves and invest their collective surplus in productive ventures, like input marketing, credit, or shared transport.

3. System Viability - In the NIA, this means that the System collects more ISF than it costs to maintain the system. Once again, this is a useful measure, but not of WUA viability or sustainability. The NIA notes a large number of cases of WUAs which pay high ISF rates at first, then taper off over the years.

In conclusion, the NIA has advanced well beyond other Asian implementing agencies in the development of indicators of WUA performance. However, these indicators do not really measure WUA sustainability or usefulness directly.

Indonesia: The DPM and its training and monitoring arm, the PTGA, use a long list of indicators of WUA viability and performance. These indicators measure bureaucratic compliance and record-keeping more than anything else. The PTGA monitoring program measures only how well WUAs follow the implementation details of the PTGA program. Examples include: do the WUAs keep all 21 books the PTGA has trained them to keep? Do they elect officers? Do they hold regular meetings and keep notes? etc.

Pakistan: The D/OFWM uses a long list of physical and financial performance indicators to measure the success of their WUA program. They keep track of farmer contributions in money and labor, of meters of canal lined, bags of cement used, mason-days paid for, etc. These measurements are consistent with the general approach of the D/OFWM: get the canals in shape, with the help of the WUAs, then let the WUAs fade away. The indicators in use measure construction progress and efficiency, not WUA performance.

Nepal: Nepal's DOI uses physical and financial measurements similar to those in use in Pakistan. They also measure the increase in irrigated hectarage. As a measure of DOI performance, the latter is useful. For any given WUA and increase in hectarage depends as much on water availability as on WUA effectiveness. In many cases an increase in hectarage may vitiate the effectiveness of a traditional FMIS WUA. The DOI in Nepal recognizes that no real work has been done to develop impact indicators. This ranks among their highest priorities.

Sri Lanka: Sri Lanka at present uses indicators of bureaucratic conformity as well as physical and financial measurements when construction programs are underway. The USAID-funded ISM Project developed an elaborate M&E system with hundreds of indicators, but the system was too cumbersome to use effectively. The MEA and the IMD/ID recognize that they need a better system of indicators to measure the impact of their programs on strengthening or creating FOs. They are working on this problem now.

5

WASTEWATER REUSE

DR. HILLEL SHUVAL, PANEL PRESENTER

* DR. HILLEL SHUVAL, born in Washington D.C., settled in Israel in the early years after the founding of the State and joined the staff of the Ministry of Health where he served as Chief Environmental Health Engineer until 1965.

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WASTEWATER RECYCLING AND REUSE IN WATER RESOURCES MANAGEMENT UNDER CONDITIONS OF SCARCITY IN THE MIDDLE EAST AND ASIA

Abstract of Panel Presentation
by
Dr. Hillel Shuval

BACKGROUND

A number of the countries in the Middle East and Asia will face severe water shortages which may bring them to well below the so called "water stress" level. For example, within a 30 year period, with an estimated doubling of their population, the Jordanians, Israelis and Palestinians will have available to them, from their current water reserves, just about the limit of what is needed for survival based solely on domestic, urban and industrial use, with no fresh water available for agriculture.

For such peoples in arid regions and others, the recycling and reuse of about 65%-80% of the waters supplied for urban/industrial use can often generate the only significant additional low cost water resources for agricultural/industrial and urban non-potable purposes.

CRITICAL ISSUES

Desalinated sea water, estimated to cost about $1.00/CuM, will not normally be economically feasible for agricultural use. There are a few Middle Eastern countries that are using highly subsidized desalinated seawater for growing grain and other agricultural crops at real costs several times that of the world market price. This practice is explained by these countries under a concept of "food security". This can hardly be seen as an economically sound or sustainable water/agricultural policy in the long run.

In those countries facing the most severe conditions of "water stress", priority in the allocation of renewable fresh water resources should go for domestic, urban,and industrial use. As populations grow and natural sources of renewable water are depleted, desalination may become a logical and economically feasible source of water for urban and industrial use. Urban users and many types of industry can normally afford the price of desalinated seawater.

Under such conditions, recycled wastewater is the only water resource whose quantity will continue to increase as more and more water is used by the urban/industrial sector and can thus provide a rational and sustainable basis for limited agriculture, in such severely water short countries. It is estimated that a Minimum Water Requirement (MWR) of 125 cubic meters/person/year(CM/P/Yr) is needed to support a reasonable level of urban life with employment based mainly on commerce and industry with no allocation of fresh water for agriculture. If total urban/industrial water consumption is 125CM/P/Yr and 80% is recycled, it would thus be possible to generate an additional 100 CM/P/Yr for agriculture or other purposes. This can provide a significant amount of water for a limited but sustainable agriculture. It is more than enough water to cover most of the local fresh food crop needs.

The capital investment in sewerage infrastructure is high, about \$300-\$500/person, which means that an investment of as much as \$500 million dollars/million urban residents will be required. However, in densely populated countries, a high level of wastewater collection and treatment is essential, in any event, to protect the public health and to prevent environmental pollution. Enteric diseases, mosquito borne disease, and severe environmental and ecological hazards and nuisances can result from the lack of an effective central sewerage system and the absence of adequate wastewater treatment prior to disposal into the environment. The cost of central sewerage systems and wastewater treatment to meet the requirement of safe and effective health and environmental protection should be seen as part of the cost of supplying safe water for urban and industrial use, and should be covered by those consumers.

Thus, the additional marginal cost of treatment, storage and conveyance of purified wastewater required for unrestricted agricultural reuse, meeting the WHO health criteria will be only a fraction of the total wastewater treatment and disposal costs, or about \$.10/Cu.M. out of a total of \$.35/Cu.M..

SOME ACTIONS BEING TAKEN

The newly developed health guidelines for wastewater recycling and reuse developed by the World Health Organization in cooperation with the international community and the United Nations agencies are based on extensive research, on sound epidemiological evidence and engineering feasibility. These quidelines restrict the number of disease causing helminth (worm) eggs to none in 10 liters of effluent and the fecal coliform bacteria to 1000/100ml. An effluent meeting such microbial quidelines can often be achieved in warm, sunny regions, where sufficient land is available, in low cost, effective and easily operated multi-celled stabilization ponds with 25-30 days of detention, which do not require expensive equipment or outside energy.

The 1992 USEPA/USAID Guidelines for Water Reuse prepared for them by one of the well known American consulting engineering firms are a much stricter version of the early strict Wastewater Irrigation Standards promulgated by the California State Health Department in 1948. These new USAID guidelines call for zero coliform bacteria in the wastewater effluent which is similar to the requirement for the microbial quality of drinking water. In order to achieve these USA Guidelines it is necessary to construct high-cost/high-tech conventional energy and equipment intensive plants, followed by additional treatment processes such as sand filtration and disinfection. Such high-tech treatment systems require a highly trained staff of operators and a sophisticated technical infrastructure to assure sustainable treatment. Despite the claims of the consulting engineering firms, it is highly questionable that such types of treatment would be technologically or economically feasible for developing countries. In reality, many developed countries, including areas of the USA, find it difficult to assure the continuous efficient operation of such plants. Never-the-less USAID has distributed the US Guidelines to all of the developing countries in which they operate.

These new American Guidelines are apparently based on the "zero exposure=zero risk" concept without adequate public health or epidemiological evidence to justify such a restrictive policy. For example, few if any of the natural rivers used without any restrictions for unregulated irrigation in the United States or elsewhere in the world could meet these standards. Even the microbial standards for seawater, at bathing beaches for human body contact sports, allow between 100-1,000 coliform bacteria/100ml. The California Standard has been copied by many of the developing countries, but since they are so expensive to meet, little or no progress has been made in achieving any reasonable treatment of wastewater which is used widely in the Third World countries to irrigate vegetables without any treatment at all.

Countries now actively considering developing a wastewater recycling and reuse strategy would be well advised to use their own judgement in establishing wastewater irrigation standards. They should carefully consider the international quidelines established by the World Health Organization which provide a high level of health and environmental protection and which are achievable with economically feasible and sustainable technology.

In conclusion, recycling and reuse of wastewater for agriculture, industry and urban non-potable reuse can have the multiple benefit of an effective strategy of environmental protection and water resource conservation.

WASTEWATER RECYCLING AND REUSE IN WATER RESOURCES MANAGEMENT UNDER CONDITIONS OF SCARCITY IN THE MIDDLE EAST AND ASIA

Dr. Hillel Shuval

INTRODUCTION

Emerging Water Short Areas in the Middle East

A recent study by Population Action International (1) has reported on the annual renewable fresh water available per person for 100 countries based on data available for 1955 and 1990 with extrapolations as to estimated available water in the year 2025, assuming certain increases in population with no change in the total available renewable fresh water resources (See Table 1).

As can be seen from Table 1, many countries in the Middle East now face or will be facing severe water shortages as their populations grow and their water resources remain fixed. The data from the P.A.I. study (1) are presented here for comparative purposes, but experts in any given country's water resources may not be in full agreement with these figures, drawn from official United Nations and World Bank sources. For example, according to my own studies (2), the 1990 figure for Israel is closer to 300 cubic meters/person/year (CM/P/Yr) while the extrapolation to the year 2025 should be about 150 CM/P/Yr. I also calculated that the 1990 figure for the Palestinians (not included in the P.A.I. study) at about 160 CM/P/Yr which will go down to 60 CM/P/Yr by 2025, if they continue having available to them only the water resources that they currently are using. Of course they are presently in the process of negotiating for a larger share of the transboundary ground and surface water from their neighbors, Israel and Jordan.

Actually, the situation may be more severe than as presented in Table 1, since it is not unlikely that there be will be an effective decrease in water resources available, for a number of important reasons. One serious and ubiquitous reason for the decreased availability of water for specific uses is the continual degradation of water quality as a result of growing contamination from urban and industrial wastewater and increasing water pollution caused by runoff and drainage from agricultural areas carrying toxic agricultural chemicals and brackish irrigation water return flows. Such changes in quality can reduce the utility of the available water resources by making portions unsuitable for domestic water supply and/or agricultural use. In effect this results in a reduction of the quantities of water available to meet specific essential demands.

Another possible cause of a decrease in the available water resources for certain countries may be the result of increasing demands for a greater share in water allocations by other neighboring countries who draw upon the same transboundary water resources on international river basins. There are a number of such disputes over water rights in the Middle East, such as between Ethiopia and Egypt; Turkey, Syria and Iraq; and Syria, Jordan, Israel, and the Palestinians.

The question that must now be addressed is: How much water does a nation living in an arid zone actually need to assure a reasonable level of economic development and human welfare?

TABLE 1

ANNUAL RENEWABLE FRESH WATER AVAILABLE PER PERSON IN MIDDLE EASTERN AND SELECTED COUNTRIES RANKED BY 1990 AVAILABILITY (1)

COUNTRY	RENEWABLE FRESH WATER IN CU.M./PER/YR (CM/P/YR)		
	1955 CM/P/Yr	1990 CM/P/Yr	2025 (MEDIUM) CM/P/Yr
DJIBOUTI	147	23	9
KUWAIT	808	75	57
QATAR	1,427	117	68
BAHRAIN	627	179	89
U.ARAB EMIRATES	6,195	308	176
SAUDI ARABIA	1,266	306	113
JORDAN	906	327	121
YEMEN	1,098	445	152
ISRAEL	1,229	461	264
TUNISIA	1,127	540	324
ALGERIA	1,770	689	332
LIBYA	4,105	1,017	359
MOROCCO	2,561	1,123	590
EGYPT	2,561	1,123	630
OMAN	4,240	1,266	410
CYPRUS	1,698	1,282	996
LEBANON	3,088	1,818	1,113
IRAN	6,203	2,025	816
SYRIA	6,500	2,087	732
TURKEY	8,509	3,626	2,186
IRAQ	18,441	6,029	2,356
UNITED KINGDOM	2,344	2,090	1,992
CHINA	4,597	2,427	1,818
GERMANY	2,843	2,516	2,284
FRANCE	4,260	3,262	3,044
SWITZERLAND	10,040	7,449	6,492
UNITED STATES	14,934	9,913	7,695

Minimum Water Requirement for Survival in Arid Areas

The Debate over the "Water Stress" Index

The question of the amount of water required by peoples living in arid zones has been widely discussed and debated. Falkenmark (3) has defined the concept of a "water stress index" based on her estimated minimum level of water required per capita/year to maintain an adequate quality of life in a moderately developed country in an arid zone. Falkenmark estimates that, while only 100 liters/person/day (or 36.5 CM/P/Yr) are the rough minimum for basic household needs required to maintain good health, a water efficient and moderately developed country requires at least 30-45 times that quantity to satisfy all the requirements of agriculture, industry and energy production.

Thus, according to Falkenmark, a level of 1,700 CM/P/Yr is considered adequate. However, she holds that when fresh water availability falls below 1,000 CM/P/Yr, countries experience "chronic water stress" and when countries fall below 500 CM/P/Yr, they experience "absolute water stress". Falkenmark's pioneering concept of "water stress" has been much debated and the numerical levels suggested have been challenged. However, a number of authorities including the World Bank (4) have accepted the 1,000 CM/P/Yr level as a benchmark which they claim can serve as a general indicator of water scarcity. Gleick (5) has called it the "approximate minimum necessary for an adequate quality of life in a moderately developed country". However, all of these authors assume that a major allocation of water is necessary for agricultural purposes both to supply local food requirements and/or assure employment for those who have traditionally lived in rural areas and made their livelihood from agriculture.

In some countries in arid areas where supplemental irrigation is required and sufficient water is still available, as much as 80% of the water supply is utilized for such agricultural purposes and some 70-80% of the population derive their livelihood from agriculture, directly or indirectly. Can this ratio of water allocation to agriculture continue as populations grow, along with rapid urbanization and with the water resource potential remaining the same?

Some countries profess that their national agricultural policy is based on a concept of "food security" which dictates self-sufficiency in most food products as a matter of national security. They claim that this is necessary in case of a long term embargo, siege or blockade which would prevent food imports. A few oil rich countries have embarked on a program of seawater desalination for agricultural use on the basis of just such a "food security" policy.

It has been reported that the motivation, in part, of certain oil rich countries to initiate programs of "food security" resulted from an unofficially reported statement by someone in one of the main oil importing countries, which also is one of the main wheat exporting countries, suggesting that there might be a grain export embargo in response to the oil embargo initiated by the oil exporting countries during the late 1960's. Such a grain embargo was never actually initiated. It is not clear whether those countries who initiated programs to grow grains with desalinated seawater to meet local grain demand, so as to achieve " food security", carefully evaluated the alternatives for achieving the same goal. One alternative might be to build cold storage warehouses and grain silos capable of storing most of the food requirements to meet periods of need. The Bible records that one of the Pharaohs of Egypt did just that when he built grain silos over 3 thousand years ago. It is indeed difficult to comprehend the rationale of one of the countries that built desalination plants to produce water for irrigation and to achieve "food security" that now has become a major grain exporting country, at a tremendous cost to its weakened national treasury which subsidizes the grain.

What about those less prosperous countries that do not have enough renewable fresh water supplies for agriculture? Is economically and socially rational to desalinate seawater so as to grow crops, including wheat for local consumption and even export, when the actual cost of the locally grown subsidized wheat is 5 times that of the world market price? The modern rational economic approach to this question is that countries with little water should import most of the high water consuming food they need, particularly the staples which can be shipped easily and stored for longer periods, from those countries with plenty of water from natural renewable sources and sufficient areas of arable land.

It is difficult to accept these concepts and numbers of "water stress" as being applicable for the really water scarce areas of the Middle East. The view of persons in the Middle East on concepts of adequate amounts of water should be quite different from that of persons from countries with plentiful amounts of year round rainfall, rivers for hydroelectric power production and transport, and copious sources of low cost water for supplemental irrigation.

The 1,000 cubic meter benchmark level supported by some authors from the countries with more temperate climates assumes that major amounts of water must be used for agriculture. However, as we have shown previously in Table 1 there are a number of Middle Eastern countries who are already well below the 500 CM/P/Yr level and are at, or are approaching, the 100-200 CM/P/Yr level. After the urban and industrial demand is fully met, such countries have little if any water left over for agriculture. With time, that list will grow.

The question that must be asked is: Can countries facing such severe water shortages, and whose main option for increasing water supplies is seawater desalination costing about $1.00/CM, consider agriculture as an essential endeavor or an economically rational way to use such expensive water? When water is really scarce, the first task is to meet the needs for domestic and urban use as well as the water needed by commerce and industry so as to supply employment for the population.

What is the real minimum amount of water for community and national survival under arid area conditions?

The "Minimum Water Requirement" - MWR for Arid Zones.

A number of Middle Eastern countries are already facing situations under which the available water supplies are now sufficient only to support most of the population in urban settings where trade, commerce and industry are the main sources of employment, such as the situation in such water and land scarce places as Bahrain, Hong Kong and Singapore. As populations grow in the future, and the urban/industrial demands for water grow, the relatively limited quantities of water available for agriculture, whose economic return per unit of water consumed is relatively low, will have to be used to cope with the growing demands of the urban/industrial sector which can pay a much higher price for water. Unless water is supplied to meet these urban, commercial and industrial needs, there is likely to be serious unemployment as well as social and even political unrest.

How much water is required for a reasonable standard of living to meet domestic/urban/industrial demand? In the United States the USEPA reported that in 1981 (6), the mean annual household water use was about 90 CM/P/Yr. Total urban use is usually twice that figure or about 180 CM/P/Yr. Some urban areas consume as much as 300 CM/P/Yr. In the water rich areas of Europe which support a high standard of living, domestic/urban/industrial demands are lower than in the United States and range between 100-150 CM/P/Yr/.

Experience in Israel indicates that a high standard of life can be maintained with a domestic/urban/industrial water consumption of about 100 CM/P/Y. This has been achieved by water metering, charging for the full combined cost of water supply and wastewater collection and disposal as part of the urban water bill, punitive increases in prices for overly high domestic water consumption as well as public education on water conservation. Water conservation measures such as the introduction of water saving fixtures in the home, and requiring all industries to recycle cooling water and process water wherever technologically feasible has been partially successful. It has been estimated in Israel that this figure might increase to 125 CM/P/Yr within a 30 year period (2).

In one study in the United States (6) it has been estimated that the potential water savings that would result from the rigorous introduction of water saving devices in the home could be as great as 33% resulting in a mean household water use of 60 CM/P/Yr. For example with proper water saving devices the amount of water used for toilet flushing alone could be reduced by 50% or by about 16 CM/P/Yr. These studies indicate that domestic water consumption can be kept low while maintaining a very high standard of living.

As a preliminary estimate for planning purposes in arid Middle Eastern countries I have proposed that the minimum water requirement (MWR) for survival in urban/industrial communities in the severely water short areas of the Middle East be assumed at the 125 CM/P/Yr level (2).

In the earlier stages of urban/industrial development such a quantity of water might also cover the use of very limited amounts of water, say 25 CM/P/Yr for the supply of truck garden type of fresh vegetables for local consumption. Based on fresh vegetable consumption patterns in Israel and data on crop requirements for water, 25 CM/YR would be sufficient, using modern irrigation techniques, to meet the water requirement for the irrigation of the supply of such fresh vegetable crops for local consumption.

While the MWR concept does not include any direct allocation of water for agriculture, recycled and treated wastewater from the urban/industrial sector can provide a major source of additional water for agriculture.

WASTEWATER RECYCLING AND REUSE

The Water Resource Potential of Wastewater Recycling

Recycled wastewater is the only source of additional water for agriculture, industry and urban non-potable reuse that actually increases in quantity as the population grows and more and more water is demanded by the urban/industrial sector.

If we assume that the total domestic/urban/industrial water supply eventually reaches 125 CM/P/Yr, then it is not unreasonable to estimate, based on experience in various countries, that anywhere between 65-80% of the incoming water supply can be recycled and reused. Thus, a city with a population of one million would require a water supply of 125 million cubic meters/year (MCM/Yr) and under optimal conditions some 80% of that amount could be collected in the central sewerage network, treated and recycled for reuse in adjacent agricultural areas. In this case some 100 MCM/yr of recycled wastewater might be made available to agricultural areas adjacent to the city.

That amount of water would be sufficient to irrigate between 10 to 20 thousand hectares depending on the irrigation technology used and the type of crops. If achieved, such recycling and reuse of wastewater can add significant amounts of water to the agricultural sector. Alternatively, it could be used for higher valued industrial purposes and even for still higher value, urban, non-potable purposes such as the irrigation of greenbelts, football fields, parks, gardens and recreational areas. In some cases treated recycled wastewater has been successfully used for flushing of toilets in municipally managed multi-storied buildings.

The Need to Construct a Sewerage System Infrastructure

A precondition for achieving this or any level of recycling and reuse of wastewater is the construction of a sewerage system infrastructure to collect the wastewater from domestic/commercial and industrial sources for all the major urban areas.

Public Health and Environmental Protection

For urban areas with central water supply to the homes and domestic water consumption of over 50 liters/p/day, local wastewater disposal methods such as septic tanks and percolation pits can only serve as temporary palliatives. Eventually, as population density increases and as water supply and wastewater flows increase, overflowing septic tanks and percolation pits become the rule, rather than the exception and the urban environment becomes saturated with the stench and mosquito breeding sites of health menacing wastewater pools and streams. The only solution is the construction of a central sewerage network and wastewater treatment plants which should be considered as an absolutely essential part of urban environmental protection to assure the public health and welfare regardless of the needs to recycle and reuse wastewater as a water resource.

Urban wastewater carries with it the full spectrum of pathogenic bacterial, viral and protozoans of the diseases endemic in the community, and can as well carry pathogenic agents of disease such as cholera, introduced by visitors to the city, coming from epidemic areas as occurred in Jerusalem in 1970 (7). Pools and streams of wastewater in urban areas have in certain tropical countries become the main breeding sites of the Culex pipiens mosquitoes that transmit the disease *filariasis* which can lead in extreme cases to the disfiguring elaphantiasis condition.

Under the densely populated conditions of urban areas, the sanitary collection and disposal of wastewater is an essential precondition for the health of the public and for economic growth and development. Wastewater flowing in the streets and in open ditches near residential areas can be a major source of infectious disease transmission. From the public health point of view alone, a central sewerage system for the collection and treatment of wastewater is vital. However, even if the wastewater is collected in a central sewerage system providing a reduction of public health risks for the urban residents, but latter dumped untreated into open rivers, dry riverbeds (wadis), lakes or the ocean, there is the danger of the pollution of surface or groundwater sources of drinking water for down stream users with the disease causing microorganisms from the upstream urban areas.

In addition, untreated wastewater dumped into the environment can cause serious ecological imbalances, oxygen depletion, odor nuisances and fish kills in receiving bodies of water such as lakes, rivers and the oceans. Further, the pathogenic microorganisms and toxic chemical wastes from industrial sources can pollute the water and present serious health problems to recreational areas, seafood and fish harvested from such polluted waters. That same wastewater, if treated, recycled and reused on the land can be prevented from ever reaching downstream populations and can become a resource.

Under conditions of plentiful year round rainfall and large flowing rivers the most commonly practiced solution is treatment of wastewater to a degree that will allow it's disposal and dilution in the nearest water bodies. However, in the arid areas of the Middle East, most rivers are small or have only seasonal flow and the disposal of wastewater effluent to dry riverbeds (wadis) can create serious environmental problems. Under such conditions, wastewater recycling and reuse through land application or irrigation can solve both the environmental problems as well as create a valuable additional source of water and nutrients for the soil.

A World Bank study (8) estimates that the fertilizer value of the natural nutrients in wastewater (nitrogen, phosphorous and potassium) is worth about three cents/CM, which can save the farmer about $130/Ha/Yr in fertilizer costs if he irrigates the land with treated wastewater. For poor farmers in arid areas, the fertilizer value alone of wastewater can be an attractive incentive.

The Cost of Sewerage Systems and Recycling of Wastewater

Without central sewerage systems, there can be no recycling and reuse of wastewater, but such systems are very expensive. Based on costs in Israel and elsewhere, it is estimated that the construction of new central sewerage systems in urban areas costs about $300-$500 per person on the average. The cost can be higher in rocky mountainous areas and lower in flat sloping areas with low costs of excavation. This means in order to install a sewerage system in an unsewered urban area a capital investment of some $500 million per million persons is required.

World Bank reports indicate that the annualized cost of central sewerage systems (capital and operating costs combined) in developing countries can range from $100-$200/person/Yr.

However, in addition to the cost for the central sewerage system of pipes and pumping stations to collect the wastewater, it is essential to provide proper wastewater treatment or purification. Wastewater treatment, to effectively remove or inactivate most of the pathogenic microorganisms and to reduce the amounts of environmental pollutants and oxygen consuming organics that might cause serious ecological imbalances, is also expensive. It is beyond the scope of this paper to go into any depth as to alternative wastewater treatment systems for environmental protection and reuse. However the costs may range from \$.05-\$.45/CM. At the low end are simple and robust, earthen, land extensive, solar energy driven stabilization pond systems, suitable where plentiful land is available, in warm and sunny arid areas, designed to meet the World Health Organization's new microbial wastewater guidelines for unrestricted agricultural irrigation (9). At the extreme high end, at \$.45/CM, are the costly high-tech equipment and energy intensive types of conventional and tertiary wastewater treatment plants such as the activated sludge process followed by additional treatment processes such as sand filtration and disinfection with various additional backup systems designed to produce wastewater effluent of a bacterial quality equal to that of drinking water, as advocated in a recent USEPA/USAID Guidelines on Water Reuse (10).

Let us assume that the annualized cost of a modern central sewerage system is \$100/person/year. If we assume that the amount of wastewater collected is 100 CM/P/Yr, (80% of the water supply of 125 CM/P/Yr = 100 CM/P/Yr), then one might say that the cost of generating recycled water without treatment is \$1.00/CM. Proper treatment might cost between \$.05-\$.30/CM, bringing the total to as much as \$1.05- \$1.30/CM. Is this the correct way of looking at the costs of recycled water? This question will be examined in what follows.

At such high costs for sewerage systems and wastewater treatment, is wastewater reuse an economical option for low income arid zone countries or any country for that matter? The answer is only indirectly associated with the question of water resource conservation and reuse needs. The primary and often sole criteria for building central sewerage systems and wastewater treatment plants are public health, environmental protection and urban development considerations. In densely populated major urban centers such as Cairo, Amman, Teheran, Tel Aviv, Tunis and Rabat, central sewerage systems are the only way of handling the growing environmental and health problems associated with the accumulation of pathogen laden wastewater from overloading and overflowing local wastewater disposal systems that have saturated the centers and residential neighborhoods of these cities.

The consumers of the water should also cover the costs of the disposal of the dirty water that results from water supply. In economics, such costs for the disposal of the wastes generated from an essential input stream are referred to as externalities. In line with these considerations, it should be clear that the costs of central sewerage systems for urban areas, as well as the cost of wastewater treatment to provide proper environmental protection at the site of the disposal of the urban wastewater, is a social or environmental cost of the urban dwellers and industries who created the wastewater and who must be responsible for all costs associated with its environmentally safe disposal.

Assuming the above, then the economic question of the cost of the water for reuse becomes much clearer. Only those additional costs associated with treating, storing and transporting the wastewater for reuse which are above and beyond the costs of environmentally safe disposal should be charged to the cost of water for agriculture. All other costs should be covered by the urban and industrial areas that generate the wastewater. These environmental disposal costs will vary from situation to situation depending on the local regulations on the degree of treatment required for discharge of wastewater into the environment and the options open for environmental disposal.

For example, in Israel, the Ministry of Health has established regulations requiring all wastewater be treated prior to disposal into the environment so that it will meet the following criteria as shown in Table 2.

TABLE 2

**ISRAEL MINISTRY OF HEALTH
EFFLUENT STANDARDS FOR WASTEWATER DISPOSAL
INTO THE ENVIRONMENT WITH OR WITHOUT REUSE**

BIOLOGICAL CHEMICAL DEMAND (5 days)	20 Mg/l
TOTAL SUSPENDED SOLIDS	30 Mg/l
TOTAL COLIFORMS	1,000/100 Ml

In the case of reuse of treated wastewater effluent for the irrigation of vegetables crops normally consumed uncooked such as lettuce and tomatoes, the Israel Ministry of Health requires additional treatment of the wastewater effluent so as to reduce the total coliform concentration to less than 10/100 ml. To achieve such low concentrations of coliforms in the effluent might require additional filtration and/or disinfection of the effluents which is above and beyond the treatment required by the Ministry of Health for environmental disposal alone.

Additional expenses associated with a wastewater recycling and reuse project might be the construction of an inter-seasonal storage reservoir to allow for storage for a period of as much as 8-10 months to catch the winter and non-irrigation season wastewater flows for use during the peak 2-4 summer irrigation months. There are some 100 such wastewater inter-seasonal storage reservoirs in operation in Israel. A further additional expense, other than pumping to a more distant irrigation site, might be special filtration and anticlogging disinfection prior to use of the effluent for drip irrigation. The labyrinth small diameter emitter/pressure reducing value at the site of each dripping orifice often gets clogged with suspended solids and as a result of the biofilms-biological growth caused by the nutrients in wastewater. Thus, special additional treatment of wastewater effluent may be required when drip irrigation is practiced.

Shelef (11) has calculated the approximate costs of all the expenses associated with the treatment and storage of wastewater effluent for reuse by conventional high tech activated sludge systems to meet the very rigorous Israeli reuse standards, and the share of that cost that should be covered by the urban and industrial sources of the wastewater to meet the environmental and public health disposal costs. He estimates that the total treatment costs are about $.35/CM while only $.10/CM of that can be considered the additional cost associated with meeting the needs of wastewater reuse. Thus, by using this economic approach of cost allocation, the resulting cost of water for unrestricted agricultural irrigation meeting the very strictest microbial standard as required in Israel, is not unreasonably expensive at all. According to Israeli agricultural calculations, farmers can afford to pay up to $.20-.25/CM for the water needed to irrigate most crops. For some high water consuming crops such as cotton, this figure may be high but $.10/CM is still a very reasonable cost for additional water in an arid zone where the next alternative water source may be from desalination of seawater at about $1.00/CM.

Percent of Population Served by Central Sewerage Systems

The availability of wastewater for reuse will always be a function of the percentage of the population served by central sewerage systems. In addition it will be a function of the official policy and regulations concerning the encouragement of recycling and reuse of wastewater. In Jordan for example their is a declared policy encouraging reuse and, as of 1993, 75% of the urban wastewater was treated and reused for agricultural irrigation. In Israel, in 1993, 85% of the population was served by central sewerage systems and 65% of the available flow was treated and recycled mainly for agricultural irrigation with some reuse going for industrial purposes.

These two examples provide an indication of what can be achieved in countries in arid areas who both have a declared policies concerning maximizing regulated wastewater reuse, both as an environmental protection measure and for water conservation and reuse in agriculture. Other Middle Eastern countries with a declared public policy to support and promote wastewater recycling and reuse are Morocco, Algeria and Egypt. There may well be others, details about which are not known to the author at this time.

The percentage of the population served by central sewerage system in the developed industrialized countries is shown in Table 3.

TABLE 3

PERCENT OF THE POPULATION SERVED BY CENTRAL SEWERAGE SYSTEMS AND WASTEWATER TREATMENT PLANTS (WORLD LINK)

COUNTRY	PERCENT
DENMARK	98
SWEDEN	95
W.GERMANY	90
SWITZERLAND	90
NETHERLANDS	89
ISRAEL	85
UK	84
USA	75
FINLAND	75
AUSTRIA	72
CANADA	66
ITALY	60
FRANCE	52
SPAIN	48
NORWAY	43
JAPAN	39
OECD- MEAN	60

For long-term water resources planning purposes, it would be wise if all of the water resource authorities in arid countries included in their inventory of potential sources of additional water, the estimate of potential available water for irrigation and other purposes derived from wastewater recycling and reuse.

As a schematic basis it might be appropriate to estimate the rate of urbanization and the expected urban population some thirty years hence, say in the year 2025. Next, it is possible to estimate the rate of construction of central sewerage systems or the amount of money required annually for investment in this purpose, so that in a thirty year period, a goal of 80% of the population served by central sewerage systems and wastewater treatment with recycling is achieved. For example, if the total urban population in a given country is estimated to be 10,000,000 in thirty years, then investments to achieve 80% coverage in 30 years will require the construction of sewerage systems for 335,000 people/year (at an assumed average cost of $500/person) at a cost of some $170,000,000/year for new sewerage systems.

Based on the estimated rate that new sewered areas and their populations come on-line and the estimated water use and wastewater production, it is possible to estimate the availability of recycled wastewater for use in agriculture or other purposes.

WASTEWATER TREATMENT SYSTEMS FOR RECYCLING AND REUSE

As mentioned previously it is beyond the scope of this paper to analyze in depth the various technological options for wastewater treatment systems that can meet the recommended health guidelines required for irrigation. For the warmer sunny countries of the Mediterranean basin and Middle East and where land is available, low cost, multi-celled stabilization ponds with a layout such as shown in Figure 1 have demonstrated their ruggedness and stability in providing a very high efficiency in pathogen removal. Well designed and operated multi-celled stabilization ponds with detention periods of 25-30 days, in warm, sunny climates can normally produce an effluent meeting the new World Health Organization Guidelines (9) of a log mean of 1,000 Fecal coli/100 ml. In such warm and sunny areas, low cost stabilization ponds can often be the most cost effective treatment method.

In other areas with colder temperatures, less sunlight and/or limitations of the areas of land available, ponds may not be appropriate. However, conventional wastewater treatment processes, such as activated sludge are not necessarily the proper alternative, since their efficiency in removal of helminth eggs, bacterial and viral pathogens is not high, while both the construction and operating cost are very high. The conventional wastewater treatment processes where developed mainly to remove the oxygen consuming fractions of the wastewater (BOD-Biochemical Oxygen Demand) to protect the fish in the rivers and to prevent the rivers from developing foul smelling anaerobic conditions. High levels of BOD removal are not normally required for wastewater irrigation. What is needed is a process that has assured and reliable removal of suspended particles, including helminth eggs, which prepares the effluent for efficient disinfection by processes such as chlorination, ozonation or ultra violet light treatment.

One newer approach which has been highly successful in over one hundred treatment plants in the Scandinavian countries is chemically assisted primary sedimentation followed by disinfection (12). Such a process would consistently produce a very clear effluent that can be effectively disinfected. The total cost of such chemical-physical treatment would be less than the so-called conventional biological methods while providing a more reliable quality of effluent that could meet the strictest health standards. The study of alternative treatment methods aimed primarily at meeting microbial effluent standards, rather than the non-relevant BOD standards should be pursued intensively so as to develop inexpensive and safe methods of treatment, specifically designed to meet the appropriate health regulations for wastewater reuse. This is a much neglected area of environmental research which should be promoted by international agencies concerned with the serious water shortages that will face many arid areas of the world.

HEALTH GUIDELINES FOR WASTEWATER REUSE IN AGRICULTURE

This section will review the history of the development of such standards and will compare the recent American wastewater reuse guidelines proposed by the United States Environmental Protection Agency (USEPA) and the United States Agency for International Development (USAID) (10) with those developed internationally by the World Health Organization (WHO) (9).

California: The First Wastewater Reuse Standards

In 1918, the State Health Department of California in the United States, was the first to draft modern regulations to control the public health aspects of wastewater reuse. These were revised and made more strict in 1948 (13). Apparently, the rational of the officials who drafted and approved the California standards was based on the judgement that a microbial standard that is safe for drinking water would obviously also be safe for agricultural irrigation. The standard was approved, even though it was generally agreed at that time that an epidemiological basis for establishing a quantitative microbial standard was not available. Members of the committee have informed me that the majority were motivated by apprehension about being criticized for being too lenient and felt safe in recommending microbial wastewater reuse standards equal to those required for drinking water. In that way no official could be accused of drafting too lax a standard based on this essentially " zero exposure=zero risk" approach.

This might be considered an example of the so called "Acheson Law" which states that "Committees usually are more concerned with protecting themselves than achieving more worthy goals." In any event, since the California Standards were the first quantitative microbial standard promulgated, they were quickly copied by many other states in the United States and then after World War II by many of the newly created developing nations of the world. Many of those nations were in arid areas and in need of developing additional water resources. They found it expedient to copy standards such as this one from the developed nations. In the process of copying standards from the United States which were the result of a unique combination of social and political circumstances, the developing countries rarely gave any thought to their economic implications.

The late Professor Thomas Sedgwick of MIT, an eminent pioneer in the field of Environmental Engineering, once wrote: "Standards are often the best guess of one man quoted and re-quoted so often that they assume the semblance of authority." This certainly was the case with those first California wastewater irrigation standards.

One result of the adoption of the overly strict California effluent standard regulations, in certain developing countries has been to block plans for improvement, since to build treatment plants to meet such strict standards involves very expensive, high technology equipment and high operational costs. Intermediate level treatment using appropriate low cost technology may not be approved since they will not meet those standards which the Government innocently become committed to when it copied the California standards. Such intermediate level, lower cost treatment can nonetheless provide a high level of health protection. This has, on occasion, resulted in a tragic situation where nothing at all is done to improve the situation since "insisting on perfection or the best often prevents achieving the good".

The New International World Health Reuse Guidelines

The World Bank and the World Health Organization became concerned about this anomalous situation and sponsored studies by several independent groups of public health experts and environmental engineers in England, the United States, Switzerland and Israel to reevaluate the scientific basis for wastewater irrigation guidelines and standards. They carried out an extensive scientific evaluation of the epidemiological evidence on health effects associated with wastewater irrigation and developed a new, scientifically sound approach for establishing new and revised health criteria for wastewater irrigation. The Engelberg Report of 1985 (14) summarized these findings and presented a radical departure from previous policy in the area of wastewater reuse guidelines and standards. On the one hand it introduced a strict new approach and numerical standard for removal of helminths eggs from wastewater effluent for agricultural reuse, based on firm epidemiological evidence that helminth-worm diseases caused by protozoans such as ascaris, trichuris and hookworm, were the number one health problem associated with wastewater irrigation in the developing countries.

On the other hand, based on the new epidemiological evidence, and their analysis, they called for a major liberalization of the earlier severe zero risk "California" bacterial guidelines which had evolved unwittingly into the world's most widely accepted standard, even though it was illogical. irrational, and unfeasible from its inception.

The WHO carefully coordinated its efforts in developing international wastewater reuse guidelines with all the other United Nations agencies including the FAO, UNEP, UNDP and the World Bank. They also sent out the draft proposals for the new guidelines for review and comments to over 100 health scientists and engineers and to Ministries of Health all over the world.

In November 1987, The World Health Organization convened a Scientific Group on "Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture" (9). The group carefully reviewed all the previous studies, the new epidemiological evidence, comments received from many experts and governments and decided to adopt the Engelberg approach and microbial guidelines for wastewater irrigation. The new microbial health guidelines for unrestricted irrigation of all crops now recommended by the WHO are:

TABLE 4

1989 WHO GUIDELINES FOR UNRESTRICTED WASTEWATER IRRIGATION

1. No helminth eggs (the cause of worm diseases such as ascaris) per liter of effluent and

2. A mean of 1,000 fecal coliforms per 100 ml of effluent.

One of the important features of the new WHO guidelines is that they are generally attainable in many tropical countries in low cost systems such as multi-celled stabilization ponds under most conditions.

Thus, by 1989, when the report was fully approved and published (9), the highest international public health authority had given its official stamp of approval to the fundamental, and in some ways revolutionary, revisions in the health guidelines for wastewater reuse in agriculture. France is one of the countries that has formally adopted the recommended WHO guidelines.

USEPA/USAID Propose New Stricter Water Reuse Guidelines

In 1992 the United States Environmental Protection Agency (USEPA) together with the United States Agency for International Development (USAID) decided to propose Water Reuse Guidelines which were an even stricter version of the California Standards on wastewater irrigation (10). This proposal was based on a report drawn up by the American consulting engineering firm of Camp Dresser and McKee. The new American Guidelines recommended that the type of treatment and the quality of effluent used for the agricultural reuse by spray or surface irrigation of any food crops including crops eaten raw which are not commercially processed should be as follows:

TABLE 5

1992 USEPA/USAID RECOMMENDED TREATMENT REQUIREMENTS AND QUALITY OF EFFLUENT FOR IRRIGATION OF CROPS EATEN RAW

TYPE OF TREATMENT: Secondary + Filtration+ Disinfection

EFFLUENT QUALITY:	
BOD	10 mg/l
TURBIDITY	2 NTU
MICROBIAL	No detectable fecal coli/100ml
CHLORINE RESIDUAL	1Mg/l Cl2 (after 30 minutes)

The guidelines also recommend very strict requirements to assure treatment reliability including reserve back up/standby units, automatic recording monitors, alarms and automatic by-pass systems.

These new recommended guidelines are not based on any new epidemiological evidence of negative health effects from wastewater irrigation but, similar to the original California standards, they are more or less based on the "zero exposure= zero risk" concept regardless of costs. It is understandable that with the mounting pressure and influence of the environmental and "green" groups in the United States, any liberalization of an environmental standard would be politically untenable and in fact the pressure is almost always for stricter standards. USEPA/USAID defended their new stricter standards by stating that Americans insist on a very high safety factor in matters of health protection and are prepared to pay for it.

Those early precedent-setting California standards, and the new even stricter USEPA/USAID guidelines evolved from them, are, in the opinion of this author, seriously flawed by being illogical, inconsistent and unreasonably strict. One example of the fundamental inconsistency of this "zero exposure=zero risk" approach is obvious when one considers the fact that few if any natural rivers in the United States, Europe, Africa or Asia could ever meet such a standard (which is equivalent to the microbial drinking water standards), but nevertheless such river waters are accepted as an unrestricted source of irrigation water. Recent World Health Organization studies have shown that the mean coliform count of the rivers of Europe ranges between 1,000-10,000 Fecal coli/100 ml. Similar conditions exist in many American rivers and in 1973 the USEPA together with the American Academy of Sciences recommended that river water be considered safe for unrestricted agricultural irrigation if it's mean coliform count did not exceed 1,000/100 ml (15).

Another example is that some of the states in the United States allow bathing in waters with mean coliform concentrations of 100-1,000/100 ml. The European Community - EEC allows bathing in seawater with coliform counts of up to 10,000/100ml. Can it be considered logical or consistent to allow the human body to be immersed in water with 1000 or even 10,000 coliforms/100ml while forbidding irrigation of crops with such water? After all, irrigated crops are exposed to the disinfection action of UV radiation from the sun and microbial inactivation due to desiccation before marketing.

The big American consulting engineering firms, such as the one that proposed the new USEPA/USAID wastewater reuse guidelines, favor such rigorous standards, which require the construction of expensive advanced high technology treatment plants. While they may claim that such plants are also feasible for lesser developed countries, such claims are questionable. Such treatment plants as required by the new American wastewater reuse guidelines are expensive to build and operate and require a high technology infrastructure to operate and maintain. Even if funds to build such equipment and energy intensive plants become available to developing nations, experience indicates that the chances of long term reliable, sustainable operation are slight. While these new very rigorous guidelines may be achievable in the United States, it is questionable whether they are technically or economically feasible in the less developed countries of the world.

The World Health Organization made several attempts to persuade USAID to join it and the other United Nation agencies in supporting the new internationally developed wastewater reuse guidelines, particularly with the goal of avoiding conflicting guidelines and double messages going out to the developing countries most desperately in need of promoting economically feasible wastewater recycling and reuse projects. USAID refused on the grounds that the new guidelines were those of the USEPA and intended primarily for internal United States use. Nevertheless USAID has distributed these new U.S. guidelines to all of the developing countries in which they operate. Despite a footnote in small print in the Guideline document, that USAID will not insist on the United States Guidelines when providing financial support for reuse projects, it is only natural that governments in developing countries, which are dependent on U.S. aid, are now confused over the conflicting U.S. and WHO guidelines.

It would be wise for countries to make their own independent judgements in establishing health regulations for wastewater reuse, free from the social, economic and political forces that shaped the American standards. The new World Health Organization wastewater reuse guidelines can serve as a sound health basis for setting such standards. The WHO Guidelines, which have been widely accepted by the United Nations agencies and World Bank, where drafted based on rational health criteria and the latest scientific evidence with the goal of providing the requisite degree of health protection, coupled with important general environmental considerations and goals for the prevention of environmental pollution and the promotion of resource recycling and recovery.

SUMMARY AND CONCLUSIONS

A number of the countries in the Middle East and Asia will face growing sever water shortages which may bring them to well below the "water stress" level. For example, within a 30 year period, with an estimated doubling of their population, the Jordanians, Israelis and Palestinians will have available to them, from their current water reserves, just about the limit of what is needed for survival based solely on domestic, urban and industrial use, with no fresh water available for agriculture.

For such peoples in arid regions and others, the recycling and reuse of about 65%-80% of the waters supplied for urban/industrial use can often generate the only significant additional low cost water resources for agricultural/industrial and urban non-potable purposes.

Desalinated seawater, estimated to cost about $1.00/cu.m., will not normally be economically feasible for agricultural use. There are a few Middle Eastern countries that are using highly subsidized desalinated seawater for growing grain and other agricultural crops at real costs several times that of the world market price. This practice is explained by these countries under a concept of "food security". This can hardly be seen as an economically sound or sustainable water/agricultural policy in the long run.

In those countries facing the most severe conditions of water stress, priority in the allocation of renewable fresh water resources should go for domestic, urban, commercial, and industrial use. As populations grow and natural sources of renewable water are depleted, desalination may become a logical and economically feasible source of water for urban and industrial use. Domestic, urban, commercial and many types of industry can afford the price of desalinated seawater.

Under such conditions, recycled wastewater is the only water resource whose quantity will continue to increase as more and more water - even desalinated water - is used by the urban/industrial sector and can thus provide a rational and sustainable basis for a limited level of agriculture in severely water short countries. It is estimated that the Minimum Water Requirement (MWR) of 125 cubic meters/person/year (CM/P/Yr) is needed to support a reasonable level of urban life, with employment based mainly on commerce and industry with no allocation of fresh water for agriculture. If total urban/industrial water consumption is 125 CM/P/Yr and 80% is recycled, it would thus be possible to generate an additional 100 CM/P/Yr for agriculture or other non-potable purposes. This can provide a significant amount of water for a limited but sustainable agriculture. It is more than enough water to cover most of the local fresh food crop needs.

The capital investment in sewerage infrastructure is high, about $300-$500/person, which means that an investment of as much as $500 million dollars/million urban residents will be required. However, in densely populated countries, a high level of wastewater collection and treatment is essential, in any event, to protect the public health and to prevent environmental pollution. Enteric diseases, mosquito borne disease, and severe environmental and ecological hazards and nuisances can result from the lack of an effective central sewerage system and the absence of adequate wastewater treatment prior to disposal into the environment. The cost of central sewerage systems and wastewater treatment to meet the requirement of safe and effective public health and environmental protection should be seen as part of the cost of supplying safe water for urban and industrial use and should be covered by those consumers.

Thus, the additional marginal cost of treatment, storage and conveyance of purified wastewater required for unrestricted agricultural reuse and meeting the WHO health criteria will be only a fraction of the total wastewater treatment and disposal costs of about $.10 out of a total of $.35.

The newly developed health guidelines for wastewater recycling and reuse developed by the World Health organization in cooperation with the international community and the United Nations agencies are based on extensive research, on sound epidemiological evidence and engineering feasibility. These guidelines restrict the number of disease-causing helminth worm eggs to none in 10 liters of effluent and the fecal coliform bacteria to 1,000/100ml. An effluent meeting such microbial guidelines can often be achieved in warm sunny climate regions, where sufficient land is available, in low cost, effective and easily operated multi-celled stabilization ponds with 25-30 days of detention time, which do not require expensive equipment or outside energy.

The 1992 USEPA/USAID Guidelines for Water Reuse, prepared for them by one of the well known American consulting engineering firms, are a much stricter version of the early strict Wastewater Irrigation Standards promulgated by the California State Health Department in 1948. These new U.S. guidelines call for zero coliform bacteria in the wastewater effluent which is similar to the requirement for the microbial quality of drinking water. In order to achieve these U.S. Guidelines it is necessary to construct high-cost/high-tech conventional energy and equipment intensive plants, followed by additional treatment processes such as sand filtration and disinfection. Such high-tech treatment systems require a highly trained staff of operators and a sophisticated technical infrastructure to assure sustainable treatment. Despite the claims of the consulting engineering firms, it is highly questionable that such types of treatment plants would be technologically or economically feasible for developing countries. For that matter many developed countries, including areas of the United States, find it difficult to assure the continuous efficient operation of such plants. Never the less, USAID has distributed the American Guidelines to all of the developing countries in which they operate and others. This has already led to some confusion as to which guidelines are most appropriate for developing countries and whether American financial aid will be tied in some way to following the American Guidelines.

These new American Guidelines are apparently based on the "zero exposure=zero risk" concept without adequate public health or epidemiological evidence to justify such a restrictive policy. For example few if any of the natural rivers used without any restrictions for unregulated irrigation in the United States or elsewhere in the World could meet these standards. Even the microbial standards for seawater at bathing beaches for human body contact sports allow between 1,000-10,000 coliform bacteria/100ml. The California Standard has been copied by many of the developing countries, but since they are so expensive to achieve, little or no progress has been made in achieving any reasonable treatment of wastewater which is used widely in the Third World countries to irrigate vegetables without any treatment at all.

Countries now actively considering developing a wastewater recycling and reuse strategy would be well advised to use their own judgement in establishing wastewater irrigation health standards. They should carefully consider the international guidelines established by the World Health Organization which provide a high level of health and environmental protection but which are achievable with economically feasible and sustainable technology.

In conclusion recycling and reuse of wastewater for agriculture, industry and urban non-potable reuse can have the multiple benefit of an effective multi-purpose strategy of environmental protection and water resource conservation.

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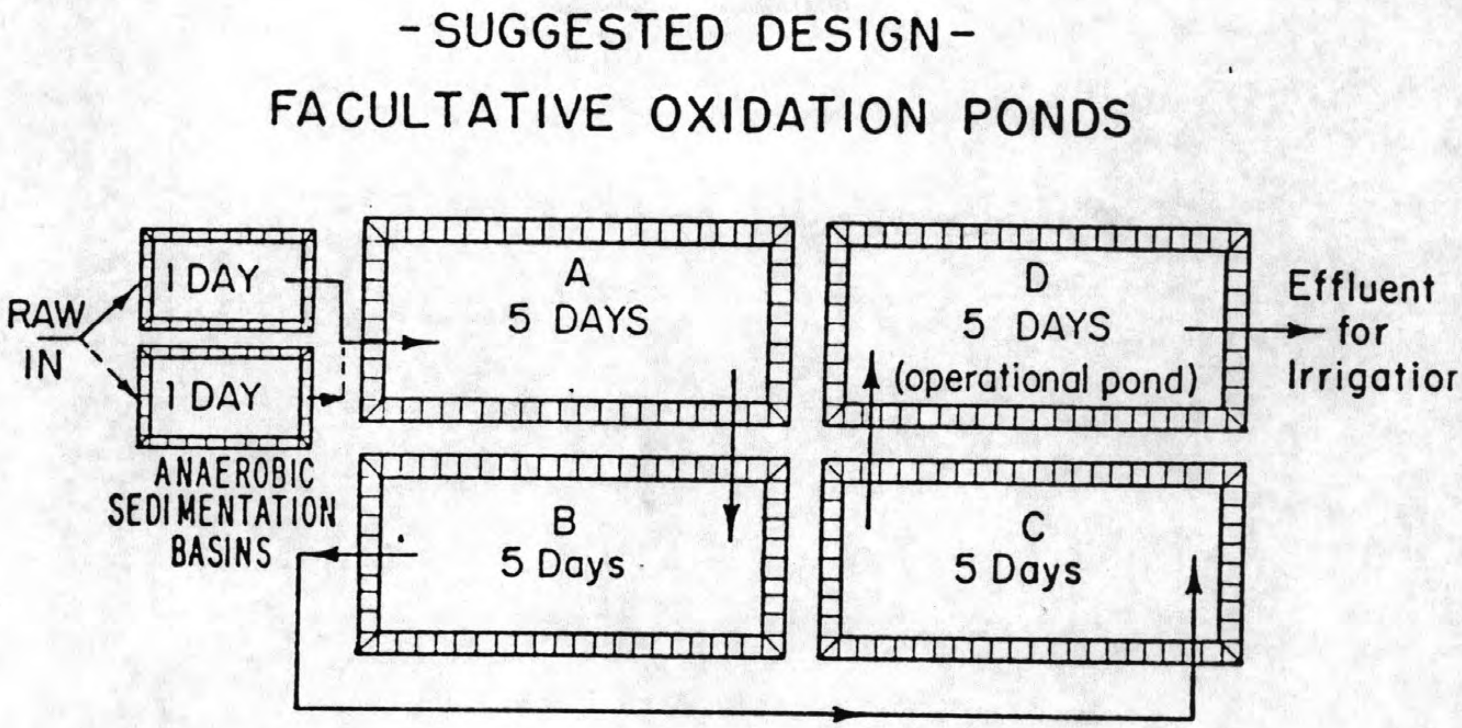
FIGURE 1



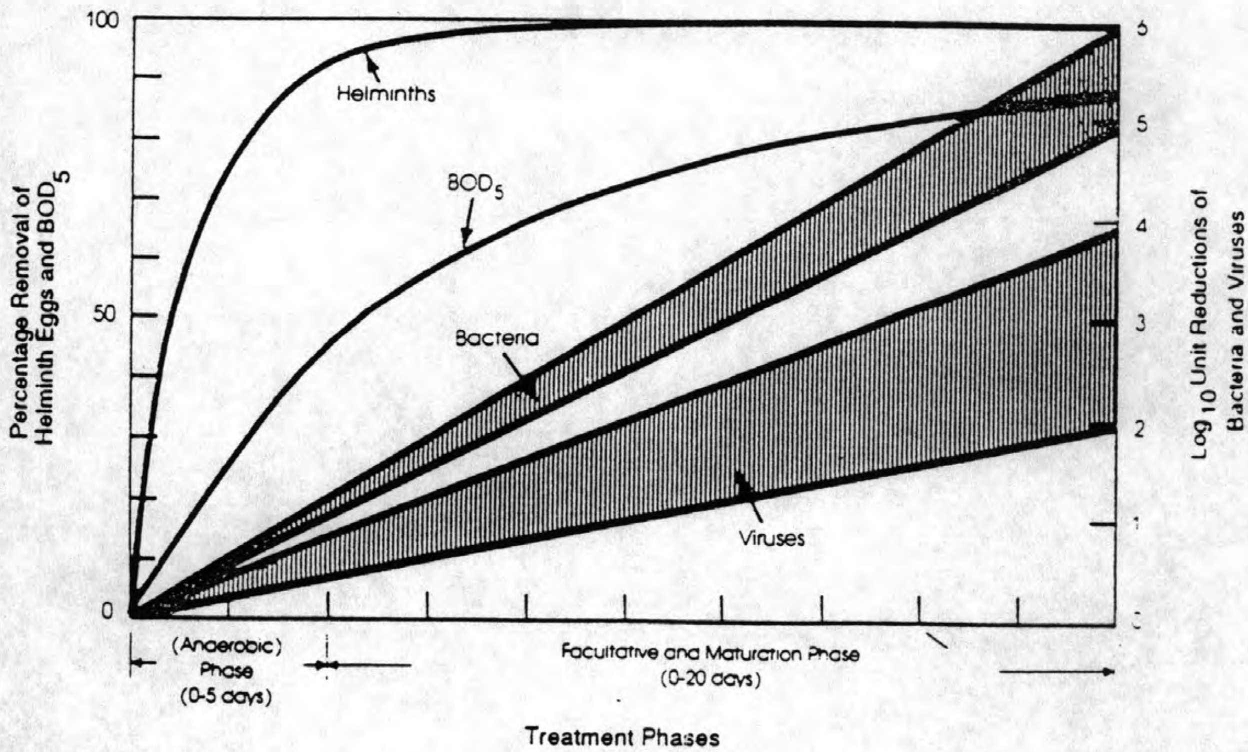


Fig. 2 Generalized removal curves for BOD, helminth eggs, excreted bacteria, and viruses in waste stabilization ponds at temperatures above 20°C.

FOR PRESENTATION AT THE CONFERENCE ON " WATER AS AN ELEMENT OF COOPERATION AND DEVELOPMENT IN THE MIDDLE EAST- HACETTEPE UNIVERSITY , ANKARA,TURKEY OCTOBER 4-8, 1993

PROPOSALS FOR COOPERATION IN THE MANAGEMENT OF THE TRANSBOUNDRY WATER RESOURCES SHARED BY ISRAEL AND HER NEIGHBORS.

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ABSTRACT

The Israelis, Palestinians, Jordanians, Syrians, and Lebanese share a common geography and a common hydrology on the Jordan River Basin. This paper presents proposals for the establishment of a Jordan River Joint International Commission to manage the water quantity and quality questions of shared transboundry water resources of the Jordan River Basin. The approach proposed is to base the solution of the quantity questions on the concept of equitable apportionment to meet the minimum human and social needs for survival as expressed in the Helsinki Rules drafted by the International Law Association. It is proposed that the method of calculation of a fair and equitable water allocation defined as the Minimum Water Requirement-MWR should be equal amounts water-- 125 cubic meters/person/ year, for essential human survival needs including domestic consumption and urban/industrial use with only a minimal allocation for local production of fresh vegetables. It is proposed that all five riparians share in the responsibility of managing the environmental aspects of the shared waters as well as sharing in the obligation,to assist,in proportion to their available resources, those riparians- Jordan and the Palestinians, who will be unable, in the future, to meet their Minimum Water Requirement-MWR needed for survival.

KEYWORDS

International river basin management,transboundary waters, Middle East, Jordan River Basin, Israel,Jordan, Syria,Lebanon,Palestinians,and Turkey

INTRODUCTION

For better or for worse Jordan, Syria, the Lebanese,Palestinians and the Israelis are bound together by a common geography and a common hydrology since they are partners in the shared use of the Jordan and Yarmuk River system. This common geography ties the fate of all five peoples together and requires that they find a common solution based on equitable apportionment and mutual help to meet the legitimate needs of all peoples. Adequate supplies of good quality water are an essential element for the survival, economic welfare and prosperity of Israelis, Palestinians, Jordanians, Lebanese and Syrians and a cause for deep concern and fears for the future by all the parties in the Middle East who are currently searching for a peaceful resolution to their long standing conflicts.

