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A STRATEGIC FRAMEWORK FOR WATER IN ASIA

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Preface

The purposes of this document are to:

- Draw attention to a critical issue facing development in Asia
- Address the water sector in terms of intersectoral relationships and conflicts
- Outline the key policy and institutional constraints that require attention and analysis
- Provide a basis for discussions on water issues with host countries and bilateral and multilateral donors
- Continue the intellectual leadership of USAID in the water sector

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SUMMARY

Demographic and economic changes in Asia have created new and serious water problems. Increasing food production, industrialization and urban growth are placing demands on surface and ground water that can no longer be met by taking it from the nearest available source. Serious competition for water now exists among water uses and between nations. Urban, industrial and agricultural pollution of water resources makes the problem more complex. The effects of floods and droughts worsen as populations and investments at risk increase. Solutions must address both the sustainability of water resources and that of water infrastructure. National policies and institutions are generally outmoded.

Every Asian country will find it necessary to change the emphasis of its water management policies and strategies. This will involve a shift from government provision of and disposal of water to good governance of both the supply and demand sides of water management, including cost recovery and greater reliance on private sector provision of services. Strategies and policies will be needed to ensure the sustainability of water resources and systems through management of competition, water quality improvement, water-related environmental protection, and institutional upgrading.

A strategic framework is presented as guidance for the Asia and Near East Bureau and Asia Missions for use in their discussions with host countries and other donors on their critical water resource issues. It is intended to serve as a discussion paper for countries interested in achieving sustainability of their water resources and systems. The paper is consistent with the economic growth, population and health, environment, democracy and participatory development objectives of the Agency and with the UNCED water sector goals as expressed in "Agenda 21."

Background: Water Problems in Asia

The rivers and groundwater of Asia support about one third of the population of the globe. Much of the development capital of Asia has been devoted to the provision and management of water. After a period of expanding water use based largely on previously developed resources, population, urban and industrial growth are creating water demands that cannot be met in the old way, by continuing to expand supplies without addressing demands. To the extent that supplies are expanded, the unit costs will be far greater than they were in the past. Pollution of water sources exacerbates supply shortfalls in relation to present and future demand. The greatest demands for water are agricultural, and food requirements continue to grow. In addition, the exploding cities and their associated industries have established localized demands for large quantities of high quality water and discharge large amounts of polluting sewage and industrial wastewaters.

Most Asian cities have inadequate water supply, treatment and distribution facilities, few have extensive sewerage systems and very few have effective wastewater treatment. Half the rural population lack potable water supply and two thirds have inadequate sanitation. Additional health risks are caused by contamination of potable water sources by toxic and carcinogenic industrial contaminants and pesticides in agricultural runoff.

Other serious water issues in Asia include periodic flooding, waterlogging and salinization of irrigated lands, lowering of water tables or salinity intrusion due to overpumping of aquifers, eutrophication by nutrients from wastewater and agricultural runoff, reservoir siltation, decline of fisheries, degradation of estuaries, and loss of ecologically valuable mangrove areas.

In many cases, solutions to these problems have been inefficient and only partially effective. They have generally been directed towards helping one subsector without regard to negative effects on other water users or to environmental and social impacts. Unit rates of consumption are generally too high to be sustained in the future because of water source limitations and increasing costs of new systems. User fees are inadequate either to ration demand or to recover costs. New approaches are needed to meet critical water needs while reducing conflicts and competition between water uses, reducing unit water demands, and reducing water pollution.

Sustainability of Water Resources and Water Infrastructure

The primary concern for the water sector is sustainability. This has two main elements: the integrity of water resources and the sustainability of infrastructure to utilize those resources. Under this overall area of concern, the key issues of sustainability can be grouped into three categories. These are:

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

Policy failures and institutional weaknesses have contributed to most of the water sector problems in Asia. Among the key policy inadequacies are lack of accountability to the public and lack of transparency in the water management processes of governing authorities. Investment decisions have generally been made without adequate user involvement and often without adequate provision for operations and maintenance. Pollution control strategies are almost universally dependent on end-of-pipe treatment rather than such measures as waste minimization and zoning.

Another policy failure in most Asian countries is government or donor provision of full funding without requiring cost recovery from users. Where attempts to recover costs are made, they have often been based on unrealistic assessments of user willingness to pay for facilities of inappropriately high cost.

Institutional inadequacies include dominance of the sector by government agencies having narrow subsectoral interests and institutional barriers that prevent the range of basin-wide issues from being addressed. Large technical bureaucracies entrenched within government water organizations institutionalize inefficiency and are unable to respond to changing conditions. There is inadequate involvement of the private and voluntary sectors.

Planning processes have frequently not taken into account the prerequisites for sustainability nor have they provided the necessary balance between economic, environmental, technical, social and other interests.

Competition for water has arisen because the resources are being outstripped by urban, agricultural and industrial demands. New sources, when available, can no longer be accessed at the costs to which governments and donors are accustomed, because the closest and least polluted sources have already been taken. The result is competition for the resources that exist and a need for all users to optimize their efficiency of water use. There are important equity issues in water development that generally are not adequately addressed.

Efficient and equitable allocation of water depends on the availability of data on water yield and storage and on water needs on country- or basin-wide bases. The focussed collection of such data is a missing component of water management in most Asian countries. Broad water sector comparative analysis and planning is made unnecessarily difficult by differences between water subsectors in terminology regarding water cycle components.

Given the population and development pressure on water resources in Asia, it is vital that water conservation, including reduction of leakage and wastage, the use of demand regulation and low-flow application technologies, wastewater reclamation and reuse, and groundwater recharge, be considered where appropriate. Common measures of performance are needed for the reporting of progress in improvement of efficiency of water delivery and use in all subsectors.