It is the objective of this paper is to analyze the nature of the water problems faced by the parties and to suggest some basic principles and methodological approaches for analyzing water needs on an equitable basis and the degree of obligation of potential water donors for consideration of the negotiators on all sides. In addition we shall propose institutional approaches for the joint management and environmental control of the shared resources.

There are numerous claims and counter claims based on arguments of historic use, geography, hydrology, riparian rights, legal rights, national rights and others as to the allocation of the above shared water resources and the prevention of their pollution. We have analyzed these claims and counter-claims in great detail previously(Shuval,1992, and 1993). Reaching agreement on the water conflicts between the five riparians on the Jordan River Basin is a sine qua non for the successful conclusion of a peace agreement. We suggest that instead of an trying to unravel the complex and almost intractable claims and counter-claims on such issues as national water rights, which might involve an endless debate, that the sides attempt to reach agreement on some fundamental basic principles based on concepts of equitable, minimal water allocations to meet human needs for survival.

PROPOSED BASIC PRINCIPLES FOR PEACEFUL COOPERATION BETWEEN THE PARTNERS TO SHARED WATER RESOURCES

There are a number of factors that can be considered when studying possible options for allocation and reallocation of shared water resources including: defacto historic use; the quantity of water arising in an up-stream territory and the amount of water that naturally flows through a down stream territory, alternative water sources available to each partner and last but not least the legitimate present and future minimum needs for human survival of each partner sharing the resource, regardless of the other factors.

The "Basic Principles" proposed in this paper are aimed at providing the parties to the dispute with a proposal for their consideration as one possible approach to assuring the minimal human needs of the parties, which could meet the criterion of a "reasonable and equitable share" as formulated under the Helsinki Rules, which are accepted as one of the corner stones of international water law (Caponera,1992). Our proposed Basic Principles could hopefully serve as a point of departure for negotiations and agreement, while it is recognized that the other factors mentioned above may also play a role in any negotiations (Shuval,1993).

PROPOSED BASIC PRINCIPLES FOR SHARED WATERS

1.Water rights should not be taken or changed by force or without mutual agreement

2.The Minimum Water Requirements-MWR of the partners to the Israeli-Arab conflict should be determined in the spirit of international water law based on the principle of equitable apportionment of the shared water resources and the other water resources available to each, in order to meet the legitimate human and social needs, with a minimum of an equal water allocation per person for domestic, urban, industrial and minimal fresh food use needed for survival.

3.Water resources within the territory of a partner will first be allocated to meet the present and future Minimum Water Requirements-MWR of that partner and after that the other water uses within the same territory.

4.Historical, actual, water usage from shared resources should generally be maintained and normalized through mutual agreement on condition that the Minimum Water Requirements-MWR of each entity, can be met from sources within each territory sharing the water resource. If the MWR of one entity cannot be met from its own current or potential sources then other entities on the shared international water resource, that can meet their present and future MWR can be asked, within the framework of a mutual agreement, to transfer water based on the real use for domestic/urban/ industrial purposes at that time. Helping another riparian entity on a shared international water resource to meet its MWR needed for minimum survival should be considered as being of a higher order of priority than the rights of an entity based on historic use and/or other geographic or political claims to water rights.

5.In the case where there are more than two entities sharing a water resource and one or more of them cannot meet all of their own present and future MWR and the other two or more entities can meet their own present and future MWR then the degree of liability of potential donors to the water short entity shall be proportional to the extent of unused water resources and/or to the excess water above the amount needed to meet its own Minimum Water Requirements-MWR.

6.The permanent or temporary transfer of water and/or water rights from one territory to another should be arranged through negotiations and mutual agreement. Compensation for transferred water or water rights must be determined through negotiations and agreement.

7. Every agreement involving the establishment of allocations, normalization, transfer or reallocation of water or water rights on a shared water resource should include factors such as financial or other forms of compensation such as water exchange, or water import from external sources or desalination. Other factors in such agreements should include: environmental protection, pollution control standards and guidelines, information sharing, joint commissions for inspection, monitoring and control of both quantity and quality on both sides of the border and agreed upon binding methods of settling disputes including arbitration and/or adjudication.

PROPOSED BASIS FOR CALCULATING THE " MINIMUM WATER REQUIREMENTS"-MWR

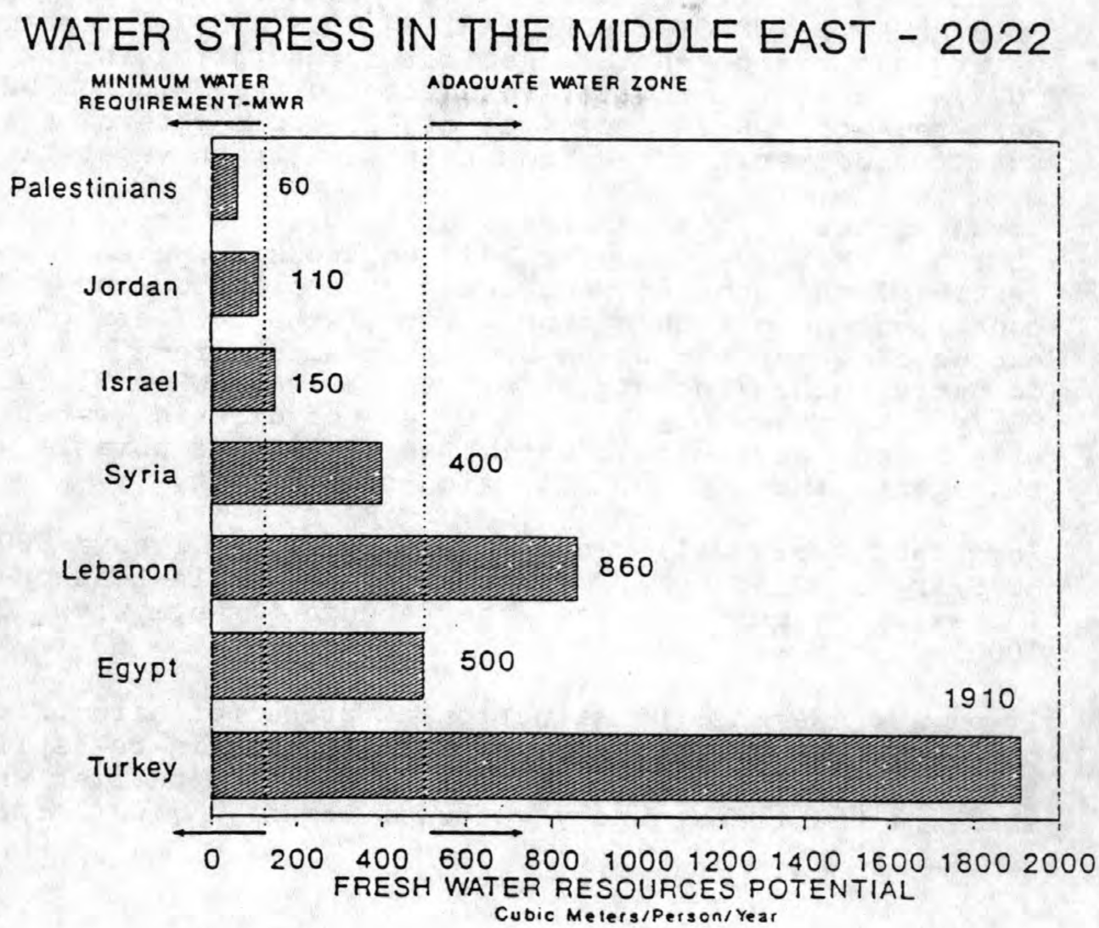
It is generally agreed that the absolute minimum water requirements-MWR, to meet basic human needs are those needed for drinking water or "domestic consumption". However we suggest that the broader concept of "urban consumption" is more appropriate, since it includes domestic use as well as drinking water needed to meet normal public uses for schools, hospitals, and services as well as the water required to provide employment through commerce, trades, and industry. The MWR proposed for consideration is 100 cubic meters/person/year (CM/P/Yr) for domestic, urban and industrial use (Shuval,1992). This amount of water per person per year has been found to be generally adequate in Israel and other water short areas with similar climate for the maintenance of a reasonable hygienic level and a high standard of living based on employment in the urban/ industrial sector not including agriculture. In addition we propose that there be a symbolic allocation of 25 CM/P/Yr of fresh, good quality water for minimal growing of fresh vegetables (such as in vegetable gardens adjacent to homes) that require the use of fresh water of drinking water quality. The MWR calculation will not include any other direct allocation of fresh water for agriculture, but does assume that additional water for agriculture and/or other industrial or urban non-potable uses can be made available through the recycling and reuse of some 65% of the water allocated for domestic/ urban/industrial use. In other words there will be, in effect, the possibility of generating another 65 CM/P/Yr if an effective, total water recycling program is introduced. Thus, the total effective allocation of water could reach 190 CM/P/Yr (125 CM/P/Yr from fresh water sources and 65CM/P/Yr from recycled wastewater.

ILLUSTRATION OF APPLICATION OF PRINCIPLES AND METHODOLOGY

As an initial trail illustration of the application of the above principles and methodology (See Table 1) we will estimate the present and future populations to the year 2023 of the five direct riparian parties to the dispute in addition to the two near-by countries,Turkey and Egypt (column 1) and their estimated known renewable fresh water resources potential (column 2)(Shuval, 1993).

From this presentation it is clear that the Palestinians will suffer in the future from serious water shortages. Assuming for the moment that they have available only the water resources that they currently use, then their per capita water use would be reduced from 100 MC/P/yr in 1993 to 40 MC/P/Yr in the year 2023. The total amount of additional water required just to meet the - MWR of the Palestinians in the year 2023 is estimated at some 425 MCM/Yr. The situation for Jordan is similarly bleak. Assuming no increase in their water potential, then their per capita water resources will be reduced from 250 MC/P/Yr in 1993 to some 90 CM/P/Yr in the year 2023. The anticipated degree of water stress in the Middle East in the Year 2022 is shown graphically in Figure 1. Nations with water resources equal to of less than 125 cubic meter/ person/year are considered to be the water stress zone.

FIGURE 1



The amount of additional water required just to meet their MWR is some 370 MCM/Yr. By the year 2023 we estimate that the Palestinians and Jordan together may have a total water deficit of 795 MCM/yr just in order to met the modest water allocation for survival which we have defined as the MWR at 125 MC/P/Yr. This does not include any allocation for agriculture.

Assuming that Israel continues to utilize the water resources that it is currently using, than by the year 2023 it too will find itself with just a bit more than the MWR.

	1 POPULATION 1993	2023 (Millions)	2 WATER RESOURCES POTENTIAL MCM/Yr	3 TOTAL WATER CAPITA/YEAR CM/P/yr 1993	2023	4 TOTAL MWR 2023 MCM/Yr	5 TOTAL EXCESS SHORT MCM/YR
Israel	5	10	1,500	300	150	1,250	+250
Jordan	3	10	880	250	90	1,250	-370
Pales-palestinians	2	5	200	100	40	625	-425
Syria	12	26	15,000	1,250	580	3,250	+11,750
Lebanon	3	4.3	9,000	3,000	2,100	540	+8,460
Turkey	55	83	250,000	4,500	3,000	10,400	+240,000
Egypt	60	120	60,000	1,000	500	12,800	+47,000

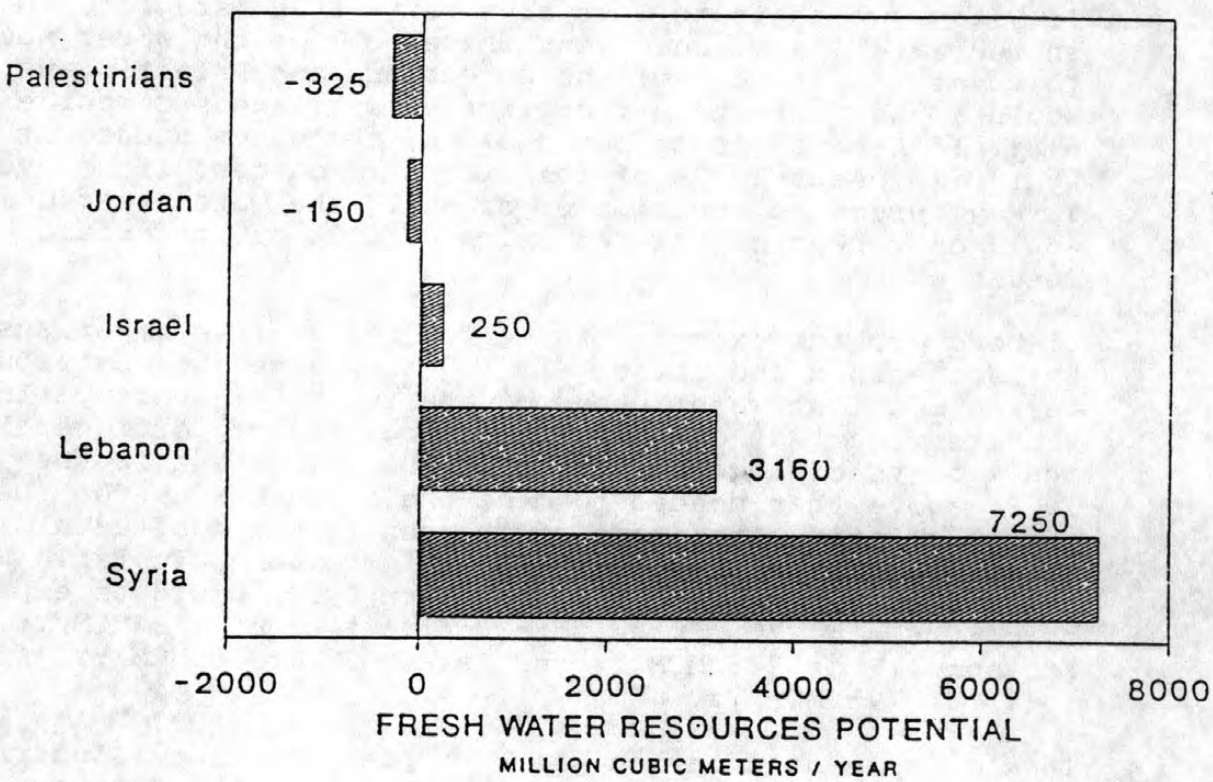
TABLE 1.CAN AVAILABLE WATER RESOURCES MEET THE MINIMUM WATER REQUIREMENTS-MWR OF MIDDLE EASTERN COUNTRIES? Estimated water resource potential, estimated population in the year 2023,and ability of water resources to meet Minimum Water Requirements-MWR for survival at 125 cubic meters/person/ year for domestic/urban/industrial and fresh vegetables.

Israel's per capita water resources will go from 300 MC/P/Yr to 150 MC/P/Yr by the year 2023 and possibly even lower as a result of the continuing process of salination and contamination of the ground water of the aquifers. The total excess of water resources above the amount required for domestic, urban/industrial use to met the MWR will be 250 MCM/yr.,but they may have no excess of drinking water at all, if our pessimistic estimates of loss of potable water through salination and pollution are correct.

Egypt and Syria will, in the year 2023, still have 500 MC/P/Yr. and 580 MCM/P/Yr respectively. While Lebanon and Turkey will remain in the water abundant range with 2000-3000 MC/P/Yr .

If we now examine the situation as presented here in terms of the general principles we have proposed in the spirit of the Helsinki Rules we find that of the five parties who share in the transboundry water of the area ,two(Jordan and the Palestinians) will face serious water shortages and will not even be able to meet their minimum requirements for drinking water unless their water resources are increased. Israel will just be able to meet its MWR, while Lebanon and Syria will be able to meet their MWR and other needs without any problems and will have considerable amounts of water in excess of the MWR(See Figure 2).

ESTIMATE OF TOTAL FRESH WATER POTENTIAL IN EXCESS/OR SHORT OF THE MINIMUM WATER REQUIRMENT IN THE YEAR 2022.



Let us assume for a moment that Israel alone is called upon to contribute water to the water short parties. Even if it transferred 100% of its theoretical excess above the MWR (250 MCM/Yr) it still would only cover less than one third of the needs (795MCM/Yr.) See column 2 in Table 2.

TABLE 2.

A PROPOSED RANKING OF POTENTIAL DONORS OF WATER TO THE WATER SHORT PARTIES BASED ON THE DEGREE OF EXCESS WATER RESOURCES IN THE YEAR 2023, ABOVE THE MINIMUM WATER REQUIREMENT-MWR OF 125 CM/PERSON/YEAR.

	1 EXCESS ABOVE MWR	2 %OF EXCESS TO MEET DEFICIT	3 % CONTRIBUTION IF SHARED S+L+I
1 Syria	12,000 MCM/Yr.	6.8 %	57%
2 Lebanon	8,460 MCM/Yr.	10.0 %	41%
3 Israel	250 MCM/Yr	100.0 %	2%
Turkey	240,000 MCM/Yr	0.3 %	--

If Syria, which is no less of a party than Israel to the shared water resources, contributed all of the water needed to cover the deficit of the Jordanians and Palestinians, it would amount only to a reduction in its excess resources of 6.8%. If Lebanon contributed all of the water needed it would represent 10.0% of its excess resources. If however Turkey agreed to contribute, or sell, the water needed it would only represent a reduction of 0.3% of its excess resources.

If however, for example, three out of the five riparians, Syria, Lebanon and Israel are together asked to contribute to the meet the water needs of the two water short partners who are riparians on the water resources, proportionately to the amounts of excess water that they will have in the year 2023, above that needed to meet their own MWR needs, then the calculated percentage of the contribution of each of the three countries would be as shown in column 3 in Table 2. Under such a proportional allocation Syria would be expected to contribute 57% of the total deficit of or 453 MCM/Yr, Lebanon 41% or 326 MCM/Yr and Israel 2% or 16 MCM/Yr. for a total of 795 MCM/Yr.

This example calculation has been presented for illustrative purposes only, as one possible methodological approach. This approach is based on the "equitable utilization" principle of the Helsinki Rules. It is designed to meet the minimum water requirements- MWR for survival of all partners. It should provide a method for analyzing the degree of need of the water short riparians and the possible degree of obligation to assist the water short riparians by the others who at least can meet their own Minimum Water Requirements-MWR.

Obviously none of the partners will be satisfied with an existence based only on the above minimum water allocation. A bold regional Water-for-Peace Plan for increasing the water resources of the area for all, by importing water or desalination sponsored by the major powers could become an important impetus to the peace process (Shuval, 1992). However, there must be a recognition that imported or desalinated water will, in general be costly and can be justified only for rational economic uses, which most likely will not include agriculture.

This methodological approach may be one way of approaching the problem of water allocations to the water short partners and hopefully will provide input into the negotiating process. It will certainly be controversial, however it is presented as food for thought. There are of course other factors that can be considered in studying the question of water allocations on a shared aquifer but the concept of equitable allocation based on meeting minimal human needs should be of prime importance. In the final analysis it is only through direct negotiation that an eventual agreement can be reached and it is not the task of this paper to prejudge the outcome of that vital process.

THE NEED FOR AN INTERNATIONAL JOINT COMMISSION FOR THE JORDAN RIVER BASIN

Assuming that agreement will be reached on questions of a just and equitable formulation for water allocations between the five riparians on the Jordan River Basin including the Syrians, Lebanese, Jordanians, Palestinians and Israelis it will be vital that such an agreement include provisions for the establishment of an International Joint Commission for the Jordan River Basin. For convenience we shall call this the Jordan River Joint Commission- JRJC. The functions of this commission should include:

1.Developing and sharing of hydrological data.

2.A procedure for joint validation of data including mutual free access to data sources and points of water flow measurement.

3.Long term water resources planning.

4 Drafting and promulgation of environmental quality and pollution control regulations which will become legally binding in all watershed areas of the shared international waters both surface water and ground water.

5.Establishment of a joint environmental monitoring and control staff including a joint laboratory for objective testing of water quality and pollution sources.

6.A system for joint monitoring and control of agreed upon water allocations including joint surveys and measurements in any one of the riparians.

7. Joint management and operation of any joint transboundary water importation project benefiting more than one riparian.

8. An agreed upon procedure for the ajudacation of disputes based on various phases, starting with negotiations, review by a higher level Joint Board, mediation, arbitration and finally by some form of agreed upon ajudication binding on all partners either by arbitration or an international court.

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6

PRICING AND COST RECOVERY

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Dr. Ian Carruthers has been Professor of Agrarian Development at Wye College, University of London since 1984. Originally trained in Horticulture (University of London) and Economics (Oxford University), he was awarded a PhD degree in Agricultural Economics in 1976 (University of London) in the field of water resource economics.

Professor Carruthers is the Director of the Wye College External Programme - a unique worldwide educational initiative that provides Masters level training for London University degrees in Agricultural Development and in Environmental Management using the methods of distance learning. There are presently 750 students registered in more than 100 countries.

He is also a Board Member of the Commonwealth Development Corporation - a British public corporation that invests in the private sector in developing countries. The portfolio is worth close to $2.7 billion, with 30% in the renewable natural resources sector and with more than 700,000 outgrowers benefiting from CDC investment.

Professor Carruthers has written numerous papers and books in the field of water resource economics, groundwater development, irrigation, drinking water and related areas of agricultural development. His books include <u>The Economics of Irrigation</u> (1983) with Colin Clark and <u>Farmer Financed Irrigation: The Economics of Reform</u> (1991) with Leslie Small. He is currently engaged as a consultant to GTZ on an applied research programme - MAINTAIN - addressing problems of irrigation maintenance. In the past he has held consultancies with the World Bank, the United Nations agencies, Ford Foundation, ODA and USAID and has extensive field experience in many countries including Pakistan, Uganda and Kenya.

THE ECONOMIC CASE FOR SUSTAINABLE IRRIGATION DEVELOPMENT

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The attached paper was first prepared in early 1994 as a piece of irrigation advocacy. It is a contribution to the current (1994) GTZ MAINTAIN project. It was presented in March 1994 to a NATO Workshop in Vimeiro Portugal. It is offered to the USAID "Future Directions for Implementing Water Policy" workshop participants as a background paper aimed to counter some of the harmful negative publicity about irrigation and the widespread complacency about world food supplies.

ABSTRACT

Continued improvement in irrigation is absolutely essential to enhance the presently fragile global food security. Improvement will require software and hardware investment in the existing infrastructure which will yield economic returns at least equivalent to alternative public and private investments. Properly planned and executed irrigation can have a positive environmental and social impact. It is in the interests of both national governments and the aid community to resist short sighted or prejudiced pressures to divest from irrigation.

1. Introduction

This review of economic aspects of irrigation is highly selective. It deliberately focuses on positive aspects of irrigation development although it is of necessity somewhat defensive in tone. It is argued that many of the current debates on irrigation policy have been relatively uninformed and unbalanced, with the critics, notably those coming from an environment perspective, dominating the arguments. The imbalance stems from the neglect of the 'without irrigation' scenario which is a necessary ingredient of any appraisal.

Many of the criticisms of irrigation are valid, but the overall impression is negative and wrong. Research is urgently required on the varied contributions of irrigation as well as an accessible digest of the information in the public domain that presents a fair picture of the opportunities and constraints to irrigation development.

An assessment of the benefits of irrigation development should come from an appreciation of the difference between the with and without irrigation scenario and a comparison of the real costs of the resources used with alternative ways of using these resources. This requires complex analysis. If the critics have their way, then the without irrigation scene will increasingly become the real situation in the absence of appropriate consideration of options. Insufficient attention and analysis of the implication of the without irrigation scenario results in a massive undervaluing of the economic and social impact of irrigation.

This paper has been prepared in recognition of the fact that for many governments and aid agencies the public sector investment in water development in general and in irrigation in particular has become extremely unpopular. The main purpose of this paper is to set out why this is considered to be an inappropriate stance for those primarily concerned with poverty alleviation and sustainable development.

2. The Rationale For Irrigation Investments

There are legitimate grounds for calling for an improvement in irrigation investment performance. Certainly there is scope for achieving considerable progress throughout the 250 million hectares presently irrigated worldwide. However, the proper response to an evaluation of what is often disappointing irrigation experience is to improve the workings of irrigation and realize the potential of the technology. This is particularly important given the vision presented later of a depressing future for global food supplies.

Most irrigable areas are already developed and therefore an improvement in the maintenance of the existing infrastructure will inevitably be an important component of any future irrigation development strategy. Aid donors can ill afford to turn their backs on the opportunities furnished by these huge, often incomplete investments in irrigation. Donor supported investments and institutional reforms can transform irrigation projects into genuine and sustainable development assets. To achieve this potential and to avoid the problems highlighted by the critics requires all parties to absorb the lessons of experience, some of which are set out below.

There are six major sets of reasons for public and private, national and aid community support for irrigation, all of which require elaboration and research before the sub-sector is either subject to investment or abandonment:

* FOOD REASONS
* INVESTMENT REASONS
* ENVIRONMENTAL REASONS
* SOCIAL REASONS
* AID REASONS
* SECTOR SPECIFIC REASONS

3. Food Reasons

Critics of irrigation claim that, *inter alia*, food will be cheaper and more reliable if purchased from Chicago today and possibly from Kiev tomorrow. However, the following propositions (3.1 to 3.3) can be regarded as testable hypotheses in future research:

3.1. TODAY MORE THAN ONE THIRD OF WORLD FOOD COMES FROM IRRIGATION, MOSTLY IN LOW INCOME COUNTRIES

This oft asserted 'fact' emerges from a set of plausible assertions. It is testable and should be tested. If correct, then sustaining irrigation is very important if we are to maintain a large part of the present global food production capacity.

3.2. MORE THAN TWO THIRDS OF ADDITIONAL (MARGINAL) FOOD WILL COME FROM IRRIGATION

This statement, if true, has profound implications for the allocation of research and investment resources. It is certainly the case that population growth continues and rural-urban migration accelerates and therefore growth in local food production is clearly important. This additional food growth has to be of the order of 3% per year to maintain supplies at current prices. Crop area growth is now virtually ended and hence if production rises are to match needs then the additional or incremental returns must come from higher yields. Yield increases will mainly come about with the application of modern agronomic methods on small as well as larger farms using costly purchased inputs. An assured water supply is part of the package of modern inputs.[1]

Without the assurance of a secure soil moisture supply, which in most areas outside the temperate zone implies irrigation, the risk factors associated with intensification will loom too large for many (especially low income) farmers.

3.3. COMPLACENCY ABOUT WORLD FOOD SUPPLY IS MISPLACED

World food prices are at unprecedented low levels which in part reflects shifts in supply as a result of successful application of modern agronomic advances. Discussed below are several sets of factors that, taken overall, show that the current secure food supply and low prices may not be as permanent as is clearly desirable.

3.3.1. *Reform of Industrial Country Agricultural Policy Will Contribute to an Increase in World Food Prices.*

Reform of the industrial countries' agriculture policies stemming from pressures from the GATT as well as their domestic financial authorities who wish to reduce subsidies will, over time, reduce the supply of food and increase food prices. This price rise will not offset a fall in the overall value added in their agriculture and consequent cut backs in agricultural research investment, first in the public sector and, as farm incomes are squeezed, then in the private sector. Developing countries that import food will be harmed, at least in the short run, by any increase in world food prices.

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[1] Mention of 'the package' of modern inputs does not imply that there is only one way forward. There are probably as many packages as there are projects and situation-specific solutions must be found. However, it is argued that the hardware package will probably include artificial fertilizer and responsive, high quality seeds. Experience suggests that designing and delivering the software package and education of users is likely to be the biggest stumbling block to progress. Research of the locally-specific package to adapt the generic technology produced by the CGIAR international research system and others is an important but neglected area.

3.3.2. *Research has Benefitted from Industrial Country Subsidies.*

Modern agronomic research has benefitted from an investment climate with product prices distorted upwards by massive industrial country subsidies (for example, Japanese farmer rice prices are over six times world levels, and the average European cow gets twice as much of an annual subsidy as the average income of a third world farmer). These subsidies were mainly production increasing and developing countries were able to pick up some spin-off benefits in terms of yield-increasing technology. In the future, subsidies are likely to be reduced overall and/or shifted to low input agriculture or environmental protection. This will not produce research output of much relevance to poor tropical countries that still need to increase their levels of production.

3.3.3. *Crop Area Growth Era is Over.*

The relatively uncomplicated method of obtaining increased food supply (the expansion of area cropped) is now practically over as virtually all suitable land is cultivated. From now on we must increase global food supplies by boosting the yield of crops on existing arable land.

3.3.4. *Easy Part of Yield Increases Completed.*

Crop yields can still be increased considerably with known technology. Unfortunately, much of the easy part of the yield increasing campaign to harness modern agronomic advance has also been completed by achieving the widespread adoption of artificial fertilizer use on stiff-strawed cereals that respond to nitrogen and do not lodge. Future developments to maintain production growth will require a wider range of inputs and much more difficult management improvements and reform of traditional institutions such as land tenure, credit systems and farmer education (especially women), all tailored to local situations.

3.3.5 *Institutional Reform Lessons Need Adopting.*

These management and institutional reforms are important but they have and will continue to prove hard to realise in practice. There are few general lessons to be gleaned from development experience, but what has been learned should make us cautious about our ability to sustain yield increases above the 2.5% per year and make us more realistic and flexible in project design and in maintaining investments than hitherto.[2]

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[2] The World Bank summarizes the lessons of their area development projects as:

* clear government commitment to rural development objectives (as evidenced by a supportive policy environment, especially pricing policies);
* participation of beneficiaries
* incentives in the form of benefits (including indirect benefits);
* realistic, not too complex and flexible project design;
* institutional capacity of government and others involved (e.g. NGO's) to implement a program efficiently;
* proven technology and support services to provide the necessary production growth.

[Source: 'Area Development Projects' Lessons and Practices No 3 Sept. 1993, OED World Bank, Washington.]

3.3.6. *Public Resistance to Biotechnology May Hinder Research Investment.*

There are clear signs of public resistance to accepting the products of biotechnology and other promising lines of research. These signs are worrying if, for example, we regard biotechnology as the major future source of crop (and animal) yield growth or for more benign methods of crop protection. If resistance to biotechnology is sustained or grows, then more resources will be diverted from agricultural research[3].

3.6.7. *Aid Commitments are Falling.*

Aid resources are generally falling or being spread more thinly (eg in the 1995 budget presented to Congress in early 1994 USA aid is scheduled to be cut from the $32 billion spent in 1993 to $17 billion in 1996 and thereafter, with 21 USAID offices closing). Aid for the rural sector is also falling (according to a recent IFPRI report, world aid to agriculture fell from $11.7 billion in 1980 to just over 10 billion in 1990)[4]. Although precise data are not available, the impression gained is that aid for water development has had a disproportionate share of the cuts just at the time when water has become recognised as a scarce valuable resource with a consequent political focus at international, national, regional, and village levels. Competition for aid resources comes particularly from new urban priorities. All of these cuts in aid can be expected to affect, after a lag, the growth in agricultural production.

3.3.8. *Urban Influences.*

Unprecedented and rapid urban growth has created a market for food (and water - releases of water by using irrigation water more efficiently will be an important future source of urban water supplies). This shift in demand for food plus future higher prices will be an incentive for farmers. However, in many countries, education and other social factors has changed peoples attitude to agricultural work and people, particularly the young and active, have permanently moved out of the rural labor force. A less well specified factor affecting production is the large amount of fertile land lost permanently to urban sprawl and far from fully compensated for by the growth of intensive production in and near cities (urban agriculture). Despite the importance of these influences and effects for policy, the research base upon which to formulate action is weak, particularly in the area of migration.

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[3] If for these or other reasons biotechnology fails to make an impact, then yield increases will inevitably slow and, given the continued growth in demand, food prices will rise. If, however, biotechnology has an impact, then irrigation is the category of production system that stands to gain most. Either way we can expect irrigation to become a potentially more important production system in the future.

[4] Joachim von Braun, Raymond Hopkins, Detlev Puez and Rajul Pandya-Lorch (1993) Aid to Agriculture: Reversing the Decline IFPRI, Washington.

3.3.9 *Part of Existing Food Supply Systems are Unsustainable.*

A proportion of current world food supplies come from what are generally agreed to be unsustainable production systems in developed and developing countries. For example, in the irrigation field, fossil groundwater abstraction, highly subsidised surface and groundwater irrigation, pumping groundwater from great depth or in excess of annual recharge (sometimes causing salt water intrusion and irreversible deterioration in aquifers) are all associated with unsustainable agricultural production systems. Other examples of production systems that are using degrading soil resources, eroding hillsides, deteriorating pastures and so forth abound, showing that the present level of production in these circumstances cannot be guaranteed. The effects of the inevitable growing population will be to increase these types of pressures. Irrigation technologies can help provide safety valves to help lower the unsustainable pressures on production systems and livelihoods[5].

3.3.10. *Pest and Disease Risk.*

The final factor that has to be considered is the risk to world food supplies from the increasingly narrow genetic base of much of the improved cereals.[6] The risk is related to the potential breakdown in resistance to virus or fungal disease and widespread loss of production. While it might be argued that it was irrigation that created one of the preconditions for the adoption of the narrow range of high yielding varieties, it can also be claimed that the production benefits have been high and are likely to remain so. Furthermore, in the unlikely event of, say, a devastating disease in rice that has a global impact, then the irrigated wheat would be invaluable.

3.3.11. *Water Resource Scarcity.*

Agriculture is the world's largest user of fresh water. The belated recognition that fresh water resources are finite and valuable and that demands on this finite supply are increasing has thrust irrigation into the limelight. It is acknowledged that water use efficiency can be markedly improved

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[5] Irrigation is sometimes argued to be unsustainable and certainly there are areas that have been abandoned for various reasons. But all irrigation is not unsustainable. The Egyptians who have cultivated the Nile valley for several thousand years indicate that concern for sustainability can be exaggerated. Current worries about physical aspects of the Nile system and about the impact of the Aswan High Dam in particular are real but soluble. There is little doubt that the major influence on Egyptian agriculture over the last 2000 years has been the harmful urban-biassed macroeconomic policy framework of the last 30 years which has done much pervasive damage and changed Egypt from an agricultural exporting country to almost certainly being a permanent importer of more than half its food.

[6] The small farmer that grows a wide range of traditional crops and varieties suffers lower yields than if a narrow range of high yielding crops were grown. However, he/she acts as a custodian of biodiversity and thereby creates an external social benefit. This could be an important economic justification for small farmer subsidies, were finance ever to be made available for that purpose.

and thereby release water for alternative use in agriculture and elsewhere[7]. Improvement in water use efficiency will require investment in the software (eg farmer education, improved management systems, agency staff training) as well as in the hardware of irrigation development. Unfortunately, in hard economic times, it is the software investments that are most vulnerable to cuts.

3.4. COSTLY FOOD HARMS THE POOR

The overall influence if some or all of these factors come about will be to affect the security of food supply and lead to an increase in world food prices. We should remember that for the most part the poor buy food and spend a high proportion of their income on it and any increase in food prices will have a particularly hard impact on their welfare. The single most effective anti-poverty instrument is low basic food prices. Efficient irrigation can help bring this about.

These are the main reasons why we have argued that the current complacency about world food security is misplaced. There is much conjecture about many of the elements. If these factors come into play, then irrigated agriculture can help compensate for these effects and produce food and fibre in the developing countries close to the rapidly growing numbers of consumers in the cities and the countryside.

4. Investment Reasons

The rate of return to investment in irrigation is widely believed to be low. This perception is wrong. Returns are generally comparable to alternative investments. For example, the World Bank portfolio includes 585 irrigation-related projects. The expected economic internal rate of return at appraisal was on average 22%. Some years later, after construction, the projects averaged a lower but acceptable level of 15%.

This realised rate of return might be considered quite modest and critics might argue that it will fall further as the schemes age and particularly so if they are not well maintained. However 15% was achieved in an era when the domestic terms of trade were stacked against agriculture with overvalued exchange rates and a variety of indirect taxes or subsidies to competing urban interests. In the future, these public (and private) irrigation investments and any new schemes promise to provide somewhat higher returns for the reasons discussed below.

4.1. SUNK COSTS IN IRRIGATION ARE HIGH

Billions of dollars of investment are already in place, much of it now free of any financial charge. Incremental investment in modernisation, completion, extension and rehabilitation will benefit from

[7] Water policy options are reviewed in detail in many official publications, but a comprehensive recent account with a strong underlying economic content is the theme chapter of the 1993 FAO Annual Report The State of Food and Agriculture FAO, Rome.

these sunk costs and yield high rates of return.[8]

4.2. ECONOMIC LIBERALISATION WILL INCREASE RETURNS

Economic liberalization and macro-economic reform tends to favor the agricultural sector and therefore, as the full effects of these changes in many countries begin to bite, we should see an improvement in rates of return to rural investment in general and to irrigation in particular. This will be especially so if overvalued exchange rates are adjusted, industry/urban subsidies are removed, and if neglect of O&M through budget squeezes, arbitrary cuts and delayed release of funds is ended. There is comparatively little research on sectoral level 'second round' effects and how they can be assisted or speeded in the sequence of reforms.

4.3. ADVANCES IN COMPLEMENTARY INVESTMENTS

Technological developments in agronomy, even if the pace of their arrival slows down, will improve the returns to irrigation. Indeed the availability of an assured supply of soil moisture is a precondition for much of the pipeline agronomic and biotechnology projects.

4.4. RATE OF RETURN WILL RISE IF FOOD PRICES RISE

As explained above we believe that it is likely that the net effect of various factors will lead to upward shifts in the demand for food in the face of slower supply shifts. This in turn will lead to increases in the price of food which will then increase the rate of return to irrigation.

4.5. HIGH RETURN INVESTMENTS REQUIRE BETTER PLANNING

The main output of the last fifty years of research on how to achieve development is that it is complex and difficult. The main practical effect of this insight is contradictory in that more criteria and tests for plans are set to match the complexity (e.g. environmental, regional impact, gender focus) but the resources available to carry out these investigations are diminishing and hence the growing popularity of rapid appraisal techniques. Poor irrigation performance can have many causes but skimpy investigations are a false economy in the search to eliminate it.

5. Environmental Reasons

The environmental critique of irrigation is an extreme response to real threats and in some cases to actual environmental damage from irrigation. Irrigation is seen by its critics as unsustainable with problems such as those associated with the salt balance, soil waterlogging, seawater intrusion into estuaries, and destruction of important ecological zones and wildlife habitats. Much of the

[8] Lessons from evaluations of irrigation need to be incorporated into new investments in any modernization or rehabilitation. Important among these lessons (in addition to those mentioned in Footnote 2 above) are the need to complete projects (including drainage, properly designed field channels and land levelling), to deal with the whole watershed including the non-irrigated upland areas, and to ensure mechanisms are in place that will maintain the scheme over the life of the project.

environmental literature that deals with irrigation can be considered to be unbalanced with an emphasis upon the negative environmental aspects (e.g. World Bank 1991 Environmental Assessment Sourcebook). The indirect and direct benefits of irrigation need to be considered simultaneously and a balanced view obtained.

Despite the reservations above there is also plenty of evidence that environmental damage can and does occur and that without reform the threat of further environmental deterioration is inevitable. However, this not a reason to withdraw from irrigation but rather a reason for engaging in a serious search for solutions. There are certainly technical solutions to each of these problems. But many of the problems require a management rather than an investment approach and where investment is needed (e.g. in the case of drainage) the financial demands are huge.

We would contend that irrigation, far from being an environmental problem area, can be an environmental asset providing that we can follow the following guidelines.

5.1. DISTINGUISH BETWEEN GOOD AND BAD IRRIGATION

Badly planned, constructed or managed irrigation schemes will create an environmental threat. Well-conceived, well-built and soundly managed schemes are a contained risk. The varied lessons of experience, often specific to a particular country or scheme, need to be incorporated into policies and practice.

5.2. COMPARE ENVIRONMENTAL RISKS OF ALTERNATIVE INVESTMENTS

Environmental risks are likely to be even worse in the hills, swamps and in marginal rainfed areas. The growing rural population has to live somewhere and it will be more readily absorbed with a livelihood onto the intensive farming of productive irrigation schemes at a relatively low environmental risk.

If irrigation is not brought up to its potentially productive level to absorb the growing rural population, there will inevitably be greater environmental risk of damage in the more fragile hillsides, streamsides and low rainfall zones that farmers and their families will be forced to occupy. Simply put the population absorptive capacity of irrigation is higher than any other farming system and providing it is well managed and maintained it is likely to be the best option to provide sustainable livelihoods. With population densities continuing to increase, research on the absorptive capacity with decent livelihoods of differing farming systems is urgently needed.

6. Social Reasons

Irrigation often disrupts traditional ways of life and patterns of settlement. Resettlement is often poorly planned and badly executed. Once again this is not grounds for not carrying out irrigation settlement but a reason to make greater effort to improve performance.

There is scope in irrigation for increased levels of participation in decision making. In the recent past, consultation procedures may have been minimal but, in introducing modern irrigation practices, an opportunity exists to bring in new institutional forms such as genuine water user groups. Women can benefit if conscious efforts are made to address their special interests and if, for example, new job opportunities and income sources encourage less male migration in search of work.

The scope for more participation has to be incorporated into working procedures. Participation is acknowledged to be an important aspect of development, but procedures to achieve it are still not well specified and tested. Some government agencies are rightly sceptical of conventional wisdom in this area. Much more action research and extension of successful experience is needed.

Public investment in irrigation is often condemned because it does not benefit the really poor (except, if successful, through lowering the price of food). It is true that capital gains are often made by the landowning elite and obviously the larger the holding the greater the gain. However, it is unreasonable to blame technology for a social ill and the minimum remedy of making sure there are no subsidies (or they are made transparent), or the more radical one of promoting land reform or betterment levies on capital gains are all in the hands of the government. Furthermore, it could be argued that to get the irrigation service working well is one precondition for a land reform. Certainly a land reform or any radical change wrought on a poorly maintained and deteriorating system would appear doomed to failure.

7. Aid Reasons

Critics argue that aid for irrigation is wasted. We have argued that economic returns (at least in the case of the World Bank projects) are equivalent to other sector and project aid. Where failures have occurred, they are generally avoidable and even predictable. Success and not failure can be the hallmark of irrigation aid.

Aid for irrigation must be maintained at least at present levels for the following reasons:

7.1. AID POLITICS

The OECD countries have the technology to develop irrigation and voters understand irrigation aid. They can see irrigation on television and for them it has existence value.

7.2. AID TRANSFERABILITY

In principal, the technology is not complex and can be maintained by the recipients.

7.3. AID ACCOUNTABILITY

Financial support for irrigation schemes are less fungible than some other forms of aid such as balance of payment support or even program or sector aid and thus there is a high degree of accountability. While policy based lending, program or sector aid can be good in principle, it does make accountability more difficult which can be an important limitation when aid is striving for political support in donor communities.

7.4. SCOPE FOR PRIVATIZATION

There is scope for elements of privatization or beneficiary management - both elements high on the aid agenda.

7.5. JOB CREATION HELPS REDUCE MIGRATION

In countries where the proportion of the population 16 years of age or less is more than 40% or even 50%, only intensive agriculture (and labor intensive catchment protection[9]) offers the prospect of creating jobs and cutting urban drift or intracountry and international migration pressures. Industry in comparison to rural development has unfavourable capital/labor ratios and employment possibilities are dismal although expectations are high.

7.6. DIRECTS AID TO WHERE MANY OF THE POOR LIVE

Irrigation already exists where many of the poor are living and to that extent it is an appropriate location for aid. There is also a potential for a greater degree of control of the project environment and aid donors can target the inhabitants for health or other forms of development assistance. If the irrigation planning includes the upper watershed catchments as advocated above where poverty is commonly found, then aid will be well targeted.

8. Sector Specific Reasons - Continued Dominance of Agriculture in the Poorer Countries

In summary, agriculture continues to dominate economic activity in low income countries, providing jobs, food and raw materials for industry and for export. Irrigation is the sub-sector of agriculture that has most unrealized potential but it also uses the most water which is increasingly recognized to have multiple uses and to be scarce and valuable.

Directing development resources to the irrigation potential with a focus upon the poor farmers and landless laborers in the irrigated areas and in the upper catchments would provide an unusual opportunity to link poverty alleviation and environmental protection. It would certainly be a poor strategic move to neglect opportunities for irrigation development at this time because of evident but soluble problems. Far better to accept the acknowledged challenges and to fully test preferred solutions to the areas of difficulty.

For the reasons set out above, it is argued that aid donors and governments should not neglect water development, but embark upon a new era of working to protect and then allocate efficiently, in a sustainable way to promote development, increasingly scarce and valuable water resources.

[9] Catchment protection also produces externalities in space (downstream - no silt and lower flood peaks) and time (longer life to reservoirs). Here again there may be grounds for subsidies to those undertaking the work to protect the land and water resources. We are in an era when the term subsidy almost automatically meets an initial negative response from governments and the aid community. Where real external social benefits that might otherwise be lost can be realised by subsidy then very careful consideration has to be given to undertaking this action. This is particularly the case if the damage that can be avoided is irreversible.

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INDUSTRIAL WASTEWATER MINIMIZATION

DR. WILLIAM J. LACY, PANEL PRESENTER

Dr. William J. Lacy, a Chemical Engineer, is President of LACY & CO., an international environmental consulting firm to industries and governments. He received his B.S. from the University of Connecticut, completed his Masters degree at New York University College of Engineering, and studied at the Oak Ridge Institute for Nuclear Studies, University of Michigan and Michigan State University. The School for Advanced Chemistry at Paul Sabatier University, France, awarded him the University Medal in 1983, and an honorary Doctorate of Science in environmental engineering.

He worked for the Corps of Engineers, in the Pentagon for the Secretary of Defense and in the Executive Office of the President prior to joining EPA.

Dr. Lacy served at EPA Headquarters from 1968-1984 as Chief of Applied Sciences, Director of the National Industrial Pollution Control Program, Director of Monitoring, and the Principal Engineering Science Advisor. He managed and directed the Minority Research Institute Program, established the National Dioxin Monitoring Network, and headed the International Cooperative Research and Development (R&D) Program.

Dr. Lacy has authored 192 technical publications, including 11 textbooks. He has three patents and serves on the editorial advisory board of five technical journals.

For his efforts, Dr. Lacy has received numerous awards and medals from Thailand, India, Egypt, Belgium, France, Poland and Italy. Other honors include American Defense Preparedness Association award, Secretary of Defense Special Service Award, Presidential Recognition Award, EPA, Bronze Medal, and the U.S. Government Distinguished Service Medal.

INDUSTRIAL WASTE MINIMIZATION

Abstract of Panel Presentation
by
Dr. William J. Lacy

Background

An increasing number of Agency for International Development (USAID) initiatives are focusing on waste minimization/pollution prevention. This presentation will serve as an introduction to a waste minimization program. The goal is to support effective program implementation chiefly by people in the field.

The terms waste minimization/pollution prevention will be used interchangeably in this presentation.

Pollution prevention is the use of materials, processes, or practices that reduce or eliminate the creation of pollutants or wastes at the source. It includes practices that reduce the use of hazardous and non-hazardous materials, energy, water, or other resources as well as those that protect natural resources through conservation or more efficient use.

A pollution prevention program is an ongoing, comprehensive examination of the operations at a facility with the goal of minimizing all types of waste products. An effective pollution prevention program will:

- reduce risk of criminal and civil liability
- reduce operating costs
- improve employee morale and participation
- enhance company's image in the community
- protect public health and the environment

Benefits

In the case of waste minimization, the developing countries' national environmental goals will coincide with industries' economic interests. Businesses have strong incentives to reduce the toxicity and sheer volume of the waste they generate. A company with an effective, ongoing waste minimization plan may well be the lowest-cost producer and the least polluting company. The result is a significant competitive edge. Their public image will also be enhanced.

What broad areas of industrial, agricultural, and other activities in developing countries offer opportunities to apply pollution prevention thinking?

> Are there particular environmental problems and issues related to economics, economic development, trade, and competitiveness in certain sectors which create conditions that pollution prevention projects can take advantage of because they offer unique benefits?

How can the best opportunities be identified, with regard to both economic and environmental paybacks?

> In any host country there will be a large number of existing and planned activities which have diverse environmental impacts. It is necessary to have some practical analytical framework and evaluation criteria to help make objective decisions about setting priorities for spending on pollution prevention projects, particularly ones that can be early pilot or demonstration projects to serve as models of success. Solid analysis and data may be necessary to overcome less objective support for particular projects.

What characteristics of existing industrial activities pose difficult obstacles to achieving pollution prevention success and should be given lower priority?

> It is important to identify: existing facilities with large traditional pollution control investments; the attitudes and educational backgrounds of the technical workforce; and ownership conditions and management structures. Various conditions can pose barriers that would require substantial time and resources to overcome.

What general characteristics of the social, economic, and political structures in a developing country need to be understood if pollution prevention initiatives are to succeed?

> Many social practices and traditions, economic conditions and priorities, and government policies, plans, and organizations will provide either a receptive or hostile set of circumstances for pollution prevention.

The above questions illustrate the goal of translating general policy support and direction for pollution prevention (such as USAID's EP3 program) into delivery systems which can rapidly deploy pollution prevention. Any person who is faced with implementing pollution prevention has many difficult decisions. Reducing complexity improves implementation. Experience with pollution prevention has shown that it is necessary to avoid being too general and too unfocused. The greatest need is to find efficient ways of identifying targets of opportunity and establishing priorities for leveraging pollution prevention investments and multiplying their positive results. Effective implementation means converting ideas into measurable economic and environmental benefits.

Another need is to identify U.S. sources of proven pollution prevention technologies and products which can be closely matched to specific opportunities in the host country. It is also necessary to balance short and long term needs and opportunities. If there is any major lesson to learn from the past decade of pollution prevention experience in the U.S., it is that the rhetoric of pollution prevention usually exceeds its actual implementation. As the 1992 Rio Earth Summit conference illustrated, however, accelerating global concerns about environmental problems necessitate a fast-track approach to pollution prevention implementation.

It is extremely important that individuals who are relatively new to the environmental area or to the pollution prevention strategy take advantage of the past decade's research and experience. The following brief discussions are designed to provide the reader with a practical understanding of issues which confront pollution prevention programs and projects, and to distill what has been learned during the past decade.

Implementing pollution prevention in a developing country is highly complex, as it has been in the U.S., and there are unavoidable obstacles to overcome, far beyond the environmental area.

Engineers alone will not make pollution prevention programs successful. There is a need to pay close attention to many institutions (e.g., financial, educational, and political) and how they can be introduced to pollution prevention, and become committed to it for the long term. It is helpful to have an idealistic vision of pollution prevention: it is the path to achieving a zero waste, zero pollution, zero environmental impact industrialized and prosperous society. A number of CEOs of American corporations have publicly expressed these kind of idealistic goals for their companies in order to motivate their workforces.

To a significant degree, pollution prevention is being offered not solely on the basis of what industrialized countries have already done with it, but also as a strategy to leapfrog and avoid what the U.S. has mostly used to address environmental problems for over 20 years. The traditional approaches have often achieved considerable environmental success in reducing pollution, but they have imposed high costs and over time they become less efficient in reaching lower levels of pollution.

Government environmental command-and-control regulations, which nearly always are based on pollution control and waste management, provide economic incentives for pollution prevention, but also divert resources away from using pollution prevention. Attempts by developing countries to replicate regulatory programs in developed countries can be so costly and difficult that they can divert attention and resources away from pollution prevention. But we know how to approach this problem.

Although regulations are important to foster pollution prevention, compromises are needed, and special attention to having the most flexible kinds of regulations which support pollution prevention is critical (e.g., delayed compliance and avoidance of fines or penalties for non-compliance if investments in pollution prevention are made). Direct support for pollution prevention through technical and economic assistance is also necessary.

To sum up, developing countries must introduce flexibility and regulatory compliance and use various economic incentives so that companies can use alternative pollution prevention responses. To some degree, developing countries with relatively young regulatory programs have more opportunity to facilitate pollution prevention that more mature programs, if they see enough advantages from employing pollution prevention as both an environmental and economic development strategy.

Developing countries must also provide active support, assistance, and public encouragement for using pollution prevention methods, and USAID and other donors can play a valuable role in this effort.

Assistance

There are a number of organizations that can assist you in developing and maintaining a pollution prevention program. This appendix lists offices of the USEPA, state agencies, and assistance programs.

US Environmental Protection Agency

Pollution Prevention Information Clearinghouse (PPIC)

The PPIC is dedicated to reducing industrial pollutants through technology transfer, education, and public awareness. It provides technical, policy, programmatic, legislative, and financial information upon request.

The PPIC provides businesses and government agencies with information to assist them in a range of pollution prevention activities, such as:

- Establishing pollution prevention programs
- Learning about new technical options arising from US and foreign R&D
- Locating and ordering documents
- Identifying upcoming events
- Discovering grant and project funding opportunities
- Identifying pertinent legislation
- Saving money by reducing waste.

The PPIC disseminates this information through a number of services. These include:

- a telephone hotline
- a repository of publications, reports, and industry-specific fact sheets
- an electronic information exchange network
- indexed bibliographies and abstracts of reports, publications, and case studies
- a calendar of conferences and seminars
- a directory of waste exchanges
- information packets and workshops.

The electronic network maintained by PPIC is designated as PIES. It provides access to information databases and can be used to place orders for documents. The subsystems of PIES include:

- a message center
- a publication reference database
- a directory of experts
- case studies
- a calendar of events
- program studies
- legislation summaries
- topical mini-exchanges.

This interactive system can deliver information to the user through screen display, downloading, and fax. It is available to off-site computers via modem 24 hours a day. For information on linking to PIES, contact:

PIES Technical Assistance
Science Applications International Corp.
8400 Westpart Drive
McLean, VA 22102
(703) 821-4800

The PPIC operates a telephone hotline for questions and requests for information. The hotline provides users who cannot access PIES electronically with access to its information and services. For information on any of PPIC's services, write to:

US EPA Pollution Prevention Office
401 M Street SW (PM-219)
Washington, DC 20460

or call:

Myles E. Morse
Office of Environmental Engineering and Technology Demonstration
(202) 475-7161

BACKGROUND MATERIAL FOR THE INDUSTRIAL WASTEWATER MINIMIZATION SESSION, PROVIDED BY DR. WILLIAM J. LACY, PANEL PRESENTER

WHAT IS POLLUTION PREVENTION

Introduction

Liquid, solid, and/or gaseous waste materials are always generated during the manufacture of any product. In addition to creating environmental problems, these wastes represent losses of valuable materials and energy from the production process and require a significant investment in pollution control. Traditionally, pollution control focusses on "end-of-pipe" and "out-the-back-door" viewpoints. The control of pollution in this way requires manpower, energy, materials, and capital expenditures. Such an approach removes pollutants from one source, through wastewater treatment or air pollution abatement, but places them somewhere else such as a landfill.

Added regulations, higher disposal expenses, and increased liability cost have caused industrial and governmental leaders to begin critical examinations of end-of-the-pipe pollution control measures. The value of reducing waste during the manufacturing process and thus eliminating some pollutants as an end product has become apparent to a number of industries. These companies are looking at broader environmental management objectives rather than concentrating solely on pollution control. As will be documented throughout this article, waste reduction is very often economically beneficial for an industry and also results in improved environmental quality.

Waste reduction techniques should be a key component of any cost-effective, comprehensive waste management program. They do not have to be based on high technology or require large capital expenditures. In fact, waste reduction techniques can be applied to any manufacturing process, from something as simple as making a paper clip to one as complex as assembling the space shuttle. Available techniques range from easy operational changes to state-of-the-art recovery equipment. The common factor in these techniques is that they reduce bottom-line operational costs.

Waste reduction techniques can be broken down into four major categories: managing inventory, modifying production processes, reducing waste volume, and recovery waste. Because the classifications are broad, there will be some overlap. IN actual application, waste reduction techniques generally are used in combination in order to achieve the maximum effect at the lowest cost.

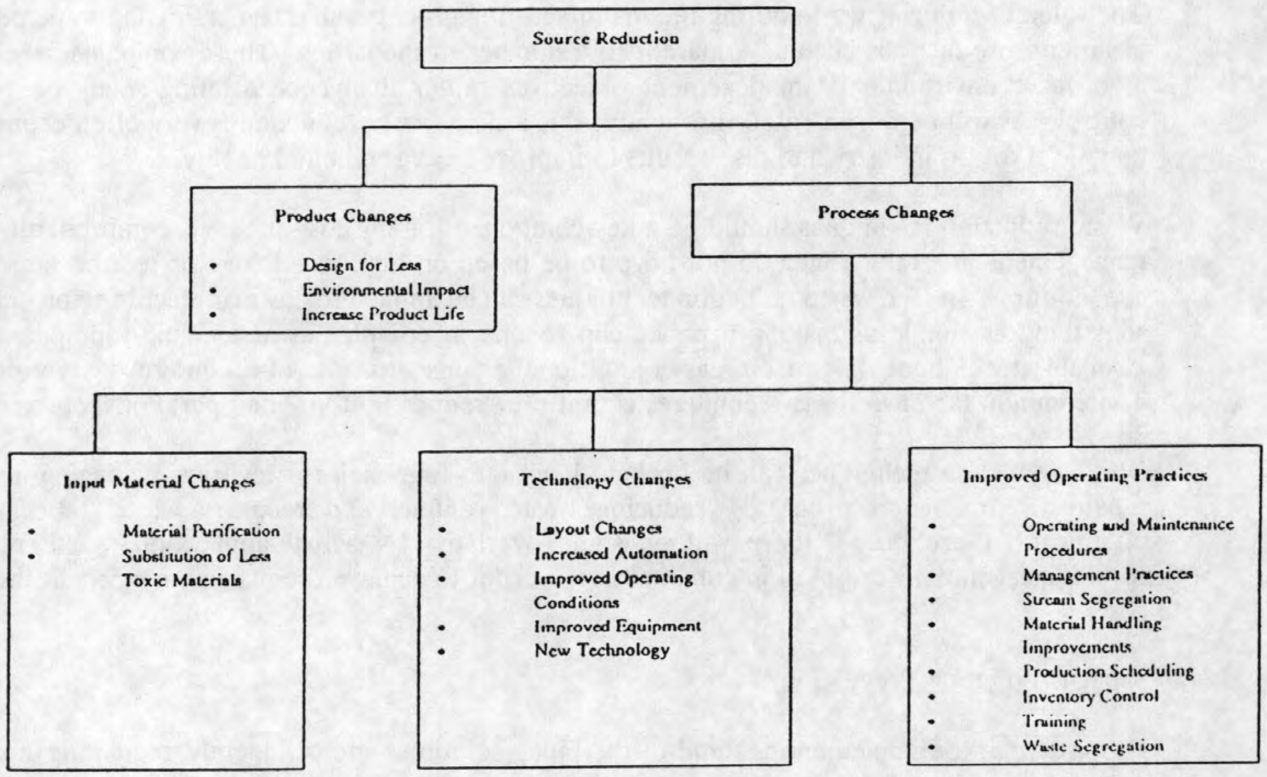
What Is Pollution Prevention?

Despite years of implementing "end-of-the-pipe" solutions and stringently regulating hazardous material disposal, substantial amounts of pollution are still being released into the environment. A new approach to environmental production is necessary in order to maintain and assess their production processes, to evaluate their purchasing decisions, and to improve their maintenance practices. Simply put, industries need to find new ways to prevent pollution at the source.

The concept of pollution prevention is very important in today's society. Industries are concerned with the increasing cost of raw materials. Stringent environmental control laws and regulations are restricting the way some businesses operate. Potential financial and criminal liability associated with disposal of waste materials increasingly concern industry executives. In addition, consumers dislike of industrial pollution and their strong influence on profit has caused industry officials to analyze their production processes. Pressure from foreign competition has also required that companies become very cost conscious. All of these examples should make one realize that pollution prevention planning can be beneficial.

What exactly is pollution prevention? Many different definitions of pollution prevention has been developed by numerous individuals and organizations over the last several years. Pollution prevention, often referred to as a source reduction, includes practices that maximize the reduction or elimination of the generation of pollution. Figure 1 illustrates several examples of source reduction.

Figure 1
Typical Source Reduction Examples
(Adapted from EPA Facilities Pollution Prevention Guide, May 1992)



Increased efficient use of raw materials energy, water, and other resources is one method of implementing pollution prevention. Conservation of natural resources is another method.

- pollution should be prevented or reduced at the source whenever feasible;
- pollution that cannot e prevented or recycled should be treated in an environmentally safe manner whenever feasible; and
- disposal or other release into the environment should be employed only as a last resort and should be conducted in an environmentally safe manner.

Pollution prevention means "source reduction"

-- increased efficiency in the use of raw materials, energy, water, or other resources, or

-- protection of natural resources by conservation.

The term "source reduction" includes: equipment or technology modifications, process or procedure modifications, reformulation or redesign of products, substitution of raw materials, and improvements in housekeeping, maintenance, training, or inventory control.

The terms recycling, energy recovery, treatment, and disposai are not included within the definition of pollution prevention. Some practices commonly described as "in-process recycling" may qualify as pollution prevention. Recycling that is conducted in an environmentally sound manner shares many of the advantages of prevention -- it can reduce the need for treatment or disposal, and conserve energy and resources.

In the agricultural sector, pollution prevention approaches include:

-- reducing the water and chemical inputs;

-- adoption of less environmentally harmful pesticides or cultivation of crop strains with natural resistance to pests; and

-- protection of sensitive areas.

In the energy sector, pollution prevention can reduce environmental damages from extraction, processing, transport, and combustion of fuels. Pollution prevention approaches include:

-- increasing efficiency in energy use;

-- substituting environmentally benign fuel sources; and

-- design changes that reduce the demand for energy.

Pollution prevention, source reduction, or any other terms that may apply are basically nothing more than a common sense approach to managing resources. No matter what the term, the philosophy is the same: reduce the quantity of waste at, or close to, its source. After all, wastes can be thought of as out-of-place resources. This philosophy makes good business sense.

Management of pollutants has most often been viewed as a bottom line issue, a cost incurred after everything else is paid for. When viewed as a cost associated with a particular product or production line, these costs can more adequately be identified and reduced, and thus are less of a drain on a company's financial resources.

<u>What You Can Do</u>

A pollution prevention program affects a variety of manufacturing and management groups within a company. In fact, almost everyone within an organization can, in some measure, impact the generation of pollution:

- Upper Management sets a corporate pollution prevention philosophy
- Engineering designs the process operations
- Operations runs the process
- Maintenance keeps the equipment in good repair
- Material Control determines and organizes material resources
- Purchasing purchases materials
- Receiving accepts/rejects production materials
- Warehousing stores and distributes production materials
- Facilities Management provides the appropriate production environment
- Quality Control ensures consumer satisfaction
- Accounting watches the bottom line
- Human Resources provides a trained work force
- Health and Safety assures a safe work place
- Research and Development develops new products and ideas
- Legal reads and interprets regulations

- Environmental Management picks up the pieces

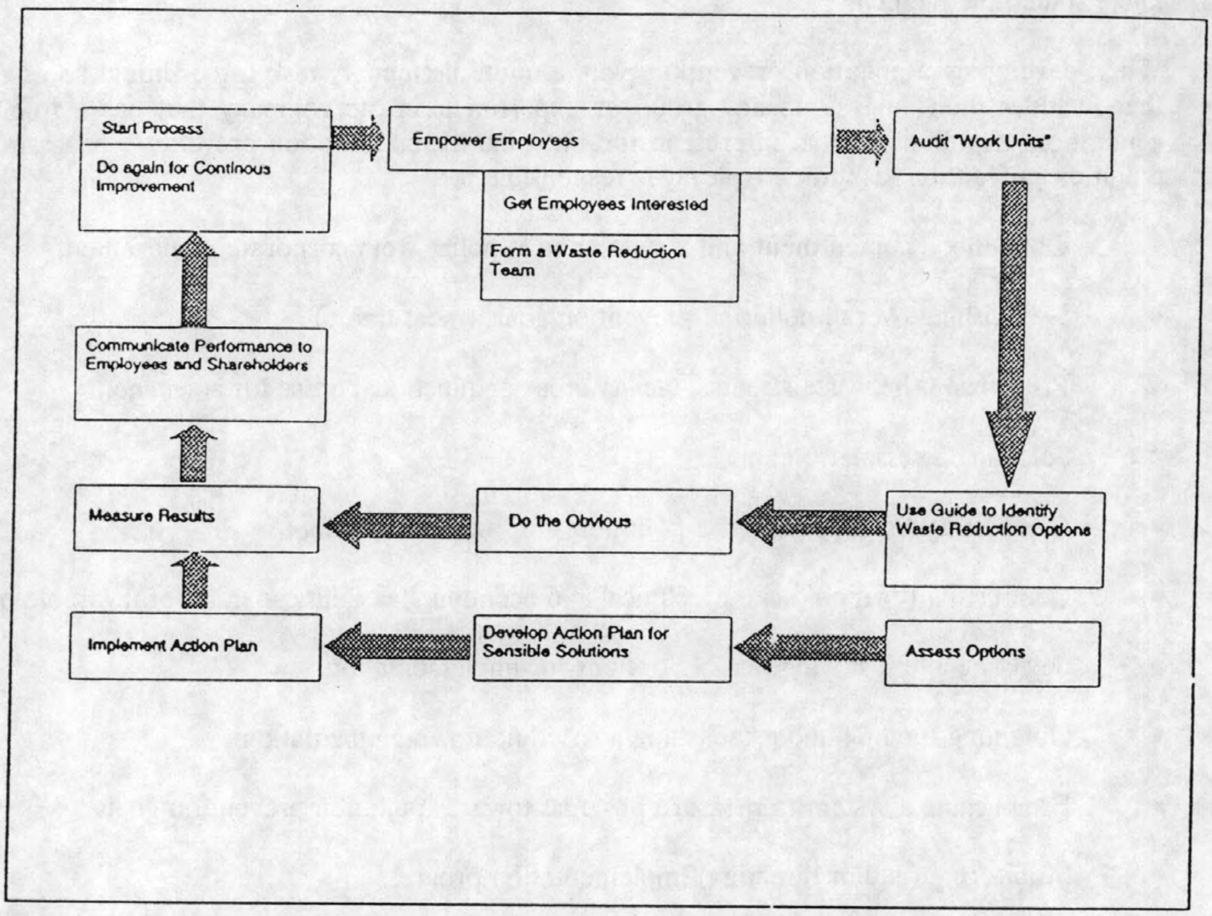
While it is important to list all of these groups within a company who impact on pollution prevention, it is important that we do not lose sight of the fact that a company is made up of individual workers. Pollution prevention can not happen if individuals do not take the initiative to make something happen.

When developing a pollution prevention plan, a multi-disciplinary task force should be assembled that includes individuals from any group or department in the company that has a role in the generation of pollution or an interest in the outcome of the pollution prevention program. This pollution prevention task force typically is responsible for:

- Obtaining a commitment and a statement of policy from corporate management
- Establishing overall pollution prevention goals (measurable)
- Prioritizing the waste streams, facility areas or functional areas for assessment
- Selecting assessment teams
- Conducting (or supervising) a pollution prevention assessment
- Conducting (or monitoring) technical and economic feasibility analyses of favorable options
- Selecting and justifying feasible options for implementation
- Obtaining funding and establishing a schedule for implementation
- Establishing a system to measure progress towards pollution prevention goals
- Monitoring (and/or directing) implementation progress
- Communicating pollution prevention success throughout the organization

Figure 2 illustrates the development of a work place waste reduction program in a simple, easy to understand format.

Figure 2
Workplace Waste Reduction Initiative
(Adapted from the President's Commission on Environmental Quality Pamphlet, Summer 1992)



WASTE MANAGEMENT TERMS

- **Waste Minimization**

  Waste minimization is the reduction, to the extent feasible, of wastes that are generated and subsequently treated, stored, or disposed. It includes any source reduction or recycling activity undertaken by a generator that results in either (1) the reduction of total volume or quantity of waste; or (2) the reduction of toxicity of the hazardous waste, or both, so long as such reduction is consistent with the goal of minimizing present and future threats to human health and the environment. Waste minimization shifts the focus away from control, transfer between media, and waste treatment to proactive generation avoidance. It concentrates on reducing the quantity and toxicity of multimedia wastes.

- **Source Reduction**

  Source reduction or pollution prevention is any practice that reduces or eliminates the quantity or toxicity of waste at the point of generation. Measures include process modifications, feedstock substitutions, improvements in feed stock purity, improvements in housekeeping and management practices, increases in the efficiency of machinery, and recycling within a process.

- **Recycling**

  The use or reuse of hazardous waste and an effective substitute for commercial product or as an ingredient or feedstock in an industrial process. It can occur on- or off-site and includes the reclamation of useful constituent fractions within a waste material, the removal of contaminants from a waste to allow it to be reused, or the use of waste as fuel supplement or fuel substitute.

- **Waste Treatment**

  Waste treatment is any method, technique, or process that changes the physical, chemical, or biological characteristic of any hazardous waste in a way that neutralizes the waste; recovers energy or material resources from the waste, or renders such waste nonhazardous, less hazardous, safer to manage, amenable for recovery, amenable for storage, or reduced in volume.

- **Disposal**

  Disposal is the discharging, depositing, injecting, dumping, spilling, leaking, or placing of hazardous waste into or on any land or water so that such waste or any constituents can enter the air or can be discharged into any water, including ground water.

- Reclamation

  Reclamation is the recovery of a valuable material from a hazardous waste. Reclamation techniques differ form use and reuse techniques in that the recovered material is not used in the facility, but rather it is sold to another company.

- Use and Reuse

  Recycling via use or reuse involves the return of a waste material either to the originating process as a substitute for an input material, or to another process as an input material.

- Good Operating Practices

  Good operating practices are procedural, administrative, or institutional measures that a company can use to minimize waste. Many of these measures are used in industry largely as efficiency improvements and good management practices. Good operating practices can often be implemented with little cost and, therefore, have a high return on investment. These practices can be implemented in all areas of a plant, including production, maintenance operations, and in raw material and product storage.

- Housekeeping

  Housekeeping is one phase of good operating practices that seeks to reduce the generation of waste through strategies such as segregation of waste streams, prevention of chemical spills and leaks, and proper storage and handling of materials.

- Input Material Changes

  Input material changes accomplish waste minimization by reducing or eliminating the hazardous materials that enter the production process. Also, changes in input materials can be made to avoid the generation of hazardous wastes within the production processes.

- Product Changes

  Product changes are performed by the manufacturer of a product with the intent of reducing waste resulting from a product's use. Product changes include: (1) product substitution, (2) product conservation, and (3) changes in product composition.

- Technology Changes

  Technology changes are oriented toward process and equipment modifications to reduce waste, primarily in a production setting. Technology changes can range from minor changes that can be implemented in a matte of days at low cost, to the replacement of process involving large capital costs.

- Waste Minimization Assessment (WMA)

  A waste minimization assessment is a systematic, planned producer to identify ways to reduce or eliminate waste.

- **Waste Minimization Program (WMP)**

  A waste minimization program is an organized, comprehensive, and continual effort to systematically reduce waste generation. Generally, a program is establish for the organization as a whole. EPA issued guidance in the June 12, 1989 Federal Register (volume 54, No.111) on the basic components that should be included in a waste minimization program. They are: (1) top management support (2) characterization of waste generation (3) periodic waste minimization assessments; (4) cost allocation system; (5) encouragement of technology transfer; and (6) program evaluation.

- **Waste Minimization Plan**

  A waste minimization plan describes in written form the facility's overall strategy for reducing waste generation. Typically, the plan applies program components to specific facility characteristics.

Total Quality Management Principles

Motivated by competition due to increased customer demand for quality. Manufacturers are driven to exceed customer expectations and to find ways to "thrill" the customer to maintain economic and market share advantages over competitors.

Requires management commitment at the highest level and decentralization of responsibilities. Manufacturing operations must have clear direction from management that quality is everyone's responsibility to implement process improvements and maintain production quality.

Policy focuses on continuous quality improvement through improved efficiency instead of one-time innovative leaps. Manufacturers rely on continuous and incremental improvement, and not on technological breakthroughs, to correct ineffective manufacturing processes. Focus is often on the human element associated with manufacturing and improved quality.

Process operations are designed, implemented, and evaluated based on facts, data, and analysis. Manufactures utilize process controls and checks to control process efficiency, reduce errors and rejects, and improve quality.

Sets an absolute goal of zero defects and attempts to achieve it through improvement of the production process instead of through final QC of product. Improved quality is achieved by control within the production process to prevent the generation of defective products.

Waste Minimization Principles

Motivated by survival due to increasing waste management requirements and costs. Manufacturers are driven to look beyond minimum compliance and find ways to reduce and eliminate waste to maintain economic, regulatory, and public relations advantages over competitors.

Requires management commitment at the highest level and decentralization of responsibilities. Manufacturing operations must have clear direction from management that pollution prevention is everyone's responsibility and all employees must have full authority and responsibility to identify and implement pollution prevention opportunities.

Policy focuses on reduced waste generation through improved process efficiency instead of standard end-of-pipe technologies. Manufacturers rely on in-process modifications and improved operating practices to achieve increased efficiency, reduced waste generation, and decreased reliance on treatment technologies. Focus is often on human factors associated with process efficiency and waste generation.

Process operating parameters are defined and implemented based on facts, data, and analysis. Manufacturers utilize process controls and checks to improve process efficiency and reduce material use and waste generation.

Sets absolute goal of zero pollution discharge and attempts to achieve it through in-process changes instead of end-of-pipe pollution controls. Pollution prevention is achieved through controls in the manufacturing process to improve efficiency and reduce wastes.

HOW TO MAINTAIN AND IMPROVE A WASTE MINIMIZATION PROGRAM

- *Integrate waste minimization into corporate planning:*
  - Assign waste minimization accountability to the operating units where waste is generated
  - Track and report program status
  - Conduct an annual program evaluation at the corporate level

- *Provide ongoing staff education programs:*
  - Make waste minimization awareness program a part of new employee orientation
  - Provide advanced training
  - Retain supervisors and employees

- *Maintain internal communication:*
  - Encourage two-way communication between employees and management
  - Solicit employees' waste minimization suggestions
  - Follow-up on suggestions

- *Reward personnel for their success in waste minimization:*
  - Cite accomplishments in performance reviews
  - Recognize individual and group contributions
  - Grant material rewards
  - Consider waste minimization a job responsibility subject to review

- *Provide public outreach and education about waste minimization efforts:*
  - Submit press releases on innovations to local media and to industry journals read by prospective clients
  - Arrange for employees to speak publicly about waste minimization measures in schools and civic organizations

What is Quality Assurance (QA)? What is Quality Control (QC)?

Quality assurance (QA) and quality control (QC) are terms which confuse most people. This is particularly true since the terms are defined differently by different groups. The Federal Programs Corporation (FPC) QA program uses the same definitions of QA and QC as their federal clients. These definitions are presented below with a bulleted list of characteristics and activities which further define the terms.

QUALITY ASSURANCE

Quality assurance is a management system designed to ensure that quality control procedures are in place and functioning. Quality assurance:

- Is implemented by a few people - the QA staff
- Is independent of FPC working groups
- Reports to management
- Defines quality objectives
- Provides guidance on appropriate QC measures
- Provides audit system to check on use of QC measures
- Provides system for correct action
- Maintains QA oversight of work in progress

QUALITY CONTROL

Quality control is the use of appropriate procedures to foster high quality work and to enable checking on quality at various points. Quality control is:

- Implemented by everyone working on the job
- Part of all FPC working groups
- Different for different types of work
- Implemented in real time while work is done
- Often just common sense

Examples of QC measures are:

- Proofreading
- Technical review procedures
- Standardized business forms
- Footing and cross-footing numerical columns
- Equipment calibration and maintenance
- Blanks, duplicates, and known value samples
- Onscreen data input prompts
- Data processing batch totals and control totals
- Test data sets
- Checking output against raw data input

Highlights of a recent article by Dr. R.B. Pojasek of the American Institute for Pollution Prevention (ENR April 1994)

There is tremendous momentum for industry to embrace pollution prevention. So far, that hasn't translated into much new business for environmental consultants, making many companies skeptical about its prospects. But the truth is, pollution prevention is replacing end-of-the pipe solutions faster than you think.

With the promulgation of the Pollution Prevention Act of 1990, there has been a host of federal and state programs to actively promote both regulatory and voluntary industrial initiatives. Carol Browner, Environmental Protection Agency Administrator, vows that pollution prevention is the Agency's first priority. Meanwhile, many of this country's larger industrial firms are considering how best to effect pollution prevention through equipment or technology modifications, process or procedure changes, reformulation or redesign of products, substitution of raw materials, and improvements in operating practices, maintenance, training or inventory control and other means. The problem is, very little of the pollution prevention activity is being contracted to outside consultants. If that doesn't change, the near-term market for consulting services will not reach its full potential.

PRESSURE BUILDING FOR POLLUTION PREVENTION

What exactly is "pollution prevention"? The U.S. Environmental Protection Agency (EPA) defines pollution prevention as "Any practice which reduces the amount of any hazardous substance, pollutant or contaminant entering any waste stream or otherwise released into the environment prior to recycling, treatment or disposal; and reduces the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants."

EPA sponsors programs to encourage and reward pollution prevention. It provided initial funding for the American Institute for Pollution Prevention, which is based in Cincinnati, Ohio. This organization represents 27 trade and professional associations in an effort to expedite the adoption of pollution prevention by industry and the engineering community.

In addition, EPA has developed "Design for the Environment," which aims at getting industry to take the environment into account from the very conception of a product idea. This program assists industry in making informed, environmentally responsible design choices by providing standardized analytical tools for industry application and providing information on the comparative risk and performance of chemicals and processes. Consulting engineers will have to become familiar with these concepts as they hope to be involved in constructing the facilities of the future.

The Administration has recently announced a five-pronged policy to encourage yet more pollution prevention:

- To incorporate multimedia prevention as the principle of first choice in all EPA activities including rule-makings, permitting and enforcement.
- To build a national network of prevention programs among state, local and tribal governments.

- To expand programs that emphasize cross-media prevention, such as the Design for Environment project.

- To increase efforts to generate and share information promoting prevention and tracking progress through such measurements as the Toxics Release inventory, and

- To increase industrial competitiveness and enhance environmental stewardship by interacting with other agencies and the private sector on the development of "clean" technologies.

This increased commitment to pollution prevention marks a cultural change in EPA which has spent the last 20 years regulating toxic emissions and pollution cleanup after the fact. The new ethic is to clean up the environment by preventing environmental deterioration in the first place. For developing countries, there is great interest in avoiding the creation of waste since they can't afford the equipment needed for end-of-the-pipe controls. Developed nations are taking a close look at programs like integrated process control and encouraging, or even requiring, formal registration of all industrial processes. The International Organization for Standardization's ISO 9000 series of standards for quality, for example, is being expanded to cover environmental management standards as well.

Engineering construction contracts for new facilities will be awarded to those who can incorporate the greatest amount of pollution prevention. By increasing production efficiency and lowering recurring environmental costs, a new unit can make a more substantial contribution to a company's profit. Pollution prevention will be crucial in energy development, water resources management, transportation planning, mining and agriculture. Almost all of the services offered by A&E firms today will be affected by pollution prevention principles by the turn of the century.

Although in its infancy, pollution prevention is rapidly becoming the wave of the future. Although there is not a strong demand for independent services in this field today, it is an area that is likely to undergo explosive growth in the next few years. No longer will environmental protection take place at the end-of-the-pipe. It will be an integral part of everyday business operations.

WASTE MINIMIZATION–PART 2

Design Your Process for Waste Minimization

Building waste-elimination considerations into the design of a process can substantially reduce waste generation during plant operations.

Richard A. Jacobs,
PPG Industries

Two stages of a chemical manufacturing operation present opportunities for waste elimination. The first is during the original design and development of a process. It is during this time that raw materials, process conditions, and equipment selection are the most flexible. Incorporating waste-elimination considerations into the design of a plant is the main focus of this article (the second in a series of three dealing with waste minimization).

The second stage is when the process is already in operation. Then the task of waste elimination involves operating parameter changes and process modifications that must be balanced against economic costs and other potentially detrimental effects on the process. This article briefly discusses waste minimization in an operating facility. The final installment of this series, which is scheduled to appear next month, will cover the topic in more detail and provide a checklist of actions that an operating plant can take. (The first article in this series, "Prepare an Effective Pollution Prevention Program," published last month, provided a guide to establishing a successful waste-minimization program.)

Before discussing strategies for waste reduction, however, a definition of waste generation is needed. In the broadest sense, a waste is any material or energy input into a process that does not become incorporated into the desired final product, Figure 1. This universal definition includes many things that one would not normally think of as wastes, such as products of combustion (CO_2, NO_X, SO_2), cooling tower blowdown, indirect-contact cooling water, and the like. While many of these by-products might play an important role in broad environmental issues like the greenhouse effect or acid rain, there are much more fruitful areas to focus on in developing a waste-elimination strategy.

A more useful definition of waste generation considers only materials that directly enter and leave the chemical process. In this definition, sources of waste can be categorized as

- unrecovered raw materials,
- unrecovered products,
- useful by-products,
- useless by-products,
- impurities in raw materials,
- spent process material,
- packaging and container wastes.

These are sources that chemical engineers can easily deal with on the familiar grounds of process optimization and yield improvement. The engineering tools, however, must be viewed with a new outlook. The goal is to not only make products of the highest quality and lowest cost, but also to make them while generating the least amount of waste. That means that waste elimination needs to assume the same position of importance in the chemical engineer's thinking as safety, product quality, and cost efficiency.

For the purposes of implementing a waste-elimination strategy, process design can be divided into four phases, each presenting different opportunities for implementing waste-reduction measures:

- product conception,
- laboratory research,
- process development (pilot plant),
- mechanical design.

Product conception

A product is usually conceived to meet a specific market need with little thought given to manufacturing parameters. At this stage of consideration, it may be possible to avoid some significant waste-generation problems in future operations by answering a few simple questions:

1. What are the raw materials used to manufacture the product? Are there any new chemicals for the company to handle

that will require new operating and environmental procedures?

2. Are there any toxic or hazardous chemicals likely to be generated during manufacturing? Special consideration must be given to by-product and waste streams.

3. What performance specifications must the new product meet? Is extreme purity required? If so, more separations will probably be needed. Can specifications be widened to encompass impurities in raw materials?

4. How reliable will the manufacturing process be? Are all steps commercially proven? Does the company have experience with the unit operations required?

5. What types of wastes are likely to be generated? What is their physical form? Are they hazardous? Does the company currently manage these wastes?

By posing these questions to management and knowledgeable technical people in the organization, significant waste issues can be identified early in the new product decision process. These issues can change the conception of the process design, or they may even eliminate the product from further consideration. If process design does move forward, though, the engineers will have a firm understanding of what waste issues are likely to arise.

Laboratory research

Once the company has decided that it wants to market a new product, the research-and-development staff begins laboratory investigations to define the key process parameters and operating conditions necessary for optimum production. Typically, chemical engineers focus on mass balances and yield calculations to determine how much of the raw materials end up in the final product.

Waste-elimination strategy, however, demands that an equal amount of attention be focused on how much of the raw materials *does not* end up in the final product. What happens to them? Are they vented or lost through fugitive emissions? Even 99% yields are not good enough if the resulting losses produce toxic emissions or by-products that cannot be accounted for. What about that speck in the bottom of the laboratory flask? In full-scale production, it could become thousands of pounds of solid waste each year. Meticulous attention to material balances with complete accounting for all process inputs is critical to waste identification and elimination in the laboratory.

Another key waste-reduction opportunity that should be explored in the laboratory is process simplification. A multistep batch process with intermediate separations and purifications is likely to produce more waste than a continuous process. PPG has developed a six-step batch process to make a complex and extremely pure fine chemical. At this stage in the process development, it also produces more than 300 lb of waste for each pound of product. Obviously, there is some waste-reduction work to be done.

On the other hand, PPG produces

chlorine and caustic soda in a large automated plant with less than 0.05 lb of waste per pound of product. But because of the volume of production, this plant actually generates much more waste than the other process. The amount of product that will be manufactured is a key consideration in evaluating the importance of the rate of waste generation per unit of a product.

In determining the rate of waste generation, considering the contribution of all those activities that are necessary for the process but that are not directly associated with production is important. This includes such things as

- start-up and shutdown losses,
- reactor washings between operations,
- sampling and analytical losses,
- catalyst usage and losses,
- incidental losses from spills, equipment cleanings, etc.,
- packaging requirements for raw materials and products.

In a complex multistep process, these losses can overshadow the losses associated with product yields. The key message is that a simpler process generates less waste than a complex one.

Process development

Now the process has been defined in the lab. Expected yields are known, and the waste streams that are most likely to be produced have been quantified. The next step is to verify these data on a scale that can be used to design the commercial manufacturing process. This is done by building a pilot plant.

In addition to verifying the chemistry proven in the laboratory, an effective waste-elimination strategy dictates that the pilot plant be used to quantify those nonproduction activities mentioned earlier and to begin to assess the impact of the process on the public. Key parameters to evaluate during pilot plant studies include

- flexibility in the selection of raw materials to minimize waste volume and toxicity,
- methods of improving process reliability to minimize losses, spills, and off-specification production,
- ability to track and control all waste streams,
- potential impacts of the process on the public, including odor generation, visible emissions, fear generated by the handling of toxic materials, emergency considerations, and so on.

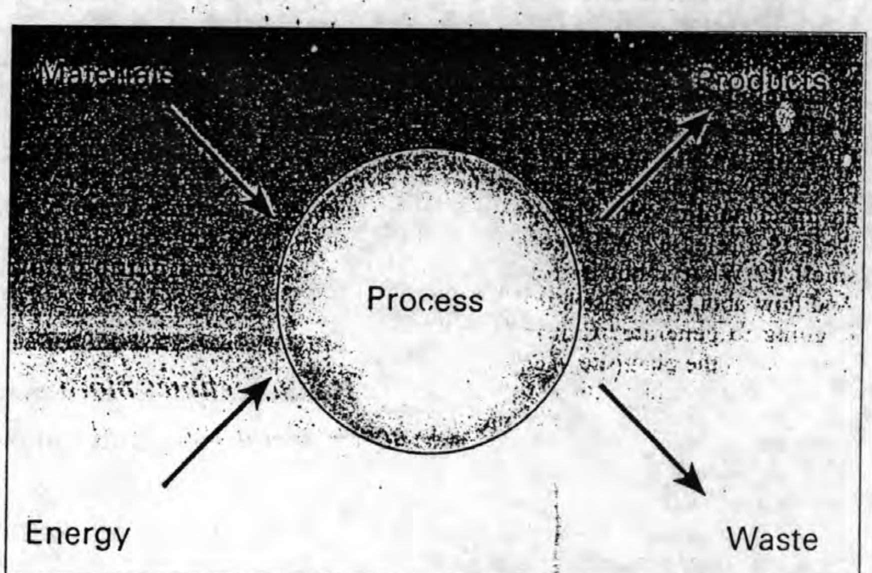
Incorporating waste elimination during process design is less complicated than modifying operations at an existing plant.

In the selection of raw materials, the key waste-generation factor, after yield-to-product, is the amount and type of impurities present. Any impurity that cannot be passed through to the product ends up as a waste. Thus, it may be more economical to purchase a higher purity raw material than to manage the waste associated with a less-pure feedstock. This economic trade-off is difficult to evaluate because many of the costs associated with waste management are difficult to quantify. Disposal costs are generally known, but the time and labor required to comply with regulations and permits, the production losses associated with waste, and the future environmental liability costs are not readily available. One estimate of future liability costs considers \$300 to \$500 per ton of waste to be the right order of magnitude.

Process reliability is generally considered from the health-and-safety perspective. Reliability also affects waste generation by preventing situations that might result in releases or the production of off-specification product. Sequencing operations to reduce equipment cleaning and reactor washing between steps also reduces the amount of nonproduction wastes associated with the process.

A major problem that interferes with the ability of many operating plants to minimize their waste is a lack of adequate process measurements. Many waste streams exit an operating unit unnoticed because they are mixed with other streams prior to being fed to a centralized treatment system that serves the entire complex. Because the waste stream is not measured at the point of generation, no one assumes responsibility for controlling the amount generated. The waste is simply treated to meet the discharge permit requirements for the complex.

One of PPG's operations provides an example of this phenomenon. The



■ *Figure 1. The broadest definition of waste includes any process input that does not end up in the desired products.*

complex produces a variety of organic and inorganic chemicals, and many of the individual operating units generate acids or alkalies that are discharged to a common sewer. At the main plant outfall, the pH is measured and appropriately adjusted to meet the limitation in the plant's National Pollutant Discharge Elimination System (NPDES) permit. In the past, the primary consideration was 100% compliance with the permit, and little thought was given to the sources of acids and alkalies in the sewer. After all, they only produced salt in the plant discharge. In 1988, as part of a corporate waste-minimization program, the plant examined its sewer system and attempted to identify sources of acid and alkali input. After some flow measurements at operating units and the installation of an automated pH measurement-and-control system, the plant discovered that it had been losing more than 4,000 ton/yr of caustic product and using 14,000 ton/yr of purchased acid for pH control. The operating units are now monitoring their contributions to the sewer, and the company is saving more than $1 million annually as a result. Without measuring the individual waste streams at the point of generation, these savings would not have been identified and realized. Thus, the installation of point-of-generation measurement systems should be incorporated into the process and plant design.

During the pilot plant stage, one has the opportunity to evaluate all of those real-world possibilities for process upset that might also lead to an upset public. What happens if there is a release? Will the public smell it? What about its toxicity? And how about the wastes the plant is going to generate? Can they be managed on the plant site in an environmentally sound manner, or will they leave the plant in trucks placarded with class B poison signs? Finally, will the plant be handling any compounds that might generate excessive public concern, such as dioxins, lead, asbestos, carcinogens, etc.? If so, advise management to begin making plans to address public concerns well in advance of starting any manufacturing operation.

AIChE's Center for Waste Reduction Technologies

The Center for Waste Reduction Technologies (CWRT) is a partnership among industry, academia, and government that serves as a focal point for research, education, and information exchange on the innovative waste-reduction technologies needed for economically competitive processing and manufacturing facilities.

CWRT's unique program revolves around three components: targeted research, technology transfer, and enhanced education. The research program will be based on the identification of target waste streams and the development of a hierarchy of technological solutions to effect their elimination or reduction. Technology transfer and related information will be disseminated through tools like practical "how-to" publications, topical conferences, and continuing education courses for practicing engineers, and through cooperation with other organizations that have related interests. And, to ensure that environmentally compatible design becomes a permanent feature of industrial practice, CWRT will develop new course materials for the undergraduate and graduate engineering curricula and promote student internship programs.

To obtain more information about the center or to inquire about becoming a sponsor, contact Lawrence L. Ross, CWRT Director, at 212/705-7407; Fax: 212/752-3297.

Mechanical design

With the waste-elimination strategy fully implemented during the product conception, laboratory research, and pilot plant stages of the new product development, the task during mechanical design is to appropriately incorporate all of the waste-elimination measures previously identified into the final plant design. Be especially attentive to process improvements in the following areas:

• reduction and/or control of fugitive emissions (spill control, leakless valves, closed-loop sampling, etc.),

• taking the measurements necessary to quantify and control wastes (which may mean putting flow meters in unusual places),

• concentration of waste streams to the maximum extent possible (via, for example, thin-film evaporation, ultrafiltration, etc.),

• reduction of interim storage and container management to the extent possible (containers must be washed or disposed of, and those activities create wastes),

• utilization of waste treatments that allow recovery and reuse of raw materials and intermediates (liquid ion exchange [LIX] vs. filtration, acid stripping vs. neutral stripping, recovery of HCl from incinerators).

It is sometimes more cost-effective to purchase a higher purity raw material than to manage the waste associated with a less-pure feedstock.

The operating plant

Well, now that the plant has been designed and fully incorporates the waste-elimination strategy, waste minimization ought to be a simple achievement, right? Wrong. Anyone who believes that probably needs to spend some time out in the plant, talking to the operators and maintenance personnel. That will place the attention on the second, more difficult stage of implementing a waste-minimization program—in the operating plant.

How can a plant implement a waste-elimination strategy in an operating facility? R. W. Rittmeyer

["Waste Minimization—Part 1: Prepare An Effective Pollution Prevention Program," *Chem. Eng. Prog.*, pp. 56-62 (May 1991)] outlines how to set up a waste-minimization program. Another good resource is by J. Newton ["Setting Up a Waste Minimization Program," *Poll. Eng.*, pp. 75–80 (Apr., 1990)]. Both articles point out that the key steps are: establishing definitions and goals; conducting an inventory of all wastes; establishing a prioritization, reporting, and tracking system for wastes; systematically examining each waste to determine how it can be managed; and implementing specific projects or actions for each waste.

This information is valuable as a knowledge base from which to initiate a waste-minimization program. Knowing how to read a cookbook, however, does not make a person a good cook. Thus, the rest of this article will discuss some of the problems we have faced in implementing a pollution-prevention program at PPG.

First, "waste" falls into the same philosophical category as beauty—it's all in the eye and mind of the beholder. At PPG, we initially had some real difficulty agreeing on what constituted a waste and on whether one waste was worse than another and, therefore, deserved more immediate capital and resources.

We finally decided that each operating plant knew best how to define and prioritize its waste streams and that, within broad corporate guidelines that provided some consistency, decisions about which wastes would be addressed first should be made by the operating plants. Periodically, representatives of all the plants gather and share their ideas and experiences with waste-reduction efforts. This enables the plants to learn from each other and allows the corporation to move toward a common understanding of its waste-generation universe.

A second problem is what can be called the "treat rather than eliminate" syndrome. This can be paraphrased at the local level as follows:

Installing measurement devices where the waste is generated will allow individual streams with waste-reduction potential to be identified.

"Don't worry about cleaning up that spill, Joe. The treatment plant will take care of it." Long before operators and line managers were asked to be concerned about waste generation, they had to place top priority on environmental compliance. A lot of time and money was devoted to collection systems and treatment facilities, and the emphasis was on treating the waste before it left the plant. To make these treatment facilities efficient, they were centralized, and wastes from all units were mixed together to obtain a relatively uniform feedstock. So much for trying to figure out which unit the waste came from!

Now, when operating units are asked to reduce their waste generation, they want to know why this is necessary. "Aren't all the wastes being treated and isn't the plant in compliance with all of its permits all of the time? Why should we fix something that isn't broken?" they ask.

These difficult questions can be countered with a program of education and communication designed to convey some very simple messages:

1. Most waste-treatment systems don't eliminate waste—they just transfer it from one medium to another.

2. The public and the regulators are leaning toward mandatory waste reductions—we need to get there on our own first.

3. Waste minimization isn't just environmental stewardship—it's good business. The public can always obtain products from outside the United States and leave the wastes behind. We must meet public expectations, or we will be out of business.

Finally, PPG is striving to get every employee to accept responsibility for waste minimization on and off the job. We want all employees who work for PPG to stop and consider what happens every time they create or throw away a waste. Was it necessary to create the waste in the first place? Where did it come from and where will it go? Does it have to be disposed of or could it be recycled, reused, or converted into energy? If it is thrown away, will it become a future liability?

One tool that we are using to persuade employees of the benefits of waste minimization is "Environmental Focus," a segment of PPG's bimonthly ChemNews video program, which is viewed by all employees. This video allows employees to see the results of waste minimization at work by presenting practical examples from the plants. Each segment presents real employees talking about solving real problems, and our hope is that every employee will be encouraged to implement his or her own personal waste-minimization program.

As our environmental reporter says at the end of each tape, "Remember that the *I* in *environment* stands for you and me. Environmental stewardship is the personal responsibility of each of us." CEP

R. A. JACOBS, manager of environmental operations for the Chemicals Group of PPG Industries, Pittsburgh, PA (412/434-2363; Fax: 412/434-2137), is responsible for the implementation of a group-wide waste-minimization program. He has also worked in process design, new product development, and technology licensing at PPG. Prior to joining the firm, he spent several years working for the U.S. Army designing and operating the first facilities for detoxifying chemical warfare stocks. He received his bachelor's and master's degrees in chemical engineering from Rice Univ. in 1967 and 1968.

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DRAFT

ISPAN LESSONS LEARNED PAPER

In the last seven years, ISPAN has performed water resources studies, technical assistance and training in 15 countries in Asia and the Near East and has included three other countries as study data sources. This work has comprised a valuable learning experience, the results of which are only partly crystallized in specific reports. Some of the earlier reports are out of print. This paper compiles, by subject area, some of the more important learnings of the project that have broad applicability.

1. INTRODUCTION

The Irrigation Support Project for Asia and the Near East (ISPAN) has provided services in the water resources area to the USAID Bureau for Asia and the Near East and to Missions in the region since August 1987. The primary focus of the project was irrigation for the first three years but its emphasis subsequently broadened to mirror the changing interests of the Agency and the Bureau. During the last four years, the project has covered such diverse water sector matters as flood management in Bangladesh, water pricing and cost recovery in Egypt, water policy adoption in Sri Lanka and Tunisia, irrigation institutions in India, and water resource sustainability issues in Egypt, Morocco, Pakistan and Thailand. It has also assisted the Bureau to prepare water resource strategic agendas for Asia and for the Near East.

The project is now coming to an end. Its environmental and geographical information systems activities related to the Bangladesh Flood Action Plan will continue through mid-1995 but other ISPAN services will terminate at the end of September 1994.

The purpose of this paper is to capture, in brief form, some of the key lessons that have been learned through the activities of the project.

This paper is organized by the key topic areas of:

- Water shortage and excess
- Water quality and environment
- Institutions for water management and delivery
- Donor assistance

Referenced documents, most of them ISPAN reports, are listed as endnotes in the final section of the paper and identified by superscript numbers in the text.

2. WATER SHORTAGE AND EXCESS

2.1 Resource Sustainability

Need for Demand Management

> *Water allocation and use patterns generally do not reflect the growing water scarcity that is occurring as a result of population growth and industrialization.*

A comparative evaluation[1] of water resource sustainability in four developing country locations showed that conservation and reuse form no part of sector policies in any of them, in spite of growing water shortages exacerbated by pollution. Measures that should be considered everywhere include:

- Conservation of water in all water subsectors through minimization of transmission losses[*] and reduction of wastage (such as through excessive evaporation) by users
- Management of demand through water pricing and removal of subsidies on such factors as electricity for pumping
- Reuse of wastewater and sludge
- Conservation of energy, funds and other resources used in water sector programs and projects
- Consideration of complete systems, and the range of stakeholder interests, in planning water facilities
- Maintenance of base flows to support ecology and biodiversity, and conduct of studies to quantify such needs.

Need for Improved Measures of Efficiency

> *Parameters for efficiency of water use and for computation of water balances are inadequate to measure progress towards sustainability.*

While efficiency of water use is generally understood to require minimization of losses and wastage, it is clearly defined only in the irrigation subsector. However, that definition does not completely isolate wastage from beneficial use. Other subsectors use conflicting terminology; for example consumptive use to a water resource manager is very different from an urban utility manager's notion of water consumption. Water use components of national water balances appear to have varying bases. Sector-wide terminology and measures of performance need to be agreed on to provide a basis for monitoring use and abuse of the water resource in both quantity and quality, and for tracking progress towards sustainability. These were among the conclusions of the ISPAN sustainability study[1] referred to above.

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[*] *With the exception of losses that are substantially recoverable such as irrigation system conveyance leakage that permits conjunctive use through tube wells.*

2.2 System Sustainability

The Need for User Participation

> *System sustainability (that is, continuation of project benefits long after the funding source for initial implementation has withdrawn) depends on both (a) the appropriateness of the design to the needs of the users and to other existing and future conditions, and (b) the setting up of institutional and financial arrangements for operation, maintenance and, where needed, rehabilitation, at the time of planning and implementation. System users have critically important roles, starting at the planning stage, in providing for sustainability.*

In several countries in which ISPAN has worked, large water management systems and facilities have been constructed by central or state governments with no arrangements or funds for maintenance. Inevitably, the facilities have deteriorated. Under today's circumstances, in which world food prices are low, economic justification of funding for rehabilitation of deteriorated facilities for irrigation, or for protection of agricultural land against flooding, is very difficult. There are numerous examples of both urban and rural water systems in which staff, often in excessive numbers, exist for operations but do not have the resources or incentives to maintain and repair facilities. Rural potable water systems are frequently fully dependent for maintenance on users, who may lack the necessary skills[2]. Revenue collection is often inadequate and sometimes non-existent.

There are some well operated and maintained systems. These include urban systems where, through public relations and other initiatives, water users are paying the full cost of service and other types of systems where users are motivated and have been empowered to own and operate them. Where revenues are adequate, there are examples of successful operation and maintenance through both public and private sector ownership and, under public ownership, through operations by direct-hired staff, by village or user associations, and by contractors[3,4].

At the heart of successful operation and maintenance is the motivation of the users either to provide the necessary revenues through user fees or to take direct responsibility for operations. Such motivation is very difficult if the users feel that the system and its costs have been imposed on them. Demand-driven initiatives are therefore very important, requiring special efforts to generate public support for any sanitation or other measures the benefits of which may tend to be seen as largely external to the individual users[5].

2.3 Flood Management

Sustainability of Flood Protection

> *Embankment systems designed to separate rivers from their flood plains are unlikely to be sustainable.*

ISPAN has conducted studies under the Bangladesh Flood Action Plan of environmental issues, responses of rural people to floods, and of measures to provide some degree of flood proofing[6]. It has also performed GIS-based studies of the densely-occupied "chars" (river islands, many of them temporary)[7]. These studies and the work of others suggest that, except to protect certain limited high value areas such as cities, embankment structures are likely to:

- Fail to provide the agricultural benefit that their proponents claim would result from avoidance of agricultural damage and curtailed crop growth during major floods
- Prevent beneficial annual flooding that brings soil, nutrients and fingerlings for subsistence fishery (which is the principal source of protein for the rural poor)[8]
- Increase the impacts of floods on residents of unprotected lands between the embankments, including the chars, by increasing flood depths, durations and velocities
- Be short-lived because of overtopping caused by elevation of the flood channels due to silt deposition between the embankments, because of possible sabotage by residents of unprotected areas, and also because of the inevitable channel migrations.
- Worsen the incidence of kala-azar disease in protected areas[9]

Where embankments are not appropriate, protection from the most serious effects of flooding can be provided through combinations of flood proofing and flood warning.

It appears that some similar lessons can be gleaned from the Mississippi River experience of 1993.

2.4 Water Rights

Tradable Rights in Water

> *Devolution of water rights from bureaucratic agencies to water users has several advantages, including provision of incentives for efficient water use, recognition of external costs, and flexibility to adapt to changing economic and social conditions. Such devolution does not imply a free market. Chile and Mexico have adopted comprehensive systems for tradable water rights and policy makers in several Asian and Near East countries are interested in them.*

Technological and management approaches to increasing the efficiency of water use and allocating water to the highest value uses have not worked as well as hoped because they have not been linked to the basic mechanisms by which water is allocated. The reform of laws and institutions to create managed markets in water has the attention of policy makers in such countries as Egypt, India, Jordan, Malaysia and Thailand. Well developed systems exist in Chile, Mexico and several western U.S. states. Such systems have the potential to:

- Provide users with security in water rights, permitting them to invest in water saving technology
- Provide incentives to use water efficiently
- Incorporate external costs into decisions on water, given proper management
- Be acceptable to farmers through formalization of existing implied rights
- Provide maximum flexibility to respond to changing economic and social conditions

Market systems in water require laws, institutions and contracts to equitably assign initial rights, deal with variability of supply, and protect against third party impairment from water transfers and water quality degradation[10]. These issues are the subject matter of a current ISPAN study in India, Jordan, Mexico, Chile and California.

3. WATER QUALITY AND ENVIRONMENT

3.1 Sewerage & Sanitation

The Talisman Complex

> *Governments frequently demand, and donors sometimes provide, expensive and inappropriate treatment facilities that cannot be operated effectively and economically. Large scale demonstrations are needed of successful low-cost, operable, socially acceptable solutions for urban populations.*

ISPAN field team members have observed, on ISPAN[1] and other assignments in the region, examples of expensive treatment facilities apparently held as talismans to ward off pollution; they are not operated because operating them properly is either too expensive (financially infeasible) or not justified by the benefits (economically infeasible). The result frequently is unnecessarily high risk to health where some degree of health protection could have been provided at less total cost. While low-cost treatment systems (such as lagoons or other natural systems) have also been installed in some locations in the region, such methods are often not considered because they are in conflict with pollution control regulations, because of difficulty or cost of acquisition of the large site areas needed, or because of fear of social unacceptability or nuisance. Large scale demonstrations are needed of successful low-cost, operable, socially acceptable solutions for urban populations.

Separation of Waste Streams

> *Combined collection of sewage and industrial wastes contaminates otherwise recoverable water and sludge with toxic and carcinogenic chemicals. Separation of non-biodegradable and toxic/hazardous waste streams from sewage should be encouraged and industrial wastes should be minimized.*

Numerous examples have been observed[1] of urban wastewater systems that carry, by design or by happenstance, uncontrolled mixed discharges of sewage from domestic and commercial premises and industrial wastewaters. Water contaminated only with biodegradable substances can be recovered for reuse, as can the sludge recovered from treatment. However, if toxic and carcinogenic substances are present, they may render the liquid or solid materials unsafe for use in agriculture. Toxic substances may even interfere with biological treatment of the wastewater. Removal of such substances after admixture with wastewater is very expensive and, in many economies, impracticable. It is therefore very important not only that discharges of toxic and hazardous waste be minimized, but also that industrial wastes be handled, to the maximum practicable extent, separately from domestic sewage.

3.2 Industrial Wastes

The Toxic Time Bomb

> *Toxic and carcinogenic substances in industrial wastes (and also in agricultural chemicals) enter the food chain even without deliberate recovery and reuse of wastewater. Water and nutrient conservation through safe reuse of wastewater liquids and solids is dependent on control of toxics and carcinogens. This is a serious potential problem but quantified data are needed.*

Industrial activity, encouraged by governments, is increasing in many developing countries. Industrial use of toxic and carcinogenic materials is also increasing. Unless they are retained, and either reused or separately disposed of, these materials find their way into wastewater streams and hence into freshwater bodies. There, together with other industrial waste components, they endanger human health, through both potable water use and the food chain, add to the costs of other water users, and damage ecological resources such as wildlife habitats. However, very little quantified information is available. Studies are needed urgently because it is possible that the health hazards from this are considerable and may not be able to be taken care of by improved treatment and disposal of urban sewage[1].

4. INSTITUTIONS FOR WATER MANAGEMENT AND DELIVERY

4.1 Water User Associations

Conditions for Sustainability

> *The primary factor that determines longevity for water user associations is satisfying members' needs. They must, for successful water management, have the capability and obligation to deal with water issues. Since the primary need of water users is usually income, associations that encompass economic activities beyond water are more likely to be sustainable than those that are limited to water alone.*

A study[11] of water user associations in six Asian countries, and one in the Near East, strongly suggests that, while farmers recognize the importance of water and of irrigation infrastructure, they see them merely as one aspect of income generation. Projects that have attempted to have water users launch water-based associations and then move them to other income-based activities have in general not worked well. Opportunity-oriented income-based organizations seem, if they are given the needed capability development, to have the best likelihood of success and sustainability.

4.2 Turnover

Turnover - the New Magic Bullet

> *Programs to turn operation and maintenance responsibility for water systems over to water users are generally supply driven. To be successful, turnover programs must be preceded by strong user associations and be demand-driven, with users wanting to take over the systems.*

The above mentioned ISPAN study[11] indicates that the hope of numerous countries and many donors that turnover programs will solve the problems of disappearing water user associations and inadequate operation and maintenance may prove to be vain. Turnover programs have generally been supply-driven and do not transfer ownership of resources to the water users. Under these conditions, users generally see limited benefit in relieving governments of their responsibilities. The success of turnover programs depends on the strength of the user associations to which systems are given, and on the perception of their members of economic benefit to themselves as a result of turnover.

4.3 Institutional Reform

Ability of organizations to change

> *The effective management of water requires interactions with water user representatives and other stakeholders in ways not familiar to many water agencies. Managing water effectively and equitably generally requires significant changes in their organizational cultures, skills and approaches. These changes depend on policies for change by responsible senior decision-makers plus iterative and consultative action-planning procedures.*

The effective management of water requires interactions with water user representatives and other stakeholders in ways generally not familiar to many water agencies, most of which are technically oriented. Adjusting to user-oriented ways of managing water requires significant changes in organizational cultures, skills and processes. Such changes are difficult to achieve and depend on a firm commitment at the highest levels as well as on the application of managed change processes. In a comparative study[12] of approaches to policy formulation in Sri Lanka and Tunisia, conducted by an ISPAN team in 1993, the amenability of organizations to change was observed to depend in part on the clear establishment of policies for change by responsible senior decision-makers after initiating and overseeing an iterative and consultative action-planning procedure.

4.4 Policies and Planning

Integrated Water Planning

> *Water management decisions made by narrowly-focussed government agencies tend to be biased. Equity and efficiency in water allocation and management, and protection of the environment, require balanced decision-making processes that provide integration across subsectors, and that discover and accommodate stakeholder interests.*

The sustainability of water resources, in the face of increasing demands for water and increasing discharges of pollutants, has been observed[1,13,14,15] to be a major issue for most countries of Asia and the Near East. Approaches to water management vary but in several countries there is a trend towards increasing autonomy of water service providers. In others, service providers operating in particular water subsectors, such as irrigation and urban water supply, retain the powers and rigidities of government. Most water projects are implemented by single purpose agencies[15]. As a result, intersectoral issues and efficiency of allocation of rights to use and pollute water tend to be considered inadequately if at all. The interests of many stakeholders, especially the poor, are in many cases not determined or taken into account. Balanced decision-making processes are needed that provide integration across subsectors, and that mandate the discovery and accommodation of stakeholder interests.

Implementation of Policy Change

> *While no generic approach to policy formulation can apply to all situations, some bases for effective policy change can be stated. The bases include sound analysis, non-confrontational approaches and coordinated donor support. They do not include concentration on either top-down or bottom-up initiatives.*

The comparative study[12] of water policy formulation referred to above suggested that successful policy change is favored by, among other factors:

- Limited policy focus and limited number of institutions affected
- Perception of the changes as desirable by all parties, with no losers
- An iterative, flexible and consultative process
- Usefulness of the process outputs to senior decision-makers
- Leadership by motivated and experienced officials
- The existence of solid data and analysis to support the change
- Support by multiple, coordinated, donors
- Implementability, based on existing capabilities and available technical assistance

ISPAN's work since 1990 in Bangladesh has also demonstrated the value of sound data, careful analysis, and thoughtful non-confrontational presentation of conclusions in support of policy change. There has been a major policy shift from fully structural approaches to flood protection to integrated, environmentally sustainable planning involving public discussion of issues. Activity by public interest groups and NGOs, and donor re-orientation, have played a role but an important factor has been the scientifically-based analyses conducted by ISPAN with USAID support.

4.5 Technology Applications

"Appropriate" Does Not Necessarily Equate to Low-tech

> *Appropriate technologies for use in developing countries are not limited to those that are simple and easily institutionalized. Where the need exists, the cost is low, and an unsustainable maintenance burden is not created, such hi-tech applications as geographic information systems can be very appropriate.*

The use of GIS technologies by ISPAN in relation to the Bangladesh flood action plan has enabled several difficult issues to be analyzed rationally for forward decision-making by the government. The combined use of digital mapping, satellite imagery and image processing has enabled the quantification and prediction of several important aspects of riverine behavior that were previously subject only to very approximate assessments. Local staff have been trained in this work, a GIS users' group has been set up in Dhaka, and a strategy for institutionalization is being prepared. The benefits of the GIS work are already significant and include evaluation of population displacement due to erosion of island chars, establishment of a national GIS database, pilot flood compartment design and environmental assessment, and a pilot evaluation of disaster planning and relief[16].

4.6 Cost Recovery

The Role of Knowledge

> *Cost recovery for water is a critical and contentious topic in many developing countries and is politically extremely difficult. Achieving it depends heavily on having adequate information on costs and distribution of benefits, and on suitable dissemination of such data.*

The implementation of full cost recovery for water systems is politically extremely difficult and in some cases is even questioned technically and socially. Cost recovery depends on the acquisition of adequate information on actual costs and on the distribution of benefits and on suitable dissemination to users of the water system. A recent cost recovery study by ISPAN illustrates[17] the array of cost distribution approaches for a large water system.

5. DONOR ASSISTANCE

5.1 Promotion of Sustainability

Opportunity and Obligation to Promote Sustainability

> *In addition to their obligation to support only environmentally sustainable water programs and projects, donors have an opportunity to help governments to develop and apply sector-wide strategies and policies to support sustainability.*

The economic, health, ecological and amenity implications of uncontrolled use of water resources by any one subsector are now so great that it is clear that sector-wide approaches are necessary by countries. Given the degree to which country water development actions are influenced by international donors, it also appears that some new approaches by donors are warranted. Past approaches have tended to be project-by-project and to rely heavily for coordination of water management on such devices as loan covenants or institutional studies that are tacked onto infrastructure projects.

Given the potential beneficial influence of donors, it is critical that they strongly support cross-jurisdictional and transparent approaches to water resources development and assist host countries, through grant assistance, to develop the necessary strategic and policy frameworks[1] and environmental assessment processes[18,19,20]. Because of countries' reluctance to borrow except for infrastructure development, this implies a need for grant assistance.

Policy Partnerships

> *Because water issues affect many agencies in governments, donors wishing to promote water policy rationalization need to take care to base their approaches on sound analyses and work in partnership with countries, if necessary engaging at high levels of government.*

Water issues generally cut across the interests of numerous line agencies in governments (such as those responsible for agriculture, irrigation, environment, health, urban planning, industry, public works, transportation and local government, for example). This makes the establishment and implementation of coherent water policies and strategies very difficult for most governments, and tends to lead to ad hoc decision-making based mainly on consideration of limited sub-sectoral interests.

The fact that water issues cut across the interests of many agencies in most governments creates difficulties not only for the governments but also for donors. Because of the vested interests of powerful individuals and agencies in certain aspects of the water sector, effective policy engagement on this subject in general is likely to require both (a) solid support based on careful analysis and (b) engagement at higher levels of government than is necessary for some other sectors. The appropriate point of access must be carefully selected, especially since some of the policy issues may not yet be fully understood or acknowledged at the start of a program of assistance[14].

Effective assistance in establishing water policies and strategies requires flexible donor-government partnerships that are programmatic in nature, do not depend on any single infrastructure project, and can adapt to changing circumstances and the lessons of local experience[1,14].

5.2 Donor Coordination

Avoidance of Undercutting

> *Some degree of understanding between donors is needed to establish and maintain a common focus on environmental sustainability and to avoid undercutting.*

International development funding agencies are to some extent in competition with one another. Without dialogue between them, there is a potential for donors to fund projects that are pressed for by governments even if at some point they are found to fail important sustainability tests. A very fine line is walked by responsible donors which do promote sustainability but which also support the responsibility of governments for their programs and projects. Some criticism of donor-funded programs has ignored the difficulty of doing this. Nevertheless, important examples do exist of donor-funded water projects which are not sustainable or which lack measures needed to mitigate important environmental or social shortcomings[1,14].

It is important that donors maintain continuous dialogue among themselves on processes and criteria for recognizing environmental sustainability in defining the objectives and conditions of assistance for water development.

Good Water Projects Depend on Good Water Policies

> *The benefits of leveraging of the effects of assistance in policy and institutional areas through linkages to infrastructure assistance are well recognized by grant assistance donors. These benefits may be lost if the policy and institutional inputs are made late.*

Multilateral and bilateral providers of assistance in policy and institutional areas of water sector development have an interest in linking their inputs with infrastructure loan assistance programs. The main reason is the greater attractiveness to most governments of visible, short term infrastructure development over policy and institutional changes the need for which may not be well understood[13,14].