Health and environmental needs and effects of water development are very important in all Asian countries. Needs include overcoming deficits in coverage by potable water supply and sanitation services, combatting water quality degradation, and minimizing or mitigating environmental and social impacts of water development. Negative environmental impacts of past water projects have included encouragement of breeding of mosquitos and other disease vectors, displacement or over-riding of perceived rights of residents, waterlogging or salinization of irrigated lands, saline intrusion into overpumped aquifers, destruction of wetlands and other habitats, prevention of fish replenishment or breeding, and loss of other biological resources.

There are very large unmet needs in the areas of potable water supply and sanitation and management of extreme conditions of floods and droughts. Increasing volumes and concentrations of urban and industrial wastewater are creating serious health, economic, amenity and ecological problems. Industrial pollution minimization and wastewater treatment have seldom been applied in Asia.

Social impacts of water projects have put into question the sustainability of some recent very large investments in the sector. Alienated residents have deliberately sabotaged water management facilities. Waterlogging and salinization of irrigated lands have reduced effectively cropped areas in some Asian countries.

Data collection on some important water quality and related health issues, such as the levels and effects of water contamination by agricultural chemicals, is deficient. Water-balance accounting systems do not allow for ecosystem water needs for functions such as watershed maintenance, fisheries, maintenance of biodiversity, or prevention of saline intrusion, or for water quality changes.

Major investments in the health and environmental aspects of water sector development, and in hydropower, have been made and continue to be needed. Some mistakes have been made that have resulted in inefficient use both of water and of other resources such as capital, energy, skilled labor, and imported equipment and materials. It is very important, in view of increasing competition for resources, that such inefficiencies be avoided or minimized during future water sector planning.

Opportunity for USAID

Many Asian governments and most donor agencies recognize the critical need for more rigorous and demand-oriented approaches to the development of the water sector. It is an obvious and important topic for interaction between bilateral and multilateral donors. Given the size of the required investments, and the competition for resources, donors and governments alike will place increasing emphasis on the efficient and sustainable use of resources, user empowerment, decentralized management, user support of costs, free market processes, and sector-wide transparent planning.

USAID has been involved in the water sector for many years. In Asia it is currently involved in several initiatives directed towards sustainable development of water resources and related infrastructure. It has a unique opportunity to apply U.S. expertise and experience to demonstrate the means to move from supply-side water resource management to a broader, integrated vision.

The Strategic Framework

The framework describes an approach that encourages governments and other organizations to (a) establish policy, legal, regulatory and institutional arrangements for water that provide good governance, accountability and balance between the relevant interests, (b) resolve issues of competition for water, and (c) resolve water quality and other water-related health and environmental issues. The policy and institutional measures to be fostered include:

- Decentralizing and democratizing water use planning and implementation, including provision of public accountability
- Encouraging the operation of market forces, including user fees for cost recovery and demand management
- Involving the full range of stakeholders
- Basing water management decisions on broad analytical assessments

Possible interventions include:

- Policy agenda discussions

  Water issues cut across the interests of many agencies in most governments. Policy assistance is generally needed to bring about improved water sector governance. In addition, effective policy dialogue on the subject of water 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.

- Conflict resolution

  Contributions to the resolution of disputes over water can include assisting in the collection and interpretation of data to support agreement by the parties. Other useful contributions may consist of conducting workshops or other fora for the discussion and informal resolution of conflicts.

- Coordination with other donors

  In order to leverage the effectiveness of USAID inputs, the Bureau and Missions will take advantage of opportunities both to influence the water sector thinking of major multilateral and other donors and also to identify ways in which USAID can

participate with them in programs and projects. Coordination is also needed to ensure that donor efforts towards sustainability in water development are not undercut by other donor-supported programs.

- Institutional development

  Institutional development assistance may include: provision of specialist inputs for diagnosing and correcting management difficulties and institutional weaknesses; assistance in organizational development; and assistance in such specific areas as demand management, pollution reduction, environmental assessments and emergency preparedness.

- Human resources development

  Assistance may be provided in the development and implementation of training and twinning programs, and in information and lessons-learned dissemination.

Policy development and implementation guidance will in general need to be provided as grant assistance because governments are reluctant to borrow internationally for purposes other than infrastructure development. Donors involved will need to work in partnership with local utilities. The U.S. should promote donor coordination and partnership approaches that support national responsibility for sustainability.

CONTENTS

1. **BACKGROUND** 1
   The Region 1
   Recent Trends 6

2. **THE MAIN ISSUES** 13
   Policy and Institutional Weaknesses 14
   Competition for Water 19
   Health and Environmental Needs and Effects 25
   Responsiveness to Change 29
   USAID Involvement 30

3. **THE WATER SECTOR STRATEGIC FRAMEWORK** 35
   The Framework 36
   Interventions 37
   Partnership 42

APPENDIXES

Appendix A. Country Water Resource Profiles in Asia A-1
Appendix B. The Full Value of Water and Water-Related Investments B-1
Appendix C. USAID Water Sector Projects in Asia (1952-1993) C-1
Appendix D. Water Technologies Available from the United States D-1
Appendix E. Some National Water Policy Options E-1

BOXES

Box 1. Illustrative Water Competition Issues 20
Box 2. Riparian Competition in the Lower Mekong River Basin 22
Box 3. Examples of Water Reuse in Asia 24
Box 4. Examples of Water Pollution 27
Box 5. Narmada: An Example of Social Impacts 28

FIGURES

Figure 1. USAID Assistance to Water Sector in Asia - Assistance by Country ... 31
Figure 2. USAID Assistance to Water Sector in Asia - Assistance by Focus and Type 32

TABLES

Table 1. Population Indicators in Selected Countries in Asia 8
Table 2. Economic Growth Distribution in Selected Countries in Asia 9
Table 3. Water and Sanitation Indicators in Selected Countries in Asia 10
Table 4. Industrial Water Conservation and Cost-Effectiveness: Selected Companies in San Jose, California 25

A STRATEGIC FRAMEWORK FOR WATER IN ASIA

Chapter 1. BACKGROUND

Much of Asia is relatively well endowed with fresh water resources by comparison with, for example the Near East and Africa. However, demographic and economic changes in Asia have created a situation in which very serious problems of competition for water and water quality degradation must be addressed. In addition, some old problems, such as frequent devastation by flooding, still remain. Attempts to provide solutions have frequently been only partially successful, often contributing to worsening of certain conditions. National policies and institutions are generally unable to deal with the problems. Approaches to water resources development are needed that focus on sector governance to enhance sustainability.