While response to country interest in infrastructure investment will often be the best opportunity for donors to introduce water policy and institutional concepts, the development of the strategies on which detailed policies and institutional arrangements should be based takes more time than is commonly allowed for facility planning and feasibility analysis for water projects[1,14].

There is therefore a great need for international donors, governments, water and environmental agencies, water professionals and voluntary water interest groups to maintain dialogue on water policy and institutional issues. A prime purpose is to disseminate the message that good water policies are needed to provide a sound basis for the development of good water projects.

5.3 Interactive Working

Local Professionals on Assistance Teams

> *The inclusion of host country and regional professionals in technical assistance teams adds credibility, local knowledge, access, and understanding of nuances to the teams, minimizes costs, builds cooperation, and improves the technical assistance products.*

Host country professionals have been included in most ISPAN technical assistance activities for USAID missions and countries. In a number of cases, professionals from other countries in the region have played important roles on teams. Such third countries have included India, Indonesia, Nepal, Morocco, Philippines, Sri Lanka, Thailand and Tunisia. The quality of ISPAN's outputs owes a great deal to these arrangements.

Project Start-up and Review/Planning Workshops

> *Specific project-related workshops, both at the beginning of the project cycle and approximately annually thereafter, provide an opportunity for host government officials, donors and technical assistance teams to clarify expectations and objectives for the project, discuss problems and issues that are hampering project implementation, and identify specific strategies for overcoming implementation constraints. The workshops also provide an opportunity to review and agree on yearly work plans.*

USAID Missions who sponsor project start-up and review/planning workshops find that they provide a process for discussing critical implementation issues and identifying specific steps needed to improve the situation. The agreements that come out of the project workshops provide a structure for monitoring progress being made toward achieving project goals and objectives. The project start-up approach is based on a guide[21] produced by the WASH project in 1988 and has been used extensively by ISPAN, especially in Egypt with the nine components of the Irrigation Management Systems Project. Project-related workshops have also been conducted in Sri Lanka, Pakistan, Thailand, Indonesia and Morocco.

Team Planning Meetings

> *Short-term technical assistance teams are most effective if they arrive in-country well prepared to perform the work they are expected to do. Team Planning Meetings comprise a very important element of team preparation used consistently by ISPAN. To be effective, they must be properly planned and rigorously facilitated.*

ISPAN conducts team planning meetings with technical assistance teams prior to their departure for the field. Additional team planning sessions are also held in-country with the local consultant team members. Such meetings help teams to understand their mandate and who they are responsible to, clarify their team and individual scopes of work, decide how they are going to work together, identify ways of dealing with conflict within and outside the team, schedule their time in-country, and agree on an outline and assignments for the final product. Team members who participate in the 1-2 day team planning meetings arrive in country with a clear understanding of their role, who they want to meet, and what they want to investigate. They also know the background and history of the activity and who the key players are. The team planning meeting design is adapted as appropriate from a guide[22] produced by the WASH project in 1985.

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9

International Conference on
Water and the Environment:

Development issues for the 21st century

26–31 January 1992, Dublin, Ireland

THE DUBLIN STATEMENT

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NOTE

Preface

The International Conference on Water and the Environment (ICWE) was held in Dublin, Ireland, from 26 to 31 January 1992. ICWE provided the major input on freshwater problems to the United Nations Conference on Environment and Development (UNCED), convened in Rio de Janeiro, Brazil, June 1992. It was also the most significant global conference on water since the United Nations Water Conference held in Mar del Plata, Argentina, in 1977.

Hosted by the Government of Ireland and convened by the World Meteorological Organization (WMO) on behalf of the more than 20 bodies and agencies of the UN system which are represented on the UN Administrative Committee on Co-ordination Inter-Secretariat Group for Water Resources (ACC/ISGWR), the Conference was attended by 500 participants from 114 countries, 38 non-governmental organizations, 14 inter-governmental organizations and 28 UN bodies and agencies.

The main objectives of the Conference were:

(*a*) To assess the current status of the world's freshwater resources in relation to present and future water demands and to identify priority issues for the 1990s;

(*b*) To develop co-ordinated inter-sectoral approaches towards managing these resources by strengthening the linkages between the various water programmes;

(*c*) To formulate environmentally sustainable strategies and action programmes for the 1990s and beyond to be presented to the UNCED Earth Summit;

(*d*) To bring the above issues, strategies and actions to the attention of governments as a basis for national programmes and to increase awareness of the environmental consequences and developmental opportunities in improving the management of water resources.

The major part of the work of the Conference was undertaken within six Working Groups which addressed:

(*a*) Integrated Water Resources Development and Management;

(*b*) Water Resources Assessment and Impacts of Climate Change on Water Resources;

(*c*) Protection of Water Resources, Water Quality and Aquatic Ecosystems;

(*d*) Water and Sustainable Urban Development and Drinking Water Supply and Sanitation in the Urban Context;

(*e*) Water for Sustainable Food Production and Rural Development and Drinking Water Supply and Sanitation in the Rural Context;

(*f*) Mechanisms for Implementation and Co-ordination at Global, National, Regional and Local Levels.

The two main outputs of the Conference, the Dublin Statement and the Report of the Conference are presented here. They were considered at the fourth Preparatory Committee for UNCED, which met in New York during March–April 1992. Many of the recommendations from ICWE were included in the Freshwater Section of the UNCED Agenda 21 document. They will also be of value in many other fora concerned with the serious problems of optimizing the use of freshwater resources in the years ahead.

[redacted] [redacted]

J.C.I. Dooge
Chairman
of the Conference

C. Candanedo
Rapporteur
of the Conference

THE DUBLIN STATEMENT

THE DUBLIN STATEMENT
ON WATER AND SUSTAINABLE DEVELOPMENT

Scarcity and misuse of fresh water pose a serious and growing threat to sustainable development and protection of the environment. Human health and welfare, food security, industrial development and the ecosystems on which they depend, are all at risk, unless water and land resources are managed more effectively in the present decade and beyond than they have been in the past.

Five hundred participants, including government-designated experts from a hundred countries and representatives of eighty international, intergovernmental and non-governmental organizations attended the International Conference on Water and the Environment (ICWE) in Dublin, Ireland, on 26–31 January 1992. The experts saw the emerging global water resources picture as critical. At its closing session, the Conference adopted this Dublin Statement and the Conference Report. The problems highlighted are not speculative in nature; nor are they likely to affect our planet only in the distant future. They are here and they affect humanity now. The future survival of many millions of people demands immediate and effective action.

The Conference participants call for fundamental new approaches to the assessment, development and management of freshwater resources, which can only be brought about through political commitment and involvement from the highest levels of government to the smallest communities. Commitment will need to be backed by substantial and immediate investments, public awareness campaigns, legislative and institutional changes, technology development, and capacity building programmes. Underlying all these must be a greater recognition of the interdependence of all peoples, and of their place in the natural world.

In commending this Dublin Statement to the world leaders assembled at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in June 1992, the Conference participants urge all governments to study carefully the specific activities and means of implementation recommended in the Conference Report, and to translate those recommendations into urgent action programmes for

WATER AND SUSTAINABLE DEVELOPMENT.

GUIDING PRINCIPLES

Concerted action is needed to reverse the present trends of overconsumption, pollution, and rising threats from drought and floods. The Conference Report sets out recommendations for action at local, national and international levels, based on four guiding principles.

Principle No. 1 – Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment

Since water sustains life, effective management of water resources demands a holistic approach, linking social and economic development with protection of natural ecosystems. Effective management links land and water uses across the whole of a catchment area or groundwater aquifer.

Principle No. 2 – Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels

The participatory approach involves raising awareness of the importance of water among policy-makers and the general public. It means that decisions are taken at the lowest appropriate level, with full public consultation and involvement of users in the planning and implementation of water projects.

Principle No. 3 – Women play a central part in the provision, management and safeguarding of water

This pivotal role of women as providers and users of water and guardians of the living environment has seldom been reflected in institutional arrangements for the development and management of water resources. Acceptance and implementation of this principle requires positive policies to address women's specific needs and to equip and empower women to participate at all levels in water resources programmes, including decision-making and implementation, in ways defined by them.

Principle No. 4 – Water has an economic value in all its competing uses and should be recognized as an economic good

Within this principle, it is vital to recognize first the basic right of all human beings to have access to clean water and sanitation at an affordable price. Past failure to recognize the economic value of water has led to wasteful and environmentally damaging uses of the resource. Managing water as an economic good is an important way of achieving efficient and equitable use, and of encouraging conservation and protection of water resources.

THE ACTION AGENDA

Based on these four guiding principles, the Conference participants developed recommendations which enable countries to tackle their water resources problems on a wide range of fronts. The major benefits to come from implementation of the Dublin recommendations will be:

Alleviation of poverty and disease

At the start of the 1990s, more than a quarter of the world's population still lack the basic human needs of enough food to eat, a clean water supply and hygienic means of sanitation. The Conference recommends that priority be given in water resources development and .nanagement to the accelerated provision of food, water and sanitation to these unserved millions.

Protection against natural disasters

Lack of preparedness, often aggravated by lack of data, means that droughts and floods take a huge toll in deaths, misery and economic loss. Economic losses from natural disasters, including floods and droughts, increased three-fold between the 1960s and the 1980s. Development is being set back for years in some developing countries, because investments have not been made in basic data collection and disaster preparedness. Projected climate change and rising sea-levels will intensify the risk for some, while also threatening the apparent security of existing water resources.

Damages and loss of life from floods and droughts can be drastically reduced by the disaster preparedness actions recommended in the Dublin Conference Report.

Water conservation and reuse

Current patterns of water use involve excessive waste. There is great scope for water savings in agriculture, in industry and in domestic water supplies.

Irrigated agriculture accounts for about 80% of water withdrawals in the world. In many irrigation schemes, up to 60% of this water is lost on its way from the source to the plant. More efficient irrigation practices will lead to substantial freshwater savings.

Recycling could reduce the consumption of many industrial consumers by 50% or more, with the additional benefit of reduced pollution. Application of the 'polluter pays' principle and realistic water pricing will encourage conservation and reuse. On average, 36% of the water produced by urban water utilities in developing countries is 'unaccounted for'. Better management could reduce these costly losses.

Combined savings in agriculture, industry and domestic water supplies could significantly defer investment in costly new water-resource development and have enormous impact on the sustainability of future supplies. More savings will come from multiple use of water. Compliance with effective discharge standards, based on new water protection objectives, will enable successive downstream consumers to reuse water which presently is too contaminated after the first use.

Sustainable urban development

The sustainability of urban growth is threatened by curtailment of the copious supplies of cheap water, as a result of the depletion and degradation caused by past profligacy. After a generation or more of excessive water use and reckless discharge of municipal and industrial wastes, the situation in the majority of the world's major cities is appalling and getting worse. As water scarcity and pollution force development of ever more distant sources, marginal costs of meeting fresh demands are growing rapidly. Future guaranteed supplies must be based on appropriate water charges and discharge controls. Residual contamination of land and water can no longer be seen as a reasonable trade-off for the jobs and prosperity brought by industrial growth.

Agricultural production and rural water supply

Achieving food security is a high priority in many countries, and agriculture must not only provide food for rising populations, but also save water for other uses. The challenge is to develop and apply water-saving technology and management methods, and, through capacity building, enable communities to introduce institutions and incentives for the rural population to adopt new approaches, for both rainfed and irrigated agriculture. The rural population must also have better access to a potable water supply and to sanitation services. It is an immense task, but not an impossible one, provided appropriate policies and programmes are adopted at all levels—local, national and international.

Protecting aquatic ecosystems

Water is a vital part of the environment and a home for many forms of life on which the well-being of humans ultimately depends. Disruption of flows has reduced the productivity of many such ecosystems, devastated fisheries, agriculture and grazing, and marginalized the rural communities which rely on these. Various kinds of pollution, including transboundary pollution, exacerbate these problems, degrade water supplies, require more expensive water treatment, destroy aquatic fauna, and deny recreation opportunities.

Integrated management of river basins provides the opportunity to safeguard aquatic ecosystems, and make their benefits available to society on a sustainable basis.

Resolving water conflicts

The most appropriate geographical entity for the planning and management of water resources is the river basin, including surface and groundwater. Ideally, the effective integrated planning and development of transboundary river or lake basins has similar institutional requirements to a basin entirely within one country. The essential function of existing international basin organizations is one of reconciling and harmonizing the interests of riparian countries, monitoring water quantity and quality, development of concerted action programmes, exchange of information, and enforcing agreements.

In the coming decades, management of international watersheds will greatly increase in importance. A high priority should therefore be given to the preparation and implementation of integrated management plans, endorsed by all affected governments and backed by international agreements.

The enabling environment

Implementation of action programmes for water and sustainable development will require a substantial investment, not only in the capital projects concerned, but, crucially, in building the capacity of people and institutions to plan and implement those projects.

The knowledge base

Measurement of components of the water cycle, in quantity and quality, and of other characteristics of the environment affecting water are an essential basis for undertaking effective water management. Research and analysis techniques, applied on an interdisciplinary basis, permit the understanding of these data and their application to many uses.

With the threat of global warming due to increasing greenhouse gas concentrations in the atmosphere, the need for measurements and data exchange on the hydrological cycle on a global scale is evident. The data are required to understand both the world's climate system and the potential impacts on water resources of climate change and sea level rise. All countries must participate and, where necessary, be assisted to take part in the global monitoring, the study of the effects and the development of appropriate response strategies.

Capacity building

All actions identified in the Dublin Conference Report require well-trained and qualified personnel. Countries should identify, as part of national development plans, training needs for water-resources assessment and management, and take steps internally and, if necessary with technical co-operation agencies, to provide the required training, and working conditions which help to retain the trained personnel.

Governments must also assess their capacity to equip their water and other specialists to implement the full range of activities for integrated water-resources management. This requires provision of an enabling environment in terms of institutional and legal arrangements, including those for effective water-demand management.

Awareness raising is a vital part of a participatory approach to water resources management. Information, education and communication support programmes must be an integral part of the development process.

Follow-up

Experience has shown that progress towards implementing the actions and achieving the goals of water programmes requires follow-up mechanisms for periodic assessments at national and international levels.

In the framework of the follow-up procedures developed by UNCED for Agenda 21, all Governments should initiate periodic assessments of progress. At the international level, United Nations institutions concerned with water should be strengthened to undertake the assessment and follow-up process. In addition, to involve private institutions, regional and non-governmental organizations along with all interested governments in the assessment and follow-up, the Conference proposes, for consideration by UNCED, a world water forum or council to which all such groups could adhere.

It is proposed that the first full assessment on implementation of the recommended programme should be undertaken by the year 2000.

UNCED is urged to consider the financial requirements for water-related programmes, in accordance with the above principles, in the funding for implementation of Agenda 21. Such considerations must include realistic targets for the timeframe for implementation of the programmes, the internal and external resources needed, and the means of mobilizing these.

The International Conference on Water and the Environment began with a Water Ceremony in which children from all parts of the world made a moving plea to the assembled experts to play their part in preserving precious water resources for future generations. In transmitting this Dublin Statement to a world audience, the Conference participants urge all those involved in the development and management of our water resources to allow the message of those children to direct their future actions.

AGENDA 21:

Programme of Action for
Sustainable Development

RIO DECLARATION

on Environment and Development

Chapter 18. Protection of the quality and supply of freshwater resources:

Application of integrated approaches to the development, management and use of water resources

UNITED NATIONS

18 Protection of the quality and supply of freshwater resources: Application of integrated approaches to the development, management and use of water resources

INTRODUCTION

18.1 Freshwater resources are an essential component of the Earth's hydrosphere and an indispensable part of all terrestrial ecosystems. The freshwater environment is characterized by the hydrological cycle, including floods and droughts, which in some regions have become more extreme and dramatic in their consequences. Global climate change and atmospheric pollution could also have an impact on freshwater resources and their availability and, through sea-level rise, threaten low-lying coastal areas and small island ecosystems.

18.2 Water is needed in all aspects of life. The general objective is to make certain that adequate supplies of water of good quality are maintained for the entire population of this planet, while preserving the hydrological, biological and chemical functions of ecosystems, adapting human activities within the capacity limits of nature and combating vectors of water-related diseases. Innovative technologies, including the improvement of indigenous technologies, are needed to fully utilize limited water resources and to safeguard those resources against pollution.

18.3 The widespread scarcity, gradual destruction and aggravated pollution of freshwater resources in many world regions, along with the progressive encroachment of incompatible activities, demand integrated water resources planning and management. Such integration must cover all types of interrelated freshwater bodies, including both surface water and groundwater, and duly consider water quantity and quality aspects. The multisectoral nature of water resources development in the context of socio-economic development must be recognized, as well as the multi-interest utilization of water resources for water supply and sanitation, agriculture, industry, urban development, hydropower generation, inland fisheries, transportation, recreation, low and flat lands management and other activities. Rational water utilization schemes for the development of surface and underground water-supply sources and other potential sources have to be supported by concurrent water conservation and wastage minimization measures. Priority, however, must be accorded to flood prevention and control measures, as well as sedimentation control, where required.

18.4 Transboundary water resources and their use are of great importance to riparian States. In this connection, cooperation among those States may be desirable in conformity with existing agreements and/or other relevant arrangements, taking into account the interests of all riparian States concerned.

18.5 The following programme areas are proposed for the freshwater sector:

(a) Integrated water resources development and management;

(b) Water resources assessment;

(c) Protection of water resources, water quality and aquatic ecosystems;

(d) Drinking-water supply and sanitation;

(e) Water and sustainable urban development;

(f) Water for sustainable food production and rural development;

(g) Impacts of climate change on water resources.

PROGRAMME AREAS

A) INTEGRATED WATER RESOURCES DEVELOPMENT AND MANAGEMENT

BASIS FOR ACTION

18.6 The extent to which water resources development contributes to economic productivity and social well-being is not usually appreciated, although all social and economic activities rely heavily on the supply and quality of freshwater. As populations and economic activities grow, many countries are rapidly reaching conditions of water scarcity or facing limits to economic development. Water demands are increasing rapidly, with 70-80 per cent required for irrigation, less than 20 per cent for industry and a mere 6 per cent for domestic consumption. The holistic management of freshwater as a finite and vulnerable resource, and the integration of sectoral water plans and programmes within the framework of national economic and social policy, are of paramount importance for action in the 1990s and beyond. The fragmentation of responsibilities for water resources development among sectoral agencies is proving, however, to be an even greater impediment to promoting integrated water management than had been anticipated. Effective implementation and coordination mechanisms are required.

OBJECTIVES

18.7 The overall objective is to satisfy the freshwater needs of all countries for their sustainable development.

18.8 Integrated water resources management is based on the perception of water as an integral part of the ecosystem, a natural resource and a social and economic good, whose quantity and quality determine the nature of its utilization. To this end, water resources have to be protected, taking into account the functioning of aquatic ecosystems and the perenniality of the resource, in order to satisfy and reconcile needs for water in human activities. In developing and using water resources, priority has to be given to the satisfaction of basic needs and the safeguarding of ecosystems. Beyond these requirements, however, water users should be charged appropriately.

18.9 Integrated water resources management, including the integration of land- and water-related aspects, should be carried out at the level of the catchment basin or sub-basin. Four principal objectives should be pursued, as follows:

(a) To promote a dynamic, interactive, iterative and multisectoral approach to water resources management, including the identification and protection of potential sources of freshwater supply, that integrates technological, socio-economic, environmental and human health considerations;

(b) To plan for the sustainable and rational utilization, protection, conservation and management of water resources based on community needs and priorities within the framework of national economic development policy;

(c) To design, implement and evaluate projects and programmes that are both economically efficient and socially appropriate within clearly defined strategies, based on an approach of full public participation, including that of women, youth, indigenous people and local communities in water management policy-making and decision-making;

(d) To identify and strengthen or develop, as required, in particular in developing countries, the appropriate institutional, legal and financial mechanisms to ensure that water policy and its implementation are a catalyst for sustainable social progress and economic growth.

18.10 In the case of transboundary water resources, there is a need for riparian States to formulate water resources strategies, prepare water resources action programmes and consider, where appropriate, the harmonization of those strategies and action programmes.

18.11 All States, according to their capacity and available resources, and through bilateral or multilateral cooperation, including the United Nations and other relevant organizations as appropriate, could set the following targets:

A) BY THE YEAR 2000:

(i) To have designed and initiated costed and targeted national action programmes, and to have put in place appropriate institutional structures and legal instruments;

(ii) To have established efficient water-use programmes to attain sustainable resource utilization patterns;

B) BY THE YEAR 2025:

(i) To have achieved subsectoral targets of all freshwater programme areas.

It is understood that the fulfilment of the targets quantified in (A) (i) and (ii) above will depend upon new and additional financial resources that will be made available to developing countries in accordance with the relevant provisions of General Assembly resolution 44/228.

ACTIVITIES

18.12 All States, according to their capacity and available resources, and through bilateral or multilateral cooperation, including the United Nations and other relevant organizations as appropriate, could implement the following activities to improve integrated water resources management:

(a) Formulation of costed and targeted national action plans and investment programmes;

(b) Integration of measures for the protection and conservation of potential sources of freshwater supply, including the inventorying of water resources, with land-use planning, forest resource utilization, protection of mountain slopes and riverbanks and other relevant development and conservation activities;

(c) Development of interactive databases, forecasting models, economic planning models and methods for water management and planning, including environmental impact assessment methods;

(d) Optimization of water resources allocation under physical and socio-economic constraints;

(e) Implementation of allocation decisions through demand management, pricing mechanisms and regulatory measures;

(f) Flood and drought management, including risk analysis and environmental and social impact assessment;

(g) Promotion of schemes for rational water use through public awareness-raising, educational programmes and levying of water tariffs and other economic instruments;

(h) Mobilization of water resources, particularly in arid and semi-arid areas;

(i) Promotion of international scientific research cooperation on freshwater resources;

(j) Development of new and alternative sources of water-supply such as seawater desalination, artificial groundwater recharge, use of marginal-quality water, waste-water reuse and water recycling;

(k) Integration of water (including surface and underground water resources) quantity and quality management;

(l) Promotion of water conservation through improved water-use efficiency and wastage minimization schemes for all users, including the development of water-saving devices;

(m) Support to water-user groups to optimize local water resources management;

(n) Development of public participatory techniques and their implementation in decision-making, particularly the enhancement of the role of women in water resources planning and management;

(o) Development and strengthening, as appropriate, of cooperation, including mechanisms where appropriate, at all levels concerned, namely:

(i) At the lowest appropriate level, delegation of water resources management, generally, to that level, in accordance with national legislation, including decentralization of government services to local authorities, private enterprises and communities;

(ii) At the national level, integrated water resources planning and management in the framework of the national planning process and, where appropriate, establishment of independent regulation and monitoring of freshwater, based on national legislation and economic measures;

(iii) At the regional level, consideration, where appropriate, of the harmonization of national strategies and action programmes;

(iv) At the global level, improved delineation of responsibilities, division of labour and coordination of international organizations and programmes, including facilitating discussions and sharing of experiences in areas related to water resources management;

(p) Dissemination of information, including operational guidelines, and promotion of education for water users, including the consideration by the United Nations of a World Water Day.

MEANS OF IMPLEMENTATION

A) FINANCING AND COST EVALUATION

18.13 The Conference secretariat has estimated the average total annual cost (1993-2000) of implementing the activities of this programme to be about $115 million from the international community on grant or concessional terms. These are indicative and order-of-magnitude estimates only and have not been reviewed by Governments. Actual costs and financial terms, including any that are non-concessional, will depend upon, *inter alia*, the specific strategies and programmes Governments decide upon for implementation.

B) SCIENTIFIC AND TECHNOLOGICAL MEANS

18.14 The development of interactive databases, forecasting methods and economic planning models appropriate to the task of managing water resources in an efficient and sustainable manner will require the application of new techniques such as geographical information systems and expert systems to gather, assimilate, analyse and display multisectoral information and to optimize decision-making. In addition, the development of new and alternative sources of water-supply and low-cost water technologies will require innovative applied research. This will involve the transfer, adaptation and diffusion of new techniques and technology among developing countries, as well as the development of endogenous capacity, for the purpose of being able to deal with the added dimension of integrating engineering, economic, environmental and social aspects of water resources management and predicting the effects in terms of human impact.

18.15 Pursuant to the recognition of water as a social and economic good, the various available options for charging water users (including domestic, urban, industrial and agricultural water-user groups) have to be further evaluated and field-tested. Further development is required for economic instruments that take into account opportunity costs and environmental externalities. Field studies on the willingness to pay should be conducted in rural and urban situations.

18.16 Water resources development and management should be planned in an integrated manner, taking into account long-term planning needs as well as those with narrower horizons; that is to say, they should incorporate environmental, economic and social considerations based on the principle of sustainability, include the requirements of all users as well as those relating to the prevention and mitigation of water-related hazards and constitute an integral part of the socio-economic development planning process. A prerequisite for the sustainable management of water as a scarce vulnerable resource is the obligation to acknowledge in all planning and development its full costs. Planning considerations should reflect benefits investment, environmental protection and operation costs, as well as the opportunity costs reflecting the most valuable alternative use of water. Actual charging need not necessarily burden all beneficiaries with the consequences of those considerations. Charging mechanisms should, however, reflect as far as possible both the true cost of water when used as an economic good and the ability of the communities to pay.

18.17 The role of water as a social, economic and life-sustaining good should be reflected in demand management mechanisms and implemented through water conservation and reuse, resource assessment and financial instruments.

18.18 The setting afresh of priorities for private and public investment strategies should take into account (a) maximum utilization of existing projects, through maintenance, rehabilitation and optimal operation; (b) new or alternative clean technologies; and (c) environmentally and socially benign hydropower.

C) HUMAN RESOURCES DEVELOPMENT

18.19 The delegation of water resources management to the lowest appropriate level necessitates educating and training water management staff at all levels and ensuring that women participate equally in the education and training programmes. Particular emphasis has to be placed on the introduction of public participatory techniques, including enhancement of the role of women, youth, indigenous people and local communities. Skills related to various water management functions have to be developed by municipal government and water authorities, as well as in the private sector, local/national non-governmental organizations, cooperatives, corporations and other water-user groups. Education of the public regarding the importance of water and its proper management is also needed.

18.20 To implement these principles, communities need to have adequate capacities. Those who establish the framework for water development and management at any level, whether international, national or local, need to ensure that the means exist to build those capacities. The means will vary from case to case. They usually include:

(a) Awareness-creation programmes, including mobilizing commitment and support at all levels and initiating global and local action to promote such programmes;

(b) Training of water managers at all levels so that they have an appropriate understanding of all the elements necessary for their decision-making;

(c) Strengthening of training capacities in developing countries;

(d) Appropriate training of the necessary professionals, including extension workers;

(e) Improvement of career structures;

(f) Sharing of appropriate knowledge and technology, both for the collection of data and for the implementation of planned development, including non-polluting technologies and the knowledge needed to extract the best performance from the existing investment system.

D) CAPACITY-BUILDING

18.21 Institutional capacity for implementing integrated water management should be reviewed and developed when there is a clear demand. Existing administrative structures will often be quite capable of achieving local water resources management, but the need may arise for new institutions based upon the perspective, for example, of river catchment areas, district development councils and local community committees. Although water is managed at various levels in the socio-political system, demand-driven management requires the development of water-related institutions at appropriate levels, taking into account the need for integration with land-use management.

18.22 In creating the enabling environment for lowest-appropriate-level management, the role of government includes mobilization of financial and human resources, legislation, standard-setting and other regulatory functions, monitoring and assessment of the use of water and land resources and creating of opportunities for public participation. International agencies and donors have an important role to play in providing support to developing countries in creating the required enabling environment for integrated water resources management. This should include, as appropriate, donor support to local levels in developing countries, including community-based institutions, non-governmental organizations and women's groups.

B) WATER RESOURCES ASSESSMENT

BASIS FOR ACTION

18.23 Water resources assessment, including the identification of potential sources of freshwater supply, comprises the continuing determination of sources, extent, dependability and quality of water resources and of the human activities that affect those resources. Such assessment constitutes the practical basis for their sustainable management and a prerequisite for evaluation of the possibilities for their development. There is, however, growing concern that at a time when more precise and reliable information is needed about water resources, hydrologic services and related bodies are less able than before to provide this information, especially information on groundwater and water quality. Major impediments are the lack of financial resources for water resources assessment, the fragmented nature of hydrologic services and the insufficient numbers of qualified staff. At the same time, the advancing technology for data capture and management is increasingly difficult to access for developing countries. Establishment of national databases is, however, vital to water resources assessment and to mitigation of the effects of floods, droughts, desertification and pollution.

OBJECTIVES

18.24 Based upon the Mar del Plata Action Plan, this programme area has been extended into the 1990s and beyond with the overall objective of ensuring the assessment and forecasting of the quantity and quality of water resources, in order to estimate the total quantity of water resources available and their future supply potential, to determine their current quality status, to predict possible conflicts between supply and demand and to provide a scientific database for rational water resources utilization.

18.25 Five specific objectives have been set accordingly, as follows:

(a) To make available to all countries water resources assessment technology that is appropriate to their needs, irrespective of their level of development, including methods for the impact assessment of climate change on freshwater;

(b) To have all countries, according to their financial means, allocate to water resources assessment financial resources in line with the economic and social needs for water resources data;

(c) To ensure that the assessment information is fully utilized in the development of water management policies;

(d) To have all countries establish the institutional a rangements needed to ensure the efficient collectio processing, storage, retrieval and dissemination to use of information about the quality and quantity of availab water resources at the level of catchments and groun water aquifers in an integrated manner;

(e) To have sufficient numbers of appropriately qual fied and capable staff recruited and retained by wat resources assessment agencies and provided with th training and retraining they will need to carry out the responsibilities successfully.

18.26 All States, according to their capacity and availabl resources, and through bilateral or multilateral coope ation, including cooperation with the United Nations an other relevant organizations, as appropriate, could set th following targets:

(a) By the year 2000, to have studied in detail th feasibility of installing water resources assessmen services;

(b) As a long-term target, to have fully operationa services available based upon high-density hydrometri networks.

ACTIVITIES

18.27 All States, according to their capacity and availabl resources, and through bilateral or multilateral cooper ation, including the United Nations and other relevan organizations as appropriate, could undertake the follow ing activities:

A) INSTITUTIONAL FRAMEWORK:

(i) Establish appropriate policy frameworks and national priorities;

(ii) Establish and strengthen the institutional capabilities of countries, including legislative and regulatory arrangements, that are required to ensure the adequate assessment of their water resources and the provision of flood and drought forecasting services;

(iii) Establish and maintain effective cooperation at the national level between the various agencies responsible for the collection, storage and analysis of hydrologic data;

(iv) Cooperate in the assessment of transboundary water resources, subject to the prior agreement of each riparian State concerned;

B) DATA SYSTEMS:

(i) Review existing data-collection networks and assess their adequacy, including those that provide real-time data for flood and drought forecasting;

(ii) Improve networks to meet accepted guidelines for the provision of data on water quantity and quality for surface and groundwater, as well as relevant land-use data;

(iii) Apply standards and other means to ensure data compatibility;

(iv) Upgrade facilities and procedures used to store, process and analyse hydrologic data and make such data and the forecasts derived from them available to potential users;

(v) Establish databases on the availability of all types of hydrologic data at the national level;

(vi) Implement "data rescue" operations, for example, establishment of national archives of water resources;

(vii) Implement appropriate well-tried techniques for the processing of hydrologic data;

(viii) Derive area-related estimates from point hydrologic data;

(ix) Assimilate remotely sensed data and the use, where appropriate, of geographical information systems;

C) DATA DISSEMINATION:

(i) Identify the need for water resources data for various planning purposes;

(ii) Analyse and present data and information on water resources in the forms required for planning and management of countries' socio-economic development and for use in environmental protection strategies and in the design and operation of specific water-related projects;

(iii) Provide forecasts and warnings of flood and drought to the general public and civil defence;

D) RESEARCH AND DEVELOPMENT:

(i) Establish or strengthen research and development programmes at the national, subregional, regional and international levels in support of water resources assessment activities;

(ii) Monitor research and development activities to ensure that they make full use of local expertise and other local resources and that they are appropriate for the needs of the country or countries concerned.

MEANS OF IMPLEMENTATION

A) FINANCING AND COST EVALUATION

18.28 The Conference secretariat has estimated the average total annual cost (1993-2000) of implementing the activities of this programme to be about \$355 million, including about \$145 million from the international community on grant or concessional terms. These are indicative and order-of-magnitude estimates only and have not been reviewed by Governments. Actual costs and financial terms, including any that are non-concessional, will depend upon, *inter alia*, the specific strategies and programmes Governments decide upon for implementation.

B) SCIENTIFIC AND TECHNOLOGICAL MEANS

18.29 Important research needs include (a) development of global hydrologic models in support of analysis of climate change impact and of macroscale water resources assessment; (b) closing of the gap between terrestrial hydrology and ecology at different scales, including the critical water-related processes behind loss of vegetation and land degradation and its restoration; and (c) study of the key processes in water-quality genesis, closing the gap between hydrologic flows and biogeochemical processes. The research models should build upon hydrologic balance studies and also include the consumptive use of water. This approach should also, when appropriate, be applied at the catchment level.

18.30 Water resources assessment necessitates the strengthening of existing systems for technology transfer, adaptation and diffusion, and the development of new technology for use under field conditions, as well as the development of endogenous capacity. Prior to inaugurating the above activities, it is necessary to prepare catalogues of the water resources information held by government services, the private sector, educational institutes, consultants, local water-use organizations and others.

C) HUMAN RESOURCE DEVELOPMENT

18.31 Water resources assessment requires the establishment and maintenance of a body of well-trained and motivated staff sufficient in number to undertake the above activities. Education and training programmes designed to ensure an adequate supply of these trained personnel should be established or strengthened at the local, national, subregional or regional level. In addition, the provision of attractive terms of employment and career paths for professional and technical staff should be encouraged. Human resource needs should be monitored periodically, including all levels of employment. Plans have to be established to meet those needs through education and training opportunities and international programmes of courses and conferences.

18.32 Because well-trained people are particularly important to water resources assessment and hydrologic forecasting, personnel matters should receive special attention in this area. The aim should be to attract and retain personnel to work on water resources assessment who are sufficient in number and adequate in their level of education to ensure the effective implementation of the activities that are planned. Education may be called for at both the national and the international levels, with adequate terms of employment being a national responsibility.

18.33 Recommended actions include:

(a) Identifying education and training needs geared to the specific requirements of countries;

(b) Establishing and strengthening education and training programmes on water-related topics, within an environmental and developmental context, for all categories of staff involved in water resources assessment activities, using advanced educational technology, where appropriate, and involving both men and women;

(c) Developing sound recruitment, personnel and pay policies for staff of national and local water agencies.

D) CAPACITY-BUILDING

18.34 The conduct of water resources assessment on the basis of operational national hydrometric networks requires an enabling environment at all levels. The following national support action is necessary for enhanced national capacities:

(a) Review of the legislative and regulatory basis of water resources assessment;

(b) Facilitation of close collaboration among water sector agencies, particularly between information producers and users;

(c) Implementation of water management policies based upon realistic appraisals of water resources conditions and trends;

(d) Strengthening of the managerial capabilities of water-user groups, including women, youth, indigenous people and local communities, to improve water-use efficiency at the local level.

C) PROTECTION OF WATER RESOURCES, WATER QUALITY AND AQUATIC ECOSYSTEMS

BASIS FOR ACTION

18.35 Freshwater is a unitary resource. Long-term development of global freshwater requires holistic management of resources and a recognition of the interconnectedness of the elements related to freshwater and freshwater quality. There are few regions of the world that are still exempt from problems of loss of potential sources of freshwater supply, degraded water quality and pollution of surface and groundwater sources. Major problems affecting the water quality of rivers and lakes arise, in variable order of importance according to different situations, from inadequately treated domestic sewage, inadequate controls on the discharges of industrial waste waters, loss and destruction of catchment areas, ill-considered siting of industrial plants, deforestation, uncontrolled shifting cultivation and poor agricultural practices. This gives rise to the leaching of nutrients and pesticides. Aquatic ecosystems are disturbed and living freshwater resources are threatened. Under certain circumstances, aquatic ecosystems are also affected by agricultural water resource development projects such as dams, river diversions, water installations and irrigation schemes. Erosion, sedimentation, deforestation and desertification have led to increased land degradation, and the creation of reservoirs has, in some cases, resulted in adverse effects on ecosystems. Many of these problems have arisen from a development model that is environmentally destructive and from a lack of public awareness and education about surface and groundwater resource protection. Ecological and human health effects are the measurable consequences, although the means to monitor them are inadequate or non-existent in many countries. There is a widespread lack of perception of the linkages between the development, management, use and treatment of water resources and aquatic ecosystems. A preventive approach, where appropriate, is crucial to the avoiding of costly subsequent measures to rehabilitate, treat and develop new water supplies.

OBJECTIVES

18.36 The complex interconnectedness of freshwater systems demands that freshwater management be holistic (taking a catchment management approach) and based on a balanced consideration of the needs of people and the environment. The Mar del Plata Action Plan has already recognized the intrinsic linkage between water resource development projects and their significant physical, chemical, biological, health and socio-economic repercussions. The overall environmental health objective was set as follows: "to evaluate the consequences which the various users of water have on the environment, to support measures aimed at controlling water-related diseases, and to protect ecosystems".[1]

18.37 The extent and severity of contamination of unsaturated zones and aquifers have long been underestimated owing to the relative inaccessibility of aquifers and the lack of reliable information on aquifer systems. The protection of groundwater is therefore an essential element of water resource management.

18.38 Three objectives will have to be pursued concurrently to integrate water-quality elements into water resource management:

(a) Maintenance of ecosystem integrity, according to a management principle of preserving aquatic ecosystems, including living resources, and of effectively protecting them from any form of degradation on a drainage basin basis;

(b) Public health protection, a task requiring not only the provision of safe drinking-water but also the control of disease vectors in the aquatic environment;

(c) Human resources development, a key to capacity-building and a prerequisite for implementing water-quality management.

18.39 All States, according to their capacity and available resources, through bilateral or multilateral cooperation, including the United Nations and other relevant organizations as appropriate, could set the following targets:

(a) To identify the surface and groundwater resources that could be developed for use on a sustainable basis and other major developable water-dependent resources and, simultaneously, to initiate programmes for the protection, conservation and rational use of these resources on a sustainable basis;

(b) To identify all potential sources of water-supply and prepare outlines for their protection, conservation and rational use;

(c) To initiate effective water pollution prevention and control programmes, based on an appropriate mixture of pollution reduction-at-source strategies, environmental impact assessments and enforceable standards for major point-source discharges and high-risk non-point sources, commensurate with their socio-economic development;

(d) To participate, as far as appropriate, in international water-quality monitoring and management programmes such as the Global Water Quality Monitoring Programme (GEMS/WATER), the UNEP Environmentally Sound Management of Inland Waters (EMINWA), the FAO regional inland fishery bodies, and the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention);

(e) To reduce the prevalence of water-associated diseases, starting with the eradication of dracunculiasis (guinea worm disease) and onchocerciasis (river blindness) by the year 2000;

(f) To establish, according to capacities and needs, biological, health, physical and chemical quality criteria for all water bodies (surface and groundwater), with a view to an ongoing improvement of water quality;

(g) To adopt an integrated approach to environmentally sustainable management of water resources, including the protection of aquatic ecosystems and freshwater living resources;

(h) To put in place strategies for the environmentally sound management of freshwater and related coastal ecosystems, including consideration of fisheries, aquaculture, animal grazing, agricultural activities and biodiversity.

ACTIVITIES

18.40 All States, according to their capacity and available resources, and through bilateral or multilateral co-operation, including United Nations and other relevant organizations as appropriate, could implement the following activities:

A) WATER RESOURCES PROTECTION AND CONSERVATION:

(i) Establishment and strengthening of technical and institutional capacities to identify and protect potential sources of water-supply within all sectors of society;

(ii) Identification of potential sources of water-supply and preparation of national profiles;

(iii) Preparation of national plans for water resources protection and conservation;

(iv) Rehabilitation of important, but degraded, catchment areas, particularly on small islands;

(v) Strengthening of administrative and legislative measures to prevent encroachment on existing and potentially usable catchment areas;

B) WATER POLLUTION PREVENTION AND CONTROL:

(i) Application of the "polluter pays" principle, where appropriate, to all kinds of sources, including on-site and off-site sanitation;

(ii) Promotion of the construction of treatment facilities for domestic sewage and industrial effluents and the development of appropriate technologies, taking into account sound traditional and indigenous practices;

(iii) Establishment of standards for the discharge of effluents and for the receiving waters;

(iv) Introduction of the precautionary approach in water-quality management, where appropriate, with a focus on pollution minimization and prevention through use of new technologies, product and process change, pollution reduction at source and effluent reuse, recycling and recovery, treatment and environmentally safe disposal;

(v) Mandatory environmental impact assessment of all major water resource development projects potentially impairing water quality and aquatic ecosystems, combined with the delineation of appropriate remedial measures and a strengthened control of new industrial installations, solid waste landfills and infrastructure development projects;

(vi) Use of risk assessment and risk management in reaching decisions in this area and ensuring compliance with those decisions;
(vii) Identification and application of best environmental practices at reasonable cost to avoid diffuse pollution, namely, through a limited, rational and planned use of nitrogenous fertilizers and other agrochemicals (pesticides, herbicides) in agricultural practices;
(viii) Encouragement and promotion of the use of adequately treated and purified waste waters in agriculture, aquaculture, industry and other sectors;

C) DEVELOPMENT AND APPLICATION OF CLEAN TECHNOLOGY:

(i) Control of industrial waste discharges, including low-waste production technologies and water recirculation, in an integrated manner and through application of precautionary measures derived from a broad-based life-cycle analysis;
(ii) Treatment of municipal waste water for safe reuse in agriculture and aquaculture;
(iii) Development of biotechnology, *inter alia*, for waste treatment, production of biofertilizers and other activities;
(iv) Development of appropriate methods for water pollution control, taking into account sound traditional and indigenous practices;

D) GROUNDWATER PROTECTION:

(i) Development of agricultural practices that do not degrade groundwaters;
(ii) Application of the necessary measures to mitigate saline intrusion into aquifers of small islands and coastal plains as a consequence of sealevel rise or overexploitation of coastal aquifers;
(iii) Prevention of aquifer pollution through the regulation of toxic substances that permeate the ground and the establishment of protection zones in groundwater recharge and abstraction areas;
(iv) Design and management of landfills based upon sound hydrogeologic information and impact assessment, using the best practicable and best available technology;
(v) Promotion of measures to improve the safety and integrity of wells and well-head areas to reduce intrusion of biological pathogens and hazardous chemicals into aquifers at well sites;
(vi) Water-quality monitoring, as needed, of surface and groundwater potentially affected by sites storing toxic and hazardous materials;

E) PROTECTION OF AQUATIC ECOSYSTEMS:

(i) Rehabilitation of polluted and degraded water bodies to restore aquatic habitats and ecosystems;
(ii) Rehabilitation programmes for agricultural lands and for other users, taking into account equivalent action for the protection and use of groundwater resources important for agricultural productivity and for the biodiversity of the tropics;
(iii) Conservation and protection of wetlands (owing to their ecological and habitat importance for many species), taking into account social and economic factors;
(iv) Control of noxious aquatic species that may destroy some other water species;

F) PROTECTION OF FRESHWATER LIVING RESOURCES:

(i) Control and monitoring of water quality to allow for the sustainable development of inland fisheries;
(ii) Protection of ecosystems from pollution and degradation for the development of freshwater aquaculture projects;

G) MONITORING AND SURVEILLANCE OF WATER RESOURCES AND WATERS RECEIVING WASTES:

(i) Establishment of networks for the monitoring and continuous surveillance of waters receiving wastes and of point and diffuse sources of pollution;
(ii) Promotion and extension of the application of environmental impact assessments of geographical information systems;
(iii) Surveillance of pollution sources to improve compliance with standards and regulations and to regulate the issue of discharge permits;
(iv) Monitoring of the utilization of chemicals in agriculture that may have an adverse environmental effect;
(v) Rational land use to prevent land degradation, erosion and siltation of lakes and other water bodies;

H) DEVELOPMENT OF NATIONAL AND INTERNATIONAL LEGAL INSTRUMENTS THAT MAY BE REQUIRED TO PROTECT THE QUALITY OF WATER RESOURCES, AS APPROPRIATE, PARTICULARLY FOR:

(i) Monitoring and control of pollution and its effects in national and transboundary waters;
(ii) Control of long-range atmospheric transport of pollutants;
(iii) Control of accidental and/or deliberate spills in national and/or transboundary water bodies;
(iv) Environmental impact assessment.

MEANS OF IMPLEMENTATION

A) FINANCING AND COST EVALUATION

18.41 The Conference secretariat has estimated the average total cost (1993-2000) of implementing the activities of this programme to be about $1 billion, including about $340 million from the international community on grant or concessional terms. These are indicative and order-of-magnitude estimates only and have not been reviewed by Governments. Actual costs and financial terms, including any that are non-concessional, will depend upon, *inter alia*, the specific strategies and programmes Governments decide upon for implementation.

B) SCIENTIFIC AND TECHNOLOGICAL MEANS

18.42 States should undertake cooperative research projects to develop solutions to technical problems that are appropriate for the conditions in each watershed or country. States should consider strengthening and developing national research centres linked through networks and supported by regional water research institutes. The North-South twinning of research centres and field studies by international water research institutions should be actively promoted. It is important that a minimum percentage of funds for water resource development projects is allocated to research and development, particularly in externally funded projects.

18.43 Monitoring and assessment of complex aquatic systems often require multidisciplinary studies involving several institutions and scientists in a joint programme. International water-quality programmes, such as GEMS/WATER, should be oriented towards the water-quality of developing countries. User-friendly software and Geographical Information Systems (GIS) and Global Resource Information Database (GRID) methods should be developed for the handling, analysis and interpretation of monitoring data and for the preparation of management strategies.

C) HUMAN RESOURCE DEVELOPMENT

18.44 Innovative approaches should be adopted for professional and managerial staff training in order to cope with changing needs and challenges. Flexibility and adaptability regarding emerging water pollution issues should be developed. Training activities should be undertaken periodically at all levels within the organizations responsible for water-quality management, and innovative teaching techniques adopted for specific aspects of water-quality monitoring and control, including development of training skills, in-service training, problem-solving workshops and refresher training courses.

18.45 Suitable approaches include the strengthening and improvement of the human resource capabilities of local Governments in managing water protection, treatment and use, particularly in urban areas, and the establishment of national and regional technical and engineering courses on the subjects of water-quality protection and control at existing schools and education/training courses on water resources protection and conservation for laboratory and field technicians, women and other water-user groups.

D) CAPACITY-BUILDING

18.46 The effective protection of water resources and ecosystems from pollution requires considerable upgrading of most countries' present capacities. Water-quality management programmes require a certain minimum infrastructure and staff to identify and implement technical solutions and to enforce regulatory action. One of the key problems today and for the future is the sustained operation and maintenance of these facilities. In order not to allow resources gained from previous investments to deteriorate further, immediate action is required in a number of areas.

D) DRINKING-WATER SUPPLY AND SANITATION

BASIS FOR ACTION

18.47 Safe water-supplies and environmental sanitation are vital for protecting the environment, improving health and alleviating poverty. Safe water is also crucial to many traditional and cultural activities. An estimated 80 per cent of all diseases and over one third of deaths in developing countries are caused by the consumption of contaminated water, and on average as much as one-tenth of each person's productive time is sacrificed to water-related diseases. Concerted efforts during the 1980s brought water and sanitation services to hundreds of millions of the world's poorest people. The most outstanding of these efforts was the launching in 1981 of the International Drinking Water Supply and Sanitation Decade, which resulted from the Mar del Plata Action Plan adopted by the United Nations Water Conference in 1977. The commonly agreed premise was that "all peoples, whatever their stage of development and their social and economic conditions, have the right to have access to drinking water in quantities and of a quality equal to their basic needs".[2] The target of the Decade was to provide safe drinking-water and sanitation to underserved urban and rural areas by 1990, but even the unprecedented progress achieved during the Decade was not enough. One in three people in the developing world still lacks these two most basic requirements for health and dignity. It is also recognized that human excreta and sewage are important causes of the deterioration of water quality in developing countries, and the introduction of available technologies, including appropriate technologies, and the construction of sewage treatment facilities could bring significant improvement.

OBJECTIVES

18.48 The New Delhi Statement (adopted at the Global Consultation on Safe Water and Sanitation for the 1990s, which was held at New Delhi from 10 to 14 September 1990) formalized the need to provide, on a sustainable basis, access to safe water in sufficient quantities and proper sanitation for all, emphasizing the "some for all rather than more for some" approach. Four guiding principles provide for the programme objectives:

(a) Protection of the environment and safeguarding of health through the integrated management of water resources and liquid and solid wastes;

(b) Institutional reforms promoting an integrated approach and including changes in procedures, attitudes and behaviour, and the full participation of women at all levels in sector institutions;

(c) Community management of services, backed by measures to strengthen local institutions in implementing and sustaining water and sanitation programmes;

(d) Sound financial practices, achieved through better management of existing assets, and widespread use of appropriate technologies.

18.49 Past experience has shown that specific targets should be set by each individual country. At the World Summit for Children, in September 1990, heads of State or Government called for both universal access to water-supply and sanitation and the eradication of guinea worm disease by 1995. Even for the more realistic target of achieving full coverage in water-supply by 2025, it is estimated that annual investments must reach double the current levels. One realistic strategy to meet present and future needs, therefore, is to develop lower-cost but adequate services that can be implemented and sustained at the community level.

ACTIVITIES

18.50 All States, according to their capacity and available resources, and through bilateral or multilateral cooperation, including the United Nations and other relevant organizations as appropriate, could implement the following activities:

A) ENVIRONMENT AND HEALTH:

(i) Establishment of protected areas for sources of drinking-water supply;

(ii) Sanitary disposal of excreta and sewage, using appropriate systems to treat waste waters in urban and rural areas;

(iii) Expansion of urban and rural water-supply and development and expansion of rainwater catchment systems, particularly on small islands, in addition to the reticulated water-supply system;

(iv) Building and expansion, where appropriate, of sewage treatment facilities and drainage systems;

(v) Treatment and safe reuse of domestic and industrial waste waters in urban and rural areas;

(vi) Control of water-associated diseases;

B) PEOPLE AND INSTITUTIONS:

(i) Strengthening of the functioning of Governments in water resources management and, at the same time, giving of full recognition to the role of local authorities;

(ii) Encouragement of water development and management based on a participatory approach, involving users, planners and policy makers at all levels;

(iii) Application of the principle that decisions are to be taken at the lowest appropriate level, with public consultation and involvement of users in the planning and implementation of water projects;

(iv) Human resource development at all levels, including special programmes for women;

(v) Broad-based education programmes, with particular emphasis on hygiene, local management and risk reduction;

(vi) International support mechanisms for programme funding, implementation and follow-up;

C) NATIONAL AND COMMUNITY MANAGEMENT:

(i) Support and assistance to communities in managing their own systems on a sustainable basis;

(ii) Encouragement of the local population, especially women, youth, indigenous people and local communities, in water management;

(iii) Linkages between national water plans and community management of local waters;

(iv) Integration of community management of water within the context of overall planning;

(v) Promotion of primary health and environmental care at the local level, including training for local communities in appropriate water management techniques and primary health care;

(vi) Assistance to service agencies in becoming more cost-effective and responsive to consumer needs;

(vii) Providing of more attention to underserved rural and low-income periurban areas;

(viii) Rehabilitation of defective systems, reduction of wastage and safe reuse of water and waste water;

(ix) Programmes for rational water use and ensured operation and maintenance;

(x) Research and development of appropriate technical solutions;

(xi) Substantial increase in urban treatment capacity commensurate with increasing loads;

D) AWARENESS CREATION AND PUBLIC INFORMATION/PARTICIPATION:

(i) Strengthening of sector monitoring and information management at subnational and national levels;

(ii) Annual processing, analysis and publication of monitoring results at national and local levels as a sector management and advocacy/awareness creation tool;

(iii) Use of limited sector indicators at regional and global levels to promote the sector and raise funds;

(iv) Improvement of sector coordination, planning and implementation, with the assistance of improved monitoring and information management, to increase the sector's absorptive capacity, particularly in community-based self-help projects.

MEANS OF IMPLEMENTATION

A) FINANCING AND COST EVALUATION

18.51 The Conference secretariat has estimated the average total annual cost (1993-2000) of implementing the activities of this programme to be about $20 billion, including about $7.4 billion from the international community on grant or concessional terms. These are indicative and order-of-magnitude estimates only and have not been reviewed by Governments. Actual costs and financial terms, including any that are non-concessional, will depend upon, *inter alia*, the specific strategies and programmes Governments decide upon for implementation.

B) SCIENTIFIC AND TECHNOLOGICAL MEANS

18.52 To ensure the feasibility, acceptability and sustainability of planned water-supply services, adopted technologies should be responsive to the needs and constraints imposed by the conditions of the community concerned. Thus, design criteria will involve technical, health, social, economic, provincial, institutional and environmental factors that determine the characteristics, magnitude and cost of the planned system. Relevant international support programmes should address the developing countries concerning, *inter alia*:

(a) Pursuit of low-cost scientific and technological means, as far as practicable;

(b) Utilization of traditional and indigenous practices, as far as practicable, to maximize and sustain local involvement;

(c) Assistance to country-level technical/scientific institutes to facilitate curricula development to support fields critical to the water and sanitation sector.

C) HUMAN RESOURCE DEVELOPMENT

18.53 To effectively plan and manage water-supply and sanitation at the national, provincial, district and community level, and to utilize funds most effectively, trained professional and technical staff must be developed within each country in sufficient numbers. To do this, countries must establish manpower development plans, taking into consideration present requirements and planned developments. Subsequently, the development and performance of country-level training institutions should be enhanced so that they can play a pivotal role in capacity-building. It is also important that countries provide adequate training for women in the sustainable maintenance of equipment, water resources management and environmental sanitation.

D) CAPACITY-BUILDING

18.54 The implementation of water-supply and sanitation programmes is a national responsibility. To varying degrees, responsibility for the implementation of projects and the operating of systems should be delegated to all administrative levels down to the community and individual served. This also means that national authorities, together with the agencies and bodies of the United Nations system and other external support agencies providing support to national programmes, should develop mechanisms and procedures to collaborate at all levels. This is particularly important if full advantage is to be taken of community-based approaches and self-reliance as tools for sustainability. This will entail a high degree of community participation, involving women, in the conception, planning, decision-making, implementation and evaluation connected with projects for domestic water-supply and sanitation.

18.55 Overall national capacity-building at all administrative levels, involving institutional development, coordination, human resources, community participation, health and hygiene education and literacy, has to be developed according to its fundamental connection both with any efforts to improve health and socio-economic development through water-supply and sanitation and with their impact on the human environment. Capacity-building should therefore be one of the underlying keys in implementation strategies. Institutional capacity-building should be considered to have an importance equal to that of the sector supplies and equipment component so that funds can be directed to both. This can be undertaken at the planning or programme/project formulation stage, accompanied by a clear definition of objectives and targets. In this regard, technical cooperation among developing countries, owing to their available wealth of information and experience and the need to avoid "reinventing the wheel", is crucial. Such a course has proved cost-effective in many country projects already.

E) WATER AND SUSTAINABLE URBAN DEVELOPMENT

BASIS FOR ACTION

18.56 Early in the next century, more than half of the world's population will be living in urban areas. By the year 2025, that proportion will have risen to 60 per cent, comprising some 5 billion people. Rapid urban population growth and industrialization are putting severe strains on the water resources and environmental protection capabilities of many cities. Special attention needs to be given to the growing effects of urbanization on water demands and usage and to the critical role played by local and municipal authorities in managing the supply, use and overall treatment of water, particularly in developing countries for which special support is needed. Scarcity of freshwater resources and the escalating costs of developing new resources have a considerable impact on national industrial, agricultural and human settlement development and economic growth. Better management of urban water resources, including the elimination of unsustainable consumption patterns, can make a substantial contribution to the alleviation of poverty and improvement of the health and quality of life of the urban and rural poor. A high proportion of large urban agglomerations are located around estuaries and in coastal zones. Such an arrangement leads to pollution from municipal and industrial discharges combined with over-exploitation of available water resources and threatens the marine environment and the supply of freshwater resources.

OBJECTIVES

18.57 The development objective of this programme is to support local and central Governments' efforts and capacities to sustain national development and productivity through environmentally sound management of water resources for urban use. Supporting this objective is the identification and implementation of strategies and actions to ensure the continued supply of affordable wate for present and future needs and to reverse current trend of resource degradation and depletion.

18.58 All States, according to their capacity and availabl resources, and through bilateral or multilateral cooperatior including the United Nations and other relevant organiza tions as appropriate, could set the following targets:

(a) By the year 2000, to have ensured that all urba residents have access to at least 40 litres per capita pe day of safe water and that 75 per cent of the urba population are provided with on-site or community fa cilities for sanitation;

(b) By the year 2000, to have established and applie quantitative and qualitative discharge standards for mu nicipal and industrial effluents;

(c) By the year 2000, to have ensured that 75 per cen of solid waste generated in urban areas is collected an recycled or disposed of in an environmentally safe wa

ACTIVITIES

18.59 All States, according to their capacity and availabl resources, and through bilateral or multilateral cooper ation, including the United Nations and other relevan organizations as appropriate, could implement the fol lowing activities:

A) PROTECTION OF WATER RESOURCES FROM DEPLETION, POLLUTION AND DEGRADATION:

(i) Introduction of sanitary waste disposal faciliti based on environmentally sound low-cost and upgrad able technologies;

(ii) Implementation of urban storm-water run-off an drainage programmes;

(iii) Promotion of recycling and reuse of wastewater an solid wastes;

(iv) Control of industrial pollution sources to prote water resources;

(v) Protection of watersheds with respect to depletio and degradation of their forest cover and from harmfu upstream activities;

(vi) Promotion of research into the contribution o forests to sustainable water resources development;

(vii) Encouragement of the best management practice for the use of agrochemicals with a view to minimizin their impact on water resources;

B) EFFICIENT AND EQUITABLE ALLOCATION OF WATER RESOURCES

(i) Reconciliation of city development planning wit the availability and sustainability of water resources;

(ii) Satisfaction of the basic water needs of the urba population;

(iii) Introduction of water tariffs, taking into account the circumstances, in each country and where affordable, that reflect the marginal and opportunity cost of water, especially for productive activities;

C) INSTITUTIONAL/LEGAL/MANAGEMENT REFORMS:

(i) Adoption of a city-wide approach to the management of water resources;
(ii) Promotion at the national and local level of the elaboration of land-use plans that give due consideration to water resources development;
(iii) Utilization of the skills and potential of non-governmental organizations, the private sector and local people, taking into account the public's and strategic interests in water resources;

D) PROMOTION OF PUBLIC PARTICIPATION:

(i) Initiation of public-awareness campaigns to encourage the public's move towards rational water utilization;
(ii) Sensitization of the public to the issue of protecting water quality within the urban environment;
(iii) Promotion of public participation in the collection, recycling and elimination of wastes;

E) SUPPORT TO LOCAL CAPACITY-BUILDING:

(i) Development of legislation and policies to promote investments in urban water and waste management, reflecting the major contribution of cities to national economic development;
(ii) Provision of seed money and technical support to the local handling of materials supply and services;
(iii) Encouragement, to the extent possible, of autonomy and financial viability of city water, solid waste and sewerage utilities;
(iv) Creation and maintenance of a cadre of professionals and semi-professionals, for water, waste-water and solid waste management;

F) PROVISION OF ENHANCED ACCESS TO SANITARY SERVICES:

(i) Implementation of water, sanitation and waste management programmes focused on the urban poor;
(ii) Making available of low-cost water-supply and sanitation technology choices;
(iii) Basing of choice of technology and service levels on user preferences and willingness to pay;
(iv) Mobilization and facilitation of the active involvement of women in water management teams;
(v) Encouragement and equipment of local water associations and water committees to manage community water-supply systems and communal latrines, with technical back-up available when required;
(vi) Consideration of the merits and practicality of rehabilitating existing malfunctioning systems and of correcting operation and maintenance inadequacies.

MEANS OF IMPLEMENTATION

A) FINANCING AND COST EVALUATION

18.60 The Conference secretariat has estimated the average total annual cost (1993-2000) of implementing the activities of this programme to be about $20 billion, including about $4.5 billion from the international community on grant or concessional terms. These are indicative and order-of-magnitude estimates only and have not been reviewed by Governments. Actual costs and financial terms, including any that are non-concessional, will depend upon, *inter alia*, the specific strategies and programmes Governments decide upon for implementation.

B) SCIENTIFIC AND TECHNOLOGICAL MEANS

18.61 The 1980s saw considerable progress in the development and application of low-cost water-supply and sanitation technologies. The programme envisages continuation of this work, with particular emphasis on development of appropriate sanitation and waste disposal technologies for low-income high-density urban settlements. There should also be international information exchange, to ensure a widespread recognition among sector professionals of the availability and benefits of appropriate low-cost technologies. The public-awareness campaigns will also include components to overcome user resistance to second-class services by emphasizing the benefits of reliability and sustainability.

C) HUMAN RESOURCE DEVELOPMENT

18.62 Implicit in virtually all elements of this programme is the need for progressive enhancement of the training and career development of personnel at all levels in sector institutions. Specific programme activities will involve the training and retention of staff with skills in community involvement, low-cost technology, financial management, and integrated planning of urban water resources management. Special provision should be made for mobilizing and facilitating the active participation of women, youth, indigenous people and local communities in water management teams and for supporting the development of water associations and water committees, with appropriate training of such personnel as treasurers, secretaries and caretakers. Special education and training programmes for women should be launched with regard to the protection of water resources and water quality within urban areas.

D) CAPACITY-BUILDING

18.63 In combination with human resource development, strengthening of institutional, legislative and management structures are key elements of the programme. A prerequisite for progress in enhancing access to water and sanitation services is the establishment of an institutional framework that ensures that the real needs and potential contributions of currently unserved populations are reflected in urban development planning. The multisectoral approach, which is a vital part of urban water resources management, requires institutional linkages at the national and city levels, and the programme includes proposals for establishing intersectoral planning groups. Proposals for greater pollution control and prevention depend for their success on the right combination of economic and regulatory mechanisms, backed by adequate monitoring and surveillance and supported by enhanced capacity to address environmental issues on the part of local Governments.

18.64 Establishment of appropriate design standards, water-quality objectives and discharge consents is therefore among the proposed activities. The programme also includes support for strengthening the capability of water and sewerage agencies and for developing their autonomy and financial viability. Operation and maintenance of existing water and sanitation facilities have been recognized as entailing a serious shortcoming in many countries. Technical and financial support are needed to help countries correct present inadequacies and build up the capacity to operate and maintain rehabilitated and new systems.

F) WATER FOR SUSTAINABLE FOOD PRODUCTION AND RURAL DEVELOPMENT

BASIS FOR ACTION

18.65 Sustainability of food production increasingly depends on sound and efficient water use and conservation practices consisting primarily of irrigation development and management, including water management with respect to rain-fed areas, livestock water-supply, inland fisheries and agro-forestry. Achieving food security is a high priority in many countries, and agriculture must not only provide food for rising populations, but also save water for other uses. The challenge is to develop and apply water-saving technology and management methods and, through capacity-building, enable communities to introduce institutions and incentives for the rural population to adopt new approaches, for both rain-fed and irrigated agriculture. The rural population must also have better access to a potable water-supply and to sanitation services. It is an immense task but not an impossible one, provided appropriate policies and programmes are adopted at all levels — local, national and international. While significant expansion of the area under rain-fed agriculture has been achieved during the past decade, the productivity response and sustainability of irrigation systems have been constrained by problems of waterlogging and salinization. Financial and market constraints are also a common problem. Soil erosion, mismanagement and overexploitation of natural resources and acute competition for water have all influenced the extent of poverty, hunger and famine in the developing countries. Soil erosion caused by overgrazing of livestock is also often responsible for the siltation of lakes. Most often, the development of irrigation schemes is supported neither by environmental impact assessments identifying hydrologic consequences within watersheds of interbasin transfers nor by the assessment of social impacts on peoples in river valleys.

18.66 The non-availability of water-supplies of suitable quality is a significant limiting factor to livestock production in many countries, and improper disposal of animal wastes can in certain circumstances result in pollution of water-supplies for both humans and animals. The drinking-water requirements of livestock vary according to species and the environment in which they are kept. It is estimated that the current global livestock drinking-water requirement is about 60 billion litres per day and, based on livestock population growth estimates, this daily requirement is predicted to increase by 0.4 billion litres per annum in the foreseeable future.

18.67 Freshwater fisheries in lakes and streams are an important source of food and protein. Fisheries of inland waters should be so managed as to maximize the yield of aquatic food organisms in an environmentally sound manner. This requires the conservation of water quality and quantity, as well as of the functional morphology of the aquatic environment. On the other hand, fishing and aquaculture may themselves damage the aquatic ecosystem; hence their development should conform to guidelines for impact limitation. Present levels of production from inland fisheries, from both fresh and brackish water, are about 7 million tons per year and could increase to 16 million tons per year by the year 2000; however, any increase in environmental stress could jeopardize this rise.

OBJECTIVES

18.68 The key strategic principles for holistic and integrated environmentally sound management of water resources in the rural context may be set forth as follows:

(a) Water should be regarded as a finite resource having an economic value with significant social and economic implications reflecting the importance of meeting basic needs;

(b) Local communities must participate in all phases of water management, ensuring the full involvement of women in view of their crucial role in the practical day-to-day supply, management and use of water;

(c) Water resource management must be developed within a comprehensive set of policies for (i) human health; (ii) food production, preservation and distribution; (iii) disaster mitigation plans; (iv) environmental protection and conservation of the natural resource base;

(d) It is necessary to recognize and actively support the role of rural populations, with particular emphasis on women.

18.69 An International Action Programme on Water and Sustainable Agricultural Development (IAP-WASAD) has been initiated by FAO in cooperation with other international organizations. The main objective of the Action Programme is to assist developing countries in planning, developing and managing water resources on an integrated basis to meet present and future needs for agricultural production, taking into account environmental considerations.

18.70 The Action Programme has developed a framework for sustainable water use in the agricultural sector and identified priority areas for action at national, regional and global levels. Quantitative targets for new irrigation development, improvement of existing irrigation schemes and reclamation of waterlogged and salinized lands through drainage for 130 developing countries are estimated on the basis of food requirements, agro-climatic zones and availability of water and land.

18.71 FAO global projections for irrigation, drainage and small-scale water programmes by the year 2000 for 130 developing countries are as follows: (a) 15.2 million hectares of new irrigation development; (b) 12 million hectares of improvement/modernization of existing schemes; (c) 7 million hectares installed with drainage and water control facilities; and (d) 10 million hectares of small-scale water programmes and conservation.

18.72 The development of new irrigation areas at the above-mentioned level may give rise to environmental concerns in so far as it implies the destruction of wetlands, water pollution, increased sedimentation and a reduction in biodiversity. Therefore, new irrigation schemes should be accompanied by an environmental impact assessment, depending upon the scale of the scheme, in case significant negative environmental impacts are expected. When considering proposals for new irrigation schemes, consideration should also be given to a more rational exploitation, and an increase in the efficiency or productivity, of any existing schemes capable of serving the same localities. Technologies for new irrigation schemes should be thoroughly evaluated, including their potential conflicts with other land uses. The active involvement of water-user groups is a supporting objective.

18.73 It should be ensured that rural communities of all countries, according to their capacities and available resources and taking advantage of international cooperation as appropriate, will have access to safe water in sufficient quantities and adequate sanitation to meet their health needs and maintain the essential qualities of their local environments.

18.74 The objectives with regard to water management for inland fisheries and aquaculture include conservation of water-quality and water-quantity requirements for optimum production and prevention of water pollution by aquacultural activities. The Action Programme seeks to assist member countries in managing the fisheries of inland waters through the promotion of sustainable management of capture fisheries as well as the development of environmentally sound approaches to intensification of aquaculture.

18.75 The objectives with regard to water management for livestock supply are twofold: provision of adequate amounts of drinking water and safeguarding of drinking-water quality in accordance with the specific needs of different animal species. This entails maximum salinity tolerance levels and the absence of pathogenic organisms. No global targets can be set owing to large regional and intra-country variations.

ACTIVITIES

18.76 All States, according to their capacity and available resources, and through bilateral or multilateral cooperation, including the United Nations and other relevant organizations as appropriate, could implement the following activities:

A) WATER-SUPPLY AND SANITATION FOR THE UNSERVED RURAL POOR:

(i) Establish national policies and budget priorities with regard to increasing service coverage;

(ii) Promote appropriate technologies;

(iii) Introduce suitable cost-recovery mechanisms, taking into account efficiency and equity through demand management mechanisms;

(iv) Promote community ownership and rights to water-supply and sanitation facilities;

(v) Establish monitoring and evaluation systems;

(vi) Strengthen the rural water-supply and sanitation sector with emphasis on institutional development, efficient management and an appropriate framework for financing of services;

(vii) Increase hygiene education and eliminate disease transmission foci;

(viii) Adopt appropriate technologies for water treatment;

(ix) Adopt wide-scale environmental management measures to control disease vectors;

B) WATER-USE EFFICIENCY:

(i) Increase of efficiency and productivity in agricultural water use for better utilization of limited water resources;

(ii) Strengthen water and soil management research under irrigation and rain-fed conditions;

(iii) Monitor and evaluate irrigation project performance to ensure, *inter alia*, the optimal utilization and proper maintenance of the project;

(iv) Support water-user groups with a view to improving management performance at the local level;

(v) Support the appropriate use of relatively brackish water for irrigation;

C) WATERLOGGING, SALINITY CONTROL AND DRAINAGE:

(i) Introduce surface drainage in rain-fed agriculture to prevent temporary waterlogging and flooding of lowlands;

(ii) Introduce artificial drainage in irrigated and rain-fed agriculture;

(iii) Encourage conjunctive use of surface and groundwater, including monitoring and water-balance studies;

(iv) Practise drainage in irrigated areas of arid and semi-arid regions;

D) WATER-QUALITY MANAGEMENT:

(i) Establish and operate cost-effective water-quality monitoring systems for agricultural water uses;

(ii) Prevent adverse effects of agricultural activities on water quality for other social and economic activities and on wetlands, *inter alia*, through optimal use of on-farm input and the minimization of the use of external input in agricultural activities;

(iii) Establish biological, physical and chemical water-quality criteria for agricultural water-users and for marine and riverine ecosystems;

(iv) Minimize soil run-off and sedimentation;

(v) Dispose properly of sewage from human settlements and of manure produced by intensive livestock breeding;

(vi) Minimize adverse effects from agricultural chemicals by use of integrated pest management;

(vii) Educate communities about the pollution-related impacts of the use of fertilizers and chemicals on water quality, food safety and human health;

E) WATER RESOURCES DEVELOPMENT PROGRAMMES:

(i) Develop small-scale irrigation and water-supply for humans and livestock and for water and soil conservation;

(ii) Formulate large-scale and long-term irrigation development programmes, taking into account their effects on the local level, the economy and the environment;

(iii) Promote local initiatives for the integrated development and management of water resources;

(iv) Provide adequate technical advice and support and enhancement of institutional collaboration at the local community level;

(v) Promote a farming approach for land and water management that takes account of the level of education, the capacity to mobilize local communities and the ecosystem requirements of arid and semi-arid regions;

(vi) Plan and develop multi-purpose hydroelectric power schemes, making sure that environmental concerns are duly taken into account;

F) SCARCE WATER RESOURCES MANAGEMENT:

(i) Develop long-term strategies and practical implementation programmes for agricultural water use under scarcity conditions with competing demands for water;

(ii) Recognize water as a social, economic and strategic good in irrigation planning and management;

(iii) Formulate specialized programmes focused on drought preparedness, with emphasis on food scarcity and environmental safeguards;

(iv) Promote and enhance waste-water reuse in agriculture;

G) WATER-SUPPLY FOR LIVESTOCK:

(i) Improve quality of water available to livestock, taking into account their tolerance limits;

(ii) Increase the quantity of water sources available to livestock, in particular those in extensive grazing systems, in order to both reduce the distance needed to travel for water and prevent overgrazing around water sources;

(iii) Prevent contamination of water sources with animal excrement in order to prevent the spread of diseases, in particular zoonosis;

(iv) Encourage multiple use of water-supplies through promotion of integrated agro-livestock-fishery systems;

(v) Encourage water-spreading schemes for increasing water retention of extensive grasslands to stimulate forage production and prevent run-off;

H) INLAND FISHERIES:

(i) Develop the sustainable management of fisheries as part of national water resources planning;
(ii) Study specific aspects of the hydrobiology and environmental requirements of key inland fish species in relation to varying water regimes;
(iii) Prevent or mitigate modification of aquatic environments by other users or rehabilitate environments subjected to such modification on behalf of the sustainable use and conservation of biological diversity of living aquatic resources;
(iv) Develop and disseminate environmentally sound water resources development and management methodologies for the intensification of fish yield from inland waters;
(v) Establish and maintain adequate systems for the collection and interpretation of data on water quality and quantity and channel morphology related to the state and management of living aquatic resources, including fisheries;

I) AQUACULTURE DEVELOPMENT:

(i) Develop environmentally sound aquaculture technologies that are compatible with local, regional and national water resources management plans and take into consideration social factors;
(ii) Introduce appropriate aquaculture techniques and related water development and management practices in countries not yet experienced in aquaculture;
(iii) Assess environmental impacts of aquaculture with specific reference to commercialized culture units and potential water pollution from processing centres;
(iv) Evaluate economic feasibility of aquaculture in relation to alternative use of water, taking into consideration the use of marginal-quality water and investment and operational requirements.

MEANS OF IMPLEMENTATION

A) FINANCING AND COST EVALUATION

18.77 The Conference secretariat has estimated the average total annual cost (1993-2000) of implementing the activities of this programme to be about $13.2 billion, including about $4.5 billion from the international community on grant or concessional terms. These are indicative and order-of-magnitude estimates only and have not been reviewed by Governments. Actual costs and financial terms, including any that are non-concessional, will depend upon, *inter alia*, the specific strategies and programmes Governments decide upon for implementation.

B) SCIENTIFIC AND TECHNOLOGICAL MEANS

18.78 There is an urgent need for countries to monitor water resources and water-quality, water and land use and crop production; compile inventories of type and extent of agricultural water development and of present and future contributions to sustainable agricultural development; evaluate the potential for fisheries and aquaculture development; and improve the availability and dissemination of data to planners, technicians, farmers and fishermen. Priority requirements for research are as follows:
(a) Identification of critical areas for water-related adaptive research;
(b) Strengthening of the adaptive research capacities of institutions in developing countries;
(c) Enhancement of translation of water-related farming and fishing systems research results into practical and accessible technologies and provision of the support needed for their rapid adoption at the field level.
18.79 Transfer of technology, both horizontal and vertical, needs to be strengthened. Mechanisms to provide credit, input supplies, markets, appropriate pricing and transportation must be developed jointly by countries and external support agencies. Integrated rural water-supply infrastructure, including facilities for water-related education and training and support services for agriculture, should be expanded for multiple uses and should assist in developing the rural economy.

C) HUMAN RESOURCE DEVELOPMENT

18.80 Education and training of human resources should be actively pursued at the national level through: (a) assessment of current and long-term human resources management and training needs; (b) establishment of a national policy for human resources development; and (c) initiation and implementation of training programmes for staff at all levels as well as for farmers. The necessary actions are as follows:
(a) Assess training needs for agricultural water management;
(b) Increase formal and informal training activities;
(c) Develop practical training courses for improving the ability of extension services to disseminate technologies and strengthen farmers' capabilities, with special reference to small-scale producers;

(d) Train staff at all levels, including farmers, fishermen and members of local communities, with particular reference to women;

(e) Increase the opportunities for career development to enhance the capabilities of administrators and officers at all levels involved in land- and water-management programmes.

D) CAPACITY-BUILDING

18.81 The importance of a functional and coherent institutional framework at the national level to promote water and sustainable agricultural development has generally been fully recognized at present. In addition, an adequate legal framework of rules and regulations should be in place to facilitate actions on agricultural water-use, drainage, water-quality management, small-scale water programmes and the functioning of water-users' and fishermen's associations. Legislation specific to the needs of the agricultural water sector should be consistent with, and stem from, general legislation for the management of water resources. Actions should be pursued in the following areas:

(a) Improvement of water-use policies related to agriculture, fisheries and rural development and of legal frameworks for implementing such policies;

(b) Review, strengthening and restructuring, if required, of existing institutions in order to enhance their capacities in water-related activities, while recognizing the need to manage water resources at the lowest appropriate level;

(c) Review and strengthening, where necessary, of organizational structure, functional relationships and linkages among ministries and departments within a given ministry;

(d) Provision of specific measures that require support for institutional strengthening, *inter alia*, through long-term programme budgeting, staff training, incentives, mobility, equipment and coordination mechanisms;

(e) Enhancement of involvement of the private sector, where appropriate, in human resource development and provision of infrastructure;

(f) Transfer of existing and new water-use technologies by creating mechanisms for cooperation and information exchange among national and regional institutions.

G) IMPACTS OF CLIMATE CHANGE ON WATER RESOURCES

BASIS FOR ACTION

18.82 There is uncertainty with respect to the prediction of climate change at the global level. Although the uncertainties increase greatly at the regional, national and local levels, it is at the national level that the most important decisions would need to be made. Higher temperatures and decreased precipitation would lead to decreased water supplies and increased water demands; they might cause deterioration in the quality of freshwater bodies, putting strains on the already fragile balance between supply and demand in many countries. Even where precipitation might increase, there is no guarantee that it would occur at the time of year when it could be used; in addition, there might be a likelihood of increased flooding. Any rise in sealevel will often cause the intrusion of salt water into estuaries, small islands and coastal aquifers and the flooding of low-lying coastal areas; this puts low-lying countries at great risk.

18.83 The Ministerial Declaration of the Second World Climate Conference states that "the potential impact of such climate change could pose an environmental threat of an up to now unknown magnitude ... and could even threaten survival in some small island States and in low-lying coastal, arid and semi-arid areas".[3] The Conference recognized that among the most important impacts of climate change were its effects on the hydrologic cycle and on water management systems and, through these, on socio-economic systems. Increase in incidence of extremes, such as floods and droughts, would cause increased frequency and severity of disasters. The Conference therefore called for a strengthening of the necessary research and monitoring programmes and the exchange of relevant data and information, these actions to be undertaken at the national, regional and international levels.

OBJECTIVES

18.84 The very nature of this topic calls first and foremost for more information about and greater understanding of the threat being faced. This topic may be translated into the following objectives, consistent with the United Nations Framework Convention on Climate Change:

(a) To understand and quantify the threat of the impact of climate change on freshwater resources;

(b) To facilitate the implementation of effective national countermeasures, as and when the threatening impact is seen as sufficiently confirmed to justify such action;

(c) To study the potential impacts of climate change on areas prone to droughts and floods.

ACTIVITIES

18.85 All States, according to their capacity and available resources, and through bilateral or multilateral cooperation, including the United Nations and other relevant organizations as appropriate, could implement the following activities:

(a) Monitor the hydrologic regime, including soil moisture, groundwater balance, penetration and transpiration of water quality, and related climate factors, especially in the regions and countries most likely to suffer from the adverse effects of climate change and where the localities vulnerable to these effects should therefore be defined;

(b) Develop and apply techniques and methodologies for assessing the potential adverse effects of climate change, through changes in temperature, precipitation and sealevel rise, on freshwater resources and the flood risk;

(c) Initiate case-studies to establish whether there are linkages between climate changes and the current occurrences of droughts and floods in certain regions;

(d) Assess the resulting social, economic and environmental impacts;

(e) Develop and initiate response strategies to counter the adverse effects that are identified, including changing groundwater levels, and to mitigate saline intrusion into aquifers;

(f) Develop agricultural activities based on brackish-water use;

(g) Contribute to the research activities under way within the framework of current international programmes.

MEANS OF IMPLEMENTATION

A) FINANCING AND COST EVALUATION

18.86 The Conference secretariat has estimated the average total annual cost (1993-2000) of implementing the activities of this programme to be about $100 million, including about $40 million from the international community on grant or concessional terms. These are indicative and order-of-magnitude estimates only and have not been reviewed by Governments. Actual costs and financial terms, including any that are non-concessional, will depend upon, *inter alia*, the specific strategies and programmes Governments decide upon for implementation.

B) SCIENTIFIC AND TECHNOLOGICAL MEANS

18.87 Monitoring of climate change and its impact on freshwater bodies must be closely integrated with national and international programmes for monitoring the environment, in particular those concerned with the atmosphere, as discussed under other sections of Agenda 21, and the hydrosphere, as discussed under programme area B above. The analysis of data for indication of climate change as a basis for developing remedial measures is a complex task. Extensive research is necessary in this area and due account has to be taken of the work of the Intergovernmental Panel on Climate Change (IPCC), the World Climate Programme, the International Geosphere-Biosphere Programme (IGBP) and other relevant international programmes.

18.88 The development and implementation of response strategies requires innovative use of technological means and engineering solutions, including the installation of flood and drought warning systems and the construction of new water resource development projects such as dams, aqueducts, well fields, waste-water treatment plants, desalination works, levees, banks and drainage channels. There is also a need for coordinated research networks such as the International Geosphere-Biosphere Programme/Global Change System for Analysis, Research and Training (IGBP/START) network.

C) HUMAN RESOURCE DEVELOPMENT

18.89 The developmental work and innovation depend for their success on good academic training and staff motivation. International projects can help by enumerating alternatives, but each country needs to establish and implement the necessary policies and to develop its own expertise in the scientific and engineering challenges to be faced, as well as a body of dedicated individuals who are able to interpret the complex issues concerned for those required to make policy decisions. Such specialized personnel need to be trained, hired and retained in service, so that they may serve their countries in these tasks.

D) CAPACITY-BUILDING

18.90 There is a need, however, to build a capacity at the national level to develop, review and implement response strategies. Construction of major engineering works and installation of forecasting systems will require significant strengthening of the agencies responsible, whether in the public or the private sector. Most critical is the requirement for a socio-economic mechanism that can review predictions of the impact of climate change and possible response strategies and make the necessary judgements and decisions.

[1] Report of the United Nations Water Conference, Mar del Plata, 14-25 March 1977 (United Nations publication, Sales No. E.77.II.A.12), part one, chapter I, section C, paragraph 35.

[2] Ibid., part one, chapter I, resolution II.

[3] A/45/696/Add.1, annex III, preamble, paragraph 2.

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THE STATE OF FOOD AND AGRICULTURE

PART III
WATER POLICIES AND AGRICULTURE

Food and Agriculture Organization of the United Nations

BOX 7

GLOSSARY: WATER TERMS

Aquifer
An underground stratum that is saturated with water and transmits water readily.

Command and control
A system of water supply or quality management based on administrative allocations (in contrast to incentive or price-based allocations).

Cost recovery
Fee structures to cover the cost of providing a service.

Demand management
The use of economic, legal, institutional and other policy interventions to influence the demand for water.

Drip irrigation
Localized drop-by-drop application of water that uses pipes, tubes, filters, emitters and ancillary devices to deliver water to specific sites at a point or grid on the soil surface.

Ecosystem
A complex system formed by the interaction of a community of organisms with its environment.

Externality
The uncompensated, unintended side-effects of one party's actions on another party.

Gravity irrigation
A system that depends on sloping canals and fields for the transportation of water to the irrigated site.

Groundwater table
The level of water storage (above mean sea level) in an aquifer; hence, the point at which the soil is fully saturated with water.

Irrigated area
i) Gross irrigated area. The area of land irrigated in a year (land having two irrigation seasons is counted twice).
ii) Net irrigated area. The area of land surface that receives irrigation water in a year (two irrigation seasons are counted as one).

Irrigation
Human intervention to modify the distribution of water in natural channels, depressions, drainageways or aquifers and to manipulate this water for improving the production of agricultural crops or enhancing the growth of other desirable plants.

Riparian state
A state through or along which a portion of a river flows or in which a lake lies.

River basin
A geographical area determined by the watershed limits of a system of waters, including surface and underground waters, flowing into a common terminus.

Seepage
The infiltration of water downwards or laterally into soil or substrata from a source of supply such as a reservoir, irrigation canal or channel.

Sewage
Liquid refuse or waste matter carried off by surface water via sewers.

Sewerage
The removal and disposal of sewage and surface water by sewer systems.

Sustainable development
The management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for the present and future generations. Such sustainable development (in the agricultural, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources and is

environmentally non-degrading, technically appropriate, economically viable and socially acceptable.

Tube wells
Wells consisting of perforated tubes or pipes placed in holes bored into the ground to tap groundwater supplies from one or more aquifers.

Underflow
The underground flow or movement of water in an aquifer.

Underground transmission
Water distribution by means of underflows within an aquifer system.

Water quality
This is defined by the level of dissolved salts and/or other contaminants. Acceptability may vary with the intended use, i.e. drinking-water requires higher-quality water than irrigation.

Waterlogging and salinization
Unproductive soil conditions that occur when the water table is very near the surface. Waterlogging is caused by overwatering and a lack of proper drainage. Salinity is caused by a combination of poor drainage and high evaporation rates that concentrate salts on irrigated land.

Watershed
An area drained by a river or stream system.

Watershed management
A process of formulating and implementing a course of action that involves natural and human resources, taking into account social, political, economic, environmental and institutional factors that operate within the watershed, the surrounding river basin and other relevant regions, to achieve desired social objectives.

Wetlands
Areas of marsh, fen, peat land or water that include natural, artificial, permanent or temporary areas with either static or flowing fresh, brackish or marine water.

WATER POLICIES AND AGRICULTURE

I. Water resource issues and agriculture

INTRODUCTION AND OVERVIEW

An interesting observation arising from the preparation of this year's special chapter on water and agriculture is how difficult it is to generalize about water. Almost any statement requires qualification. For example, while we can say that water is one of the most abundant resources on earth, we know that less than 1 percent of the total supply is reliably available for human consumption. Water is a liquid for the most part, but it can also be a solid and a vapour. Drinking-water is certainly essential for human survival but water-related illnesses are the most common health threat in the developing world. An estimated 25 000 people die every day as a result of water-related sicknesses.[1]

One statement, however, needs no qualification: human existence depends on water. The geosphere, the atmosphere and the biosphere are all linked to water. Water interacts with solar energy to determine climate and it transforms and transports the physical and chemical substances necessary for all life on earth.

In recent years, water issues have been the focus of increasing international concern and debate. From 26 to 31 January 1992, the UN system sponsored the International

[1] UNEP. 1991. *Freshwater pollution*. UNEP/GEMS Environmental Library. No. 6. Nairobi.

Conference on Water and the Environment (ICWE) in Dublin, Ireland. The ICWE called for innovative approaches to the assessment, development and management of freshwater resources. In addition, the ICWE provided policy guidance for the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in June 1992. UNCED highlighted the need for water sector reforms throughout the world.

In 1993, the World Bank issued a comprehensive policy paper defining its new objectives for the water sector. FAO recently established an International Action Programme on Water and Sustainable Agricultural Development (IAP-WASAD). Likewise, the UNDP, WHO, UNICEF, WMO, Unesco and UNEP are all coordinating or participating in special programmes related to water resources.

Other international, national and local organizations are becoming more active in water issues. The 1990 Montreal meeting, "NGOs Working Together", focused attention on drinking-water supply and sanitation. The Canadian International Development Agency, the French Ministry of Cooperation and Development, the German Agency for Technical Cooperation (GTZ), the United Kingdom's Overseas Development Administration and the United States Agency for International Development (USAID) have recently developed water resource strategies for foreign assistance.

The message highlighted by all these efforts is that water is an increasingly scarce and valuable resource. Of principal concern is our failure to recognize and accept that there is a finite supply of water. The consensus is that the growing water scarcity and misuse of freshwater pose serious threats to sustainable development.

Competition among agriculture, industry and cities for limited water supplies is already constraining development efforts in many countries. As populations expand and economies grow, the competition for limited supplies will intensify and so will conflicts among water users.

Despite water shortages, misuse of water is widespread. Small communities and large cities, farmers and industries, developing countries and industrialized economies are all mismanaging water resources. Surface water quality is deteriorating in key basins from urban and industrial wastes.

Groundwater is polluted from surface sources and irreversibly damaged by the intrusion of salt water. Overexploited aquifers are losing their capacity to hold water and lands are subsiding. Cities are unable to provide adequate drinking-water and sanitation facilities. Waterlogging and salinization are diminishing the productivity of irrigated lands. Decreasing water flows are reducing hydroelectric power generation, pollution assimilation and fish and wildlife habitats.

At first glance, most of these water problems do not appear to be directly related to the agricultural sector. Yet, by far the largest demand for the world's water comes from agriculture. More than two-thirds of the water withdrawn from the earth's rivers, lakes and aquifers is used for irrigation. As competition, conflicts, shortages, waste, overuse and degradation of water resources grow, policy-makers look increasingly to agriculture as the system's safety valve.

Agriculture is not only the world's largest water user in terms of volume, it is also a relatively low-value, low-efficiency and highly subsidized water user. These facts are forcing governments and donors to rethink the economic, social and environmental implications of large publicly funded and operated irrigation projects. In the past, domestic spending for irrigation dominated agricultural budgets in countries throughout the world. For instance, since 1940, 80 percent of Mexico's public expenditures in agriculture have been for irrigation projects. In China, Indonesia and Pakistan, irrigation has absorbed more than half of agricultural investment. In India, about 30 percent of all public investment has gone into irrigation.[2]

A significant portion of international development assistance has also been used to establish irrigation systems. Irrigation received nearly 30 percent of World Bank agricultural lending during the 1980s. Spending commitments for irrigation by all aid agencies exceeded $2 billion per year in the past decade.

Once established, irrigation projects become some of the most heavily subsidized economic activities in the world. In the mid-1980s, Repetto [3] estimated that average subsidies to irrigation in six Asian countries covered 90 percent of the total operating and maintenance costs. Case-studies indicate that irrigation fees are, on average, less than 8 percent of the value of benefits derived from irrigation.

Despite these huge investments and subsidies, irrigation performance indicators are falling short of expectations for yield increases, area irrigated and technical efficiency in water use. As much as 60 percent of the water diverted or pumped for irrigation is wasted.[4] Although some losses are inevitable, in too many cases this excess water seeps back into the ground, causing waterlogging and salinity. As much as one-quarter of all irrigated land in developing countries suffers from varying degrees of salinization.[5] Moreover, stagnant water and poor irrigation drainage escalate the incidence of water-related diseases, resulting in human suffering and increased health costs.

Today, agriculture is often unable to compete economically for scarce water. Cities and industries can afford to pay more for water and earn a higher economic rate of return from a unit of water than does agriculture. (For economists, water flows uphill to money.) For the first time in many countries, agriculture is being obliged to give up water for higher-value uses in cities and industries. Irrigators in some areas are now asked to pay for the water they receive, including the full cost of water delivery. In other

[2] R. Bhatia and M. Falkenmark. 1992. *Water resource policies and the urban poor: innovative approaches and policy imperatives.* Background paper for the ICWE, Dublin, Ireland.

[3] R. Repetto. 1986. *Skimming the water: rent-seeking and the performance of public irrigation systems.* Research Report No. 4. Washington, DC, WRI.

[4] FAO. 1990. *An International Action Programme on Water and Sustainable Agricultural Development.* Rome.

[5] Ibid.

areas, new regulations require farmers to pay for polluting streams, lakes and aquifers.

The irony is that irrigated agriculture is expected to produce much more in the future while using less water than it uses today. At present, 2.4 billion people depend on irrigated agriculture for jobs, food and income (some 55 percent of all wheat and rice output is irrigated). Over the next 30 years, an estimated 80 percent of the additional food supplies required to feed the world will depend on irrigation.[6]

These developments are placing enormous pressure on agricultural policy-makers and farmers. Throughout the world, governments assume the prime responsibility for ensuring food security and, because food depends increasingly on irrigation, food security is closely linked with water security. Between 30 and 40 percent of the world's food comes from the irrigated 16 percent of the total cultivated land; around one-fifth of the total value of fish production comes from freshwater aquaculture; and current global livestock drinking-water requirements are 60 billion litres per day (forecasts estimate an increase of 0.4 billion litres per year). Food security in the next century will be closely allied to success in irrigation.

Irrigation can help make yield-increasing innovations a more attractive investment proposition but it does not guarantee crop yield increases. The overall performance of many irrigation projects has been disappointing because of poor scheme conception, inadequate construction and implementation or ineffective management. The mediocre performance of the irrigation sector is also contributing to many socio-economic and environmental problems, but these problems are neither inherent in the technology nor inevitable, as is sometimes argued.

Irrigation projects can contribute greatly to increased incomes and agricultural production compared with rain-fed agriculture. In addition, irrigation is more reliable and allows for a wider and more diversified choice of cropping patterns as well as the production of higher-value crops. Irrigation's contribution to food security in China, Egypt, India, Morocco and Pakistan is widely recognized. For example, in India, 55 percent of agricultural output is from irrigated land. Moreover, average farm incomes have increased from 80 to 100 percent as a result of irrigation, while yields have doubled compared with those achieved under the former rain-fed conditions; incremental labour days used per hectare have increased by 50 to 100 percent. In Mexico, half the value of agriculture production and two-thirds of the value of agricultural exports is from the one-third of arable land that is irrigated.

Irrigation is a key component of the technical package needed to achieve productivity gains. In the future, as high levels of costly inputs are added to cropland to sustain yield increases, the security and efficiency of irrigated production will become even more important to world farming. Water will no longer be plentiful and cheap. It will be scarce, expensive to develop

[6] International Irrigation Management Institute. 1992. *Developing environmentally sound and lasting improvements in irrigation management: the role of international research.* Colombo, Sri Lanka, IIMI.

and maintain and valuable in use. The prospect of high-cost water may at first seem to be another problem looming for low-income economies. However, the high cost will be an incentive to use water more efficiently. The single most important factor limiting the adoption of proven irrigation and drainage technology is the low cost of water. Moreover, if farmers have opportunities for higher-value uses and can make profits, both governments and farmers will invest in irrigation.

This water dilemma – to produce more in a sustainable way with less water – points to the need for demand management mechanisms to reallocate existing supplies, encourage more efficient use and promote more equitable access. Policy-makers need to establish a structure of incentives, regulations, permits, restrictions and penalties that will help guide, influence and coordinate how people use water while encouraging innovations in water-saving technologies.

In the past, supply-side approaches dominated water resource management practices. Water itself was physically managed through technical and engineering means that captured, stored, delivered and treated water. However, the era of meeting growing demand by developing new supplies is ending. In our present-day water economy, resource management is shifting away from the goal of capturing more water towards that of designing demand- and user-focused approaches that influence behaviour.

PURPOSE AND SCOPE

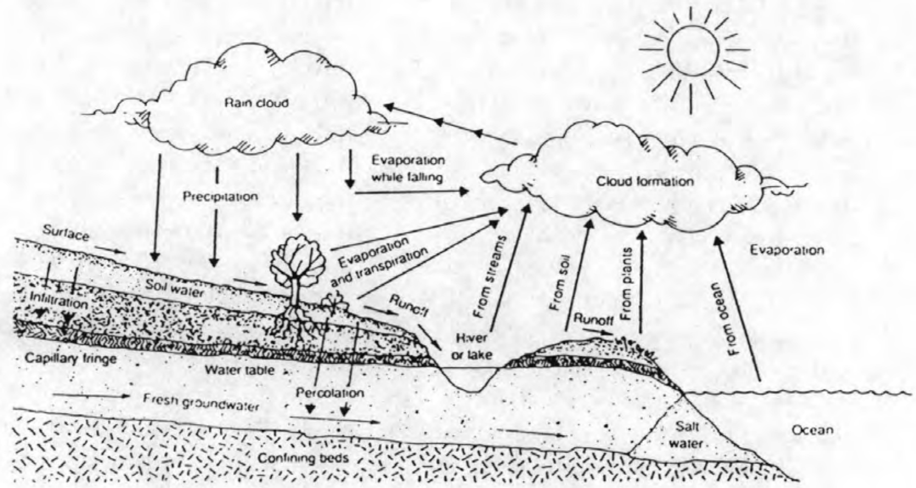
This special chapter is primarily intended for agricultural policy-makers, water managers, researchers, students, development planners and agricultural project donors. It is meant to help us reflect on the way water resources are managed at present; to contribute to the discussion on sustainable water use; and to stimulate thinking, research and change. Decisions made in this decade regarding how water is used will have a profound effect on our future supplies.

This first section gives an overview of world water resources and briefly discusses the key issues: scarcity, quality and health.

The second section stresses the need to integrate the water sector with the national economy and analyses the physical, economic and social aspects of water. It then provides a conceptual foundation for understanding the circumstances under which water policies either work or fail. Section II also assesses the advantages and disadvantages of broad alternative approaches to public water policy.

Section III examines how policy analysis is applied to water resource planning, including both supply-side (physical and hydrological) and demand-side considerations. It discusses the advantages and disadvantages of various policy options for urgent water policy issues related to surface water and groundwater.

The fourth and final section reviews three specific policy issues in irrigated agriculture: declining growth and investment trends; the difficulties imposed by irrigation-induced environmental degradation; and efforts to reform managerial and administrative systems.



BOX 8

THE HYDROLOGICAL CYCLE

Water continuously circulates on the planet. The hydrological cycle has no beginning or end but we can describe it as starting with the waters of the oceans, which cover about three-quarters of the earth. Radiation from the sun and wind energy, which is itself indirectly derived from solar energy, cause evaporation of water which rises as a vapour and forms clouds. In turn, if conditions are right, these condense and fall back to earth as rain, hail or snow.

Some of this precipitation evaporates from leaves and soil, some runs over the surface and forms streams and some percolates into the soil where it may be drawn on by plants and transpired back into the atmosphere or returned to the surface by soil capillarity. Some soil moisture evaporates and some soaks down below the root zone to join the groundwater reservoir. Groundwater percolates through pores in the soil and rocks and may reappear on the surface at lower elevations as a spring or as seepage into streams and rivers which eventually re-enter the ocean. Still some lies in the groundwater reservoir or aquifer and may be tapped by a mechanical tube well or an open well.

The hydrological cycle illustrated in the Figure is the system by which water circulates from the oceans through the atmosphere and back to the ocean overland and underground. Available freshwater is a rare form of water, for 99 percent is either saline (97 percent of all water is in the ocean) or frozen (2 percent in the ice caps and glaciers). Most of the remainder (1 percent) is groundwater with minute proportions in freshwater lakes, soil moisture, rivers and biological systems.

WORLD WATER RESOURCES

Every day the hydrological cycle renews the world's freshwater resources through evaporation and precipitation (see Box 8). The average annual rainfall over land is 110 000 km^3, but some 70 000 km^3 evaporate before reaching the sea. The remaining 40 000 km^3 are potentially available for human use. Global freshwater consumption is currently around 4 000 km^3, only 10 percent of the annual renewable supply.

These numbers suggest that plenty of water is available for human use but a closer look reveals a more complicated situation. The 40 000 km^3 of available water are distributed very unevenly and two-thirds of it runs off in floods. That leaves around 14 000 km^3 as a relatively stable supply. A substantial share of this supply should be left to follow its natural course in order to safeguard wetlands, deltas, lakes and rivers.[7] For example, 6 000 km^3 of water is needed to dilute and transport the estimated 450 km^3 of waste water now entering the world's rivers each year.[8] Without substantial investment in waste water treatment and more effective regulation, even more water will have to be diverted to dilute and transport wastes.

Precipitation, withdrawals and availability of water vary widely around the world. Table 6 demonstrates regional changes in per caput water availability since 1950 and shows forecasts for 2000. Per caput availability is highest in Latin America and lowest in North Africa and the Near East, while withdrawals are highest in North America and lowest in Africa. Per caput water availability in Europe and North America is not expected to change greatly by 2000, while Asians, Africans and Latin Americans will face less per caput water availability as their populations continue to grow.

At present, Asia accounts for over one-half of the world's water withdrawals. Figure 11 illustrates regional water consumption during the past century. Forecasts to the year 2000 suggest that Asia will consume 60 percent of the world's water, followed by 15 percent in North America, 13 percent in Europe and less than 7 percent in Africa. Latin America's share of world water consumption is forecast to be less than 5 percent in 2000, although the region's consumption has nearly quadrupled since 1950.

Water scarcity

Human actions bring about water scarcity in three ways: through population growth, misuse and inequitable access.[9] Population growth contributes to scarcity simply because the available water supply must be divided among more and more people. Every country has a more or less fixed amount of internal water resources, defined as the average annual flow of rivers and aquifers generated from precipitation. Over time, this internal renewable supply must be divided among more and more people, eventually resulting in water scarcity.

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[7] S. Postel. 1992. *Last oasis: facing water scarcity.* New York, Norton.

[8] See footnote 1, p. 230.

[9] T.F. Homer-Dixon, J.H. Boutwell and G.W. Rathjens. 1993. Environmental change and violent conflict. *Sci. Am.* (February).

TABLE 6

Per caput water availability by region, 1950-2000

Region	1950	1960	1970	1980	2000
	(..........	....	'000 m^3..........	....	..........)
Africa	20.6	16.5	12.7	9.4	5.1
Asia	9.6	7.9	6.1	5.1	3.3
Latin America	105.0	80.2	61.7	48.8	28.3
Europe	5.9	5.4	4.9	4.4	4.1
North America	37.2	30.2	25.2	21.3	17.5

Source: N.B. Ayibotele. 1992. *The world's water: assessing the resource.* Keynote paper at the ICWE, Dublin, Ireland.

When annual internal renewable water resources are less than 1 000 m^3 per caput, water availability is considered a severe constraint on socio-economic development and environmental protection. Table 7 lists the countries where per caput internal renewable water availability will fall below 1 000 m^3 by the end of this decade. Most countries facing chronic water scarcity problems are in North Africa, the Near East and sub-Saharan Africa. Countries with less than 2 000 m^3 per caput face a serious marginal water scarcity situation, with major problems occurring in drought years. By the end of the 1990s, water availability is expected to fall below 2 000 m^3 per caput in more than 40 countries.

In many countries, while scarcity is less of a problem at a national level, serious water shortages are causing difficulties in specific regions and watersheds. Notable examples include northern China, western and southern India and parts of Mexico.

People also bring about water scarcity by polluting and overusing existing supplies. Box 9 describes some of the pressing water pollution issues. This type of scarcity can be regarded as the consumption of the resource's "capital". For instance, an aquifer represents resource capital, providing what is generally a renewable source of water "income" that can be tapped for human consumption. Sustainable use of the aquifer leaves the capital intact so that future generations can continuously use the renewable portion or income. If pumping is greater than recharge, the aquifer is depleted and the capital is consumed.

Overuse of groundwater has become a major problem in China, India, Indonesia, Mexico, the Near East, North Africa, Thailand, the western United States and many island countries where seawater intrusion results.

The overpumping of aquifers not only results in a water source that is too depleted to serve as a supply, it may also cause the land above the aquifer to settle or subside, resulting in widespread structural damage in extreme cases. Bangkok and Mexico City are well-known examples.

Finally, a shift in access or distribution patterns may concentrate

TABLE 7

Countries predicted to have scarce water resources in 2000

Country[1]	Population in 2000	Water availability: Internal renewable water resources	Water availability: Water resources including river flows from other countries
	(millions)	*(.... m³ per caput ....)*	
Egypt	**62.4**	**29**	**934**
Saudi Arabia	**21.3**	**103**	**103**
Libyan Arab Jamahiriya	**6.5**	**108**	**108**
United Arab Emirates	**2.0**	**152**	**152**
Jordan	**4.6**	**153**	**240**
Mauritania	**2.6**	**154**	**2 843**
Yemen	**16.2**	**155**	**155**
Israel	**6.4**	**260**	**335**
Tunisia	**9.8**	**384**	**445**
Syrian Arab Republic	**17.7**	**430**	**2 008**
Kenya	**34.0**	**436**	**436**
Burundi	**7.4**	**487**	**487**
Algeria	**33.1**	**570**	**576**
Hungary	**10.1**	**591**	**11 326**
Rwanda	**10.4**	**604**	**604**
Botswana	**1.6**	**622**	**11 187**
Malawi	**11.8**	**760**	**760**
Oman	**2.3**	**880**	**880**
Sudan	**33.1**	**905**	**3 923**
Morocco	**31.8**	**943**	**943**
Somalia	**10.6**	**1 086**	**1 086**

[1] A number of other countries with smaller populations, e.g. Barbados, Cape Verde, Djibouti, Malta, Qatar and Singapore, are also included in the water-scarce category.
Source: FAO calculations based on World Bank/WRI data.

TABLE 8

Ratio of prices charged by vendors to prices charged by public utilities in selected cities

Country	City	Ratio
Bangladesh	Dacca	12-25
Colombia	Cali	10
Côte d'Ivoire	Abidjan	5
Ecuador	Guayaquil	20
Haiti	Port-au-Prince	17-100
Honduras	Tegucigalpa	16-34
Indonesia	Jakarta	4-60
	Surabaja	20-60
Kenya	Nairobi	7-11
Mauritania	Nouakchott	100
Nigeria	Lagos	4-10
	Onitsha	6-38
Pakistan	Karachi	28-83
Peru	Lima	17
Togo	Lomé	7-10
Turkey	Istanbul	10
Uganda	Kampala	4-9

Source: R. Bhatia and M. Falkenmark. 1992. *Water resource policies and the urban poor: innovative approaches and policy imperatives.* Background paper for the ICWE, Dublin, Ireland.

water resources among one group and subject others to extreme scarcity. In many cities of the developing world, large numbers of people depend on water vendors and may pay 100 times as much as the rate of public utilities (see Table 8). Numerous recent studies document that large numbers of urban poor pay much higher prices and a much larger share of their income for water than families with access to a city water system.[10] Poor families in some large cities spend up to 20 percent of their income on water. When the cost is so high, they use little water for washing and bathing, which results in serious health problems.

[10] See footnote 2, p. 232.

Figure 11

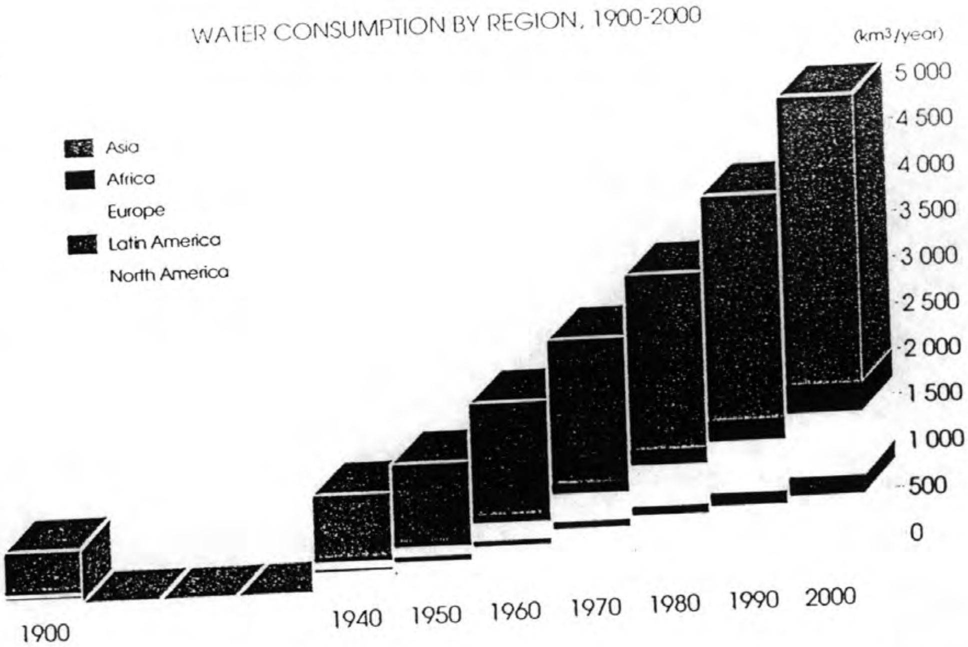
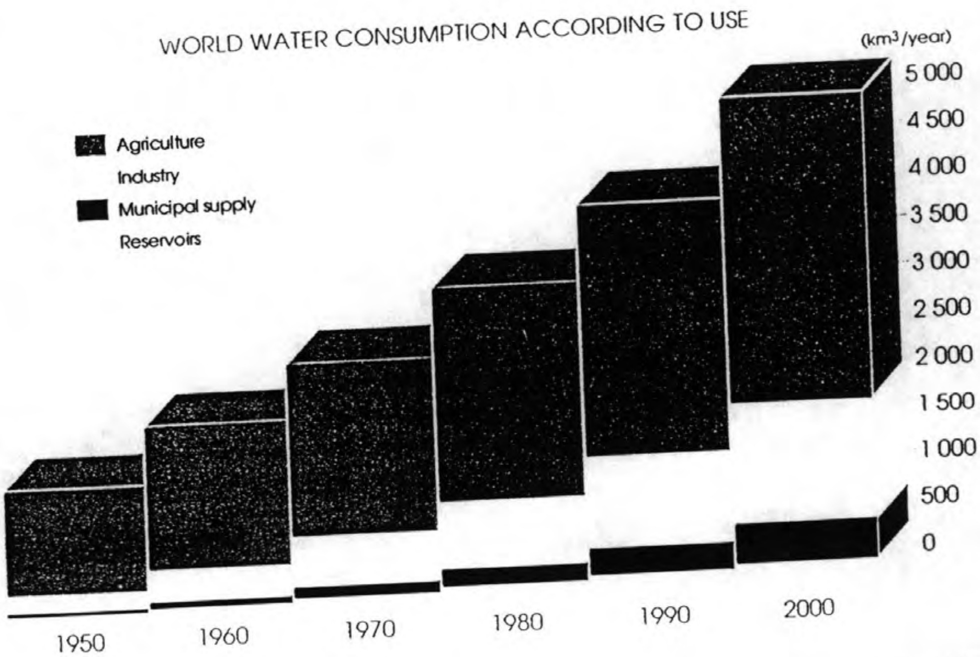


Figure 12



Source: I.A. Shiklomanov. 1990. Global water resources. *Nat. Resour.*, 26: 34-43

Note: Consumption by reservoirs is through evaporation

World water use

The early civilizations of Asia, Africa and Latin America organized cooperative efforts to develop river valleys for irrigated agriculture. Through irrigation technology, societies controlled and manipulated natural water supplies to improve crop production. The result was often reliable and ample food supplies which led to the creation of stable agricultural villages, the division of labour and economic surpluses.

Many scholars still argue over whether irrigation technology facilitated political control and development of the state or whether political developments led to advancement of the technology. No matter the direction of cause and effect, no one disputes the association of development with control over water use.

In today's world, agriculture still accounts for the majority of human water use. Globally, around 70 percent of water withdrawals are for agriculture. Domestic and industrial uses consume the remaining 30 percent.[11]

Water uses differ greatly depending on access, quantity, quality and socio-economic conditions. For example, Table 9 illustrates that agricultural water use is higher as a proportion of total water use in the low-income countries (91 percent) than in the high-income group (39 percent). Nevertheless, on a per caput basis, the high-income countries use more water

TABLE 9

Sectoral water withdrawals, by income group

Country income group	Annual withdrawals per caput	Withdrawals by sector		
		Agric.	Ind.	Dom.
	(... m^3...)	(..............	%..............	)
Low-income	386	91	5	4
Middle-income	453	69	18	13
High-income	1 167	39	47	14

Source: World Bank. 1992. *World Development Report 1992*, based on WRI data.

for agricultural purposes than the low-income countries.

The trends in world water use during this century are presented in Figure 12. Overall, global water consumption has increased almost tenfold. Agriculture's share, which was 90 percent in 1900, will have dropped to an estimated 62 percent by 2000. During this same period, industrial consumption will have grown from 6 percent to 25 percent, while consumption by cities will have increased from 2 percent to nearly 9 percent. By 2000, around 35 percent of available water supplies will be in use, compared with less than 5 percent at the beginning of the century.

Water quantity and quality requirements also differ widely depending on the type of use. Net agricultural requirements are especially large in relation to other uses. For instance, around 15 000 m^3 of water are normally sufficient to irrigate 1 ha of rice. This same amount of water can supply: 100 nomads and 450 head of stock for three years; or 100 rural families through house connections for four years; or 100 urban families for

[11] Domestic uses include drinking-water supplies, private homes, commercial establishments, public services and municipal supplies.

BOX 9
WATER AND POLLUTION

The quality of water from different sources varies widely. Precipitation absorbs gases from the atmosphere and removes particles from the air. When the precipitation strikes the ground it becomes surface water runoff or enters the ground. The surface water flows into larger and larger channels, ponds, lakes and rivers until some of it reaches the sea. Along its course, surface water picks up both organic and mineral particles, bacteria and other organisms as well as salts and other soluble substances. The water in lakes and swamps sometimes acquires odours, tastes and colours from algae and other organisms and from decaying vegetation.

Since ancient times, heavy metals from mining and pathogens from cities have caused serious, although localized, contamination. Since the industrial revolution, water pollution problems have become first regional, then continental and now global in nature. Much water is polluted when it is used in industry and agriculture or for domestic purposes. Mining is the major cause of metal contamination, whereas other industries contribute to acidification. The intensification of agricultural activities has led to the contamination of groundwater by fertilizers and other chemicals. Moreover, irrigation projects often cause a rapid rise in the level of groundwater, which leads to waterlogging and soil salinity.

Since 1977, the UNEP/WHO Global Environment Monitoring System (GEMS) has been working with Unesco and WMO to develop a global water quality monitoring network. More than 50 water variables are monitored to provide information on the suitability of water for human consumption and for agricultural, commercial and industrial use. Recent assessments have found that the main water pollutants are: sewage, nutrients, toxic metals and industrial as well as agricultural chemicals.

Conclusions drawn from the GEMS assessment include: the nature and level of freshwater pollution strongly depends on socio-economic development; the most common water pollutant is organic material from domestic sewage, municipal waste and agro-industrial effluent; and the high water nitrate levels found in Western Europe and the United States are a result of the nitrogen fertilizers and manure used for intensive agriculture. The GEMS assessment also noted a dramatic increase in the use of fertilizers in developing countries, particularly where intensive

irrigation allows for double or triple cropping.

Other conditions highlighted in the GEMS report include deforestation, eutrophication, suspended particulate matter (SM) and salinity.

Deforestation, i.e. the clearing of land for agriculture and urban development, often leads to water contamination. When the soil is stripped of its protective vegetative covering, it becomes prone to erosion. This in turn leads to higher water turbidity, because of the increased amounts of suspended matter, to nutrient leaching and to a decreased water-retention capacity of the soil. There is also concern about the destruction of wetlands, which destroys the habitat of many species and removes natural filter mechanisms, permitting many common pollutants to reach water supplies.

Eutrophication is the enrichment of waters with nutrients, especially phosphorus and nitrogen. It can lead to enhanced plant growth and depleted oxygen levels as this plant material decays. It is not always a human-induced problem, but is often linked to organic waste and agricultural runoff. Today 30 to 40 percent of the world's lakes and reservoirs are eutrophic. Not all interventions have proved successful, but eutrophication can be reversible if mid- and long-term strategies are enacted. Laws and measures introduced to reduce tripolyphosphates (used mostly in detergents) and to remove phosphorus from waste water have had positive effects.

SM consists of materials that float in suspension in water. There are three main sources of SM: natural soil erosion, matter formed organically within a water body and material produced as a by-product of human activity. SM settles on the sediment bed and forms deposits in rivers, lakes, deltas and estuaries. Evidence of human-induced SM from Roman and Mayan times has been discovered in lake beds, implying that this was one of the first types of water pollution. River damming affects the amount of SM flowing from rivers to the oceans because reservoirs act as effective sinks for SM. An estimated 10 percent of the global SM discharge to the sea is trapped in reservoirs. Approximately 25 percent of the water currently flowing to the oceans has been previously stored in a reservoir. Damming can also greatly modify water quality; waters flowing out of reservoirs not only have reduced SM quantities, they are also depleted of nutrients and are often more saline, which consequently has detrimental effects on downstream agriculture and fisheries.