Demographic and economic changes in Asia have created serious problems of competition for water and water quality degradation.

The Region

Water dominates daily life in much of Asia. The great rivers that sweep out of the Himalayas and the plateau of Tibet sustain about one-third of the population of the globe. They also bring recurrent disasters to hundreds of millions of people. With other bodies of freshwater, both surface and underground, they are essential for food production, domestic and industrial water supplies, and disposal of wastewater, for about 3 billion people.

Much of the development capital of Asian nations, and of the international agencies that assist them, has been devoted to the provision and management of water. Yet much of the development has been difficult to implement, less than fully effective, and impermanent. The benefits of water schemes often have been less than expected and frequently have been attended by serious negative impacts.

After a period of expanding water use based largely on previously developed resources, population, urban and industrial growth are creating water demands that exceed the reliable capacities of natural and man-made systems. This is occurring under circumstances in which national development funds are in short supply, pollution is reducing the availability of

water, and more distant and expensive sources must be used because those readily accessible have been fully exploited. Some Asian countries also have major flood management and silt accretion problems, and most have inadequate potable water supply and sanitation facilities.

The issues vary somewhat from country to country. Following is a listing of some major water problems, present and future, in Asian countries:

Afghanistan:

- Underdeveloped water infrastructure
- Catchment degradation
- Deterioration of existing facilities
- Lack of functional water institutions

Bangladesh:

- Flooding by river waters and tidal surges
- Dry season irrigation water shortage in the southwest
- Pollution by urban and industrial wastes
- Poor potable water supply and sanitation coverage in urban areas
- Lack of maintenance of water facilities
- Lack of appropriate policies on water management
- Border water conflicts with India
- Catchment degradation

Bhutan:

- Catchment degradation
- Inadequate domestic/potable water supplies
- Sewage contamination of potable water supplies

Cambodia (Kampuchea):

- Catchment degradation
- Undeveloped hydropower potential
- Underdeveloped water infrastructure
- Lack of agreement with other riparians on the shared use of the Mekong River

China:

- Catchment degradation
- Regional water shortages
- Water pollution by urban and industrial wastewaters

- Groundwater overdraft

India:

- Untreated urban and industrial wastewaters
- Regional irrigation water shortages, leading to inter-state disputes
- Salination of irrigated lands
- Catchment degradation by deforestation
- Lack of maintenance of irrigation structures
- Need for additional power generation capacity
- Border water conflicts with Bangladesh

Indonesia:

- Catchment degradation, especially in densely populated areas, leading to stream siltation and lowland flooding
- Competition between urban and agricultural water demands
- Poor potable water supply and sanitation coverage in urban and rural areas
- Pollution of surface waters by untreated urban and industrial wastewater
- Excessive ground water abstraction
- Contamination of shallow groundwater by excrete in urban areas

Korea (Republic of):

- Border water conflict with North Korea
- Incomplete potable water supply coverage in rural areas
- Water pollution by urban and industrial wastewaters

Laos:

- Catchment degradation
- Underdeveloped water infrastructure
- Lack of agreement with other riparians on the shared use of the Mekong River

Malaysia:

- Catchment degradation
- Need to reallocate water from irrigation to other uses
- Pollution due to partially treated urban wastewater
- Pollution due to untreated industrial and tin-mining discharges

Mongolia:

- Regional water shortages
- Lack of water infrastructure
- Need to renegotiate water agreements with upstream source, Russia
- Lack of experienced water institutions

Myanmar:

- Lack of urban water infrastructure
- Water pollution by urban wastewater
- Competition between fishing, rice-growing and other water interests in rural areas
- Lack of experienced water institutions

Nepal:

- Catchment degradation
- Lack of maintenance of irrigation facilities
- Poor potable water supply and sanitation or sewerage coverage in urban areas
- Poor operation and maintenance of urban water supply facilities

Pakistan:

- Catchment degradation
- Competition for water near the main population centers
- Pollution by untreated urban and industrial wastewater
- Waterlogging and salinization
- Poor rural access to potable water supply and sanitation

Philippines:

- Urban, industrial and non-point pollution of future urban water sources
- Lack of sewerage services in urban areas except Metro Manila
- Competition for water near the main urban centers
- Catchment degradation

South Pacific Islands:

- Continental and high oceanic islands, including Papua New Guinea, Fiji and Western Samoa:
  - Catchment degradation
  - Need for seasonal storage

- Coral atolls and raised coral atolls:
  - Dependence on shallow freshwater lenses and rainwater harvesting
  - Salinity due to overpumping of groundwater

Sri Lanka:

- Poor rural access to potable water supply
- Need to decentralize water sector planning and operations
- Poor drainage and flood control in low areas
- Untreated urban and industrial wastewaters
- Catchment degradation

Thailand:

- Competition for water
- Poor potable water supply coverage in some urban areas
- Lack of urban wastewater collection and treatment
- Lack of agreement with other riparians on the shared use of the Mekong River
- Catchment degradation
- Seasonal water shortage in the northeast and competition for water in the Chao Phrya basin
- Poorly defined responsibilities for water policy development and for resolution of competition

Vietnam:

- Catchment degradation
- Pollution by untreated urban wastewater
- Flooding and saline intrusion in the Mekong delta area
- Lack of agreement with other riparians on the shared use of the Mekong River

Some of the above problems are the effects of water-related natural conditions and events. Others are the visible manifestations of increasing water demands or of inappropriate water development and management policies, decisions and actions, or of lack of action.