Salinity is a significant and widespread form of freshwater pollution, particularly in arid, semi-arid and some coastal regions. The primary cause of salinization is a combination of poor drainage and high evaporation rates which concentrate salts on irrigated land. Salinity can adversely affect the productivity of irrigated crops and is also detrimental to industrial and household water users. It is not a new phenomenon; salinization of soil and water in the flood plain of the Tigris and Euphrates Rivers contributed to the decline of the Mesopotamian civilization some 6 000 years ago. The estimated global gross area of irrigated land is 270 million ha. About 20 to 30 million ha are severely affected by salinity while an additional 60 to 80 million ha are affected to some degree. Waterlogged soil, which aggravates the problem of salinity, is usually caused by overwatering and a lack of proper drainage systems. Runoff from agricultural areas fertilized with manure and chemicals pollutes watercourses and groundwater by increasing levels of nutrients.

The present level of water pollution warrants that steps be taken to control further contamination of water resources. More serious action needs to be taken in water resource management, waste water treatment and the provision of safe public water supplies. In developed and developing countries there should be controls and regulations regarding the treatment and recycling of industrial effluents, while efforts must be made to replace harmful products and ban dangerous pesticides.

There is compelling evidence that at least 20 to 30 percent of the water currently used in households and industries can be saved by adopting appropriate regulatory and policy instruments (tariffs, quotas, groundwater extraction charges). The twin benefits of clean water and reduced demand can be obtained if the recycling or reuse of water is encouraged in industries through pollution control legislation and economic incentives (water tariffs based on economic costs, effluent charges and low-interest loans for effluent and sewage treatment plants). Similar savings may be possible in irrigated agriculture by investments in canal lining, by encouraging less water-intensive crops (through relative output prices) and by raising irrigation rates.

Source: UNEP. 1991. *Freshwater pollution.* UNEP/GEMS Environmental Library. No. 6. Nairobi.

two years; or 100 luxury hotel guests for 55 days.[12]

Industry requires large amounts of water, but most of it is recycled back into the water system. The major problem is that much of this water is returned polluted with wastes, chemicals and heavy metals. Over 85 percent of total withdrawals by industry are recycled as waste water.[13]

Domestic water demand is moderate in comparison with agriculture and industry but its quality requirements are high. Domestic and municipal water uses include drinking, washing, food preparation and sanitation.

Water and health

Two of the most troubling domestic water supply issues for policy-makers are access and health. Nearly one billion people in the world are without clean drinking-water. Providing easier access to safe drinking-water significantly improves health conditions. Personal hygiene increases when water availability rises above 50 litres per day (which generally means that it must be delivered to the house or yard). An estimated 1.7 billion persons contend with inadequate sanitation facilities. The lack of sewage collection and treatment is a major source of surface and groundwater pollution.

[12] I. Carruthers and C. Clark. 1983. *The economics of irrigation*. Liverpool, Liverpool University Press.

[13] D.B. Gupta. 1992. The importance of water resources for urban socioeconomic development. In *International Conference on Water and the Environment: Development Issues for the 21st Century*. Keynote Papers. Dublin, Ireland.

Health officials identify five categories of disease related to water: *i)* water-borne diseases (typhoid, cholera, dysentery, gastroenteritis and infectious hepatitis); *ii)* water-washed infections of the skin and eyes (trachoma, scabies, yaws, leprosy, conjunctivitis and ulcers); *iii)* water-based diseases (schistosomiasis and guinea-worm); *iv)* diseases from water-related insect vectors such as mosquitoes and blackflies; and *v)* infections caused by defective sanitation (hookworm).

The World Bank's *World Development Report 1992* estimates that providing access to safe water and adequate sanitation could result in two million fewer deaths from diarrhoea among young children and 200 million fewer episodes of diarrhoeal illnesses each year.

Water as a strategic resource

Water, even when plentiful, is frequently drawn into the realm of politics. Domestic laws and well-established customs can help resolve water-related disputes at national and village levels but international law has not developed fast enough to deal with the growing number of water-related conflicts between many countries and regions. In 1989, Egypt's then Minister of State for Foreign Affairs, Boutros-Ghali, declared: "The national security of Egypt is in the hands of the eight other African countries in the Nile basin."[14] As Postel notes, Boutros-Ghali highlights the importance of water to Egypt's economy as well as the advantage upstream countries have over downstream neighbours.

[14] See footnote 7, p. 236.

The increasing value of water, concern about water quality and quantity, and problems of access and denial have given rise to the concept of resource geopolitics or "hydropolitics". In this context, water joins petroleum and certain minerals as a strategic resource. Its increasing scarcity and value will only intensify the prevalence of water politics and relevant international conflicts.

Several countries depend heavily on river flows from other countries. Botswana, Bulgaria, Cambodia, the Congo, Egypt, the Gambia, Hungary, Luxembourg, Mauritania, the Netherlands, Romania, the Sudan and the Syrian Arab Republic all receive over 75 percent of their available water supplies from the river flows of upstream neighbours. More than 40 percent of the world's population lives in river basins that are shared by more than one country.

Along with land and energy sources, water has been the focus of disputes and, in extreme cases, even wars. The division of the Indus waters and its tributaries among India and Pakistan provided a salutary warning example. War was only just avoided in the early years of independence by a binding agreement, backed by massive international aid, to build two huge water storage dams and a system of canals. Water could then be channelled to the areas of Pakistan that were deprived of water when some of the Indus tributaries were diverted into Indian territory.

The costs to all parties of this settlement were high but certainly less than the human and financial costs of a conflict. Many other international rivers, including the Nile, Euphrates, Ganges and Mekong, are prospective risk points for disputes. The future of the Jordan waters is already an integral component of regional peace talks and illustrates how complicated hydropolitics can be. The fact that groundwater resources are also involved in the talks adds another dimension of difficulty.

BOX 10

THE INTERNATIONAL CONFERENCE ON WATER AND THE ENVIRONMENT: DEVELOPMENT ISSUES FOR THE 21ST CENTURY

The International Conference on Water and the Environment (ICWE) was held in Dublin, Ireland, from 26 to 31 January 1992. The conference provided the major input on freshwater problems for UNCED, convened in Rio de Janeiro, Brazil, June 1992. The ICWE was attended by 500 participants from 114 countries, 38 NGOs, 14 intergovernmental organizations and 28 UN bodies and agencies.

The major work of the ICWE was undertaken by six working groups which addressed:

- integrated water resources development and management;
- water resources assessment and impacts of climate change on water resources;
- protection of water resources, water quality and aquatic ecosystems;
- water and sustainable urban development and drinking-water supply and sanitation;
- water for sustainable food production and rural development and drinking-water supply and sanitation;
- mechanisms for implementation and coordination at global, national, regional and local levels.

The two main outputs of the conference are the Dublin Statement and Report of the Conference, which set out recommendations for action based on four guiding principles. First, the effective management of water resources demands a holistic approach linking social and economic development with the protection of natural ecosystems, including land and water linkages across catchment areas or groundwater aquifers; second, water development and management should be based on a participatory approach that involves users, planners and policy-makers at all levels; third, women play a central part in the provision, management and safeguarding of water; and, finally, water has an economic value in all its competing uses and should be recognized as an economic good.

THE WATER SECTOR AND NATURAL RESOURCE POLICY

In January 1992, the ICWE concluded that scarcity and misuse of freshwater pose a serious and growing threat to sustainable development and protection of the environment.[15] The conference emphasized that human health and welfare, food security, economic development and ecosystems are all at risk, unless water and land resources are managed more effectively in the future.

To address water problems at local, national and international levels, the ICWE recommended a range of development strategies and policies based on four principles (see Box 10). While the conference participants readily agreed on the wording of the first three principles, the fourth provoked a long and contentious debate. Principle 4 declares that water has an economic value in all its competing uses and should be recognized as an economic good.

For many, it is difficult to reconcile the concept of water as an economic good with the traditional idea of water as a basic necessity and human right. Older elementary economic textbooks explain this conceptual puzzle – why diamonds, which have so little utility, are expensive while freshwater, which is so essential to life, is cheap. More recent texts leave water out of these vignettes. Like fresh air, water was once considered a classic free good; now that it is growing scarce, while not yet expensive, it is at least acknowledged to be valuable.

Scarcity is one of the most important issues in considering the various socio-economic tradeoffs in allocating water among different users. Allocation policies and decisions determine who will have access to water and under what conditions, and what impact this will have on society and the economy.

The cheapness of water is often more apparent than real. It is a free good not because water provision is without cost – obviously this is far from true – but because governments have chosen to charge less than full costs for water services for one or more reasons.[16] These subsidies are now coming under scrutiny. The ICWE's final report acknowledges that failure in the past to recognize water's economic value and the real cost of service provision has led to wasteful and environmentally damaging uses. Moreover, the conference report states that managing water as an economic good is an important way of achieving efficient and equitable use, as well as encouraging the conservation and protection of scarce water resources.

It is in this context that the ICWE and UNCED called for a new approach to the assessment, development and management of freshwater resources. The proposed approach involves the management of freshwater as a finite and vulnerable resource and the integration of sectoral water plans and programmes within the framework of national economic and social policy.[17]

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[15] *The Dublin Statement and Report of the Conference.* 1992. ICWE, Dublin, Ireland.

[16] Water may be considered a "free" good in the form of rain, but when this free good is captured and delivered to customers by canal, pipe or other means, it becomes a water service. There is generally much less resistance to water service fees than there is to water charges.

BOX 11

FRAGMENTED PLANNING AND WATER RESOURCES IN SOUTHERN INDIA

The World Bank's water resources management policy paper presents several examples from southern India to illustrate the kinds of problem caused by fragmented decision-making. The Chittur River's highly variable flows have traditionally been diverted at many points into small reservoirs to irrigate the main rice crop. The diversion channels are large enough to accommodate flood flows following the monsoon rains. Thus, when a storage dam was constructed, the uppermost channel was able to absorb virtually all the regulated flow. The upper tanks now tend to remain full throughout the year, concentrating benefits and adding to evaporation losses. The more extensive lower areas have reverted to uncertain rain-fed cultivation, and total agricultural value added has decreased. Construction of the storage dam without adequate consideration of downstream users or the existing storage capacity of the basin is one example of how individual project development in isolation can cause significant economic losses.

The construction of the Sathanur Dam on the Ponnani River in Tamil Nadu to serve a left bank command area deprived productive delta areas of irrigation water. While the rights of downstream irrigators are recognized in the dam operating rules, most of the regulated flow is diverted upstream; water losses have greatly increased in the wide sandy bed and no surface water has reached the sea for 20 or more years. Continued spills in about 50 percent of all years were used to justify the subsequent construction of the right bank command, further aggravating shortages in the delta and leading to continual conflicts between the two Sathanur commands. Meanwhile, additional storage dams on upstream tributaries are

A more integrated and broader approach to water sector polices and issues is important because of water's special nature as a unitary resource. Rainwater, rivers, lakes, groundwater and polluted water are all part of the same resource, which means global, national, regional and local actions are highly interdependent.[18] Water use in

[17] UN. 1992. Protection of the quality and supply of freshwater resources: application of integrated approaches to the development, management and use of water resources. Chapter 18, Agenda 21, *Report of the United Nations Conference on Environment and Development.*

[18] P. Rogers. 1992. *Comprehensive water resources management: a concept paper.* Policy Research Working Paper. Washington, DC, World Bank.

adding to evaporation losses in what was already a fully developed basin. Irrigation in the productive delta has declined further and the Sathanur commands in turn are suffering. The high-value crops that were once grown on the main river are being replaced by cultivation on less productive lands, served by tributaries that are more variable than the main river.

The Amaravati River, a tributary of the Cauvery, is the most disputed major river in India. In the absence of a Cauvery agreement, Karnataka (the upstream riparian state) has steadily developed large irrigation schemes, depriving the delta (Tamil Nadu's rice bowl) of its accustomed supplies. Meanwhile, Tamil Nadu has been developing the Amaravati. As at Sathanur, water releases are made from the Amaravati Dam for the traditional areas, but these are far downstream and the substitution of regulated flood flows has encouraged the development of private pumps along the river bank. Even though the new electric connections have now been banned, little can be done to control illegal connections or diesel pumps and, consequently, little water now reaches the lowest commands, let alone the Cauvery. Meanwhile, new storage dams are being constructed on tributaries both in Kerala and Tamil Nadu, further depriving not only the old lands but also the new lands and the pump areas.

Source: World Bank. 1993. *Water resources management: a policy paper.*

one part of the system alters the resource base and affects water users in other parts.

Dams built in one country frequently reduce river flows to downstream countries for years afterwards, thereby affecting hydroelectric and irrigation capacity. When a city overpumps a groundwater supply, streamflows may be reduced in surrounding areas; when it contaminates its surface water, it can pollute groundwater supplies as well.

Certain human actions at local levels may contribute to climate change, with long-term implications for the hydrological system worldwide.

Water policies, laws, projects, regulations and administrative actions often overlook these linkages. Governments generally tend to organize and administer water sector activities separately: one department is in charge of irrigation; another oversees water supply and sanitation; a third manages hydropower activities; a fourth supervises transportation; a fifth controls water quality; a sixth directs environmental policy; and so forth.

These fragmented bureaucracies make uncoordinated decisions, reflecting individual agency responsibilities that are independent of each other. Too often, government planners develop the same water source within an interdependent system for different and competing uses (see Box 11). This project-by-project, department-by-department and region-by-region approach is no longer adequate for addressing water issues.

To help resolve the growing number of water resource issues, policy-makers are increasingly being called on to review and explain the conditions, problems and progress in the overall water sector.

This integrated approach requires water managers to understand not only the water cycle (including rainfall, distribution, ecosystem interactions and natural environment and land-use changes), but also the diverse intersectoral development needs for water resources.

The next section further explores this important concept of linking the water sector with the national economy and provides a conceptual basis for understanding the role of economic policy-making.

WATER POLICIES AND AGRICULTURE

II. Water resources: economics and policy

In early civilizations, water played a relatively simple role. It was needed for transportation and drinking and it provided a fishing and hunting source. Over time, sedentary agricultural societies evolved and water use became more important. Families began settling near springs, lakes and rivers to supply livestock and crops with water, gradually developing technologies to divert water for irrigation and domestic purposes. Babylonian, Egyptian, Hittite, Greek, Etruscan, Roman, Chinese, Mayan, Incan and other empires constructed water delivery systems such as long aqueducts to carry water to large cities.[19] In fact, until the middle of the twentieth century, most societies were able to meet their growing water needs by capturing reliable and relatively inexpensive sources.

When water is plentiful relative to demand, water policies, rules and laws tend to be simple and only casually enforced. As populations grow and economies expand, water sectors evolve from an "expansionary" phase to a "mature" phase.[20] At a certain point during the expansionary phase, the financial and environmental costs

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[19] V. Yevjevich. 1992. *Water Int.*, 17(4): 163-171.

[20] A. Randall. 1981. Property entitlements and pricing policies for a maturing water economy. *Aust. J. Agric. Econ.*, 25: 195-212.

of developing new water supplies begin to exceed the economic benefits in the least productive (marginal) uses of existing supplies. The reallocation of existing supplies, rather than the capture of unclaimed supplies, then becomes the least costly method to maximize benefits.

A water sector in the "mature" phase is characterized by rising marginal costs of providing water and increasing interdependencies among users. In this phase, conflicts over scarcities and external costs arise. (External costs result when one user interferes with another's supply, e.g. when an upstream user pollutes a river and raises costs for downstream users.) These conflicts eventually become so complex that elaborate management systems are needed to resolve disputes and allocate water among different users and economic sectors.

Developing effective water sector policies is troublesome for a number of reasons. First, water has unique physical properties, complex economic characteristics and important cultural features that distinguish it from all other resources.[21] Second, water resource management is administratively complicated because it involves legal, environmental, technological, economic and political considerations.[22] In most societies, political considerations dominate decisions on water resource use. Nonetheless, most policy options are framed and discussed in economic terms.

This section attempts to provide a conceptual basis for understanding water policy interventions while examining the circumstances under which water policies work or fail. It comprises three parts: the first examines the relationship between the water sector and the overall economy; the second explains the social, physical and economic nature of water; the third assesses the advantages and disadvantages of broad alternative approaches to public water policy and also reviews policy issues related to the economic organization of water resource management.

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[21] R.A. Young and R.H. Haveman. 1985. Economics of water resources: a survey. *In* A.V. Kneese and J.L. Sweeney, eds. *Handbook of natural resources and energy economics*, Vol. II. Amsterdam, Elsevier Science Publishers.

[22] For example, water resource management depends on the government's ability to establish an appropriate legal, regulatory and administrative framework. In fact, markets are based on a system of enforceable private property rights. Private water markets require secure and transferable property rights, including the right to exclude other users.

LINKING THE WATER SECTOR WITH THE NATIONAL ECONOMY

Economic policy-makers tend to confront policy issues one at a time, stating policy objectives in single dimensional terms. This approach presents difficulties because a policy aimed at achieving a single objective usually has unintended and unrecognized consequences. Water managers and policy-makers need to assess the entire range of government interventions to understand fully the economic, social and environmental impacts on a given sector, region or group of people.

Improving water resource management requires recognizing how the overall water sector is linked to the national economy. Equally important is understanding how alternative economic policy instruments influence water use across different economic sectors as well as between local, regional and national levels and among households, farms and firms. For too long, many water managers have failed to recognize the connection between macroeconomic policies and their impact on, for example, technical areas such as irrigation.

Macroeconomic policies and sectoral policies that are not aimed specifically at the water sector can have a strategic impact on resource allocation and aggregate demand in the economy. A country's overall development strategy and use of macroeconomic policies – including fiscal, monetary and trade policies – directly and indirectly affect demand and investment in water-related activities. The most obvious example is government expenditures (fiscal policy) on irrigation, flood control or dams.

A less apparent example is trade and exchange rate policy aimed at promoting exports and earning more foreign exchange. For example, as a result of currency depreciation, exports of high-value, water-consuming crops may increase. If additional policy changes reduce export taxes, farmers are provided with an even greater incentive to invest in export crops as well as in the necessary irrigation (see Box 12).

National development strategies can directly influence water allocation and use in other ways. In the case of a food self-sufficiency strategy, the government may subsidize water-intensive inputs to encourage farmers to produce more rice. By providing financial incentives for rice producers, the government is influencing the demand for water and private irrigation investment through price policies.

Apart from the direct effects on water use resulting from such price policies, the increased demand for irrigation water also has intersectoral, intrasectoral, distributional and environmental implications. The agricultural sector is provided with an economic advantage in access to water *vis-à-vis* the industrial sector (intersectoral); water used for rice gains an economic advantage over water used for other crops (intrasectoral); rice producers with more land and access to water gain over those with less land and water (distributional); and increased pesticide and fertilizer use are likely to affect water quality (environmental).

Sectoral policies affect water use and allocation in non-agricultural sectors in a variety of ways. For example, in the western United States, 70 to 80 percent of the region's water yield results from

BOX 12

ECONOMIC POLICIES AND WATER USE IN THE SYRIAN ARAB REPUBLIC

After struggling throughout the 1980s, the Syrian economy has performed well over the past few years. The end of a two-year drought allowed agriculture and agro-industries to recover in 1991. During the drought, the government was forced to import large quantities of wheat and barley, thereby draining foreign currency reserves. In addition, the lower water levels meant a reduction in hydropower generation, increasing the need for thermal power and, in turn, lowering crude oil exports.

Two of the Syrian Arab Republic's major national development objectives are: achieving food self-sufficiency to reduce dependency on imports; and expanding agricultural exports to earn more foreign exchange. To support these objectives, the government has invested 60 to 70 percent of the entire agricultural budget in irrigation over the past ten years.

Several factors explain this special attention for irrigation development. The irrigated area comprises only 15 percent of the cultivated land yet produces over 50 percent of the total value of agricultural production. A large part of wheat production as well as all major industrial crops, including cotton, tobacco and sugar beet, are produced on irrigated farms. Production on the remaining rain-fed area, representing 85 percent of the total area, varies greatly from year to year. At present, agriculture accounts for about 85 percent of the country's water consumption, but competition is increasing. During the 1980s, industrial water demand increased by nearly 900 percent. Current projections suggest that water requirements will be two to three times greater by 2010.

The government's effort to promote food self-sufficiency has produced a second generation of water-related problems. To encourage growth in agricultural production and enhance rural incomes, interest rates, seeds, fertilizers, pesticides, transport and energy prices

snowmelt from the high-elevation forests, many of which are under public jurisdiction. Water yields are significantly affected by timber harvest policies on these lands. Rangeland management policies on lower elevations also alter vegetation conditions and thus affect the rate of evapotranspiration, in turn affecting streamflow and groundwater recharge.[23] In such cases, it is important for downstream city water managers to recognize, understand and become involved in the decisions of

[23] B. Saliba, D. Bush, W. Martin and T. Brown. 1987. Do water market prices appropriately measure water values? *Nat. Resour. J.*, 27 (summer).

are subsidized. The government also establishes purchase prices and buys industrial crops, major cereals and feedgrains; e.g. the 1992 domestic wheat price was almost twice the international price.

These policies are contributing to the proliferation of wells in the Syrian Arab Republic. Digging wells to pump groundwater accounts for 80 percent of the newly irrigated land since 1987. With irrigation, farmers obtain higher yields, more stable production and greater profit. Since water is free, the only investment expense required is the well and the pumping gear – a one-time fixed cost. Farmers obtain subsidized credit to purchase subsidized fuel for operating imported pumps purchased with overvalued currency (an implicit subsidy). With these economic opportunities, most farmers want to dig wells or pump surface water.

Other current economic pressures are also influencing farmers' decisions to dig wells and expand irrigation. For example, as incomes in urban areas increase, consumers are demanding more fruit and vegetables. At the same time, recent changes in trade and exchange rate policies are making Syrian agricultural products more competitive in regional markets. Farmers who inititally planned only on supplementary irrigation for winter wheat are finding summer vegetables and irrigated fruit production increasingly profitable.

other sectors such as livestock and forestry.

With the continuing importance of structural adjustment and stabilization programmes, many developing countries are implementing fundamental changes in macroeconomic and sectoral polices. Typical adjustment programmes call for a greater reliance on markets, more open trade, fiscal austerity and a phasing out of producer and consumer subsidies (input and product markets). Budget-reducing measures imply increased competition between and within sectors for funding new water projects. In these situations, the overall economic, social and environmental implications of choices must be carefully addressed. For example, when governments must choose between financing either irrigation projects or hydroelectric power projects, there is an additional social opportunity cost of the irrigation water in countries that are dependent on imported energy sources. At the same time, when water scarcity keeps some farmers on uneconomical lands such as steep watersheds, the country suffers twice: once in terms of reduced production compared with what would be possible with irrigation; and again in terms of erosion and resource depletion, with erosion possibly shortening the life of existing waterworks.[24]

In most countries, pressure has increased not only to modify investment allocations but also to recognize and accommodate new demands for water. The direct implications for water managers include fewer capital investments in new water projects, the elimination of irrigation subsidies, increased efforts to recover its cost and more emphasis on demand management to improve the efficiency of existing supplies.

THE SOCIAL, PHYSICAL AND ECONOMIC NATURE OF WATER

Policy-makers throughout the world treat water as more than a simple economic commodity. Because water is essential to life, they often reject competitive market allocation mechanisms. Many societies believe that water has special cultural, religious and social values. Boulding observed that "the sacredness of water as a symbol of ritual purity exempts it somewhat from the dirty rationality of the market".[25] In many cultures, goals other than economic efficiency play an unusually large role in selecting water management institutions. Some religions, such as Islam, even prohibit water allocation by market forces.

The international community recognizes that access to water is a basic human right. The ICWE asserted that "...it is vital to recognize first the basic right of all human beings to have access to clean water and sanitation at an affordable price".

The connection between water and human life is most dramatic in arid regions, where crop irrigation is essential to food production. In Egypt, little food can be grown without the help of the Nile for irrigation. However, the focus on water's special status tends to obscure the fact that, in most societies, only a tiny fraction of water consumption is actually for drinking and preserving life. In fact, a large portion of urban water is used for convenience and comfort. In the arid

[24] D.W. Bromley, D.C. Taylor and D.E. Parker. 1980. Water reform and economic development: institutional aspects of water management in the developing countries. *Econ. Dev. Cult. Change*, 28(2).

[25] K.E. Boulding. 1980. The implications of improved water allocation policy. *In* M. Duncan, ed. *Western water resources: coming problems and policy alternatives*. Boulder, Colorado, Westview.

western United States, per caput water withdrawal by households frequently exceeds 400 litres per day, about half of which is used to irrigate lawns and gardens. Most of the remainder is for flushing toilets, bathing and washing cars.

Another important influence on water resource policy is societies' partiality for technical solutions. In most countries, water management is typically relegated to the engineering domain. Indeed, most water managers are engineers, who are trained to solve technical problems. As inadequate public policies are increasingly blamed for water-related problems, a strong case is emerging for emphasizing human behaviour as an additional component of water systems.

Physical attributes of water

Water has two additional features that further complicate management efforts: bulkiness and mobility. The value per unit of weight tends to be relatively low (placing water among the commodities that are termed "bulky"). Unlike petroleum, the costs of transporting and storing water are generally high relative to its economic value at the point of use. In crop irrigation, the water applied may yield additional economic values of less than \$0.04 per tonne of water. Water is also difficult to identify and measure because it flows, evaporates, seeps and transpires. This evasive nature means that exclusive property rights, which are the basis of a market economy, are hard to establish and enforce.

Many water management problems are site-specific and so elude uniform policy treatment. While water consumption and quality requirements are tied to local populations and development levels, local water availability usually changes with climatic variations throughout the year and over longer cyclical swings. These supplies may be highly variable and unpredictable in time, space and quality. In regions throughout India, for instance, most rainfall is concentrated during a three-month period and there are large year-to-year variations. In addition, forecasts of significant global climate change – attributable to both natural and human causes – raise concerns about longer-term supply trends (see Box 13).

Water projects that attempt to compensate for extreme seasonal variations such as floods and droughts frequently require enormous investments. The economies of size are so large in these cases that unit costs continue to exceed the range of existing demands. This is a classical "natural monopoly" situation in which a single supplying entity is the most economically efficient organizational arrangement.

On the other hand, most economies of size for pumping groundwater are achieved at relatively small outputs and multiple suppliers can therefore operate efficiently. However, aquifers are usually hydraulically linked with rivers or streams – part of a river's volume may come from underground flows and rivers may replenish groundwater stocks. This hydraulic linkage is affected when an aquifer is heavily pumped. A lowered groundwater table may draw water from a connected stream, reducing its flow to surface water users. Box 14 describes the special policy concerns related to aquifers.

Aquifer management is often complicated by the aggregate impact

BOX 13

CLIMATE CHANGE, WATER RESOURCES AND AGRICULTURE

To date, research has not been able to provide clear conclusions about the prospective impacts of climate change and global warning. Among the potential impacts of climate change is its effect on the hydrological cycle and water management systems. For instance, an increase in floods and droughts will increase the frequency and severity of disasters. Relatively small changes can cause severe water resource problems, especially in semi-arid regions and humid areas where demand or pollution has led to water scarcity.

The statement adopted by the Second World Climate Conference, held in Geneva in 1990, concluded that the design of many costly structures to store and convey water, from large dams to small drainage facilities, is based on analyses of past records of climatic and hydrological parameters. Some of these structures are designed to last from 50 to 100 years or even longer. Records of past climate and hydrological conditions may no longer be a reliable guide for the future. The possible effects of climate change should be considered in the design and management of water resource systems.

Data systems and research must be strengthened to predict water resource impacts, detect hydrological changes and improve hydrological parameterization in global climate models.

Agricultural impacts could be significant but researchers are uncertain whether global agricultural potential will increase or decrease. Increases in drought risk are potentially the most serious effect of climate change on agriculture. Disease and pest patterns, raised sea levels and storm surges are additional problems. It also appears that many areas will have increased precipitation, soil moisture and water storage, thus altering patterns of agricultural ecosystems and other water uses.

Source: WMO/UNEP/FAO/Unesco/ICSU. 1990. Second World Climate Conference. Geneva; and UNEP. 1992. *The state of the environment.*

of the actions of many individuals. Even though each individual may have a negligible impact when taken alone, the sum total can be of major importance. One example is the rapid spread of tube well irrigation in South Asia. One tube well has little effect on the total water supply, but thousands of tube wells can quickly deplete an aquifer. Establishing effective policies to regulate these many small, scattered decision-makers is exceedingly difficult.

Economic attributes of water use

Water provides four types of important economic benefits: commodity benefits; waste assimilation benefits; aesthetic and recreational benefits; and fish and wildlife habitats. Individuals derive commodity benefits from water by using it for drinking, cooking and sanitation. Farms, businesses and industries obtain commodity benefits by using water in productive activities. These commodity benefits represent private good uses of water which are rivals in consumption (e.g. one person's or industry's water use precludes or prevents its use by others). Government policies and regulations that concentrate on improving market access and competition are important means for improving the productive and allocative efficiency of the commodity uses of water.

The second and increasingly important economic benefit of water is waste disposal. Water bodies have a significant, but ultimately limited, assimilative capacity, meaning that they can process, dilute and carry away wastes.

Recreation and aesthetic benefits and fish and wildlife habitats were once regarded as luxury goods outside the concern of governments. Today, these two types of benefit are gaining increased attention. In developed countries, more and more people are focusing their recreational activities around lakes, rivers and seas. In developing nations, as incomes and leisure time grow, water-based recreation is becoming increasingly popular and an adequate supply of good-quality water helps provide a basis for attracting the tourist trade. Examples are cruises on the Nile in Egypt and visits to the Iguazú Falls on the Brazil-Argentina border. Likewise, information and knowledge about how humans have an impact on ecosystems have raised concern about the fish and wildlife benefits provided by water. Fish and wildlife habitats are related to both commodity and recreational uses.

Waste assimilation and recreational and aesthetic values are closer to being public goods than private goods. Public goods are non-rivals in consumption – one person's use does not preclude use by others. For example, the enjoyment of an attractive water body does not deny similar enjoyment to others. Non-rival goods require large amounts of resources to exclude unentitled consumers from using the good. Exclusion costs are frequently very high for water services such as flood control projects and navigation systems. Goods and services that are non-rivals in consumption are normally better suited to public sector interventions, including ownership, provision and regulation.

BOX 14

AQUIFER OVERDRAFT

An aquifer is a geological formation, actually or potentially containing water in its pores and voids. Aquifers consist of the porous rock or soil media (sand, gravel or rock materials) within which water is collected and through which it flows. Moisture from rain or snow that escapes evaporation collects in streams as surface water or seeps into the ground. Soil water not taken up by plants seeps downwards until it reaches the water-saturated zone. Water in aquifers is called groundwater. Groundwater deposits are economical to use for human purposes if they are close to the surface (and thereby inexpensive to pump) and are of good quality.

Aquifers vary greatly in their nature and extent. The quantity, quality and ease of extraction can be determined accurately only after extensive exploration. Underground geology varies widely and is expensive to map. Aquifers may be very thin or hundreds of metres thick; some are local in character, while others extend for hundreds of kilometres. The Ogallala-High Plains Aquifer in the central-western United States underlies more than 10 million ha over six states.

Relative to surface water, groundwater moves very slowly – in some cases only a few metres per year. While aquifers may have accumulated over thousands of years, modern pumping devices can easily exhaust them more rapidly than the natural recharge rate. It is also possible to divert surface water to recharge an existing aquifer artificially and make it available for future use.

Aquifer status reports from many parts of the world suggest that all is not well with our groundwater resources. Symptoms of management problems begin with pumping rates that exceed the natural recharge. Primary symptoms are: an exceedingly rapid exhaustion of groundwater stocks and the consequent increase in pumping costs; the intrusion of poorer-quality water into the deposit being exploited; salt water intrusion from rapid pumping near seacoasts; and mineralized deposits interspersed with better-quality water.

Subsidence of overlying lands is another adverse impact of aquifer overexploitation. As water is withdrawn, the soil and rock particles comprising the aquifer are compressed into a smaller volume and, consequently, crack the earth's surface. This results in damage to buildings, roads, railroads, etc. Another consequence of overpumping may be the interruption of flows in neighbouring wetlands and streams; deprived of their water source, they are reduced in size or may dry up altogether. Other adverse effects from overpumping result when residential or farmers' wells dry up because of the presence of larger and deeper wells.

From a broad perspective, aquifer exploitation can bring about either or both of two types of social dilemma. First, overdraft is an example of a class of resource problems, usually called "common pool" problems.[1] A common pool resource can be defined by two characteristics. The first is subtractibility (meaning that a unit of resource withdrawn by one individual is not available to another individual user). The second is the high cost of excluding potential beneficiaries from exploiting the resource. Fugitive or mobile resources, such as water, petroleum or migratory fish and wildlife, are typical examples of resources with high exclusion costs.

Common pool problems or dilemmas arise when individually rational resource use leads to a non-optimal result from the perspective of the users as a group. Three conditions are necessary to produce a common pool resource **dilemma: first, large numbers of users withdraw the resource; second, the actions and characteristics of the individual users and the extraction technology bring about suboptimal outcomes from the group's viewpoint; third, there must be an institutionally feasible strategy for collective resource management that is more efficient than the current situation.[2]**

The roots of the problems associated with common pools are found in the inadequate economic and institutional framework within which the resource is exploited.[3] Common pool resources have been typically utilized in an "open access" framework, within which resources are used according to a rule of capture. When no one owns the resource, users have no incentive to conserve for the future and the self-interest of individual users leads them to overexploitation. The characteristics of the economic institutions governing their use is the fundamental issue in managing common pool resources.

The second type of social dilemma associated with groundwater exploitation is the imposition of external costs or externalities. In the presence of significant externalities, the calculation of costs and benefits by exploiters does not yield a collectively optimal rate of exploitation.

[1] R. Gardner, E. Ostrom and J.M. Walker. 1990. The nature of common pool resources. *Rationality and Society*, 2: 335-358.

[2] Ibid; and E. Ostrom. 1990. *Governing the commons: evolution of institutions for collective action.* Cambridge, UK, Cambridge University Press.

[3] R.A. Young. 1993. Aquifer overexploitation: economics and policies. *Proc. 23rd Conference of the International Association of Hydrogeologists*, Santa Cruz, Spain.

ECONOMIC ORGANIZATION OF THE WATER SECTOR: MARKETS OR GOVERNMENTS?

Most countries rely on a mix of market policies and direct government interventions to manage water resources. Each system has its own advantages and disadvantages.

A competitive market has the potential to allocate resources (water supplies) efficiently among competing demands. Producers and consumers acting in their own self-interest reach the price at which available supplies are allocated. Private producers, guided by prospective profit, seek to buy inputs as cheaply as possible, combine them in the most efficient form and create products that have the highest value relative to cost.

Consumers' incomes, tastes and preferences influence expenditure patterns, which encourage firms to produce the commodities people are willing and able to buy. Prices are forced upwards for the commodities most desired, and producers allocate resources in the direction of the greatest potential profits. The firms producing desired goods most efficiently are rewarded by profit while the unsuccessful are eliminated, so production occurs at the least cost. However, the needs of potential consumers with limited incomes may either not be met at all or be met only partially.

While the private market has the potential to produce the maximum private-valued bundle of goods and services, the public sector also plays an important role. Public actions incorporate a broader range of social goals than the private sector. The public sector can ameliorate income inequalities, promote development in disadvantaged regions, regulate private activities that harm the environment and control other undesirable effects of a private, profit-oriented monopoly.

Market failures

If water as a commodity, or the economic system in which water is used, meets the preconditions for a market system, government interventions can be minimized. In competitive markets, government's primary role is to emphasize "incentive structures" and to establish "rules". Some of the most important rules are the laws governing the establishment of property rights and the enforcement of contracts.

Market economies experience shortcomings called market failures.[26] Market failures occur when incentives offered to individuals or firms encourage behaviour that does not meet efficiency criteria or, more generally, because efficiency or economic criteria fail to satisfy national social welfare objectives. In these cases, the public sector may intervene to influence water provision and allocation. Market failures affecting water resources include externalities, public goods and natural monopolies. In other cases, even efficient markets may not meet societies' equity criteria so public intervention is necessary to compensate for distributional inequity.

Externalities are inherent in water sector activities. An example is the detrimental effect of saline return water flows (caused by irrigation) on

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[26] C. Wolf. 1988. *Markets or governments; choosing between imperfect alternatives.* Cambridge, MA, Massachusetts Institute of Technology Press.

downstream water users. Another example is the waterlogging of downslope lands through inefficient irrigation practices. Most irrigators do not normally consider the external costs they impose on others, so governments attempt to protect affected individuals through regulations, taxes, subsidies, fees or technical standards. For instance, irrigation practices can be regulated by setting and enforcing standards to control salinity and waterlogging.

In recent years, the "polluter pays" principle has attracted increased attention in industrialized countries (and to a lesser extent in developing countries). This principle requires producers to pay the "full" cost of their production process, including externalities such as polluting water.

Water storage projects and flood control programmes represent examples of *public goods*. The market does not adequately supply public goods because private entrepreneurs cannot easily exclude non-paying beneficiaries and capture a return on investment. For example, it is not possible to exclude people living along a river from the benefits of a flood protection plan on that river.

A firm that experiences decreasing costs throughout its range of production is easily able to dominate the entire market and become a *natural monopoly* (a common situation in the water sector). Decreasing costs imply increasing returns; thus, the first firm to begin production can always underprice new entrants. Urban water supply systems, hydropower plants and canal irrigation projects are subject to this type of market failure. Unregulated monopolies can restrain production and charge excessive prices; they also have little incentive to innovate. A water supplier acting as a natural monopoly has the power to impose exorbitant costs – even economic ruin – on its customers.

Public regulation or public ownership can mitigate the undesirable effects of a private, profit-oriented monopoly. When increasing returns exist, the lowest-cost production is that of a single producer. Society is likely to benefit by regulating or owning the monopoly rather than by encouraging competitive suppliers. More than one competitive supplier would present much higher distribution costs.

While free competition is viewed as the most efficient system for allocating resources, potential market imperfections can accentuate income disparities. Societies' public welfare goals often incorporate a broad range of social objectives. Primary among these is ameliorating income inequalities between members of the society and sometimes among political subdivisions or regions. In these situations, the government may direct investment and subsidies towards specific regions or groups. Water projects provide important investment strategies both for human welfare (drinking-water and food supplies) and for infrastructure to support economic development.

Government failures

Even in the event of market failures, public sector interventions or non-market approaches may not lead to the socially optimum solution. In many cases, non-market responses to market failures lead to less than optimal outcomes. In particular, some government agency performance incentives result in a divergence from socially preferable outcomes (both in terms of allocative efficiency and distributional equity criteria). The problem areas relevant to water sector services are:

- *"Products" are hard to define.* The outputs of non-market activities are difficult to define in practice and difficult to measure independently of the inputs that produced them. Flood control or amenity benefits of water storage reservoirs are examples of water system outputs that are hard to measure.
- *Private goals of public agents.* The internal goals, or "internalities", of a public water agency as well as the agency's public aims provide the motivations, rewards and penalties for individual performance. Examples of counterproductive internal goals include budget maximization, expensive and inappropriate "technical-fix" solutions and the outright non-performance of duties. In addition, agencies may adopt high-tech solutions, or "technical quality", as goals in themselves. For example, they may recommend sprinkler or drip irrigation systems when other less expensive but reliable methods are more economical. Finally, irrigation agency personnel may be persuaded, by gifts or other inducements, to violate operating rules for a favoured few.[27]
- *Spillovers from public action.* Public sector projects can also be a major source of externalities. Salinity and waterlogging of downslope lands can occur just as easily from inappropriately managed public irrigation projects as from private irrigators.
- *Inequitable distribution of power.* Public sector responsibilities, however noble their intent, may not be scrupulously or competently exercised. Yet the monopoly control of water supplies by public agencies provides certain groups or individuals with so much power over the economic welfare of water users that procedures to protect those of limited influence should be of prime importance.

[27] R. Wade. 1982. The system of administrative and political corruption: land irrigation in south India. *J. Dev. Stud.*, 18: 287-299.

Economic structure and irrigation

For many years, the economic systems in a number of developing countries discriminated against agriculture through policies such as high levels of protection for domestic manufacturing sectors, overvalued exchange rates and taxes on agricultural exports. Most developing countries today are at some stage of structural reform, attempting to adjust and transform their economies towards a more liberal economic trade regime – modifying government involvement and increasing market influence.

The developing world's recent record in consolidating macroeconomic stability with solid economic growth is very mixed. Where success is evident, most of the economic transformation has taken place at the macro level and much remains to be done to effect the consequent adjustments at the micro level, at the level of water users in other words.

Even with widespread acceptance of the need for macroeconomic price policy reforms for all other sectors since the early 1980s, the dominant supporting actions for agriculture have been non-price policies. For non-agricultural sectors, the new policy mix includes minimizing state involvement in the pricing and marketing of inputs and outputs, privatization and limiting government borrowing.

Despite the irrigation sector's often being sheltered or even benefiting from the effects of these economic policy reforms, government subsidy cuts are inevitably affecting the scope and efficiency of agricultural support services. In most countries, there is a pressing need to discuss how various policy options, including both public interventions and market-oriented, private sector activities, may assist the irrigation sector in the process of economic reform.

Section III reviews the advantages and disadvantages of some of these policy measures for surface water, groundwater and water quality.

WATER POLICIES AND AGRICULTURE

III. Water policies and demand management

To help select the most appropriate policy option or programme alternative, policy analysts divide the water sector into supply-side and demand-side components. The supply-side approach is structure-oriented; investments in water projects are combined with engineering and technical expertise to capture, store and deliver water and to make systems operate effectively. The supply side focuses on providing water and related services.

For most of the twentieth century, policy-makers have focused their attention on the supply side. Economists have evaluated public water supply and policy options through benefit-cost analysis (BCA). The main purpose of BCA is to assure that scarce resources (such as labour, capital, natural resources and management) are all employed to their best advantage. BCA attempts to quantify the advantages and disadvantages to society of alternative policies or actions in terms of a common monetary unit.[28]

With new water-related problems arising in many parts of the world, policy-makers are increasingly emphasizing non-structural approaches to water management. A non-structural approach encompasses demand management, scientific research,

[28] See footnote 21, p. 252.

education and persuasion to coordinate how humans use water. These demand-side policies attempt to address the human causes of water problems such as water quality degradation, overexploitation of aquifers and the decreasing availability of water flows to meet non-consumptive water uses (hydroelectric power, pollution assimilation and fish and wildlife habitats).

In part, this user-focused approach entails coordinating and influencing people through organizations and institutions. This focus on water users aims to promote least-cost, environmentally sound water planning and takes both demand and supply options into account. Voluntary associations, government bureaucracies and private businesses are examples of organizations that operate on both the demand (user) side and the supply (delivery) side of water supply systems. On the supply side, large hierarchical organizations usually control the capture, storage, conveyance and distribution of surface water. Demand-side organizations, for example water user associations, are established to represent the interests of irrigators and to introduce and enforce water allocation rules.

This section examines how water institutions and water allocation systems incorporate a user-focused approach to address surface water, groundwater and water quality issues related to agriculture.

INSTITUTIONS AND WATER POLICY

Institutions are defined more broadly than simply government agencies and private organizations. Institutions are "...sets of ordered relationships among people which define their rights, exposure to rights of others, privileges and responsibilities".[29] In this context, institutions set the "rules of the game" within which the economic system operates. For example, the property rights system is considered a water institution because it includes provisions which determine access to water and land. The property rights structure helps define the incentives, disincentives, rules, rights and duties (including informal customs and formal legal systems) that guide human activities and encourage conformist behaviour.[30] Thus, property rights are part of an institutional arrangement governing economic activities including water use.

Many demand-side policies attempt to coordinate water use through institutions such as property rights and incentive structures such as prices. Altering the institutional system of permissions, restrictions, incentives and penalties can compel consumers to do what they might not otherwise do. For instance, financial inducements (monetary rewards and penalties) can encourage people to use water in a more socially desirable way.

Two factors significantly influence the form of water institutions in a

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[29] A.A. Schmid. 1987. *Property, power and public choice*, 2nd ed. New York, Praeger.
[30] D.W. Bromley. 1989. *Economic interests and institutions: the conceptual foundations of public policy*. New York, Blackwell.

society: the relative scarcity of water and the transactions costs required to establish and enforce water rights. While scarcity is both supply- and demand-dependent, the human pressures on the demand side are probably the most important. Transactions costs include the resources required to obtain information, negotiate agreements on property rights and police these agreements. Water supply and demand characteristics make transactions costs for water relatively high and the value of water relatively low compared with other resources or commodities.

Many economists are trying to find ways to improve water-use efficiency through improved institutional performance. Research to date suggests that institutions and technological change are altered in response to the same types of incentives.[31] When water is plentiful relative to demand, laws governing water use tend to be simple and enforced only casually. Where water is scarce, more elaborate institutional systems evolve. Higher population and income levels as well as technological advances are prompting many governments to establish formal water-use and water quality management systems.

Establishing an institutional structure for allocating water is a fundamental role of social policy for any nation. The choice of structure is ultimately a compromise between the physical nature of the resource, human reactions to policies and competing social objectives. Not surprisingly, different cultures make tradeoffs based on the relative importance of their particular objectives. Countries try various means to balance economic efficiency (obtaining the highest value of output from a given resource base) and fairness (assuring equal treatment).[32] Individual freedom, equity, popular participation, local control and orderly conflict resolution are other important objectives which societies must juggle when choosing a structure for water allocation.[33]

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[31] V.W. Ruttan. 1978. Induced institutional change. *In* H.P. Binswanger and V.W. Ruttan, eds. *Induced innovation*. Baltimore, The Johns Hopkins University Pr

[32] P. Bohm and C.F. Russell. 1985. Comparative analysis of policy instruments. *In* A.V. Kneese and J.L. Sweeney, eds. *Handbook of natural resources and energy economics*, Vol. I. Amsterdam, Elsevier Science Publishers.

[33] See D.A. Stone. 1988. *Policy paradox and political reason*. Glenview, Illinois, USA, Scott, Foresman; and A. Maass and R.L. Anderson. 1978. *... and the desert shall rejoice: conflict, growth and justice in arid environments*. Cambridge, MA, Massachusetts Institute of Technology Press.

WATER ALLOCATION SYSTEMS

In an "ideal" market-based water allocation system, entitlements (water rights) are well defined, enforced and transferable and they confront users with the full social cost of their actions. This type of market-dependent institutional arrangement requires security, flexibility and certainty.[34] Security refers to protection against legal, physical and tenure uncertainties.

The assumption is that users will undertake profitable long-term investments to obtain and use water supplies only if water entitlements are reasonably secure.

A system is flexible if allocations between users, uses, regions and sectors can be changed at a low cost in relation to benefits. Flexibility implies that changes in demand are accommodated easily by reallocating water to higher-valued uses as they emerge. Certainty is also necessary: water-use rules must be easy to discover and to understand.

The three basic types of "water rights" systems are: *i)* riparian – only those owning the land in physical contact with a natural watercourse have a right to use it; *ii)* prior appropriation – based on beneficial and actual use; and *iii)* public administration – a public authority authorizes water distribution and use. Prior appropriation and public administration are the most common systems in use throughout the world.

[34] S.V. Ciriacy-Wantrup. 1967. Water economics: relation to law and policy. *In* R.E. Clark, ed. *Waters and water rights: a treatise on the law of waters and related problems*, Vols I-VII. Indianapolis, Allen Smith.

Property rights systems and surface water allocation

Some water allocation systems are relatively decentralized and based on entitlements or rights to specific quantities of water. Examples of these types of system are found in the western United States and southern Australia. In contrast, France uses a more centralized public utility model of water allocation (see Box 15). Chile is the only country with a comprehensive water allocation system that establishes tradeable property rights.[35]

Chile's water law: allows trade between and among economic sectors; protects third party rights; establishes compulsory water user associations and a national water authority to resolve conflicts; and allows for judiciary solutions to those conflicts not resolved by water user organizations or the water authority.[36] Water transfers require authorization at two levels – those of the local water user associations and the national water authority.

While formal tradeable water rights systems have not been established in other developing countries, Rosegrant and Binswanger[37] document the expansion in surface water and groundwater markets. One recent study on surface water trade in

[35] M.W. Rosegrant and H.P. Binswanger. 1993. *Markets in tradeable water rights: potential for efficiency gains in developing country irrigation*. Washington, DC, IFPRI.

[36] R. Gazmuri. 1992. *Chilean water policy experience*. Paper presented at the World Bank's Ninth Annual Irrigation and Drainage Seminar, Annapolis, Maryland, USA.

[37] See footnote 35.

BOX 15

A "PUBLIC UTILITY" MODEL FOR WATER ALLOCATION AND POLLUTION CONTROL

France's model for allocating water could be termed a "public utility" model. Administration is centred in six river basin committees (RBCs) and six river basin financial agencies (AFBs) which control water abstraction, treatment and delivery. The RBCs are the centre for negotiations and policy-making regarding water management at the basin level. The AFBs base action plans on extensive water data (quality and quantity needs) and are the centre of knowledge and technical expertise for the government and other interested water users. The RBCs collect fees, award grants and loans, develop long-term plans, collect and analyse water data, conduct studies and finance research.

The RBCs approve 20- or 25-year water development plans and, every five years, establish action plans to improve water quality. They also set two fees to be paid by water users: one for water consumption and the other for point source pollution. The fees provide incentives fo. users and also form a fund to encourage better water use through grants or soft loans. The RBCs include representatives from national, regional and local government administrations as well as individuals from industrial, agricultural and urban interests.

Those withdrawing water outside the authority (excluding small units) must measure and pay for it. Costs depend on the source (surface or ground) and how valuable it is in the specific basin. This approach also employs the "polluter pays" principle. While pollution assimilation is recognized as a legitimate water use, the entity causing pollution must pay for the costs of remediating the pollution and must compensate for any damages. Reports indicate that the system is self-financing and that it has performed well over 25 years.

The French approach provides feasible and apparently effective solutions to the major concerns about public water management: water scarcity, pollution and conjunctive use of ground and surface water.

It does, however, appear to rely more on centralized administrative discretion and less on the preferences and initiatives of private individuals. For example, water charges are set without regard for scarcity values based on bids and offers by users.

Source: World Bank. 1993. *Water resources management: a policy paper.*

Pakistan reported active markets in 70 percent of watercourses.[38]

The water allocation system in the western United States originated last century and evolved out of the customs of miners and farmers.[39] This system is called the "prior appropriation" doctrine because water entitlements are granted according to the date on which a person applies the water to a beneficial use. The phrase "first in time, first in right" describes the basic principle, as the date of appropriation establishes the order in which users may draw from the water source.

In the western United States system, the individual's property interest in water is limited to the right to divert and use a specified quantity. Private individuals cannot "own" water but have "usufructuary" rights. The state retains ownership and determines which uses are beneficial. Beneficial uses were originally limited to private sector, off-stream purposes in agriculture, households and industry. More recently, in-stream uses for recreation and for fish and wildlife habitats are being recognized.

Water rights are generally tied to a specific parcel of land. However, in most states these water rights can be sold, without loss of priority, to another individual for use on another parcel. Rights are protected by the state from other appropriators and cannot be taken from an individual by the government without just compensation for the foregone economic value.[40]

In the prior appropriation system, irrigation water rights are administered by private non-profit cooperative organizations or by public districts, under the supervision of the state government. Financing requirements and cost recovery are normally based on area served rather than on a strict volumetric pricing system. Early in the history of western irrigation, private capital was the main source of funds. In the twentieth century, private financing has mostly been replaced by federal subsidies. In contrast, municipal and industrial water supplies are typically financed by the users, with a full-cost pricing rule.

In recent years, southern Australian states have begun to allocate water through a system of transferable water entitlements.[41] The Australian water law is based on a non-priority permit system under state control and ownership. Individuals obtain a right to use water through a licence issued by a state agency; this right is usually for a specified type of use on a designated tract of land. In contrast to the United States doctrine of prior appropriation, all users share equally in supply shortfalls and permits expire after a specified time period. Recent studies indicate the need to base permits on the water system's capacity in proportion to the quantities assigned in the original permit.[42]

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[38] See footnote 35, p. 269.

[39] D. Getches. 1990. *Water law in a nutshell*, 2nd ed. St Paul, Minnesota, West Publishing.

[40] R.A. Young. 1986. Why are there so few transactions among water users? *Am. J. Agric. Econ.*, 68: 1143-1151.

[41] J.J. Pigram. 1992. *Transferable water entitlements in Australia.* Centre for Water Policy Research, University of New England, Armidale, New South Wales, Australia.

[42] N.J. Dudley and W.F. Musgrave. 1988. Capacity sharing of water reservoirs. *Water Resour. Res.*, 24: 649-658.

In southern Australia, the transfer of rights is generally limited to water users in the same watershed, with special conditions imposed to protect supply reliability and to prevent third-party damages. Reports evaluating water market performance highlight two points: first, the system is facilitating reallocation from low-value to higher-value uses; and, second, transferable entitlements should be considered as part of a broad package of decentralized decision-making for the entire water sector.[43]

Prices and surface water allocation

In practice, market forces rarely establish prices for water. Instead, prices are set by publicly owned supply agencies or regulated private utilities. Water prices ("rates" in public utility jargon) have an impact on both efficiency and equity as well as influencing agency revenues. The charging scheme for recovering costs and allocating water is a decision variable for the supplying or regulating agency.

Rate-setting can be evaluated within a multiple objective framework in which allocative efficiency, equity of income distribution and fairness in apportioning costs all play a role in evaluating pricing policies. The secondary criteria of simplicity, administrative feasibility and stability are also taken into account.

The most commonly employed pricing policy for water is a *flat rate charge*, designed primarily to recover costs. Flat rates are not set according to the volume received, although a proxy for volume usually provides the basis for the charge. In agriculture, the most frequent basis for a water charge or service fee is the area irrigated. For residential use in the industrialized world, flat rate charges have been based on the number of residents, the number of rooms, the number and type of water-using fixtures or measures of property value.

Flat rates are criticized because they do not include incentives for rationing water in line with willingness to pay. Such schemes are, however, simple to administer and assure the supplier adequate revenue. The high cost of installing and monitoring meters is suggested as being the main reason for continuing the flat rate approach. This argument is convincing in cases where water is plentiful, supply costs are low and managers doubt the rationing effects of volumetric pricing. In other cases, water managers are turning to volumetric pricing to address water scarcity problems and the high costs of developing new supplies. Box 16 presents evidence from developing countries that pricing does indeed restrict water use.

Policy-makers who are primarily interested in allocative efficiency (maximizing net social product) as the goal for a pricing scheme advocate *marginal cost pricing*. The marginal cost represents the incremental cost of supplying a good or service. The marginal cost is a schedule of costs related to quantity and typically rises as further increments are supplied. When water prices are set at the marginal cost, rational consumers demand additional water only as long

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[43] For an extended discussion, see K.D. Frederick. 1993. *Balancing water demand with supplies: the role of management in a world of scarcity*. Technical Paper No. 189. Washington, DC, World Bank.

BOX 16

PRICE IMPACTS ON WATER USE

In Australia, Canada, Israel, the United Kingdom and the United States, studies have demonstrated that water demand drops by 3 to 7 percent when prices charged to households rise by 10 percent. While it is difficult to measure elasticity of demand without metering consumption, some research in developing countries indicates how prices, combined with other policy efforts, affect water use.

China

In Beijing a water quota and high rates for exceeding it led to a 37 percent reduction in industrial water use in the 1980s. During the same period, the industrial sector was able to expand rapidly.

India

A fertilizer plant at Goa reduced water consumption by 50 percent in response to higher water prices. The Goa plant now uses 10.3 m^3 to produce 1 tonne of nutrient, paying \$0.12 per m^3. In contrast, a similar plant at Kanpur pays \$0.01 per m^3 but uses 24.35 m^3 per tonne of nutrient.

Indonesia

In Bogor a water tariff increase ranging from 200 to 300 percent (from \$0.15 to \$0.42 for the first 30 m^3 per month) decreased monthly consumption by around 30 percent for domestic and commercial connections.

Source: R. Bhatia and M. Falkenmark. 1992. *Water resource policies and the urban poor: innovative approaches and policy imperatives.* Background paper for the ICWE, Dublin, Ireland.

as willingness to pay (demand) exceeds the incremental costs. In theory, marginal cost pricing yields the most economically efficient allocation.

A number of obstacles are encountered in the application of marginal cost pricing. One problem is the variety of definitions of the appropriate marginal cost concept, particularly whether to use a short-run (variable cost) concept or a long-run, full-cost approach. A long debate ensued from the "short-run marginal cost" pricing proposal which emerged from welfare economists' work in the 1930s. For example, Coase [44] strongly objected to setting utility prices at

[44] R. Coase. 1971. The theory of public utility pricing and its applications. *Bell J. Econ.*, 1: 113-128.

short-run marginal costs, especially where marginal costs are below average costs (thereby incurring a deficit and requiring a public subsidy). Coase also criticized the absence of a market test to determine whether users are willing to pay the full cost of supplying the commodity; the redistribution of income to favour users of decreasing-cost industrial products; and the impetus towards centralization of the economy.

Most of these criticisms can be dealt with by a multipart pricing system: the first part sets marginal price equal to marginal cost while the second part levies an assessment to recover those costs that exceed marginal costs. Even so, multipart schedules often fail to reflect the economic concept of opportunity costs correctly, focusing instead on recovering historical or embedded costs. The relevant opportunity costs include both the cost of securing incremental supplies of water and the value of water in alternative uses.[45] Opportunity costs should be determined after adjusting prices to allow for distortions brought about by government interventions in pursuit of other objectives. In economic jargon, "shadow prices" must be used.[46]

The *average cost pricing* principle calls for recovering all costs by charging for each unit according to the average cost of providing all units. It is simple and easy to understand, as well as fair and equitable. Beneficiaries pay only the resource costs incurred on their behalf. The desired signals to users are provided, although not in as precise a way as with multipart pricing. Here, too, often only historical costs, not opportunity costs, serve as the basis for calculating average costs.