Water resource profiles of the above 19 Asian countries, including selected Pacific island territories, are presented in Appendix A.

Agriculture accounts for up to nine-tenths of all water withdrawals. Urban and industrial users share the balance about equally. Only about 15 percent of total river potential is utilized because flood flows, which make up a predominant part of many river system flows, occur outside the dry season, when irrigation needs are greatest. To utilize the untapped

portion is difficult since the most convenient and economical sources have already been developed and seasonal storage is very expensive.

Increased population and food production not only demand greater quantities of water, but also create downstream problems by pesticide and nutrient contamination, and waterlogging.

Competition for water occurs both within and between countries, in some cases because of complete or partial river diversions. Some water uses impact on others as, for example, when groundwater withdrawals reduce aquifer heads and lead to seawater intrusion. Health risks have been created by discharges of inadequately treated or untreated urban and industrial wastewater into rivers from which potable supplies are taken, and by the presence of pesticides, salinity, and nutrients in agricultural drainage. Almost half of the population lack adequate supplies of potable water and more than half do not have adequate sanitation.

Recent Trends

Two related trends, population growth and combined urbanization and industrialization, have sharply affected present use and future development of water resources in virtually every Asian country. Both trends have become increasingly significant in the past thirty years and are mutually reinforcing. Between 1960 and 1990 the population of Asia has almost doubled. Present annual growth rates range from less than 1 percent in Korea to 2.7 percent in Pakistan. Although with a few exceptions (such as Afghanistan, Laos, and Vietnam) the rates are decreasing, absolute population numbers will continue to grow well into the 21st century (refer to Table 1).

Accompanying the overall population increase is the even more dramatic trend of urbanization and industrialization. As indicated in Table 1, urban growth rates greatly exceed overall population growth rates. In parallel with this demographic phenomenon, nonagricultural economic activity (industry, manufacturing, and services) is estimated to represent more than 75 percent of the gross national product in each of the same seven selected countries (Table 2).

Urbanization and industrialization compete with agriculture for water, even as urban and industrial pollution is reducing the available supply of water of adequate quality.

These two trends have significant implications for water demand and water quality. The population increase has been accompanied by a "green revolution," the product of many factors such as new seed varieties, increased irrigated areas, new agricultural technology and new markets, which has greatly increased water demands. Agriculture is by far the dominant water user, and the need for water is illustrated by the growth in rice production, which has increased almost two and a half times over the last 30 years, and wheat production, which has increased approximately five-fold during the same period. Increased population and food production not only demand greater quantities of water, but also create downstream problems by pesticide and nutrient contamination of groundwater and waterlogging of soils. In some coastal areas, groundwater withdrawals for agriculture are causing seawater intrusion into good-quality aquifers.

Meanwhile urbanization and industrialization compete with agriculture for water, even as urban and industrial pollution is reducing the available supply of water of adequate quality for all uses, and is adversely affecting public health and the environment.

Throughout much of Asia today, easily tapped and readily accessible run-of-river surface water sources are no longer available because they have generally been fully developed during the recent period of accelerated growth. Where untapped sources still exist, their development involves higher cost than currently used sources. Examples include pumping costs associated with groundwater development and the costs of long conduits and/or treatment needed to utilize surface supplies. The need for greater volumes of water, especially during the dry season, must now in part be met by storage. However, storage is expensive and frequently has important social and/or ecological implications. Increasingly vocal demands for sustainability will require that dam projects provide for multiple uses including maintenance of species diversity and deal appropriately with any population displacement.

Today's competing demands for limited supplies require that water be used much more efficiently in all subsectors.

Many countries of Asia (for example, Pakistan, India, Bangladesh, Thailand, Indonesia and the Philippines) are facing new subsectoral water problems that require a different approach to resource allocation. Previously, it was possible to plan and design urban, hydropower and irrigation water projects without much regard for their impacts on other needs, because all needs could be met by tapping new sources or by increasing withdrawals from existing sources. Today's competing demands for limited supplies, however, require that water be used much more efficiently in all subsectors.

TABLE 1
Population Indicators in Selected Countries in Asia

Country	Population[a] (millions)	Population Growth [a] (percent)			Urban Population [b] (percent)	
	1990	1965-1980	1980-1990	1989-2000	1965	1990
Bangladesh	107	2.6	2.3	1.8	6	16
China	1,134	2.2	1.4	1.3	18	56
India	850	2.3	2.1	1.7	19	27
Indonesia	178	2.4	1.8	1.6	16	31
Pakistan	112	3.1	3.1	2.7	24	32
Philippines	61	2.8	2.4	1.8	32	43
Thailand	56	2.9	1.8	1.4	13	23
TOTAL	**2,498**	-	-	-	-	-
AVERAGE	-	**2.6**	**2.1**	**1.8**	18	33

(a) World Development Report 1992, Development and the Environment, IBRD, May 1992, Table 26, p.268
(b) Ibid, Table 31, p.278

Growing demand for water is paralleled by increasing demand for power, the needs for which outstrip supply and restrain economic growth. The addition or enlargement of power generation facilities at existing irrigation or water supply headworks is often an economically attractive way to increase power supply. Rehabilitation and/or increasing the capacity of existing power plants is also frequently cost effective and quickly achievable. In many cases, especially in mountainous areas, this can be done with little or no adverse environmental consequence and with beneficial flood regulation effects. Where storage must be avoided for environmental or social reasons, and where the terrain is steep enough, run-of-river hydropower facilities can be provided.

Most major cities in Asia have inadequate water supply, treatment and distribution facilities. Areas that are elevated, farther from the water sources or pumping stations, or economically disadvantaged (such as the ubiquitous peri-urban squatter developments) receive intermittent or no formal water supplies. Intermittent supplies open the way for contamination by polluted groundwater and are a health hazard, even where treatment is

TABLE 2
Economic Growth Distribution in Selected Countries in Asia

Country	Distribution of Non-agricultural GNP [a] (percent)	
	1965	1990
Bangladesh	47	62
China	62	73
India	56	69
Indonesia	49	78
Pakistan	60	74
Philippines	74	78
Thailand	68	88

(a) World Development Report 1992, Development and the Environment, including Industry, Manufacturing, Services, etc. IBRD, May 1992, Table 3, p. 222.

adequate. Frequently, however, treatment facilities cannot cope with highly polluted river sources, especially where the cost of disinfectants and other needed chemicals is high.

Table 3 illustrates both the generally inadequate provision of potable water supplies and the lack of sanitation services in Asia. Few Asian cities have adequate sewerage systems. Excreta from homes are generally discharged either into street drains or into streams or shallow groundwater. Rivers and lakes receiving wastewater from urban areas and industries serve in turn as sources for potable water supplies for other communities, frequently without reliable treatment to protect the health of consumers. The installation of conventional sewer systems in cities where they were not originally installed as part of the basic infrastructure is prohibitively expensive. Peri-urban areas present some unique challenges related to lack of land tenure, difficult topography and inability to afford high-cost conventional solutions. There is a growing body of experience in the successful application of low-cost technologies for urban wastewater management but important difficulties remain for large-scale application.

There are effective low-cost or no-cost industrial pollution reduction techniques, but they have been given limited application in Asia.

The industrialization of Asian cities has brought about new water-related problems. Metal finishing and battery manufacturing plants, or those that use industrial solvents or petroleum derivatives, or produce or handle pesticides, are very likely to contaminate water sources. Textile factories, slaughterhouses, breweries, fruit and vegetable canneries, and bottlers discharge large amounts of putrescible organic materials that can deplete oxygen, and

TABLE 3
Water and Sanitation Indicators in Selected Countries in Asia

Country	Population with Safe Drinking Water [a] (percent)		Population with Sanitation Services [a] (percent)	
	Urban	Rural	Urban	Rural
Bangladesh	25	66	20	6
China	50	14	-	-
India	79	60	40	4
Indonesia	41	37	32	38
Pakistan	85	28	56	5
Philippines	81	68	76	66
Thailand	57	78	81	57

[a] South Asia and East Asia and Pacific Regions: Asia Water Resources Study - Draft, Main Report, IBRD, 1992, Table 2.6, p. 14.

thereby kill life, in the receiving waters. There are effective low-cost or no-cost industrial pollution reduction technologies, but they have been given limited application in Asia.

Increasing human expropriation has reduced the flow of freshwater to critical wetlands. River channelization for flood protection reduces floodplain fisheries that are vital to the diet of the poor.

Agricultural operations also contribute to water quality degradation by introducing salinity, nutrients, and pesticides. The increasing human expropriation of water resources by dams, diversions or consumptive extraction has reduced the flow of freshwater to critical wetlands and estuaries, including mangrove habitats and coastal lakes. The consequent drying out and/or salinization (by intrusion of seawater) of these ecosystems, among the most productive on the planet, has economic effects such as reducing vital fisheries and degrading

the flood-protection benefits of these natural systems. River channelization for flood protection in rural areas reduces floodplain fisheries (temporary wetlands) that are vital to the diet of the poor in countries such as Bangladesh.

Reductions in the amount of water available for the ecosystem at large, while not well documented, result in a broader loss of biological resources such as genetic diversity through extinction and habitat elimination, which are likely to be irreversible. These losses, accelerating due to human population and development pressures, do take place not only through planned trade-offs with human water uses, but also through the accumulation of thousands of small, individual actions.

Water systems can no longer be designed and operated without regard for wasteful use, and in most countries conservation is an urgent need. Prevention of losses in transmission and distribution, and of wastage by users, will be critical for most urban, industrial, and irrigation water systems. Such measures as wastewater reclamation and reuse, and reserving high-quality water for users with high-quality needs by means of exchanges of water rights, will be increasingly important.

The environmental and social effects of projects will need to be given much greater weight in future water resource planning. While health improvement has been the primary objective of numerous water supply and sanitation projects, water developments to serve other needs have affected health adversely in some cases by enabling the multiplication of disease vectors or releasing toxic or carcinogenic substances or pathogens into the receiving waters. While some environmental damage is reversible, the degradation of aquifers, soils, or wetlands through salinization or contamination by toxic chemicals or nutrients is likely to be long-lasting.

Institutional and social concerns extend beyond project impact. Appropriate roles for end users and corresponding government entities must be identified as users increasingly take over management responsibility and, in some cases, ownership of water distribution systems. In the interim, governments will need to assist users to define and articulate their problems, provide strategic technical assistance, and open access to other resources. Women have historically been neglected in these empowerment efforts which often fail. Gender analysis and measures to ensure women's participation must be integral to any water resources program in order to reflect actual patterns of water use for household needs, agriculture, and industry.

In the past, the planning process has largely ignored linkages between water uses. Policies and plans should fully take into account the intersecting interests of the many stakeholders in water.

The changes that have occurred require a new and more democratic approach to water development and use in Asia. It is no longer economically feasible or environmentally acceptable to supply water to cities, farms, or industries without fully addressing the range of interests that may be affected. In the past, the planning process has largely ignored linkages between water uses, between parts of single water systems such as river basins, and between water and such important considerations as health, income, equity, and ecology. Policies and plans should fully take into account the intersecting interests of the many stakeholders in water.

Chapter 2. THE MAIN ISSUES

Sustainability, the primary issue for the water sector in Asia, encompasses:

- Integrity of water resources so that meeting present needs does not compromise ability to meet future requirements, and

- Appropriateness, efficiency and longevity of facilities and systems to utilize those resources.