The *ability-to-pay* principle rests heavily on the equity criterion. Water charges are dependent on income or wealth rather than on costs. This principle is the most common basis for setting irrigation rates throughout the world and is also regularly applied to village water supplies in developing countries. Economists who view water as a commodity tend to be critical of the ability-to-pay approach. Since charges bear little relation to costs, no allocative test of willingness to pay is provided. This ability-to-pay concept is inherently subjective and political pressures frequently influence the formula in ways that distribute wealth from taxpayers to water users.

In many places throughout the world, water is scarce enough to justify the tangible and intangible costs of establishing formal pricing systems. Flat rates could satisfy cost repayment requirements in the absence of serious shortages. However, when the signals of water scarcity are absent, pressures arise for structural solutions (more construction to capture, store and deliver water) to satisfy incorrectly perceived water "needs".

The inevitability of scarce water supplies suggests the eventual adoption of multipart rate schemes that reflect the real or opportunity costs of water and other resources required for service provision. The literature describing the most desirable form for

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[45] G.M. Meier. 1983. *Pricing policy for development management*. EDI Series in Economic Development. Baltimore, The Johns Hopkins University Press.

[46] L. Small and I. Carruthers. 1991. *Farmer-financed irrigation*. Cambridge, UK, Cambridge University Press.

water markets and the literature dealing with water pricing have converged on the notion of a pricing system that reflects the opportunity cost of water via the mechanism of transferable water entitlements.[47]

Coordinating groundwater extraction
Groundwater is an extremely important resource for many developing countries, including Bangladesh, India, Pakistan and the entire Near East region. In India, tube wells accounted for nearly one-half of the net irrigated area by the late 1980s.[48] Because it deals with the complex interaction between society and the physical environment, aquifer management presents a formidable problem of policy design. Two types of collective policy decisions must be addressed in the management or regulation of overexploited aquifers. For one type, termed "managing the water", decisions are based on: *i)* the appropriate annual rate of pumping; *ii)* the geographic distribution of pumping; and *iii)* whether water supplies are augmented and/or the aquifer artificially recharged. The other type of policy decision, "coordinating the pumpers", determines: *i)* the institutions and policies that divide the extraction rate among potential individual users and user classes and that influence pumper behaviour; and *ii)* how rules for limiting pumping are monitored and enforced.

The three broad types of institutional arrangement for managing aquifers are prices and charges, quantity-based controls and exchangeable permits.

Prices and charges to control pumping. Charging pumpers is one potential method of achieving economically efficient extraction rates. An appropriately scaled charge or tax confronts pumpers with both the foregone user cost and the external cost (from increased pumping costs) imposed on neighbouring pumpers. This type of water charge internalizes user costs and external costs and achieves an optimal extraction rate.

In aquifer management, this approach takes care of one important difficulty – pumpers impose costs on themselves (that is, the external costs are reciprocal). The reduction in water use resulting from a tax would be at the expense of redistributing rents to the taxing authority, thus lowering the net income of the aquifer exploiters.

Quantity-based controls. Quantity-based control mechanisms range from simple well permits to exchangeable pumping entitlements. Well and pump permits grant the right to install and operate a well of a particular capacity. Irrigation permits frequently specify the lands on which well water can be used, thereby restricting the transport of water to other sites.

To protect existing pumpers, permits for new wells may restrict locations. For example, the state of Colorado in the United States identifies "designated groundwater basins" (for aquifers with

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[47] See, for example, R.K. Sampath. 1992. Issues in irrigation pricing in developing countries. *World Dev.*, 20(7): 967-977; and A. Randall. 1981. Property entitlements and pricing policies for a maturing water economy. *Aust. J. Agric. Econ.*, 25: 195-212.

[48] P. Crosson and J.R. Anderson. 1992. *Resources and global food prospects.* World Bank Technical Paper No. 184. Washington, DC, World Bank.

limited natural recharge) in which new well permits must meet specific criteria – no more than 40 percent of stocks may be exhausted within a three-mile radius over a 25-year period. In most cases, well permits do not set limits on the quantity of water pumped. The economic limitations imposed by pumping costs and crop prices are assumed to be sufficient to inhibit excessive withdrawals.

Permits with appropriate size and spacing specifications can slow extraction rates. They are relatively easy to monitor and are reasonably palatable to pumpers who strongly reject more stringent regulatory devices. On the other hand, permits are most effective before problems have become severe and complex – in cases when preventing new wells and pumps solves the problem or when pumped water is not exported away from the area overlying the aquifer. In more serious cases, where all existing users must reduce annual extractions, regulating rates of withdrawals must be considered.

A pumping "quota" is a more precise quantity control mechanism. The quota specifies a fixed annual rate of extraction for each water user. The initial quantity might be assigned in proportion to use in a base period (although such an approach might set off a pumping race to establish initial rights) or be based on the proportion of land that is owned overlying the aquifer. The technology for metering withdrawals is neither complex nor expensive so, if the pumpers are willing to be metered, regulatory monitoring and enforcement need not be difficult. In principle, pumping quotas are no different from conventional surface water rights, which entitle owners to fixed shares of each year's available flow.

Anecdotal evidence suggests that farmers who have previously enjoyed an unregulated aquifer believe they are entitled to unlimited withdrawals for use on lands overlying the aquifer. They are frequently reluctant to submit to metering and the meters, once installed, are reportedly subject to high rates of unexplained "breakdowns".

Very small wells for livestock or individual households could be exempted from the permit and quota system. At moderate levels of overdraft, the cost of monitoring every small pump set might outweigh gains from reduced pumping. Also, for income distribution reasons, policy-makers may not want to restrain smallholders.

Transferable pumping entitlements. When a fixed quota is too inflexible in the face of changing water stocks and demand conditions, transferable pumping entitlements are an alternative. The pumping entitlement can be divided into two parts: one component may provide a claim to the stock of water and the other to the annual recharge. Both claims may vary from year to year, with allotments set by the groundwater authority. Annual rights to the basic stock would vary according to current and anticipated economic and hydrological conditions (including energy and commodity prices, interest rates and the remaining stock of groundwater). Rights to the natural recharge and return flows from human uses could be set to reflect a moving average of estimated recharge in recent years.

The transferability of entitlements promotes economic efficiency over the long term, permitting a reallocation to higher-valued uses as economic conditions change. Transferable rights are also consistent with local control criteria and require minimal interference with individual freedom to operate a farm or business enterprise.

One recent study suggests that tradeable rights and water markets for groundwater appear to be increasing in India, where as much as one-half of the gross area irrigated by tube wells involves purchased water.[49] Box 17 provides an additional example, explaining how agricultural water sellers operate in Bangladesh.

In groundwater management, the quantity-based approaches appear to be preferable to pumping charges. They can yield economically efficient solutions with simpler monitoring and enforcement burdens, while avoiding the redistributive implications of taxes or subsidies. While some new outside controls on pumping are required, they need not be any more repressive than property rights for other resources or commodities.

Conjunctive groundwater and surface water management

Joint management of interrelated stream-aquifer systems is called *conjunctive ground-surface water management.* Aquifers interrelated with flowing streams frequently present both distinct management opportunities and problems. Unrestricted access to groundwater may reduce the water available to those holding rights to streamflows.

In the state of Colorado in the United States, a problem arose two decades ago for irrigators in the South Platte basin. Groundwater exploitation reduced streamflow, but by only a small fraction of the amount pumped. The most obvious option – placing the pumpers into the existing surface water rights system while protecting those holding existing rights to surface water – would have sacrificed most of the substantial economic benefits of exploiting the aquifer.

After several methods had been experimented, a solution was found based on markets for existing rights to surface water. In the event of a shortage, groundwater users could replace the portion of streamflows taken by pumping the aquifer. They could also replace water by purchasing and delivering rights to reservoir water. Young, Daubert and Morel-Seytoux[50] demonstrated that this decentralized approach is economically superior to the alternative of forcing pumpers into the surface water rights system. The ready availability of substitute water supplies and the existence of flexible water transfer institutions are necessary to implement a solution of this type. Numerous opportunities for this market-based approach do exist, however, in the large alluvial basins of the Indus and Ganges-Brahmaputra.

[49] See footnote 35, p. 269.

[50] R.A. Young, J.T. Daubert and H.J. Morel-Seytoux. 1986. Evaluating institutional alternatives for managing an interrelated stream-aquifer system. *Am. J. Agric. Econ.*, 68: 787-791.

PRESERVING WATER QUALITY

Human production and consumption activities generate pollution by extracting and processing raw materials into consumer goods. Some wastes (residuals) from the production process are returned to the environment (e.g. waste chemicals from petroleum refineries discharged to rivers). Similarly, households return unwanted by-products of consumption activities to the environment – to sewers, to the air or to sites receiving solid waste. The *materials balance* principle, derived from basic laws of physics regarding the conservation of matter, asserts that, over the long term, the mass of residuals discharged to the

BOX 17

THE WATER SELLERS

One does not have to be a landowner or even a farmer to benefit from irrigation. Irrigation increases employment and provides the landless with opportunities to work on farms or in upstream or downstream activities. In Bangladesh irrigation has also opened profitable new avenues for the landless by enabling them to exploit and sell water. The "water sellers" are organized with the help of PROSHIKA, one of a number of NGOs that aim to develop an irrigation service for farmers by tapping the abundant groundwater which underlies much of Bangladesh.

Fresh groundwater is a widespread resource but is usually present in small amounts, only sufficient to service household needs. However, in the great alluvial basins such as the Nile, the Indus and the Ganges-Brahmaputra, the alluvium may be 100 m or more deep and 10 or even 20 percent of its volume may be freshwater. The vast reserve of groundwater is recharged annually by floods, canal and field seepage and rainfall infiltration.

Groundwater is particularly valuable because it is available consistently and, unlike surface reservoirs, evaporation losses are minimal. Where surface canal supplies are also available, and provide a more or less constant base supply, groundwater can be used conjunctively to satisfy the peak demands of crops. In addition, groundwater is usually available close to farms and is more under the control of farmers.

In rural Bangladesh more than 50 percent of the population is landless or has less than 1.2 ha of land. Providing the poor access to productive resources such as water is clearly important. The PROSHIKA experience was based on organizing landless groups, using credit effectively to purchase mobile pumping equipment and providing a reliable service to farmers and share-tenants.

The water sellers targeted their service in areas where

environment must equal the mass of materials originally extracted from the environment to make consumption goods. The environment's importance as an assimilator of residuals is equal to its importance as a source of materials.[51]

One important policy implication of the materials balance principle is that residuals must end up somewhere, either as mass or energy. The management of discharges into

[51] For further discussion see D.W. Pearce and R.K. Turner. 1990. *Economics of natural resources and the environment,* Chapter 2. Baltimore, The Johns Hopkins University Press.

farmers had very small scattered plots of land and irrigated their fields from shallow low-cost boreholes, using portable diesel pump sets. The farmers pay the sellers in crop share, cash or, occasionally, a fixed amount in kind.

The success of the PROSHIKA mission depended primarily on access to credit (which PROSHIKA helped to organize) as well as skills training and technical support relating to agriculture, management, literacy, health and group solidarity.

The water sellers: improved water-use efficiency and equity by improving the direct access of small farmers who are usually tail-enders in other systems of irrigation; benefited from the more equitable distribution of productive assets between those with and those without landholdings; created additional employment within and outside the group as a consequence of more productive agriculture; obtained cash to buy more food and promote commercial agriculture; participated in the developing water market, which has prevented richer peasants or landlords becoming monopoly "waterlords"; and showed that the poor can be creditworthy without land as collateral.

The PROSHIKA experience is being replicated throughout Bangladesh and has many lessons that may serve for other developing countries.

Source: G.E. Wood, R. Palmer-Jones, Q.F. Ahmed, M.A.S. Mandal and S.C. Dutta. 1990. *The water sellers: a cooperative venture by the rural poor.* West Hartford, Connecticut, Kumarian Press.

watercourses must be integrated with waste disposal into the atmosphere and landfills. Reducing the amount of waste discharged into water may not solve society's overall problem if the waste is sent elsewhere, such as into the atmosphere by burning or to a land site by dumping.

There are two types of water pollution: *point source* and *non-point source*. Point source pollution refers to cases where a readily identifiable source, such as a pipe or ditch, transports the pollutant to a water body. Regulation and monitoring focus on the point of discharge. In non-point source pollution, no single source of pollutant discharge is easily identifiable but the collective effect of numerous sources results in a significant impact. Non-point pollution problems pose a difficult and costly management challenge.

Non-point pollution control options

Policy options to control non-point water pollution present special difficulties because of the great variety of sources and pollutants. The primary source of non-point pollutants is the agricultural sector. Fertilizers and pesticides are carried off the soil surface into lakes and streams or percolate into groundwater deposits. Aquifers become polluted by nitrates from fertilizer application and livestock wastes. Timber harvesting, land clearing for urban development and mining also originate non-point pollution of waters. Urban storm drainage, leakage from buried fuel tanks and subsurface and surface mining are other contributors.

Runoff from farms and forests may carry suspended solids and sediments, dissolved solids and chemicals (mineral fertilizers, particularly nitrogen and phosphorous, and pesticides). Other substances that often occur in diffuse source runoff are oxygen-demanding organic matter, petroleum products, heavy metals and faecal bacteria. Non-point source pollution is also characterized by its episodic nature. Occasional heavy rainfall or snowmelt is typically the trigger, in contrast to the more even flows of discharge from point sources. These characteristics of source type and timing imply that a variety of control technologies may be required for effective abatement.

Non-point pollution control may also be determined by the nature of human activities causing the problem. For example, the pollution resulting from a farmer's land depends not only on the rainfall patterns and the land characteristics (slope and soil texture), but on numerous prior land-use and production decisions, including choice of crops, tillage practices and pesticide and fertilizer use. The farmers' production choices are, in turn, influenced by market prices for inputs and products as well as by government price and income support programmes. In fact, pollution from the farm sector is exacerbated by government policies that make certain crops overly attractive. Successful policy interventions must change those aspects of farmers' decisions that are the source of pollutants.

Policy options for non-point pollution control are classed as *cognitive, regulatory* and *incentive-based*. Cognitive (voluntary) approaches use education, moral persuasion and technical assistance to influence the behaviour of polluters. Cognitive approaches are attractive because of their low economic and political costs. They have been tried in some countries but have had limited success. Several factors account for this; for example, private costs incurred to change land-use practices can be substantial while private gains may not be obvious. Because of the uncertain linkage between changing production decisions and improving water quality (often at distant locations), individuals have little incentive to try new approaches.

Regulatory policies call for specific actions or prohibitions against those responsible for water quality degradation. One approach is to use "design standards" that specify actions to be taken (such as a management plan for sediment control) or actions prohibited (such as certain cropping practices on highly erodible lands).[52] "Performance standards", in contrast, place limits on the rate of pollution discharge to a water body. In this case, interference with land-use practices is only in response to observed violations.[53]

Neither technique is without limitations. Design standard regulations are easier to enforce; however, they may be unnecessarily costly because their general application may impose costs on those who contribute little to the problem. Performance standards, in principle at least, focus more directly on the pollutant source but are difficult to monitor and enforce. Because an accurate measurement of discharges (particularly from small farms) is nearly impossible, disputes over actual sources of pollutants are unending.

The alternatives to regulatory policies include various incentive methods such as taxes, subsidies and emission trading policies.[54] Taxes or fees can be levied on either inputs or pollution outputs. For example, extra charges have been imposed on agricultural fertilizers in Sweden, with proceeds used to fund water quality monitoring. Higher costs are expected to reduce fertilizer application rates and, therefore, water pollution. However, taxes are unlikely to be set high enough to affect land use significantly because of the adverse effects on income.

Alternatively, charges may be levied for pollution by imposing an "effluent charge". However, the technical and administrative complexity of setting fees and linking numerous farmers precisely to the damages caused by their effluent is mind-boggling. No successful example of this type of taxation of non-point source pollution is presented in the literature.

Subsidies could encourage farmers to reduce pollution, adopt more appropriate land-use practices or make environment-friendly investments. Subsidies to prevent soil erosion (and

[52] W. Harrington, A.J. Krupnick and H.M. Peskin. 1985. Policies for non-point source pollution control. *J. Soil Water Conserv.*, 40: 27-33.

[53] G. Anderson, A. De Bossu and P. Rush. 1990. Control of agricultural pollution by regulation. *In* I.B. Braden and S.B. Lovejoy, eds. *Agriculture and water quality: international perspectives.* Boulder, Colorado, Reiner.

[54] K. Segerson. 1990. Incentive policies. *In* J.B. Braden and S.B. Lovejoy, eds. *Agriculture and water quality: international perspectives.* Boulder, Colorado-London, Reiner.

the associated productivity losses) have a long history in many countries and are the most politically attractive of the available options. In contrast to other approaches, which impose costs on the emitting source and spread benefits over the entire society, subsidy costs are spread over the general population and gains are offered to the land user. Nonetheless, paying polluters to avoid polluting activities remains objectionable to some groups. Moreover, payments may be made to individuals who would adopt proper practices anyway.

Finally, the outright purchase of water rights and/or land-use rights is another approach. For instance, a public agency could acquire rights to part or all of the polluting lands and manage them to safeguard water quality. The purchase of tropical forest lands by either public or private agencies has been undertaken to preserve first-growth forests, with water quality improvements as a side-benefit. Again, costs are borne primarily by beneficiaries rather than by the land users whose practices are actually responsible for the pollution.

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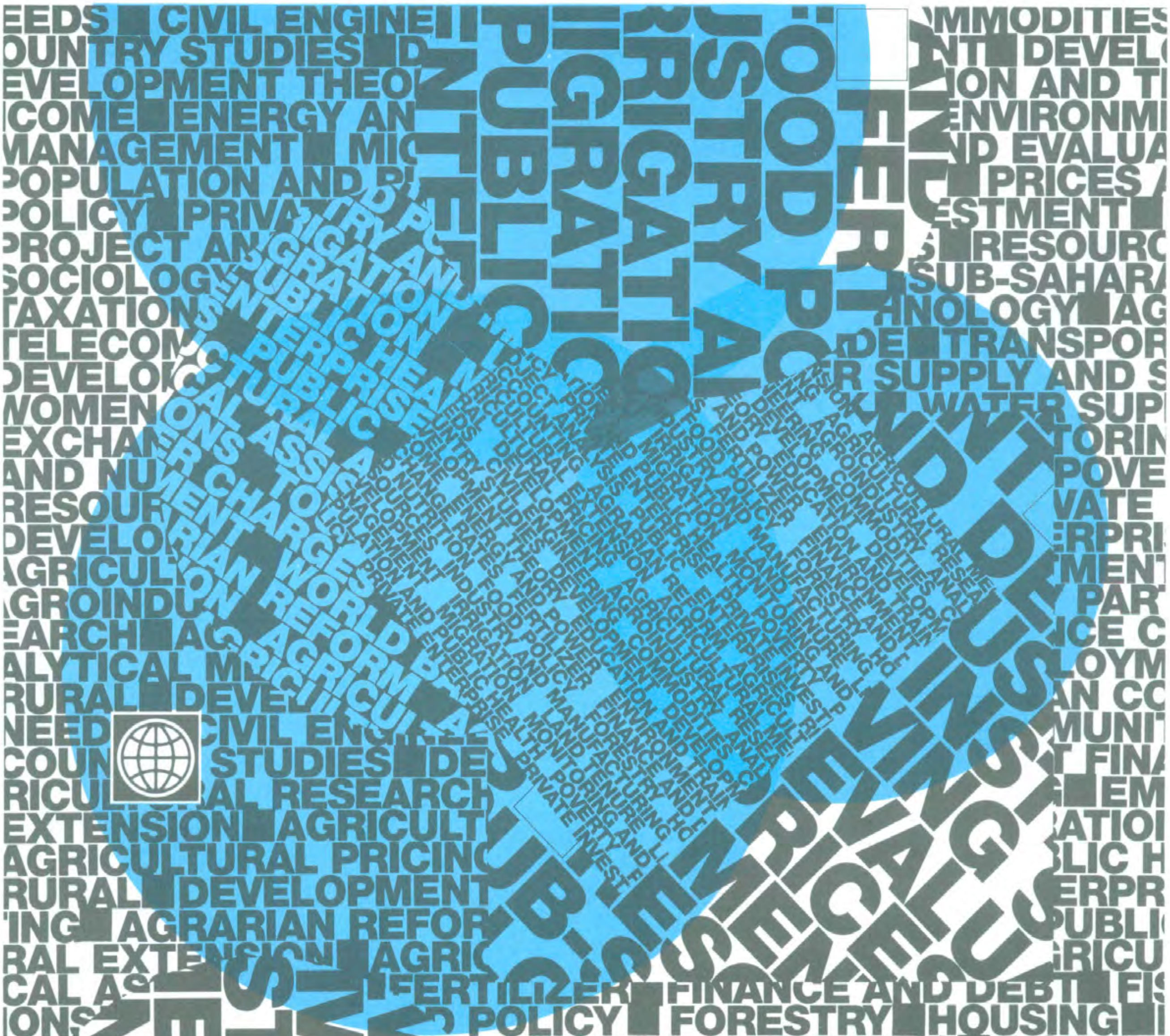

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ABSTRACT

The dominant water resources issues and the principles and practices proven effective in dealing with the issues have been placed in four categories: Institutional, long-term management and planning, real-time management and operations, and financial. Such an arrangement provides a perspective for examining issues across all economic sectors and allows formulation of solutions that will constitute a truly comprehensive, balanced approach to the situation encountered in managing these resources. The presentation reflects information gathered from various sources, most important being, a review of current successful resources management in numerous countries throughout the world that identified basic principles and best practices that apply across a range of governmental structures, cultures and physical conditions.

FOREWORD

The World Bank has been engaged in water resources development and management since its inception. Nowhere has the impact of this program been greater than in Asia. It has helped provide adequate food for the population (about 52 percent of the world's total), water for its immense urban centers and energy that both improves the people's quality of life and underpins the region's overall development. Several of the countries are emerging from conditions of extreme poverty to participate in Asia's accelerating economic growth. But the task of timely, effective development and management of water resources is far from complete.

Indeed, it is this very growth in Asia's population and economic development that has multiplied the demands on water resources. In the case of water supply today, these demands are exceeding availability in several areas. And the excess demand applies against normal runoff creating conditions for disaster under the inevitable drought conditions that will occur. These countries now confront requirements that cannot be met by additional development alone. New institutional arrangements, more sophisticated management and altered uses of water are essential to meet their needs.

The report, Water Resources Management in Asia, will serve as one of the references for formulating the type of changes that can meet this challenge. It identifies and categorizes the problems and issues from a broad perspective on water resources management. Building largely on the experiences of successful management elsewhere, alternative programs and projects are set forth within a framework of proven practices. But improvement in water resources management can only be realized if the leaders of the individual countries and participating agencies have the foresight and political will to aggressively address the most daunting issues -- many of which are very unpopular. Otherwise, reports such as this are of little value.

Annex 1 to the report, Water Resources Management in Asia, details proven principles and best practices for dealing with the primary issues encountered when instituting effective, comprehensive management of water and related resources. Its focus includes the issues set forth in the Bank's water policy paper examined in the context of the situations found in Asia, though the cited principles and practices may apply more broadly. The variation of existing institutions and cultures found among nations requires that the set of actions and the time frame for its enactment, though built upon proven principles and practices, must be tailored to each particular country. The consequences of misguided actions demands that society and its leaders carefully consider all aspects. The set of actions finally adopted must be practical and "doable" within the time and means available to the individual country.

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CONTENTS

INTRODUCTION

This report is Annex 1 of the Bank's Technical Paper No. 212, "Water Resources Management in Asia : Volume 1 - Main Report."

Every country is confronted with problems pertaining to the management of its water resources. Some of the problems have straightforward solutions, though the countries may lack funds. Most problems, however, entail issues that warrant debate yet remain undebated, and proposed policies are found to be counter to those generally professed. Common issues include the allocation of resources, mechanisms for managing resources, social equity, regional stability, poverty alleviation, the responsibilities of government and the private sector and ways to finance the costs of a given action. Indeed, issues multiply as resource constraints increase and the environmental objectives become more explicit.

Unfortunately, policy debate often commences in limited subject areas before many of the preconditions that should form the basis for the discussion have been resolved. The extent of the resources and their allocation must be established before development can be efficient, organizations can be structured or management mechanisms devised. Longer-term goals and plans are essential guides for the formulation of effective, consistent near-term plans and real-time operations. And, of course, all programs and responsibilities, including the responsibilities of the beneficiaries, must be decided before financial policies can be detailed. Thus, each issue and each proposed policy must be considered in the context of all other issues and policies. The issues and policies in the following paragraphs are presented in the general sequence in which they should be resolved, with the understanding that many policies, because they are interdependent, are formulated concurrently.

Policies may be formally stated or they may be only implicit in an agency's actions. Typically, both in developing countries and in lending agencies, internal guidelines in the water resources area are limited in scope and vague in content. Though some aspects receive considerable attention, key areas remain unaddressed or lack sufficient detail to guide staff in formulating programs. For example, although data collection may be inadequate to measure and assess environmental conditions or even to devise sound projects, no policy is enforced to remedy the situation. Proposals to address water planning and management at the basin level as a precondition to sound project planning and operation have met with indifference or outright opposition. Fortunately, this situation seems to be changing.

Some countries have evolved an extensive framework of policies and enacted measures that, in their view, are essential to manage their water resources. By contrast, others lack these and now must formulate detailed policies to address the more difficult water problems that have resulted. General policies do little but further postpone crucial decisions. Difficult as it may be and agonizing as the debate will be, developing countries must take action to better meet their responsibilities. And that requires prompt formulation of specific policies in the entire water resources sector. Similarly, some believe that assistance agencies should not set forth detailed policies to guide staff in advising borrowers on actions pertaining to water development and management. But is this sensible in light of the results of past efforts during simpler times and the conditions that must be dealt with today?

This paper presents a detailed set of Recommendations to address issues in the principal water resources management areas (and the related land resources issues) to serve as a framework for formulating and executing policies, programs and projects. These Recommendations have been distilled from a number of references. A primary source is the topic papers prepared under the Water Resources Management in Asia, which are among the references listed. These, in turn,

are founded on the experiences of countries successfully dealing with their situation. Further information may be found in those reports.

The proposals are forward looking and form a practical set that will deal with the crucial problems in a way that will best sustain development into the future. The principal issues common to many water-related problems are identified and constitute the basis used in this paper for considering water resources development policy options. The list is extensive, as each issue has been narrowly focused to facilitate debate and the formulation of unambiguous Recommendations. The issues and associated proposals are grouped in the categories selected for framing the presentation in the following chapters of this report: Institutions; Resources Planning and Long-term Management; Real-time Management of Water Resources; and Financing Aspects of Water Resources Programs. Each issue is briefly discussed followed by recommended actions. Some apparent repetition was found necessary to assure each area is addressed in a comprehensive chapter that can essentially stand alone.

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INSTITUTIONS

I. PREAMBLE

The institutional policies cover such matters as resources allocation and rights, resources monitoring, standards and regulations, government and nongovernmental roles, and organizational structure and responsibilities. The first issue is, perhaps, how the entire institutional area should be addressed. Then, the resources ownership area should be confirmed. After resource policy is set, policies on the standards and regulations for measuring compliance and for monitoring conditions can be formulated. Lastly, the policies on government/nongovernment responsibilities, organizational structure and responsibility for managing the resource can be devised. The issues and proposed policies are presented below under five groups: General; Water Resource Allocation and Rights; Standards, Regulations and Administrative Rules; Resources Monitoring and Data Compilation; and Government/Public Responsibilities. (Further details on this subject may be obtained from World Bank Technical Paper 191, "Water Resources Institutions: Some Principles and Practices.")

II. GENERAL INSTITUTIONAL ISSUE

COMPREHENSIVE MODERNIZATION OF INSTITUTIONS

People see a need for various changes in the institutional area of water resources. Those frequently cited include the contention that existing water rights should be altered; water should be priced on a different basis; operation and maintenance (O&M) of government-built systems should be shifted to beneficiaries; agencies should be decentralized and functions should be consolidated. Unfortunately, problems are frequently addressed in isolation and solutions formulated without an assessment of their impact on other aspects of water resources management. Often narrow issues are resolved on a basis of urgency largely because comprehensive institutional reform is considered to be too difficult.

It is generally agreed that the major causes of problems in the entire water resources sector stem directly from a number of institutional deficiencies and that the solution to these problems is to treat the sector in its entirety. The deficiencies are inevitably interlinked throughout the country's legislation, organizational structure, rules and procedures and the exercise of public/governmental responsibilities. Consequently, the remedy entails an all-encompassing approach. The nature of reform of water institutions demands a will to attack the situation in a coherent, comprehensive manner. There are no piece-meal or simple solutions. Though several developing countries have started to change their institutions to better meet today's demands, even they would benefit from a broader view. The first step is to formulate a framework for institutional reform to guide all activities.

Recommendation

Borrowers should initiate a comprehensive review to reform their water resources institutions, including legislation, policies, the functions and organization of government and the participation of the public and beneficiaries. A commission composed of government officials, academics and outside specialists should be created to draft a set of Recommendations and a framework for action. The Bank could assist in the exercise by examining the borrowers' water institutions and preparing detailed discussion papers with proposals for change. This would open a dialogue with the borrowers so that aspects of change could be incorporated into existing and proposed Bank lending.

III. Water Resources Ownership, Allocation and Rights Issues

Issues of water resources allocation objectives, water allocation mechanisms and water rights are often introduced interchangeably in debate. Most often, allocation mechanisms are put forth without a clear statement of national allocation objectives or an understanding of how the mechanism will, indeed, help to effect national objectives. And water rights are formulated without a clear decision on the combination of allocation mechanisms to be adopted. Care must be taken to distinguish among these. For the purpose of discussion, it is assumed that the nation owns the water resources. This is true in most developing countries.

Water Allocation Objectives

Water allocation among categories of uses involves a political decision that reflects broader social, economic, environmental and security objectives. Indeed, in every country most water is allocated directly through project authorizations by the legislative bodies -- the legislation both states the objective and serves as the allocation mechanism. Water, after all, is only one resource whose availability and cost affects broader economic growth, human well-being and the environment. Water allocation objectives may be stated in terms of general priority of use at the national level, but they are often made more specific or modified at regional or basin levels to reflect local conditions and objectives. The linkage for meeting land-use objectives is often implicit, particularly when the objective is to control pollution or meet environmental purposes.

Water allocation should support long-term goals and related investments, optimize overall benefits by mixing complementary uses, have geographical bounds that facilitate administration and be flexible enough to meet interannual variations. Water allocation should ideally incorporate a review/renewal mechanism (such as multiyear licensing) so that the changing priorities of future generations can be accommodated. The specific economic objectives -- be they directed sector development, regional strengthening, equity, poverty alleviation or efficiency of returns on unit of water -- must be decided and clearly stated so that the allocation mechanism selected is compatible with and will help to meet the adopted objectives. Water allocation mechanisms cannot be considered productively without clear, unambiguous allocation objectives firmly set forth by a country.

Recommendation

In order to address this issue, borrowers should formulate detailed allocation objectives in economic, social and environmental terms that may be readily understood by the public and can be effected through public and private actions. Explicit interdependency with land use and other resource allocations or rights should be set forth. Particular attention should be given to assure that the allocation objectives are presented in terms that allow factual evaluation of the appropriateness and effectiveness of potential allocation mechanisms.

Proportioned Allocation of All Classes of Priority Under Normal Hydrologic Conditions

Most countries set general priorities for water to meet the diversion needs of communities, industry and agriculture and the needs of various instream uses. The allocations based on these priorities will be different in periods of normal and of abnormal supply. Thus, the allocations of a given fully committed supply are shifted without question to satisfy high-priority needs as they expand. Sufficient attention, however, is not given to the effects of such resource reallocation policy under different hydrological conditions, specifically in periods of normal conditions and in periods of prolonged drought. As stated, as demands grow and exceed supply, resources are shifted to the higher priority users, permanently increasing the absolute volume of the resource upon which high priority users rely. In an extreme situation, all of a resource available in normal years is used to meet highest priority community needs. However, when large absolute volumes of a given resource available under normal conditions are committed to priority uses, severe stresses will occur during droughts on even the highest uses. There will be no cushion of low-priority supplies available to temporarily divert to the higher need. Both economic and human crises will arise, particularly in the urban areas in developing countries, where systems have little internal luxury uses that may be cut back. A more prudent management and resources allocation policy is based on meeting high-priority uses in times of prolonged droughts and allocating the excess under normal conditions to progressively lower priority uses.

Recommendation

Borrowers should take account of the possible impacts of severe droughts when allocating water resources. They should ensure that priority uses can be met under such conditions and should permit no further commitments of that type that would exceed that limit. Additionally, plans for the long-term management of the water resources should clearly define proposals for meeting priority requirements under conditions of extreme shortage. Permanent allocation of supplies among the range of priorities from the highest to the lowest under normal conditions will necessitate firm policies and enforcement of land-use and urban growth limits.

WATER ALLOCATION MECHANISMS

Countries have adopted a variety of water allocation mechanisms to attain their water allocation objectives. The most commonly applied mechanisms are designated use by legislation; riparian land ownership; rigorous priorities of use; "first-in-time, first-in-use" appropriation and a limited-period use. As noted previously, because allocation objectives change through time, allocation mechanisms also may have to change.

Currently applied mechanisms usually reflect the type and location of uses, including consumptive or nonconsumptive uses and diverted or instream uses. An allocation mechanism may simply consist of regulations that set priorities among categories of use of whatever water is available at a given time. These regulations may dedicate a proportion of water for each category of use and include more elaborate allocation mechanisms for the users within each of the categories. There may be a changing share among users as resource deficiencies occur -- long term, annually or seasonally. Although the environmental needs often do not have to compete, the mechanism for determining their allocation must be clarified.

The use of free-market mechanisms has been proposed for guiding water allocation. Conflicts with other objectives and issues of market failure and pervasive externalities, however, rule out economic efficiency pricing in almost all situations. The broad national and regional water allocation objectives cannot be simply distilled into the ability to pay. Quasi free-market mechanisms have been used in a few instances within one category of use or within one geographical area, and the application of this approach may be expected to expand particularly at the community level. But, no long proven examples of completely free-market examples of consequence are found today in either developed or developing countries. Chile enacted legislation and is now in a period of trial. Modification through court proceedings and further legislation are being made so it can better assure that other objectives are met.

"Water banking," which allows water-rights holders with stored water within a basin to exchange water during droughts, has been introduced for trials in some of the western states in the United States. The only firm exchanges are from jointly owned reservoir systems. Water is also allocated through a mechanism of a supply of "water shares" that are purchased by cities and leased back to farmers during periods of surplus. But this is carried out only within a defined rural area covered by the serving district in which all have a common interest in the economic health of the region. And, in this case, the water subject to sale is imported to the basin with explicit laws precluding third parties to gain ownership to return flows. An increasingly more common allocation mechanism is the use of limited-duration specific-use licenses that facilitate reallocation as objectives change. This system is widespread in countries with recently enacted constitutions.

In many countries, society desires to govern land use to meet various objectives, including environmental, rural economic development, poverty alleviation, agricultural production or reduction in migration to urban areas. In such situations, the water allocation mechanism will be a process of committing water to the designated land use. Most countries allocate through a combination of mechanisms that are linked both to broader non-water objectives and to the hydrologic conditions.

Recommendation

Borrowers should establish water resource allocation mechanisms that are carefully tailored to attain their national, regional and local resources allocation objectives. The mechanisms should assure transparency in meeting the allocation objectives in the social, economic and environmental areas. Administrative practicality, a means to establish the rights of the investor/user/third parties and a provision for future change should be inherent in provisions of the combined group of mechanisms.

WATER RIGHTS SYSTEMS

Most countries set forth primary water resource ownership in their constitutions and clarifying legislation. In some countries, this may be somewhat vague, particularly as it pertains to groundwater. Other countries legislate detailed provisions for type and ownership that include regulations for its administration. Some agencies in developing countries do not, however, understand the concept of rights, nor do they apply a water concept to assist in orderly water developments. Farmers dependent on a given irrigation supply lose water to farmers on newly added lands in the same project. New government projects are constructed that compete with established projects for the same resource, ignoring prior established demands. In federal countries with poorly defined water-rights systems, downstream riparian states in a basin lose supplies to established projects when upstream states divert to new uses.

National water resources allocation objectives cannot be assured, nor can practical allocation mechanisms be implemented without a system of water rights. Sound investment protection for all -- government, water utility and user -- and real-time water allocation can only be managed effectively by detailed rights assignment and the effective administration of those rights. The nature and duration of the right may, indeed, vary from permanent rights to a liberal adoption of licenses for limited duration and use. But, if rights are clarified, all can invest and act with full knowledge of resource availability, and the government can carry out its responsibilities to manage the resource.

Recommendation

To address the issue of water rights, borrowers should enact comprehensive legislation on water and land rights as they affect water use and water quality. This legislation may build upon existing laws, but it should address all aspects relative to surface water, groundwater and coastal waters; category and class of use; quantity and quality implications; priority, time and duration of use; and administrative procedures. The legislation should define the source of water; geographical restrictions on its use, including linkages to land use; limitations such as class of use (nonconsumptive versus consumptive); water quality restrictions on source and return flows; and the extent to which there is a freedom of sale or transfer of right.

INTERSTATE WATER RIGHTS AGREEMENTS IN FEDERAL GOVERNMENT SYSTEMS

In many countries with a federal system of government, the states or provinces own the water resources. A number of federal countries with this arrangement confront internal concerns that arise from or affect their long-term management of water resources. Each state may have a quite comprehensive water rights code, but the riparian states of a shared water resource may not have fully formulated rights agreements. Impending conflicts over the resources resulting from lack of agreements influence basic policy decisions and development strategies. States construct new projects, ignoring what other states have already built. The great advantages of regular data exchange and joint real-time basin water operations by riparian states are lost. No means exist for effective long-term planning and management, and the complex measures necessary to manage droughts, water quality and toxic pollution spills are not in place.

Recommendation

Borrowers should secure comprehensive interstate water rights agreements on all shared bodies of water for the purposes of data exchange, resource planning and long-term management and real-time operations under normal and emergency conditions of flood, drought and pollution spills. The agreements should provide for basic allocations and detailed real-time operations to meet quantity and quality rights.

INTERNATIONAL WATER RIGHTS AGREEMENTS

Because there are relatively few comprehensive water rights agreements on international bodies of water in the developing world, riparians are confronted by serious problems in resources allocation and cannot devise solutions with confidence. They cannot rationally commit their internal resources without knowing their share of the international resource. Sound national and regional water planning and management are impossible without information on the availability and conditions of use of all resources. Serious conflicts that exist on a number of international rivers have an impact on the economic and environmental conditions in the affected countries. Under severe drought conditions, these conflicts could extend far beyond economic considerations to issues of security.

Recommendation

Riparian borrowers should enter into comprehensive international water rights agreements on international bodies of water for purposes of data exchange; resource planning and long-term management and operations under normal and emergency conditions of flood, drought and pollution spills. The agreements should provide for basic allocations and should detail real-time operations to meet quantity and quality rights.

LAND-USE RIGHTS

Land ownership and the associated freedom of use varies from country to country. Private land ownership is common, except in some countries where it is evolving. The custom of communal land ownership and communal determination of use is also common, though the land so classified varies greatly, as do the uses. But in developed and in many developing countries, local government and the state or central governments have powers to control land use. Historically, these powers have excluded industrial and commercial developments from residential areas, provided park lands in or near urban centers, protected forests and range lands and limited urban expansion into agricultural lands. In some instances, governments have sought to retain highly productive lands in crop production.

A rapidly growing trend is to impose land-use restrictions for the purpose of water pollution control. Examples include restrictions on the application of agricultural chemicals, the density of livestock feeder/fattening operations, operation of mines, siting of industries and thermal power plants and urban configuration as affecting the quality of drainage runoff. The effectiveness of such actions has been recognized, and it has been realized that they offer one of the best available means to control major pollution sources. These resources management actions are gaining increased public support, even though they may infringe on historic ownership rights. They now constitute a basic water resources management tool.

Several countries have social and regional development objectives that require land use to support a selected level of healthy agriculture. Rain-fed agriculture is sufficient under some climatic and soil conditions, but, under others, irrigation is essential. Water is also required to support the associated agricultural processing and supply industries. Thus, again, land use may dictate water use.

Land-use restrictions can also help assure the availability of enough water to meet regional priority purposes during periods of severe water stress. As the high-priority class of uses increases as a percentage of total water available, the cushion of low-priority allocations that can be transferred to priority needs during droughts shrinks. When a region's entire water supplies are fully used by domestic users and critical industries under normal conditions, human welfare problems and economic stress will occur during shortages. An obvious solution is to retain a suitable mix of low- and high-priority uses of normal supplies to assure the flexibility to manage available water in times of drought. Thus, it is prudent to limit total high-priority water use allocation, and hence related land use, to the water supply level available under a prolonged drought. The water supplies above the critical drought quantities should be set aside and allocated to lower priority uses.

Recommendation

As a policy, borrowers should jointly evaluate water and land resources and formulate land-use objectives and land-use rights in parallel with water rights. The land-use rights should contain explicit statements concerning any reserved water rights or restrictions on surface water and groundwater use or on land uses that affect water resources management (including water-quality restrictions and floodplain reservation). The rights statements must be in terms easily understood by the public and should be easy to enforce by the appropriate agencies.

ACQUISITION OF KEY WATER DEVELOPMENT SITES

Water demands are compelling countries to construct a range of physical works to develop their remaining water resources. But the use of the sites essential to develop and efficiently manage the waters are also under conflicting pressures. The topographical and geological characteristics of the sites often makes them location specific. The costs of relocating the inhabitants from needed sites is rising dramatically, as are the political consequences of such relocations. Yet, dams and associated reservoir areas, groundwater recharge areas, water conveyance channels, flood plain reservations, drainage by-passes and routes for large pipelines are essential to water resource development and substitutions cannot readily be made. Pollution control often dictates restricted use of watersheds and lands that overlie sensitive aquifers.

The majority of potential sites for future water resources development are already known or can readily be identified. But, traditionally, sites are not acquired until projects are authorized or, much later, funded. Meanwhile, public and private investments in infrastructure, industry, urbanization or intensified agriculture expand on these sites. Acquisition costs become immense. Resettlement is proving to be a great obstacle to site acquisition, and it has become the rallying point for all that wish to halt use of a site, even if society pays dearly in funds and loss of scarce water.

Recommendation

Borrowers should identify the sites for facilities that are essential for efficient water resources management in the longer term and, to the extent possible, acquire such sites before relocation problems become unsurmountable. Acquisition alternatives include fee title and vacating the seller, fee title with leaseback to existing owners for restricted use of the land until it is needed and land-use zoning with compensation paid to existing owners for land-use restrictions.

IV. STANDARDS, REGULATIONS AND ADMINISTRATIVE RULES ISSUES

Standards, the regulations and administrative rules for their administration and the means and will to enforce them must all be in place if a nation is to manage its resources in a way that will meet its objectives. Nothing will result if any one of the three is missing. The first step is to devise the standards and then formulate the regulations and administrative rules. But often governments do not even reach this second point. The considerations in assigning the responsibilities are discussed later, in addition to the other considerations, including organizational structure.

RULES FOR ADMINISTERING WATER RIGHTS

Even when countries have detailed water-rights legislation, the regulations and rules for administering the rights may be absent or cause undue delays. In these cases, the means to obtain information from the user to facilitate monitoring are not defined, the triggering values signifying noncompliance with regulations under various conditions are not specified and the enforcement actions are not promulgated.

Recommendation

Borrowers who do not have adequate water-rights administration rules and regulations in place should prepare comprehensive rules and procedures for administering the adopted forms of rights. This will require a range of measures, including clarifying legislation, preparing manuals and educating and equipping the staff of concerned entities to carry out this regulatory function.

RULES FOR ADMINISTERING LAND-USE RIGHTS

A system of land-use rights is inherent in the land-use zoning used to control development in larger urban centers in many countries. The administration of this land-use control system normally falls under the municipal government and is part of the programs for construction and property evaluation. However, in most developing countries, the issuance and administration of land-use rights for purposes of water resources management is a vague concept. Yet, it is necessary for controlling pollution, limiting flood damage risks and managing regional supply shortages. All responsibilities of water agencies and rules and regulations for administering such a system will have to be developed.

Recommendation

Borrowers who do not have an adequate system in place to administer land-use rights should prepare comprehensive rules and regulations for administering the adopted land-use rights. A proposal should be developed jointly by the agencies responsible for land-use management and those responsible for water quality/pollution management. As in the case of water rights, this will require a range of actions that include clarifying legislation, preparing manuals and educating and equipping the staff of concerned agencies to carry out this regulatory function.

Environmental Quality Standards and Regulations and Rules for Their Administration

Environmental quality management calls for the ability to measure existing conditions and compare them with stated objectives. Water quality standards for health objectives have been adopted in all countries, though they are often found to be incomplete for purposes of management. Standards for instream flow and for meeting other environmental management objectives are often lacking in developing countries, as are the regulations for administering the standards and applying enforcement measures.

Recommendation

Borrowers should prepare comprehensive standards for measuring compliance with environmental objectives, including public health and instream water quality and quantity conditions. Water-related environmental management objectives for natural and scenic conditions should be stated in measurable terms that are understood by the public, the planners and the operators. This should be followed with regulations and rules to administer the standards, including the range of actions from clarifying legislation to preparing manuals.

Regulations and Rules for Administration of Dam Safety Standards

The assurance of the safety of large government and nongovernment-owned dams is a traditional responsibility of government. Almost all countries have enacted legislation and have adopted the general principles put forth by the International Commission on Large Dams. However, few developing countries have a comprehensive dam safety assurance program in place. Regulations may cover technical aspects, but only minimal rules, if any, exist for administering the standards.

Recommendation

In response to this issue, borrowers should prepare regulations and rules for administering their dam safety standards, stating measurable conditions of acceptability, owner reporting requirements and agency monitoring and enforcement provisions. The owner's responsibilities for failures and penalties for noncompliance should be set forth and disseminated to all owners.

Quality of Service Standards and Regulations and Rules for Their Administration

The quality of a water service greatly influences the economic possibilities for the customer or, in the case of domestic use, the well-being of the consumers. It determines the customers' satisfaction and willingness to pay. Standards for water quality and service reliability can readily be set for community water supply, and most countries have adopted standards. Pollution-control standards are less frequently set forth in the detail required, and the rules for administering the standards often do not exist. The health problems found in many countries attest to the lack of administration rules to enforce the water-supply quality and pollution control standards and regulations. Standards for irrigation delivery are rarely set forth in the detail required for the administrative of an irrigation scheme. Illegal off-takes and the "head-ender" problems demonstrate the farmers' lack of discipline and the non-existence of regulations and rules to administer most schemes. Standards for performance and the rules to enforce them are also necessary for drainage and flood control services.

Effective water-service standards and regulations, together with their fair and prompt administration, are essential if the investment benefits of physical facilities are to be realized. This applies equally to government-owned, user-group-owned and private utility operations.

Recommendation

Borrowers should establish appropriate standards and regulations for all services -- supply, waste collection and treatment, irrigation, drainage and flood control -- in the water sector, set rules for administering the service standards and regulations and provide organizations, staffing, equipment, and the legal means to carry out enforcement.

Financial and Management Standards and Regulations and Rules for Their Administration

User-owned, for-profit private utilities and local government service entities have a responsibility to customers and to their financiers for efficient management and fiscal integrity. The customers must fund the operation of the entity by paying service charges, and the owners must secure financing by borrowing from customers, the government or commercial sources. All forms of service entities can be created under appropriate legislation that includes legal provisions to be met in the management and financing of the entity. Some countries have government regulatory units that oversee fiscal activities of local government units. Strong utilities commissions, independent of line agencies, have been created to provide this regulatory function for nongovernment entities in many countries. But in many developing countries, the rules for administering the regulations concerning management of public and private service entities are not in place, or the means are not provided for their enforcement.

Recommendation

Borrowers should prepare regulations for financial and administrative management of service entities and should tailor existing legislation and regulations to fit the anticipated service and ownership forms. The rules and regulations must assure independence, coupled with strong enforcement powers. And for-profit service entities should not be considered without these in place.

V. Resources Monitoring and Data Compilation

With regard to water resources, data collection, analysis and dissemination should be a well-entrenched, smoothly functioning activity of every government. The availability, condition and use of each physical resource, together with the related history and future projections, are the foundation for decisions on major infrastructure expenditures and the country's economic policies and programs. Yet, these activities remain scattered and grossly underfunded. The mundane nature of the activities and ignorance of the true worth of sound information leaves them out of the budget allocations of finance and line ministries.

Water Resources Information

Most developing countries lack the information that is essential for the effective planning, development and management of water resources. Information on the quality and quantity of both surface water and groundwater resources is often not accurate enough to make sound allocation or operating decisions. Heavily polluted surface waters are not recognized as unusable for planned purposes. Groundwater resource availability is often not known within plus or minus 50 percent accuracy. The groundwater contamination found in countries with comprehensive data collection causes concern about conditions in developing countries where chemical usage and disposal remain uncontrolled and unmonitored. Planning for management of shortages under drought conditions is ineffective without sufficient historical data. Without sufficient and reliable data, costly planning errors and mismanagement are unavoidable, as proved by too many examples in the field.

Recommendation

Borrowers should develop comprehensive water resources data collection, processing and dissemination programs together with their related support systems. Planning, regulatory and operating agencies should use a common format to define their needs. This should include both the traditional water agencies and others, such as transportation entities. A joint effort should establish the intensity of sites, communication system, standards for data quality, verification procedures, reports content and frequency. The respective responsibilities of the federal, state and project agencies should be clarified and data sharing should be spelled out. Information should be readily accessible to the public.

CLIMATE AND WEATHER INFORMATION

Water resources management under normal and emergency conditions requires comprehensive weather forecasting and real-time information. Relatively few developing countries have adequate systems for flood forecasting, though population increases on flood-prone lands place proportionately more people at risk. Day-to-day operation of large reservoirs and irrigation schemes during wet season require weather information. The four-month advance forecasting in the southeast Asia monsoon region now under trial offers significant opportunities for improved scheduling of irrigation crops in the affected areas. Newly developed procedures allow near-term drought conditions to be forecast through the use of weather forecasts, past and present regional soil moisture measurements and local stream flow information. This capability is particularly important as countries approach full development of their available water resources. Currently, a few individual schemes are investing in programs and equipment to provide forecasting information, but they are isolated and have little real-time coordination with others.

Recommendation

Borrowers should develop comprehensive programs to collect, process, and analyze weather and related information. Services for forecasting near-term climate, weather and stream flow should be considered. A central unit should have responsibility both for the scope and quality of the program and for its operation. The program should incorporate the existing data collection and forecasting efforts of operating agencies, though such agencies may continue to collect information to the extent dictated by their individual needs. In addition to federal and state agencies, linkages with neighbor countries' programs should be devised. The World Meteorology Organization offers considerable assistance in these matters.

LAND CAPABILITY INFORMATION

Proper implementation of water resources investigation, planning and management activities requires reliable information on land capability, as opposed to that on present land use. Project performance reports repeatedly identify serious deficiencies in land capability decisions resulting from lack of information and from the substitution of poor assumptions for facts. Information on land capability and environmental restrictions on its use are needed to decide about long-term water commitments. Lacking detailed land capability information, water commitments and expenditures are made without sound evaluation of alternative water uses. Lands that can produce under rainfed conditions may receive the basin's remaining supply for irrigation, while lands that require water for acceptable production levels are shorted.

Recommendation

Borrowers should complete a land capability assessment program with the least possible delay. This information should indicate possible alternative uses and limitations, without comment as to preferred use. Present land-capability programs should be consolidated under one central (or state) unit to take best advantage of current technology and trained staff. Broader Geographic Information Systems (GIS) capabilities and the need for information on economic development and environmental protection as they relate to water allocation and management should be reflected in the programs.

Land-use Information

Land use is a primary determinant of water use and water quality. The activities in every area of a basin (including the lands in natural vegetation, the agricultural lands, the urban areas and the mines) must be described in terms of the basin plans to make timely land-use and water management decisions. This is of obvious importance in environmental monitoring programs. Pollution of surface water supplies and groundwater resources can only be addressed with knowledge of present use and land-use trends, coupled with water quality measurements. Yet, many borrowers lack land-use information and their databases are inadequate to monitor changes in use or to enforce land-use regulations for pollution control purposes.

Recommendation

Borrowers should establish land-use monitoring programs tailored to their planning, monitoring and management programs. Although actual land use should be presented without interpretation as to preferred use or potential use, it would be helpful to display any current land-use zoning for reference. Present monitoring programs should be consolidated under one central (or state) unit to take best advantage of current GIS technology. The program should not collect information specifically for the purposes of land tax assessment or similar activities, though this recommended data collection program may serve as sources of basic information to these and other agencies.

VI. Issues Relating to Government/Public Water Management Responsibilities and Organization

Several issues arise when discussing government and public responsibilities and the organizational structure to carry out the responsibilities. Such discussion requires consideration of the linkages among the various physical factors to be managed, appreciation of basic principles for assigning responsibilities, and consideration of proven structures that are most suitable for given forms of government and the magnitude of the assignments.

Linkage Between Water and Land-use Management

Water and land-use interrelationships are inherent in resources development and management. Urban and industrial developments depend on assured water supplies of defined quality. Irrigation requires both land and water with suitable characteristics. Essentially all economic activities require certain quantities of both resources. The water-quality impacts of urban, industrial and intensive agricultural land use are now becoming a dominant concern in managing surface water and groundwater resources. Land-use controls are an essential means to control pollution and to protect scenic and ecological resources, all inevitably entailing water commitments. Yet, governments continue to address these two resources in an uncoordinated manner under separate programs. Water-use issues are addressed without consideration of the impacts of land use, and much of the water allocation debate ignores the objectives of land use. Some agencies intentionally use water allocation to affect local land use as they judge wise, instead of addressing both land and water use together in considering the broader ramifications of the proposed action. The severe restrictions placed on drought management that result when all water available under normal conditions is used for high-priority purposes is not recognized. Without the flexibility to divert water from low-priority land uses (such as field crop irrigation) to critical uses in periods of drought, large urban areas face dire choices, as has been mentioned. And without farm land set aside near urban areas, waste water reuse may be infeasible. The physical configuration and location of wastewater collection and disposal system when designed in isolation often preclude the use of recycled wastewater for irrigation.

Recommendation

Borrowers should fully integrate all water use and land use in their planning and regulatory functions and, as appropriate, in their management and operations functions. This would entail defining water and land-use objectives jointly; preparing local and regional plans that reflect the defined water needs (consumptive, nonconsumptive and quality) of the land uses, the waste generation by the land use and the available means for managing the wastes; and identifying the regulatory controls and enforcement requirements of the water and land-use plans. The government should hold operating entities -- government and nongovernment -- responsible for complying with both resource plans and standards.

Linkage Between Quantity and Quality in Water Management

Effective water management requires that water quality and quantity be dealt with conjunctively. The options for use of a given water source depend on its quality and the maintenance of that quality. In turn, the specific use of a water source determines the quality of return flows, and, hence, the potential for subsequent use. The quantity of instream flow required to meet quality objectives is dictated in large part by the waste discharges that must be diluted. If water management does not focus on this aspect, the potential for toxic waste entering prime water supplies arises. Yet, governments commonly assign responsibilities for planning, management and operations affecting water quantity to units separate from those responsible for the water-quality management (not regulatory) functions. The cost tradeoffs between pollution control and water-supply treatment in the same watershed are not evaluated. National investment policies and programs do not reflect the interrelationship between water quality and quantity.

Recommendation

Borrowers should be encouraged to consolidate responsibilities for water quality and quantity management within the same functional units in the areas of planning, operations/services and regulation, particularly in the case of water supply and waste-treatment services. Specifically, planning should provide for allocating water sources and identifying the beneficial uses of returns. The operating functions should be combined in the local "utility" and in any governmental agency that provides wholesale services to local entities. Enforcement of supply allocations should be linked to compliance with the quality requirements of return flows.

Linkage Between Surface and Groundwater Management

Conjunctive planning, management and regulation of surface water and groundwater is rarely undertaken. The common separation of responsibilities for these two water resources gives rise to overly optimistic estimates of resource availability, conflicting exploitation projects, ineffective control of groundwater buildup and inefficient investments. Groundwater reserves can be extracted to meet annual demands or managed for drought needs. Some water service agencies have active programs for water recharge, now of greater interest as suitable dam sites are lost. Through proper management, irrigation entities save money and add operational flexibility by recovering percolation losses rather than by funding costly preventative measures that yield less water. Nevertheless, countries continue to ignore the large operational benefits from conjunctive management of these resources.

Recommendation

Borrowers should consolidate responsibilities for surface-water and groundwater development and management in the same functional units in the areas of planning, operations/services for supply and regulation, with emphasis on the principle of conjunctively managing these resources at all levels. Though treated briefly here, this important principle can yield large benefits.

Linkage of Service Agency Jurisdiction and Civil Administrative Boundaries

Political and hydrologic boundary inconsistencies present few obstacles to broad planning, data collection and regulatory functions, though this may not be the case at the local level where more detailed attention and actions are involved. However, if service agency jurisdiction violates the hydrologic boundaries at the operational levels of water distribution, drainage and flood protection schemes, substantial difficulties can arise. This most commonly happens when irrigation services from one system are the responsibility of several local civil governments with jurisdictional boundaries different from the water systems. When this occurs, the most fundamental function for ensuring sustainability, O&M, suffers. Sound O&M, with the essential participation of farmers, dictates that customers and service beneficiaries of a given scheme should be included within one unit covering the involved hydrologic area

Recommendation

Borrowers should reorganize service entities as necessary to match the hydrologic bounds of the scheme. Where schemes overlap into two jurisdictions, and thus reorganization is precluded, single-purpose service utilities jointly directed by the two jurisdictions will prove best. Otherwise, uniformity in O&M will be difficult to attain. This would apply to all water supply, distribution, drainage and flood control projects.