> **The primary issue for the water sector in Asia is sustainability of water resources and systems.**

Sustainability has received insufficient attention in past water planning with resulting impacts on the environmental soundness and social acceptability of developments and projects, equity of water allocation, efficient use and protection of water resources, economic and environmental health returns on water-related investments, and the availability of financial and other resources to support operation and maintenance of water systems.

The principal areas of concern in Asia regarding sustainability of water resources and systems can be grouped as follows:

- Policy and institutional weaknesses

  Even where very large investments have been made in water sector development, policy and institutional weaknesses pose serious problems in Asia. The degree of success of any government in bringing about sustainable water development and use depends on its skill in identifying and implementing appropriate policies, including establishing a suitable environment for non-governmental actors. Existing policy, legal, regulatory, and administrative arrangements in many cases fail to assign accountability; to balance economic, environmental and social interests; to provide appropriate incentives under conditions of shortage of financial and other resources; or to take into account the full range and interests of users, including women.

- Competition for water

  Competition for water has arisen because the resources are being outstripped by demand. It is exacerbated by water quality degradation and is especially intense between users requiring high-quality water. There is competition by subsector, such as irrigation, urban water supply, urban wastewater disposal, power generation, and

industrial water supply and wastewater disposal; by location, as between upstream and downstream users; and between nations, whose disputes in some cases also center on upstream or downstream use.

- Health and environmental needs and effects

  Environmental health conditions are very poor in many parts of Asia, especially in peri-urban areas. A prime cause is lack of adequate potable water supply and sanitation services. Urbanization and industrialization have caused water quality degradation with very serious environmental and economic consequences. Water development activities have led to widespread salinization of land, waterlogging saline intrusion into aquifers in coastal areas, and destruction of fish-life and wetlands. Important environmental and social linkages have often ignored or under-valued during the planning stage of water projects. As a result, important potential uses of clean water have been pre-empted by economically and socially inferior prior uses, and population groups have been displaced or become disaffected. Women are critical determiners of how the resource is actually used because of their control over the household. Government programs which have failed to address gender issues have not dealt realistically with health and sanitation issues, as well.

Policy and institutional weaknesses include: lack of accountability and transparency; lack of policies to encourage conservation; narrowness of planning focus; operation and maintenance inadequacies; and failure to generate adequate revenues.

Policy and Institutional Weaknesses

Public policies, or lack of them, and public and private institutional inadequacies contribute to most of the water sector problems in Asia. Their resolution is vital to achieving significant improvements in the sector. Issues of major concern in Asia include:

- Policy inadequacies:

  - Lack of accountability and transparency
  - Combination in single organizations of aspects of water sector governance with service provision or sponsorship functions related to particular water subsectors
  - Multiple organizations with overlapping, often conflicting, water sector governance functions
  - Lack of policies to encourage conservation, waste minimization and reuse

- o Separation of capital development and operational responsibilities, resulting in user costs that include no capital component (leading to over-use) or to lack of effective provision for maintenance
- o Provision of direct or indirect subsidies for water use and the absence of policies requiring revenue generation to support operation and maintenance and to reduce demands for water

- Narrowness of planning focus:

  - o Failure to address basin-wide issues such as surfacewater-groundwater continuity and interactions between water uses, including both interactions between classes of abstractive use and those between abstractive uses and non-abstractive needs such as ecosystem maintenance
  - o Lack of transparency in project decision-making and failure to involve all stakeholders, especially water users who are expected to provide financial or other support
  - o Lack of provision for appropriate private sector and voluntary organization involvement
  - o Failure to consider adequately long-term trends in demands, water quality degradation, and the availability and value of water and other resources

- Operation and maintenance inadequacies:

  - o Organizational responsibility of operating utilities oriented to government in lieu of accountability to the users
  - o Inadequate operational resources, procedures and capabilities
  - o Continued acceptance of poorly supported and managed governmental operations without serious attempts to apply alternatives such as user associations or contract operations
  - o Lack of training programs

- Failure to generate adequate revenues to support operation and maintenance and to control demand:

  - o Failure to reflect real costs in water charges
  - o Lack of effective means of measuring delivered water volumes
  - o Inefficiency of collection of billed revenues
  - o Lack of effective financial management systems including provisions for internal capital generation and debt management

Decisions about water are often made on too narrow a basis to encompass the range of interests and stakeholders involved. Narrow centralized planning is a common feature of many large Asian water development programs that today evidence signs of incipient failure or marginal utility. Illustrations can be found in Pakistan, India and Bangladesh, for

example. Many of these systems have suffered for lack of maintenance. Funds for repair are short and, where efficiency of use is low, benefit/cost ratios for rehabilitation are also low. Meanwhile the systems continue to deteriorate.

In the past, narrowly focused investigations and planning have led to projects in which intended benefits have not been realized because the needs of the users were not identified and provided for, downstream problems such as pollution, soil salinization, or waterlogging have been created, users or abutters have destroyed project works, and lack of maintenance has caused systems to deteriorate. It is critical, under the economic conditions that prevail in the countries under consideration, that future water development projects not repeat these failures.

Such issues must be addressed from inception through operation. All of the prerequisites for sustainability must be recognized at the planning stage. Where water quantity and competition are concerned, a prerequisite is adequate information and a framework for evaluating and comparing the effects of alternative actions.

Open, cooperative decision making should be a common goal, to be implemented in steps with which governments are comfortable. Active citizen groups should be able to hold governments accountable.

Policy, legal, regulatory and organizational arrangements must assign accountability and balance between economic, environmental, technical, social, bureaucratic, and other interests, in order to ensure sustainability. While there is no single short-term approach that should be applied in all countries, open, cooperative decision-making should be a common goal, to be implemented in steps with which governments are comfortable. Active citizen participation groups should be able to hold governments accountable.

Decision-making on water use should, in the interests of equity, economic efficiency and ecological protection, avoid bias in favor of agencies or subsectors that happen to be ready to make investments, even if their programs and projects have health-oriented or environmental goals. An essential component of decision making on water allocation and use is interagency and public participation.

Improved policies and oversight procedures are needed rather than conventional "strengthening" of centralized planning and implementation organizations.

The organizations, whether regional, municipal, or private sector, that provide water service often have difficulties with bankable development projects, customer and business operations, and facility operation and maintenance. Improved policies and oversight procedures are needed rather than conventional "strengthening" of centralized planning and implementation organizations. Improved policies are needed to protect public health, welfare and environment, supported by legislation, administrative arrangements and procedures for oversight and performance monitoring.

Some aspects of water sector infrastructure and service planning are conducted at such distance from the sites and intended beneficiaries that fundamental issues are not addressed. Planning and implementation often does not involve private sector and voluntary organizations that could bring rigor to analytical processes and important insights to the consideration of options. Service delivery organizations are frequently hampered by lack of autonomy, inability to manage and right-size staff, and lack of authority to generate adequate revenues and manage their financial affairs. Key oversight processes related to water infrastructure planning and implementation, such as preparation and approval of environmental assessments, are frequently absent.

A key requirement for the longevity of systems is revenue generation to support operation, maintenance, repairs, rehabilitation, and system expansion where appropriate. Appropriate use and sustainability of water resources also requires that costs to users reflect the true value of water. Many water projects have been funded entirely by government grants. Being subject to budgeting pressures, the annual funding allocations for operations then tend to bear little relevance to the needs of the systems. Recovery of at least part of the costs from beneficiaries is generally accepted in the case of urban and industrial water supply projects, and is achieved with varying degrees of effectiveness. Provisions for revenue generation for existing or planned urban wastewater systems, which in general have higher costs than water supply systems, are seldom adequate, however.

A better understanding of successful and unsuccessful models is necessary for revenue generation to support infrastructure sustainability.

Collection of fees from agricultural water users is difficult, especially if increased production brings crop prices down or if poor maintenance interrupts supply. A better understanding of successful and unsuccessful models is necessary for revenue generation to support sustainability.

Large water sector bureaucracies that combine powers of governance with service-provision functions tend to select services they will provide on the basis of benefits to themselves rather than to water users. Governance and service provision are generally better separated.

Policies, planning procedures, regulations, and project implementation and operation are often inadequate. Even where institutional competence exists, it is often so narrowly focused as to prevent, rather than support, consideration of the full range of concerns on which sustainable development must be based. Large water sector bureaucracies that combine powers of governance with service-provision functions tend to become selective as to the services they will provide (e.g. performing design and construction but not operation and maintenance, and preferring large-scale civil works to the provision of less capital-intensive facilities and services), and often make their selections on the basis of benefit to the organizations and their employees rather than benefits to their ostensible clientele, the water users. Governance and service provision are generally better separated.

The development and implementation of sound water policies require provision both for efficiency and competence in governance of the water sector and for governmental accountability to the citizens.

An important concern for national governments is how to overcome intellectual inertia and bureaucratic traditions and behaviors inhibiting the rational resolution of the very complex issues concerning development and management of local and regional water resources. The development and implementation of sound water policies require provision both for efficiency and competence in governance of the water sector and for governmental accountability to the citizens.

Sustainable water development requires involving water users and other stakeholders in water program and project initiation, decision-making and ownership.

Planning and implementation involving the stakeholders are now recognized by the major international development agencies as critical to sustainable development. This has been a very important lesson from the 1981-90 International Drinking Water Supply and Sanitation Decade. Such processes are in many cases most effectively applied through

decentralized and democratized procedures involving both government and nongovernment organizations. Sustainable water development over the long term also implies the freedom of water users, working within defined water quality and other protective rules, to treat water as a tradable good like any other. Above all, it requires involving water users and other stakeholders in water project initiation, decision-making, and ownership.

The expansion of the water sector in recent years was facilitated by many factors, including strong technical and financial support from outside the region. During the 1981-90 Water Decade, approximately $12 billion was spent by external donors (out of a total expenditure of about $66 billion) on potable water and sanitation improvements in Asian countries. Combined lending for irrigation in Asia by the World Bank, Asian Development Bank, OECF, and the U.S. government increased sharply to over $1 billion per year in the early 1980s but has fallen steadily since then. The decline essentially is a response to lower returns on investment in irrigation. These returns in part reflect previous successes: lower food prices (grain prices have declined with increased production) and higher costs of irrigation (most of the least-cost opportunities have already been exploited). Yet today's problems are more challenging than the relatively straightforward ones of earlier expansion. They call for a new balance between responses to agricultural, residential, and industrial demands for water, and for solutions to environmental degradation caused by population concentrations and more intensive agriculture. Moreover, these problems must be faced in circumstances that render the past institutional frameworks inadequate.

New sources of water can no longer be developed at costs to which governments are accustomed. The result is competition for the resources that exist and a need for all users to optimize their efficiency of water use.

Competition for Water

Urban and agricultural demands for water are increasing, while pollution is reducing access to supplies of acceptable quality and new sources of water can no longer be developed at costs to which governments are accustomed. The result is competition for the resources that exist and a need for all users to optimize their efficiency of water use. Some key aspects of water competition are listed in Box 1.

Diversions above national boundaries impact on countries downstream. An example is the diversion of the waters of the Ganges in India, depriving southwest Bangladesh of dry-season irrigation water. International rivers such as the Mekong River, whose waters could benefit several countries, remain undeveloped because these countries cannot agree on joint or coordinated projects (see Box 2).