Separation of Line Agency Functions

Planning, design, construction and O&M are the four primary line agency functions in the water sector. Comprehensive data collection and dissemination may be separately managed as a fifth function, but if it is not independent, this function is usually attached to a planning or resources regulatory entity. The most effective governments are organized with specialized units in each functional area in order to attain specialization and performance accountability. The level of government expertise and the quality of governmental programs depends on this principle and the associated personnel policies of staff selection, performance review, retention and promotion. However, some governments still have all-purpose units that handle several different functions and, shift staff between assignments as work demands dictate. Under this system, a central body of expertise is not developed, and program continuity, currency with evolving technology, maintenance of performance quality and agency accountability are sacrificed.

Recommendation

Borrowers should assure functional focus in the organizational structure of their government line agencies to attain high technical capability, quality control of work and accountability for results. Comprehensive, formal review and transfer procedures should be followed with documentation as programs pass from planning, to design, to construction, and finally to O&M. Staff tenure, training, performance, promotion and compensation policies should encourage retention of capable, experienced personnel in the respective functional units.

Separation of Service Operations from Regulatory Functions

Many government organizational structures do not separate responsibilities for providing services from responsibilities for regulating actions pertaining to the services. In these cases, because government water-service agencies independently determine the allocation of water among their projects, overcommitments and overconstruction result. Some water-supply agencies have responsibilities for enforcing water-quality standards for their own supply services. Some industrial ministries that have power to promote industrial development, regulate industrial land use and sometimes even industrial waste disposal. Owners of major water facilities are often the sole judges of the safety and adequacy of the maintenance of their facilities. No one monitors the business and financial performance of governmental service units. And regulatory environmental protection activities are sometimes incorporated into the functions of water using agencies.

Recommendation

Borrowers should clearly separate responsibilities for the service functions from those for regulatory functions. This is one of the most important principles of effective management and quality assurance. It applies to all areas: Water rights, safety of structures, water quality, water use, business and financial integrity and customer participation. Regulatory units should report to the senior levels independently of the service units that they regulate and should be directed at the national or state level by an independent central office that reports directly to a minister.

Definition of Functions and Responsibilities in the Environmental Area

Regulatory and operational responsibilities are frequently intermixed in the environmental area. One serious institutional complication in effectively addressing environmental problems and issues lies in the definitions used today for environmental activities. Population growth is the major cause of environmental degradation, yet it is not placed under the jurisdiction of environmental units. Similarly, activities such as urban waste treatment, land drainage, watershed protection and groundwater management are better called by their original descriptive terms than classified as environmental activities. Activities relating to relocating people from lands required for major works should not be linked with environmental activities. They are separate problems and should be treated as such in organizing government agencies and assigning expertise. The institutional arrangements and responsibilities to set criteria and standards, monitor conditions, introduce improved operational procedures, enforce regulations and execute remedial programs that affect, and always have affected, the environment can then be set forth in these terms. The assignments can follow the principle of separating the execution from the regulatory functions. The government's directly labeled "environmental" functions should constitute Recommendations on standards (enacted by legislation), and the associated regulatory, monitoring and enforcement actions. The importance of sound environmental management in the water field, together with effective institutional development of water resources, dictates the need for care in defining areas of responsibility for achieving these aims.

Recommendation

Borrowers should clearly separate responsibilities for the service/operations functions from those for the regulatory functions in the environmental area. They should exercise particular care to define and assign actions in the traditional fields to the line agencies that have the involved expertise and means. The environmental regulatory functions should reside in regulatory units directed by a central office at the national or state level that reports to the ministerial level. Line service agencies, private entities and individuals directly concerned must be responsible for physical actions that affect the environment, including utilization, protection, mitigation and enhancement programs. These parties should be held accountable for complying with the environmental standards and regulations in their routine work, and the environmental regulatory units should be responsible for monitoring government and private-sector activities and the enforcement of the established regulations and standards.

PUBLIC PARTICIPATION IN ADVICE AND OVERSIGHT

In many developed countries, individuals outside government traditionally have advice and oversight roles in the water resources sector. Beneficiaries who serve on agency boards, experts who serve on technical committees and public figures who serve on policy and oversight commissions provide timely inputs to decisions from an outside perspective. Such participation is particularly effective with regard to environmental, regulatory and resources allocation issues. An important result is greater public understanding and support of all government actions. This is often essential for instituting major changes. For example, the public will more readily accept drastic measures inherent in drought plans if the need for such plans is overseen by a citizens' panel and fully understood by the public. This institutional principle is not followed in most developing countries. Political leaders may be wary of public participation and direct influence. Bureaucracies oppose sharing management decisions or being subject to oversight. The public may lack information. But the growing importance of public opinion and nongovernmental organizations activities must be recognized and accommodated, and direct participation in decisionmaking from those outside government will be productive for everyone.

Recommendation

Borrowers should institute actions to secure the participation of nongovernment individuals in appropriate advisory and oversight capacities on agency boards, technical committees and commissions in the policy areas. Material should be prepared that describes the typical use of such entities in water resources planning, management and regulation, including the environmental area. Agencies should make all staff aware of the purpose, nature and effectiveness of such programs. Support of public information programs and limited workshops is a beginning. The latter should include construction of permanent informational features in major facilities.

WATER SERVICES AS UTILITIES

The easily identified water services include community water supply and waste disposal. In many countries, these are operated as utilities that provide a well-defined service to the customer. They own assets, conduct O&M, procure new facilities and equipment, finance capital improvements and charge for services. Where the beneficiary organization owns the system, the management board is constituted of users. Where the utility is privately owned for profit, management has a corporate form. Where a unit of government (usually at the local level) functions as an independent service utility, management, staffing, budgeting and accounting are carefully isolated from the parent government organization. The "utilities form of organization" also is common in irrigation, drainage and flood control in developed countries. The utility form of service entity, when made properly accountable, assures greatest operational efficiency, accountability for quality of services to the beneficiaries and through cost recovery from the beneficiaries, financial self-sufficiency.

The water services entities in the urban areas of many developing countries have, to a varying extent, the form of a utility, but budgeting and receipts often are not isolated from general government operations and subsidies cloud the financial situation. The organizational forms of irrigation services vary. Those directly funded and constructed by governments typically remain government operations, characterized by high subsidies and minimal accountability. Yet, those financed and constructed by farmers are operated under all the principles of an independent utility with no expense to government. Drainage and flood-control facilities are always managed as government operations (without cost recovery) in developing countries and, as a consequence, many are not satisfactorily operated or maintained.

Recommendation

Borrowers should structure all water service entities as independent, financially self-sufficient utilities with rigid management, programing, budgeting, financing and public accountability. This is another institutional principle that is key to effective, affordable water resources management. All government services should be performed by such units, managed and funded independently as a subunit of the parent agency. Local government entities should be responsible to the customers through their elected representatives or appropriate oversight bodies. Any subsidies to these entities should be transparent to the public. Government irrigation and drainage schemes should be turned over to farmer owned utilities under an ongoing program. However, no utilities should engage in other support or non-water service activities.

Assigning Line Agency Functional Responsibilities

Governments' success in meeting their responsibilities depends on their matching the required technical capability to the tasks best carried out at each level -- central, state, local and scheme. This is not a simple structuring of government agencies. It requires carefully assessing ongoing work in the various functional areas, locating the capability at the level demanded by the tasks and participants and supporting the unit by appropriate procedures, personnel policies and communications capability.

As project complexity has grown, governments have replaced the early regional all-purpose public works units that covered all aspects of water development and management with specialized central agencies . The central public works agencies typically carried out planning and design and dispatched its staff to execute the works. The subsequent O&M (a permanent local effort) often became orphans of the agencies. Regulatory activities were limited to water diversions and elementary drinking water standards. In many countries, program evaluation, task assignment and agency structuring has progressed no further. Available individuals are rotated through positions in whatever functional area is open, precluding the attainment of a satisfactory level of management.

As discussed earlier, functional areas require specialization. Several different functions should not be lumped in one unit. In the same way, a functional unit's location within the governmental levels is a critical consideration when assigning the functional activity. It is recognized that certain technical skills can only be sustained in small central units, that sound quality control demands a central technical review and that balanced programming requires a central budget review. These points must be satisfied. But excessively centralized direction can frustrate local input and jeopardize tailoring the program to the conditions. Experience shows that the nearer the agencies' responsibilities are assigned to the beneficiaries, the greater the probability of success. This may be partially aided by active local participation with the agency, if possible. Today, transport and communications remove many past constraints, including that of technical capacity, to assigning responsibilities at whatever location best suits the most advantageous of the available choices.

Recommendation

Borrowers should assign line responsibilities to units of government at the lowest level at which high quality work can be attained, balanced with the need to interact with the public. The policies and procedures to assure specialization and necessary capability should be spelled out in detail. But reporting lines and staffing must assure central/state review for quality assurance and central/state coordination for programing and budgeting. This is an iterative process that examines near-term and long-term workload, required expertise, proper utilization of consultants to augment permanent staff, location of work, role of beneficiaries and the communications network. External oversight mechanisms should be introduced where matters are of public concern.

ASSIGNING WATER RESOURCE'S PLANNING RESPONSIBILITIES

Water resources planning should be assigned to the level of government appropriate to the purpose of the plan and the decisions to be made. The degree of planning detail depends on the maturity of the resources development and the management mechanisms adopted by the government. Water and land-use framework planning should be conducted at the level at which resource ownership resides and allocation is made. And this should be reflected in national, state and basin plans. Line agencies and service entities must plan in the detail required for the long-term development and scheduling of their project-specific programs.

Unfortunately, many aspects of water resources planning are often scattered, with only minimal coordination, among government agencies. Too often, the planning is incomplete and narrowly focused. The relative powers of the agency doing the planning determine the priorities. Some countries have national plans, but these also often suffer from the dominant-agency syndrome. Some plans are one-time efforts by consultants and are often produced with limited budgets, inadequate dialog with government leaders and insufficient data. Consequently, they soon reside on a back shelf, are not updated and become of little use.

Recommendation

Borrowers should create small permanent national or state water and land-use planning units, preferably located within the economic planning or budgeting/financing agencies to help maintain impartiality. These units should have two roles: to maintain the document-reflecting decisions and to offer advice to the legislative body and policymakers on the consequences of proposed actions or lack thereof. Line agencies with development responsibilities should be assigned responsibility for detailed project planning in their respective geographical and subject areas of responsibility. Review/approval mechanisms must assure compliance with the framework plans.

ASSIGNING WATER SERVICE FUNCTIONS TO BENEFICIARY ENTITIES

Local government service units or nongovernmental entities can provide most water services more efficiently than can central or state government agencies. Three of the more common services to which this applies are municipal water supply, waste collection and treatment and irrigation distribution. Agricultural drainage has long been a responsibility of local entities in many countries. Flood control is often assigned to a local government agency with a user entity in charge of O&M. Yet, government agencies in many countries procrastinate about relinquishing control.

In most developing countries, the government assumes O&M responsibility for all government built irrigation and drainage facilities, in many cases down to the level of ten or twenty beneficiaries. Beneficiaries have come to expect that government also will maintain the facilities and that they need contribute little or nothing in service charges or labor. Since they have made no capital investment and pay little for O&M, the beneficiaries have no concern for the condition of the facilities. The result is vandalism and service interference. By contrast, on farmer-owned schemes, the systems perform well, customers are disciplined, and all costs are covered by the beneficiaries. Though arguments are made to the contrary, similar farmer behavior should be attained on government schemes. Because O&M on government schemes must be seen by the beneficiaries to be in their interest, beneficiaries should participate in construction and O&M decisions and funding.

Thus, line agencies should recognize that for several reasons they will have to relinquish O&M and financing responsibilities for services to beneficiaries as performance and financing advantages become evident. Indeed, government budget constraints will force transfers. And moving O&M to the beneficiary-owner will assure that these budgets receive priority from the immediate owners and do not have to compete with other government programs, many of which are subject to political whims. The transfer will usually require beneficiaries to organize as a public corporation which has adequate taxing and jurisdictional powers. Private for-profit water service entities are being promoted in a few countries. But as they require a strong, unbiased, independent government regulatory unit, their early consideration is precluded in most developing countries.

The government should actively engage beneficiaries in rehabilitation and O&M decisions that affect them on both turnover and government-retained facilities. Beneficiaries should pay at least 20 percent of rehabilitation costs on facilities turned over and full O&M costs on government facilities not transferred. A permanent program of internal staff orientation and beneficiary contact should support these efforts.

Recommendation

To facilitate orderly turnover, borrowers should assist beneficiaries to form local government or nongovernment water service entities as part of a comprehensive program to turn over existing facilities, once they have been rehabilitated, and new facilities. Each entity should incorporate the principles of a utility with self-reliant management and financing without government intervention or assistance. Legislation that complicates creation of service entities in the water sector must be modified. The program would include the turnover of individual schemes to individual entities and of bulk supply facilities to a federation of user entities. The guiding policies and the implementation program measures should address scope of service, jurisdiction, facilities ownership, beneficiary contribution to facilities' costs, membership, administration, O&M, cost recovery, financing replacement and government oversight.

Assigning Regulatory Functions

When the standards and regulations have been enacted, the assignment of the regulatory function and the capability of the regulatory units determine the regulatory contribution to meeting the resources management and environmental quality objectives. Typical areas for regulatory action are water quantity and quality, other environmental attributes affected by water, structural safety and fiscal accountability of service agencies. Central government, and state governments in federal systems, must issue explanatory materials on the standards and regulations for the activities related to the resources that they own. They must also assure compliance with the regulations. But the responsibilities for the enforcement of regulations must be separated from the user entities, while the responsibility for compliance with regulations is assigned to the operating entities. The regulatory function is weak in most developing countries. Enforcement assignments are often given to the user agencies, and many regulatory actions are not established or are rarely and unevenly enforced.

Recommendation

Borrowers should assign the regulatory functions to the appropriate levels of government in accordance with the principle of separating user agencies from regulation enforcement responsibilities. The monitoring and enforcement of all water quantity and quality regulations and of environmental regulations should be assigned at the government level of resource ownership. (In federal countries, central government may have over-riding jurisdiction in some respects.) Administrative and financial monitoring should be assigned to the level of government responsible for entity formation and registration -- often the "interior" ministry. Where public health is involved, government public health or environmental protection agencies should administer standards. Standards for irrigation projects can be effectively administered through local operator/customer agreements, with oversight by a central O&M office in the case of government projects.

ASSIGNING DATA COLLECTION FUNCTIONS

The inadequacy of the available information for water planning and management stems in part from the dispersed assignment of responsibilities for data collection. Typically, the water development agencies collect only that amount of information necessary for formulating a project and terminate much of the data collection program upon completion of the study. The quality of information suffers because inexperienced personnel conduct such temporary efforts. Records are lost or are not processed for storage, and other entities, which may need the information, do not know of the records or have access to the files. Unless comprehensive information is collected, processed and made available promptly, sound resources management is impossible.

Recommendation

Borrowers should assign basic resources information collection, processing and dissemination, if not the actual execution of these activities, to a center or state unit with powers to set data collection standards and to review all data collection programs to assure the quality of the information. Users of the information should be free to stipulate the nature of the information they require. A central unit, in coordination with all line and regulatory units, should have responsibility for the scope and quality of the entire program. Although operating entities may augment the collection to meet their needs, the information they collect that is useful to others should be readily incorporated into the central system. Information should be made available promptly to all potential users, including resources planning agencies, water supply agencies, regulatory (including environmental) agencies and the public.

RESOURCES PLANNING AND LONG-TERM MANAGEMENT

I. PREAMBLE

The policies and principles for resources planning and long-term management guide the longer term programs and projects in each country's water sector. The issues and proposed policies and principles are presented under six groups: (i) Water Resources Development Goals, Objectives and Policies; (ii) Planning and Management Considerations; (iii) Framework for Long-Term Planning and Management; and (iv) Planning Criteria and Methodology.

II. WATER RESOURCES DEVELOPMENT GOALS, OBJECTIVES AND POLICIES

Many countries do not have well articulated goals, objectives and policies to guide long-term resources development and management. Aspects of this concerning water allocation were noted earlier. Local and regional programs and projects often have a single purpose, which may be inconsistent with national objectives. Many water resources programs of parallel line agencies at the same level of government have uncoordinated and even conflicting goals and objectives. Environmental objectives are not defined in the detail that is necessary to guide project planners. Overall resource allocations and commitments in support of investment decisions cannot be formulated with confidence.

RECOMMENDATION

Countries should develop a set of comprehensive goals, objectives and policies pertaining to long-term water resources development. These should be detailed in the fields of: (i) Social well-being, (ii) environmental quality, (iii) national economic development and (iv) regional economic development. The goals would define the broad aspirations, the objectives would describe in measurable terms what is to be accomplished, and the policies would guide actions to meet the objectives. This set of policies would not address organizational or physical aspects of management, but would focus entirely on meeting the objectives contained within the water management goals.

III. PLANNING AND MANAGEMENT CONSIDERATIONS

TIME HORIZON FOR PLANNING AND MANAGEMENT

Different time horizons are appropriate for different levels of water resources planning and management. The period required to formulate and execute a major resources development action dictates that increasingly longer time horizons be reflected in the decisions. The gestation period of major infrastructure developments and the impact of population growth on all decisions today warrant committing to a period of time at least equal to the useful life of the largest commitments. Many countries, even those with minimal population growth, use a fifty-year time horizon for national planning, long-term resources development and related major project formulation.

Unfortunately, many developing countries do not apply consistent criteria for selecting the time horizons used in configuring projects. The time horizons are rarely defined within a comprehensive forty- to fifty-year basin plan. Indeed, many projects are formulated with complete indifference to existing commitments or to major future demands of a higher priority on the involved resources. Project justification may use a thirty-year payout, after completion, when even a cursory analysis demonstrates that the dedicated resources will have to be diverted to other purposes long before that time has passed. And such documents do not describe and estimate the costs of the actions necessary to meet conflicting demands fifty years ahead, or the social and economic consequences of failing to take such actions. Financing needs, demands on future government budgets and the role of the resource users are ignored in both long- and short-term programming and budgeting even though the sustainability of investments depends on large financial commitments.

Recommendation

Countries should formulate a comprehensive set of criteria defining time horizons and their specific application in water resources planning and management. A minimum fifty-year horizon should be used in all national planning and basin planning and in long-term government programing. The criteria also should set the time horizons to be applied when considering matters such as socioeconomic and demographic projections, economic activities affected by the plan, projects that are components of the plan, and financial considerations to be incorporated in the planning efforts.

Resources Allowance for the Future

Water resources allocation for the future is not a pressing concern where the resources are ample for present and foreseeable future needs. However, it becomes a primary consideration as countries approach the limits of their resources, particularly when the magnitude of the resources are not accurately known. Moreover, the uncertainty of demand projections, the deteriorating quality of resources that limit their use, and the impossibility of forecasting the nature of droughts in terms of extents of shortfall and duration require a safety margin in committing the country's waters. The greater the uncertainty of these factors, the greater should be the resource allowance to cover the uncertainty, and the magnitude of the allowance will influence decisions on the nature of near-term commitments

Recommendation

Countries should provide a resources allowance for the future that is proportionate to the factors bearing on the possible variability of the supply and the potential demands on it, noting the consideration used for each factor and how they are cumulated in the allowance. Sound risk analysis and sensitivity analysis should be applied to all factors to provide guidance and information both to the political bodies and to the responsible agency officials. Absolute set aside and the schedule for conversion of lower priority uses to higher priority uses should be clearly defined in a document for use in planning and management.

Multipurpose Projects and Programs

Multipurpose projects and programs offer immense opportunities and are essential to efficient water management. Irrigation, power and community water supply projects, however, are too often formulated and operated by single purpose agencies under restricted charters (and would be a risk with for-profit entities). Some of these agencies are fearful of involving the other services because they may lose control of "their" project or have it altered. Nevertheless, increasing populations and tightening water situations in many areas force irrigation systems to function as water suppliers that also serve community and other priority customers. Energy demands and environmental objectives favor installation of hydropower facilities on all conveyance and storage facilities that have any significant head drops. Treated wastewater disposal, joined with irrigation or groundwater recharge, conserves resources. Such multipurpose uses of projects should be primary objectives in planning.

Recommendation

Borrowers should pursue national and basin planning to meet the national objectives from a truly comprehensive, multidisciplinary perspective that reflects cost-and-benefit allocations among purposes in selecting the most advantageous undertaking. Agency purposes should be satisfied within this broader framework.

COMBINED WATER AND LAND-USE PLANNING

Some countries are acting to combine aspects of water and land use in planning and management. As noted, the best use of each resource demands that it be viewed and treated as interdependent rather than in isolation or recognizing its dependency only in the obvious situations. There is no alternative to planning jointly with these resources, a principle that must be formally recognized in every functional agency and program in government. More narrowly, cost savings with less disruption to the area can be realized in locating facilities, particularly joint transportation and conveyance corridors in congested areas.

Recommendation

Borrowers should explicitly address water and land-use jointly in formulating plans for long-term management of water resources, and should specifically reflect this in the resulting programs and projects. Statements should describe the linkages between these two resources as reflected in individual policies and programs.

PROGRAM AND PROJECT FLEXIBILITY

Some project objectives may be met by alternative facilities and some facilities can be configured to allow flexibility in their later operation. Water-storage capacity is fixed by construction, but some facilities may be designed to leave expansion options for future decision-makers. Lowering outlets to drain reserves during emergencies, designing conveyance and storage features to accommodate hydropower equipment, assuring capacity to serve future community water demands from irrigation canals and establishing groundwater regulations that allow shifting uses are examples of conscious planning decisions that provide flexibility for future generations. Another sound long-term planning and management action is to set aside rights-of-way for future conveyance facilities, particularly for supply and drainage. In spite of the benefits of adopting site acquisitions and project configurations that allow flexibility to deal with future uncertainties, many agencies plan only for the immediate and often narrow purpose.

Recommendation

Borrowers should adopt formal policies and procedures to seek maximum flexibility in all plans. Cross-sectorial review among the economic and infrastructure agencies should become established procedures. These procedures should assure comprehensive examination of proposed programs and projects in order to identify measures that give options to future generations. In particular, the cost of precluding future options should be explicitly set forth.

LARGE VERSUS SMALL STORAGE PROJECT

Much has been written and many seemingly unyielding positions have evolved in the debate about large versus small storage projects for developing and managing water resources. However, long-term planning of water resources development must consider all means available to best meet a country's development objectives. For flood control and significant seasonal and multiyear carry-over storage, large capacities are needed, and they must be where the water can be captured. Without doubt, enormous cost and land savings result from creating storage in a few large reservoirs rather than numerous small reservoirs. If large facilities are the best means to meet a future need, then they must be scheduled in the planning to be operational when the need arises. Delays in resolving this issue or arbitrary completion of all small projects before starting the large ones can seriously compromise future supplies and the related human and economic health of the nation.

Recommendation

Borrowers should fully examine all surface water storage options, both large and small, in their long-term planning process and should select the options that both best fit their goals and objectives in water resources development and meet long-term demands on the resources. This effort should include the necessary scheduling of works to deliver water in a timely manner to meet the needs of the population and projected economic growth.

IV. Framework for Long-term Planning and Management

National or State Water and Land-use Master Plans

Lack of a national or state level water plan is not a critical shortcoming when water is plentiful. But, as resource limits are approached and pollution control and other environmental objectives impose new demands, comprehensive national or state plans become essential. For the objectives of meeting water demands for domestic, industrial and agricultural purposes and for flood damage prevention, land-use zoning and budget allocations must be viewed from the national perspective and for extended periods into the future.

The national or state water plan should not be greatly detailed, but it should accurately forecast demographic, economic and social changes and relate these to projections of water quantity and quality needs. It should record the conditions of current resources and commitments against them, and should be updated as changes occur and new commitments are adopted. It should not be an advocacy document, but rather it should document the nation's decisions, and it should permit all to visualize present and future conditions and the impact of contemplated decisions. The plan should form the basis for assessing basic policy and reevaluating objectives.

Recommendation

Borrowers should prepare and maintain comprehensive national or state water and land-use plans to serve as the government's framework for its long-term planning and management. The status of these plans should be such that they guide enforcement of other actions. Changes should be incorporated as they occur and an updated document should be issued at least every five years.

Basin Plans

Basin plans form the basis for allocating the specific water and land resources and for verifying the compatibility of long-term programs and projects with conditions within a hydrologic system. Few developing countries prepare such plans in sufficient detail, and thus they undertake programs and projects with no guiding framework. Even such obvious benefits as use of return flows, conjunctive use of surface and groundwater and reuse of wastewater are forfeited. A basin plan should be a comprehensive document detailing the availability of water and the conditions for its use by government and private entities. Real-time water quality and quantity management and operations can only be coordinated within an adopted framework for the hydrologic system.

Recommendation

Borrowers should prepare basin plans for long-term development and management of water and land resources. Each plan should document present and projected resources availability, water uses by category (consumptive or nonconsumptive, diverted or instream), class (domestic, industrial, agricultural), location under all conditions of flow and the location and description of the involved water control facilities. Allocation and uses should be defined in terms of seasonal, normal and drought conditions. Basin plans should conform to national/state plans, but should contain much greater detail.

PROJECT PLANS

Project planning proceeds from project identification through feasibility studies to final design and implementation. Plans for operation and maintenance (O&M) follow. Sound resource commitments demand that project planning is conducted in strict conformance with a basin plan. Feasibility plans should meet criteria for data adequacy, identification and study of alternatives, evaluation of the costs and benefits of the selected project and assessment of the environmental impact. Feasibility plans are then converted into final facilities plans for implementation and ultimately to "as-built" documents for use by O&M units and safety regulators. In reality, full feasibility planning requirements are not met on many projects. Physical alternatives are inadequately investigated, and costs and benefits left in doubt because of insufficient data from resources characteristics to site exploration. Construction concepts sometimes prove impractical, excessive and cost over-runs occur and construction schedules are often overambitious. O&M considerations are often inadequately addressed.

Recommendation

Borrowers should apply rigorous criteria in the preparation of feasibility plans and final project plans. The unquestioned adequacy of data, the multipurpose possibilities, the alternatives considered and the conformance with basin plans should be assured and fully documented. These criteria should override any scheduling objectives.

INTERNATIONAL BASIN PLANS

The resources of international bodies of water are important to all riparians. The best use of both the international and the national resources depends on knowing what is available and how it will be managed. Even security issues arise from uncertainty about management of the basin. Nevertheless, many international water bodies are being developed today without firm plans because there are no agreements on which to base such plans.

Recommendation

Borrowers should enter into active discussion that lead to joint planning and operation of their bordering international waters. They should be informed of use as appropriate the general and specific assistance offered by the international agencies. These have often proven to be the catalyst that helps resolve long-standing disputes.

V. PLANNING CRITERIA AND METHODOLOGY

ECONOMIC PLANNING CRITERIA

Standard and well-known techniques are available for the economic evaluation of multipurpose water development programs. These techniques normally seek to evaluate the costs and benefits of alternative scenarios with a view to advising the decisionmaker of the economic implications of different decisions. All values need to be expressed at shadow prices to reflect real resource implications, and all taxes and transfer payments should be excluded. Estimates of shadow prices and other assumptions to be used in a particular country are frequently prepared by the national planning commission or some similar agency. In evaluating alternative programs, it is essential to include all costs not only the direct costs associated with the physical investment but also all opportunity costs arising as a result of externalities and similar effects associated with the investments. If costs and/or benefits cannot be adequately quantified in an economic numeraire, then multiobjective planning techniques may need to be used. These seek to optimize total economic returns subject to specified (not quantifiable) constraints. They can, therefore, be used to inform the decision-maker about the economic costs of alternative lines of action.

ENGINEERING PLANNING CRITERIA

Consistent, sound planning requires that all government agencies within a country follow a common set of planning criteria and methodologies on water resources. These must not be overly restrictive or in minute detail, particularly with reference to standard engineering principles. However, in countries with well-managed resources, planning documents generally note the reference manuals used and state in greater detail any criteria specific to the plan. Unfortunately, such means to assure consistency with well-thought-out criteria are not applied in many developing countries. The resulting plans and subsequent projects exhibit serious oversights and conflicting principles.

Recommendation

Borrowers should establish and rigorously apply a comprehensive set of planning criteria (economic and engineering), including a mechanism for regular updating, for guiding water resources planning by agencies at all levels of government. Plans should formally note the criteria used to facilitate review and inclusion in subsequent project records for future reference. (Some common factors that seriously distort plans are discussed in the following paragraphs.)

ADEQUACY AND RELIABILITY OF RESOURCE DATA

Sound planning is impossible without adequate information on the resources to be developed. This is self-evident and should not be an issue. Nevertheless, irrigation projects and programs are proposed and implemented by some countries in which water resources, land capability and water demands are not known within 40 percent accuracy. Storages, flood control and river training works are designed and constructed with inadequate hydrological data. Even urban water supply facilities are designed with inadequate data to forecast the extent and recurrence periods of supply shortages and, therefore, the means to meet such events. Despite these data deficiencies, "feasibility" reports for projects purport to estimate their economic rates of return with levels of accuracy to the third significant figure.

Recommendation

Borrowers should secure data on water and land resources and on water commitments and demands at the project and basin levels. These data should be reliable and extensive enough to conform with the planning at the designated level of accuracy. The accuracy of data used and the governing planning criteria should be referenced and compliance stated in the project planning document.

WATER-USE EFFICIENCY AND EFFECTIVENESS

Many papers and lengthy debates focus on water-use efficiency and huge sums are spent on improving system efficiencies. Modifications to irrigation, a favorite target of such programs, has the objective of freeing up large amounts of "new" water for use within the scheme or for other purposes. Unfortunately, when it is related to water management, the term "efficiency" is often completely misunderstood. Efficiency, the ratio of the quantity of water consumptively used to the quantity diverted, does not in itself indicate whether water is used effectively and wisely. Most of the water diverted for an irrigation project in the upper areas of a basin, but not consumed by the plants, returns to the surface water or groundwater systems and is subsequently put to other downstream uses (irrigation, aquaculture, urban or rural supply and/or instream uses). It is not lost. Indeed, increased efficiencies, coupled with increased use on an upstream project, reduces resources available to downstream users, that may have consequent detrimental effects. Additional investments on the upstream project render earlier downstream investments less productive and equate to spending money to lose money.

The important water quantity question relating to efficiency is whether water is lost from an area and flows to the sea or to a polluted sink from which it cannot be recovered. The measure to use when considering total resource use is basin efficiency, not farm or project efficiency. If upstream water "losses" are available to and used by downstream users, there is no quantity gain by changing individual project efficiencies. If there is wastage to the sea at a time when possible users exist within the basin or in an adjacent basin, there is potential for a gain in water quantity from efficiency measures.1/

Recommendation

Borrowers, when considering reduction in project water "losses," should analyze water use in terms of effectiveness in meeting allocation and other objectives within the basin and in terms of efficiency on a basin-wide basis. All proposals to improve efficiency should be measured against all objectives and the cost-effectiveness of the proposals in meeting these objectives. Costs or damages that result from raising groundwater levels or from increased pumping should be analyzed and all measures, not just "loss" reduction efforts, should be assessed in selecting actions.

STRUCTURAL VERSUS NONSTRUCTURAL FLOOD PROTECTION

Many countries control flood damages only through the use of levees and storage reservoirs. The concepts of excluding high-value activities from flood-prone lands through

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1/ The reality of the situation and the water saving opportunities may be clarified by examining some examples. The average irrigation project efficiency in the United States is 43 percent. By comparison, U.S. urban supply schemes have an average efficiency of 19 percent and water-use efficiency on industrial/mining operations averages 16 percent, far below those of irrigation. Of greater consequence, the majority of urbanized areas lie near the sea, where there is no opportunity for downstream use of the return flows. By contrast, the overall irrigation sector efficiency in the United States is 87 percent, with only 13 percent of the water diverted for irrigation lost to the sea or otherwise unavailable to other users. This is due to the typical upper basin locations of irrigation schemes in the United States. Thus, contrary to popular thinking, the irrigation sector has the highest efficiency among the major water users, at both scheme and basin levels. (See World Bank Technical Paper No. 185, "Drought Planning and Water Efficiency Implications in Water Resources Management.")

floodplain zoning and nominal flood proofing of structures generally are not applied. Rarely are flood-prone areas permanently set aside for agriculture or the construction of any structures in the area or obstructions in drainageways prohibited. Inevitably, without such controls, the high-value developments pressure government to provide costly, yet not fully reliable, protective works.

Recommendation

Borrowers should consider nonstructural measures (floodplain zoning and floodproofing) for flood damage reduction in equal detail with their consideration of dams and levees, and incorporate such measures where suitable into their long-term planning and management. These concepts should be incorporated into both basin water plans and local land-use planning and management.

Applications of Computer Modeling to Planning and Management

Computer applications that are useful, if not essential, in project analysis are available from a range of sources. Multiyear simulation of weather and runoff permits close evaluation both of crop water demands and supply and of project yields. Similarly, future urban demands and alternative facilities can be examined. Planning the operation of several reservoirs within a basin to meet multipurpose objectives requires the use of an interrelated set of models, and these are even more necessary for planning the operation of multibasin systems. Though many developing countries have adopted computer technology, their water resource agencies still do not use appropriate models to the extent possible in their long-term planning and management activities.

Recommendation

Borrowers should systematically review the agencies' needs and use of modeling and establish a library of proven models with a procedure for regular updating. A collection of models already in the public domain can serve most purposes with little investment by the agencies. Further, countries should have a formal verification procedure to assure that staff utilize appropriate, proven models for all evaluations, such as simulation of weather and water systems; conjunctive operation of surface water and groundwater systems and all project, basin and interbasin operations.

Environmental Assessment Considerations

Most governments have or are preparing guidelines for evaluating the environmental impact of programs and projects. However, as with all guidelines, the user must apply a sound interpretation. Some consider only negative environmental impacts thus implying that only the economic benefits can be listed as positive project results. This stems from past project evaluation procedures that did not explicitly recognize either negative or positive environmental affects. For example, positive and negative effects of projects on wildlife, recreation, public health, instream and reservoir fisheries and stabilized streamflow were cited, but not defined as environmental. And they were usually treated only in subjective terms, though cost and benefit allocations and related funding were assigned to some. Now that many of these elements have been incorporated under the environmental category, care must be taken that environmental accounts present both the positive and the negative impacts in each of the environmental classes so that evaluators (and the public) can readily assess the net environmental impact of a project or program. The environmental benefits of clean hydro replacing nuclear or fossil fuel alternatives is an obvious example. Safe drinking and wash water for urban and rural poor is a second. Also, the costs of siltation and seismic possibilities should not be counted twice. Reservoir siltation is always reflected in the project life. Potential seismic affects are accommodated in the design and related costs.

Recommendation

Borrowers should conduct comprehensive environmental assessments for programs and projects in accordance with sound guidelines. They should present both the positive and negative impacts in all classes so that the net environmental impact of programs and projects can be evaluated. Indeed, the wide range of environmental impacts of not constructing a project should be set out as a basic reference for use in evaluating alternatives. These impacts should be fully explained in terms that the public can readily understand and evaluate.

REAL-TIME MANAGEMENT OF WATER RESOURCES

I. PREAMBLE

Primary activities in real-time water resources management include planning for operations and maintenance (O&M) of the services, management of related programs at all levels and administration of rules and regulations. The issues and proposed policies and practices are presented here under five groups: (i) Administration and Support Activities; (ii) Plans for Real-Time Operations; (iii) Water Operations; (iv) Maintenance and (v) Regulatory Functions.

II. ADMINISTRATION AND SUPPORT ACTIVITIES

PROGRAMING AND BUDGETING OF ACTIVITIES

Sound programing and budgeting are essential to efficient and cost-effective government operations and services. If these basic actions are not carried out in a timely manner, all other project planning is of little use. Though the issue is not peculiar to water resources activities, it is introduced here because most underfunding and inaction in the regulatory, planning, data collection and O&M areas is caused by inadequacies in the related programing and budgeting. Unless this issue is treated equally with other issues, sound water resources management is impossible.

Recommendation

Borrowers should apply sound, realistic and supportable programing and budgeting procedures for all government activities in the water sector. The programs and budgets should be presented by line item and organizational unit with complete cross-references, thus allowing verification of staff and funding that is linked to the tasks decided upon to meet the year's goals. The program and budget for each project should be detailed and the activities displayed, ideally on a critical path method type diagram presenting both applied resources and activity status.

PERSONNEL POLICIES

Civil service regulations differ from country to country. Many were formulated under circumstances far different from today's in terms of type and level of activities, required skills, communications and compensation. To complicate matters, social objectives govern staff selection in some countries. Overall, most existing personnel policies seriously constrain the modernization of organizations and operational systems. Though it is difficult to change civil service regulations, aspects can be modified within the existing policy framework; for example, staff rotation. The technology of modern water management requires staff skills and unit organizations to match the task. Wise laws and soundly devised project concepts are meaningless deceptions without the means to execute them. Legislating modern environmental monitoring is useless without the technical equipment and permanent skilled staff to collect and analyze the data. New technological aids, from models to remote sensing lose value without staff continuity. And massive training programs are a waste when those trained are transferred to other tasks.

Recommendation

Borrowers should modify personnel regulations with the objective of developing a highly skilled capability in each functional area. Following their policy framework, they should tailor position descriptions, compensation, staff selection and staff promotions to the specialized units. Rules should provide for rigid enforcement of position qualifications, select training and service continuity within the specialized area.

III. Plans for Real-time Operation

Basin and Scheme Operations Plans Under Normal, Flood, Drought and Emergency Conditions

Many basins, particularly those in Asia, are now developed to the level that carefully prepared plans for real-time basin operating plans are necessary to make maximum use of the resource and to take full advantage of all facilities to manage both water supply and flood conditions. The reliability and equity of the individual scheme services would be greatly improved by one master system that monitors weather and flow conditions in a basin to serve all projects and one central office that coordinates and makes real-time decisions for operating the principal facilities. Plans to guide operations during floods, droughts and pollution emergencies should state the priorities, the actions to be taken, the triggering conditions and the public notification requirements.

Recommendation

Borrowers should prepare real-time operating plans and establish organizational arrangements for each river basin covering all water quantity and quality aspects of water management under normal, flood, drought and pollution emergencies conditions.

Plans for Operation and Maintenance of Scheme Facilities

Many agencies do not address the O&M of individual water systems sufficiently during all phases of implementation to assure the planned service to the beneficiaries and sustainability of the facilities. The agencies do not reach agreement with the customers or customer entities on the services or the responsibilities, service rules and penalties for violation. Designers do not consider O&M impacts of adopted designs. Frequently, O&M buildings, equipment and supplies are not included in the project plans, nor are they procured and available at start-up. Few prepare project-specific comprehensive O&M manuals. The construction organization hands over the incomplete facilities to people that may have inadequate O&M training and experience. The consequences, in terms of deteriorating systems, poor service and vandalized facilities, are evident in too many countries.

Recommendations

The preparation of the plan for operation and maintenance (POM), should be initiated as part of the early project configuration studies and defined in great detail in the final design phase. A clear description of the operational concept and O&M program avoids many of the design inadequacies and service shortcomings that are often encountered. Permanent O&M facilities can be constructed for use during the construction phase with a cost savings to both functions. The guidelines for preparing POMs that have been developed by various international groups provide an excellent basis for agencies when they prepare their project-specific POMs.

Borrowers should prepare detailed POMs for every water development project and any subschemes from the basin level to the customer. Each plan should set forth organization, staffing and equipment and incorporate all relevant documents from the field investigations, planning, design and construction phases. It should state operating objectives and policies; rules and criteria on such matters as water allocation, water quality, conjunctive use of surface water and groundwater, conservation of water and reuse of water; beneficiary responsibilities and service charges. It should specify maintenance and replacement procedures in manuals, both routine and scheduled. It should stipulate customer conduct and penalties for violating rules or abusing facilities. It should include comprehensive project documentation to facilitate operation, maintenance and regulatory actions and any subsequent facilities modifications. Basic documents should include basin and project plans (by reference), the design criteria and analysis reports, as-built drawings, geological reports and construction reports.

IV. Water Operations

Basin versus Scheme Focus

Even the best of operating plans are useless without an organizational structure that can effectively implement the plan. The level of overall basin authority and the extent of direct physical control of facilities will vary, but one office should have jurisdiction over the key structures. This office may in turn be under one organization or it may be the representative of joint operating entities in the basin. Given the limited extent of the actual tasks, the operating unit will be quite small, and will have no responsibilities other than those necessary to meet the objective of coordinated operation of the principal structures. Though a small operations unit following agreed-upon operating rules can coordinate and direct basic operations, the debate on creating powerful all-purpose basin authorities sidetracks efforts to introduce a simple means to meet this fundamental principle.

Recommendation

Borrowers should institute coordinated basin operations of primary storage and diversion features of all water operations and services and provide an operations unit with the necessary monitoring, communications and analytical capability to carry out this function. The basin operations unit mandate should be limited to projecting conditions, coordinating major storages and diversions and monitoring results. It should not engage in any activities in the schemes of the individual diverters.

Water Supply Service Measurement and Accounting

Flow measurement at key points is essential to operating a basin or a scheme. Ideally, all water supply services should be measured volumetrically for purposes of administering a system of charges. Many countries meter urban deliveries, particularly deliveries to industry. In the case of irrigation, facilities and operation costs preclude direct measurement of deliveries to very small farms. Indeed, most deliveries are to a service area within which the farmers distribute. Nevertheless, the measured area service permits service costs to be charged to that area and in turn to the farmers in proportion to land area served. Long established farmer-owned schemes and some low-lift pumping systems in developing countries use this method to assess members. Drainage services may be similarly measured. Land area within calculated zones of benefit in the protected area is the best basis for assessing flood control and drainage services. However, observations of depth and duration at selected points will indicate the actual service and allow the facility to be corrected or charges, usually property taxes, to be adjusted. Waste collection and treatment, and, more broadly, pollution control measures, are complex, and both the service measurement and the charge mechanism can be addressed in ways that necessitate special consideration of the concept to be adopted.

Regardless of the nature of the water service, it is important to establish the concept of service measurement and to institute regular measurement of the services rendered by each system.

If this is done, the O&M entity will become accountable and seek operational improvement, the benefits will become explicit and a rational basis for charging beneficiaries will be created.

Recommendation

Borrowers should install water meters as possible for industrial and urban residential services. They should also install service measuring devices at the head of service areas within irrigation schemes. In all cases the intended service should be public knowledge. Waste effluent measurements should relate to the charges for collection and disposal services. For irrigation, the actual service provided should be publicly posted at biweekly or monthly intervals at each scheme diversion and at key points within delivery areas. Similarly, flood control and drainage system performance at key locations could be defined in specific terms and publicly posted. Waste management results in terms of measured quality of receiving waters should be publicly posted.

WATER CONSERVATION MEASURES

Water conservation receives attention in every discussion about how to satisfy expanding water demands and water-related environmental concerns. However, "habit modification," low water-use plumbing and desert landscaping of residential areas, have little practical application in developing countries. The urban and industrial metering of water supply services offers conservation opportunities and are being promoted. (They may have a marginal impact in many large Asian cities where residential use is already limited to essential needs.) Demand management through pricing should be considered, but the consumption patterns, physical restrictions on supply and difficulties in collecting even cost-recovery charges will determine its applicability. Water price levels can have an impact and some water service entities have adopted tiered or escalating service charge rates. Water deliveries to meet basic needs for domestic, industrial or crop production are charged at a base rate, with increasing rates for amounts above that. This charge structure may not generate significant funds, but it causes users to improve operations, whereas the combination of water and pollution charges to urban and industrial customers has a double effect on reducing water demand. Some users seek improved industrial processes and modified cooling systems for electric generation that offer significant reductions in water use.

The opportunities to conserve irrigation water vary considerably. Usually the full reuse of return flows from upstream irrigation or the recovery of seepage through groundwater pumping limits the amount of water that can be conserved by additional measures. Reduced conveyance losses and improved application offer considerable opportunities in situations where irrigation runoff or seepage are otherwise lost to saline aquifers or to the ocean. Better practices, including sprinkler and drip equipment, should be introduced in those situations. Equally important, delivery stream size and scheduling can greatly affect the uniformity of application and directly affecting the efficiency of soil-moisture management possible by the farmer.

As is noted previously, repairing urban pipe systems, lining conveyance canals and improving user efficiencies may conserve little water at the basin level, though the reduction in diversions may be important enough to justify expending the necessary effort. The impact on overall supplies of such efforts depends on the location of use and the level in the hydrologic unit at which the savings are made. Overall supplies will be affected by improving "efficiencies" of all users near the sea or where return flows cannot be readily recovered for productive use.

Recommendation

Borrowers should adopt effective conservation measures in the operation of urban and industrial systems. These should include: Service metering with an appropriate service charge structure, combined billing of water supply and waste service charges, and distribution system improvements for metropolitan systems with priority given to regions located near the sea. Local government should zone sufficient areas near urban centers for waste water irrigation (or groundwater recharge) if quality can be assured and should promote user operations that minimize water quality degradation of return flows to permit reuse. Borrowers should promote both as much water conservation in irrigation and urban systems as possible through service water charges and advanced low-water use in industrial processes and cooling.

V. Maintenance Issues

Maintenance Priorities

In developing countries, the maintenance of facilities suffers from funding shortages. This is often exacerbated by the low priority accorded to this activity by the responsible agencies. Commonly, routine maintenance is inadequate and facilities deteriorate until total project rehabilitation is necessary. The "replacement" category is rarely found in O&M plans, schedules or budgets and project sustainability is sacrificed. As deficiencies grow, countries face huge funding demands, and the hoped-for transfer of O&M responsibilities to users becomes impossible. This situation holds equally in flood control, drainage, irrigation and in components of urban water supply and wastewater collection and treatment systems.

Recommendation

Borrowers should ensure that all categories of maintenance on existing water facilities are fully funded and that capable staff and equipment are provided in a timely manner so that the facilities can continue to operate as designed into the future. This objective should have the highest priority on funds, ahead of new construction, as sustainability was explicitly assured in the original project evaluation and investment decision.

Acceptance, Transfer and Guarantee of Facilities

Project sustainability and services depend directly on the completeness and soundness of the facilities' construction at the time of transfer from construction to O&M status, and on the timeliness of the transfer. Some projects linger under the construction unit's jurisdiction for years without O&M budget, equipment or knowledgeable staff to maintain the works. In other cases, projects lack facilities and incomplete site work is transferred to O&M units. The receiving O&M units lack construction capability and budget to complete the works.

Formal transfer procedures, incorporating clear assignment of responsibilities with accountability for quality and completeness of works, can overcome much of the problem. The construction unit must assure completeness of all work, guarantee the quality and promptly correct deficiencies found within a warranty period using capital construction funds. Before acceptance, the O&M unit must be satisfied in all respects and receive all manuals, as-built drawings and start-up results on equipment and facilities.

Recommendation

Borrowers should institute formal facility transfer procedures, which should include conditional acceptance by O&M units upon satisfactory completion of the facilities and site clean-up. Provisions should also be included for the construction unit's warranty to correct deficiencies encountered within the first three years after conditional transfer. The final transfer should be made when such work has been completed and its quality proved.

METHODS OF EXECUTING MAINTENANCE

In most governments, the O&M entity's staff execute all maintenance on public irrigation schemes. Where there are fluctuating budgets and shifting surplus agency staff, gross inefficiencies result and personnel costs can approach 90 percent of the total O&M budget. Equipment shortages, inappropriate means and ill-trained operators are prevalent constraints to effective O&M. Some governments contract maintenance to the private sector, offering flexibility in scheduling as well as competition to control costs. In these instances, multiyear maintenance contracts allow contractors to secure efficient equipment and retain capable staff. Local conditions dictate the most suitable approach, but regular review of maintenance costs and results by senior officials or oversight units should have the objective of adopting the most cost-effective approach.

Recommendation

Borrowers should evaluate their methods for conducting irrigation facilities maintenance and carefully consider the use of maintenance contractors for routine as well as special maintenance. Trial routine maintenance contracts should be undertaken at intervals to serve as a comparison for existing means for maintenance used by the agency.

The regulatory functions and their necessity for overall resources management were discused under Institutions, Section IV. But effective real-time resources management is impossible without the rigorous administration of the regulatory legislation. This is a key principle or the physical operation and services will have no bounds and individuals will ignore the laws whenever they find it in their interest.

Recommendation

Borrowers should establish staff and equip units at the central, state, basin and local levels as appropriate to actively perform the regulatory functions necessary to manage their resources. The regulatory areas include surface/grounded rights; land-use rights; water quality and dam safety.

ADMINISTRATIVE AND FINANCIAL INTEGRITY OF SERVICE ENTITIES

Though governments have auditing procedures for agencies' fiscal performance and oversee some administrative activities, the water service sector is largely unsupervised. There are no administrative or fiscal performance reports that can be examined. However, efficient, real-time services in the water sector will never be realized until agency performance is thoroughly and regularly evaluated.

Recommendation

Borrowers should implement regular administrative and fiscal audits of government service entities and issue regular reports of their findings. Staff, equipment and offices should be provided to a unit reporting to the ministerial level. The actions of management and the service rendered should be included in the review and discussions.

FINANCIAL ASPECTS OF WATER RESOURCES ACTIVITIES

Financing water resources activities is not entirely an institutional subject. In discussion, however, it is often linked to the institutional issues of allocation mechanisms, pricing services and organizational responsibilities. Principles have evolved for calculating and allocating project costs; financing project investment, operation and maintenance (O&M) and subsidies; cost recovery; and service pricing.

I. PROJECT COST AND ALLOCATION AMONG PURPOSES

Several countries successfully apply standard principles for project cost allocation among project purposes. These identify categories of uses and direct and indirect benefits and assign associated costs -- capital, interest, operation, replacement and maintenance being typical. Yet, many borrowers do not apply consistent cost allocation rules to their projects, and some have no rules. This prevents proper analysis of potential benefits during project formulation and the correct costing for subsequent use in setting service prices.

Recommendation

Borrowers should adopt formal cost allocation procedures and apply them consistently in their planning and management. Allocation categories should include all services -- municipal, industry and irrigation supply, waste collection and treatment, flood control, drainage, navigation and hydro and the nonservice purposes such as recreation and any environmental enhancement, but not mitigation. Allocation should be made in full to all purposes, and any subsidies should be identified and applied during the subsequent pricing/funding decisions.

II. SERVICE COST COMPONENTS

There is debate over what should be included in costing services in the water sector. Typically, developed countries apply the principle that service costs comprise all costs to constrict, operate and maintain the single-purpose service facilities and the same categories of costs allocated from multipurpose projects serving the scheme. These costs are measurable, easily examined and can be judged to be fair by beneficiaries and the public alike. Differing from system to system, they match what the beneficiaries receive in each situation. No approximation or outside rationalization is involved. Recovery of most of these costs would allow governments to continue future undertakings without sacrificing other obligations.

Recently, some countries have charged water quality degradation as an operating cost, since downstream users will incur direct expenses by the polluters' action. This most obviously applies to urban and industrial dischargers. Theoretically it could apply to agricultural discharges when they are caused by chemicals or livestock operations rather than by natural runoff.

It has been suggested that "opportunity costs" should be used as the basis for charging customers of water supply services, even where the water use, and hence the water allocated, is authorized under legislative action. The concept would replace the use of the cost of facilities as the basis. But the mechanics of calculating opportunity costs, the rate of change in this component as it affects investor plans, its application to environmental uses and how to free it of political and worse influence are not resolved. Of course, as "free market" pricing, this would function as an allocation mechanism, overriding any other water allocation objectives such as social, environmental and security.

Foregone opportunities are one of a great many "costs" of a society's decisions in allocating its land, water and other resources. Since opportunity cost pricing is not yet applied in the developed countries, it should remain under study for application in the developing countries. Even if a practical application method is devised, this can only be considered after a country's society has set its allocation objectives and undertakes to select its allocation mechanisms.

Recommendation

Borrowers should calculate costs for all water related services -- supply, waste collection and treatment, flood control, drainage, navigation and hydropower -- using the cost allocation principles described. The calculation of service costs should be kept independent of the subsequent decisions on setting service charges, subsidies and general cost recovery mechanisms.

III. COST RECOVERY

One cause of deteriorating systems is governments' unwillingness or inability to budget to meet their clear obligations to maintain the facilities. The linkage of O&M funding to cost recovery has served to justify this underfunding. (The excessive level of maintenance sometimes required is often caused by construction deficiencies.) The first principles relating to cost recovery are that government should fully budget system O&M and separate that from the effort to institute cost recovery. This is discussed further under O&M Funding.

The full costs of government-provided water services is seldom recovered from the beneficiaries, though some countries are moving aggressively in that direction. Flood control, navigation, drainage, most irrigation, most large water supply systems and essentially all waste treatment are subsidized. The primary exception is the hydropower sector, where subsidies are minimal. Yet, private and farmer-owned irrigation systems in these same countries are financially self-sufficient. These unsubsidized schemes serve the majority of irrigated lands in some countries. Often municipal and local government water-supply schemes are essentially self-sufficient. In a few countries, small government-built irrigation systems are turned over to the farmers to operate and maintain, but usually no capital costs are recovered.

Private and water-user-owned systems that have existed for decades and even centuries prove that water supply and irrigation schemes can be physically and financially self-sustaining. They follow common principles that are important to their success. The system is designed as an affordable facility consistent with the benefits; the construction is of a type and quality that results in affordable maintenance, the beneficiaries invested in the facilities, the government does not guarantee rehabilitation when deficiencies or failures occur, the service is reliable as measured by the rules, and a disciplined operation is supported by strong beneficiary enforcement of rules. As may be seen, cultural and economic conditions in most developing countries justify beneficiaries paying for services, unless government has undertaken costly or unsuitable projects or is not providing a reliable service.

Recommendation

Borrowers should institute a system of direct and indirect charges to beneficiaries to recover the costs of most services in the water sector including municipal and industrial (M&I) supply and waste removal; irrigation and drainage for agriculture; flood control (to the extent it is not a national benefit on major rivers); hydropower and navigation (again to the extent it is not a national benefit such as with rural ports for fishing and transport). Project investment subsidies may be justified so a country can meet adopted objectives through construction of expensive schemes. (This helped nations to settle new lands, and it is now used to control urban and industrial pollution.) Flood control for major urban areas commonly receives such subsidies. However, no O&M subsidies should be warranted, except for delayed collection during a brief start-up period. The only exception would be where abnormally high O&M costs occur as the result of poor construction. However, government should never force an O&M agency to assess charges below full cost recovery unless it directly and fully augments the O&M agency budget as required to sustain the system.

IV. SERVICE CHARGE MECHANISMS

Several direct and indirect factors influence the selection of service charge mechanisms. These include the service, conservation incentives, subsidies, poverty alleviation, equity and the ability to pay. Every advocate of the various mechanism can find a cause in its resolution. However, the recovery of costs is not only a question of paying for a service, but a necessity as government budgets tighten.

A variety of customer service charges are used. Examples are delivery charges for M&I and irrigation; stand-by charges for a service that enhances the property value or for fire protection; and zoned property tax assessments to beneficiaries and, at different tax rates, to the adjacent public that reflects the level of flood control and drainage protection. Usually, a mix of mechanisms best suit irrigation O&M financing. A component property tax will carry a water supply service through low-delivery years of drought, while delivery charges will reflect actual benefits derived by the customer. A tiered or escalating rate structure will encourage water conservation in municipal and irrigation systems. Minimal rates will apply to the system's low-income group. Experience shows that drainage and flood control costs are most effectively and equitably charged through zoned property taxes. Several countries are experimenting with new waste-charge mechanisms. These should be viewed from the standpoint of adequacy of recovery, equity and effectiveness if they serve as a pollution management tool.

Recommendation

Borrowers should establish a clear, detailed policy document that includes procedures to determine service charge mechanisms. Further, borrowers should calculate service charges on each specific system to reflect the system's peculiarities, the level of services by the beneficiaries and the basic principle of no cross-subsidizing by beneficiaries among different systems. All should be applied in an open, easily monitored manner. The collected funds should be rigorously accounted for, assigned in total to the entity providing the service and dedicated to the purpose and isolated from other funds.

V. FUNDING CAPITAL EXPENDITURES

The funding of capital expenditures concerns countries at every stage of development, but particularly those with limited means. Their growing development demands exceed outside funding assistance, thus forcing attention to other sources for funds for future undertakings. The most obvious method of funding is substantial or full payment of all capital costs by the beneficiaries. This both provides replenishments to fund future reports and improves agency performance through customer pressures.

Recommendation

Borrowers should finance, at fair interest rates, local governments' and user entities' needs as a condition for pursing new projects. In many instances, government loans should replace grants for rehabilitation and emergency repairs. Service entities use a variety of charge mechanisms for reimbursing government. They should establish the goal of financing local works through revenue or obligation bonds on the financial market. Hydropower and M&I systems offer particular opportunities for using such means, as do larger irrigation schemes when they are backed by government.

VI. FUNDING OPERATION AND MAINTENANCE EXPENDITURES

GOVERNMENT GUARANTEE OF FULL OPERATION AND MAINTENANCE FUNDING

Borrower governments long have assumed responsibility for water development. They have allocated the resources, planned the developments and executed the work without considering options. Indeed, even the beneficiaries have not been engaged in devising the program, though they had demonstrated capabilities by prior development. With development and construction of infrastructure goes the responsibility to maintain the facilities. Though not necessarily stated, this is as obvious an obligation as any component of the program. There can be no question that governments know their inherent responsibilities and that they must meet them. Unfortunately, the O&M situation today demonstrates some borrowers' continuing neglect.

Recommendation

Borrowers should guarantee O&M funding of government-owned facilities at a level to sustain the facilities in a condition to fully provide the designed services on into the future. This should override all other agency budget demands. The principle followed in bond financing of such facilities should be rigorously applied by the government and by any lending agencies supporting construction of such facilities. The principle is that the first call on any revenues (government budget) produced by the scheme is to fund O&M fully at the level necessary to permanently sustain the facilities. The adequacy of the O&M effort must be verified by an outside review unit. Any revenues surplus to O&M may be applied to other budget items. Any shortfall should be made up by the owner. This principle should never be violated, even in the short term. In no other way can a country reconcile its wishes with its means. Neither is there any other action that is as effective in assuring sound, affordable investment in resources development.

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