Box 1 - Illustrative Water Competition Issues

Among the most important elements of competition for water in Asian countries are:

Interference with other current water uses:
- Dams and diversions that reduce flows available to other users
- Pollution by sewage and industrial wastewaters
- Non-point pollution by agricultural runoff and seepage
- Groundwater contamination by seepage from solid waste and hazardous waste dumps
- Reduced freshwater flows to support fisheries, wetlands, mangroves and other estuarine products

Damage to water resources reducing their future usefulness:
- Degradation of watersheds by land-use conversions that reduce their capacity to regulate flows
- Overpumping of aquifers or destructive mining of fossil groundwater
- Accumulation in aquifers of toxic or oily substances, carcinogens, salts, or other substances affecting potability
- Accumulation of toxic, oily, or putrescible substances in bottom sediments in lakes and rivers

Inefficiency of water use and development, exacerbating competition:
- Water transmission losses
- Water wastage by users
- Lack of value-based pricing
- Lack of relevant data

Economic and financial inefficiency, reducing resources and options available to other potential water users:
- Inadequate or unrealized economic return on investment
- Accrual of benefits to others than the users and payers of costs
- Failure to collect the revenues needed for operation and maintenance
- Failure to provide economically available external benefits (such as pollution control), and to recover the costs
- Uneconomical use of other resources such as energy and foreign assistance

Lack of technical soundness and operability, with the potential to force users to other sources and to decrease the efficiency of water use:
- Failure to achieve the intended objectives
- Lack of provision to survive predictable natural events and processes such as floods, storms, erosion, corrosion, and siltation
- Lack of facilities and organization to conduct operations, maintenance, and emergency repairs

International issues:
- River diversions that reduce dry-season flows to downstream countries
- Control systems that worsen downstream flooding
- Lack of agreement between riparian countries that would permit joint or coordinated water projects.

There are important equity issues in water development and use that generally are not adequately addressed. Urban consumers who can afford to pay frequently enjoy subsidized service through underpriced water, while poorer residents depend on water vendors, who charge much higher prices. Farmers near the head ends of irrigation systems gain de facto prior rights to water, even if their lands yield lower economic returns than those of farmers farther downstream. Failure to deal with such distributional inequalities can thwart the intended economic benefits of systems.

In many places, water is abstracted directly by users, either at the expense of others less advantageously located, or in such a way as to deplete a limited resource. This is frequently because water rights are not allocated in the interest of the best use of resources, or because of a lack of adequate information, and is contributed to by underpricing of electricity for pumping. Groundwater depletion is a common result of uncontrolled pumping that can lead to ground subsidence, lowered water levels and consequent increased pumping costs, or saline intrusion. For example, excessive exploitation of groundwater in Bangkok, Thailand, has led to drastic lowering of groundwater levels and to sinking of the overlying land surface. Between 1960 and 1988 parts of the city sank about 1.6 meters, and the current rate for some sections is about 5 centimeters per year . This groundwater depletion and land subsidence have led to saltwater intrusion, increased flooding, and damage to buildings, highways, bridges, and underground pipelines, as well as to increased costs of pumping.

The construction and operation of dams and associated power generation facilities can enhance or interfere with other users' access to water. Downstream uses that need low-flow augmentation are likely to benefit from hydropower reservoir releases. In dry periods, however, hydropower generation competes for water with other users that draw separately from shared reservoirs. All uses that need to maximize the amount of water stored may be in competition with flood control. There is a general lack of awareness and planning for ecosystem water needs, even ones that are immediately instrumental for human purposes (such as fisheries and flood protection).

Siltation of dams, scarcity of good unused sites for hydropower generation, and the unacceptable environmental or social impacts of large-scale water storage, will raise the cost of energy. Since energy for water pumping is at present subsidized in many countries that cannot afford to provide this subsidy indefinitely, many schemes depending on pumping face an uncertain future. Sustainable solutions will require the application of energy prices that reflect long-term real costs and strenuous efforts to reduce reservoir sedimentation. Other non-abstractive uses of water, such as recreation, wastewater assimilation, ecological habitat maintenance, and prevention of saline intrusion, are usually competitive with abstractive uses under conditions of water scarcity. Recreational uses of reservoirs that demand constant water levels compete with all other uses.

Efficient allocation, delivery and use of water depends on the availability of data on water yield and storage and on water needs for entire countries or river basins, as appropriate. The collection and use of such data, including applied research, constitute an important missing component of water management in most Asian countries. Efficiency of water allocation, delivery and use also depends on the existence of commonly applied measures of performance in the improvement of efficiency. For water use in particular, while there is a general understanding that efficiency corresponds to a high level of beneficial use as compared with flows delivered, common performance measures or definitions across water subsectors do not exist.

Water programs and projects often involve competition not only for water but also for energy, land, capital, foreign assistance or other resources. In order to improve effective

Box 2 - Riparian Competition in the Lower Mekong River Basin

The Mekong is the tenth largest river in the world in terms of annual flow, with a mean annual discharge to the sea of 475 BCM. Of the total catchment area of the river, 77 percent is situated in the riparian countries of Thailand, Laos, Cambodia, and Vietnam. Skewed resource endowment among the riparians is the cause of widely different development priorities for each country. Thailand has ample land resources for new agricultural lands but lacks water. Laos has abundant water but lacks land resources. Thailand can utilize hydropower potential to meet projected future power demands but lacks development sites. Hydroelectric development sites exist in Laos, but projected power demands are only a fraction of the potential power that could be generated. Cambodia and Vietnam rely on fishing in the basin as a major source of protein. Not only is the great Tonle Sap Lake a major source of fish, it also serves as a natural flood regulator for the basin. Cambodia and Vietnam rely heavily on the Mekong and its tributary waters as a source of irrigation water. Navigation is also important in Cambodia and Vietnam.

Thailand has an economic and political advantage over its neighbor riparians, considering the extreme lack of funds available for development in Vietnam, Laos, and Cambodia. Laos and Vietnam also suffer from inadequate bureaucracies, and civil strife in Cambodia has diverted attention from development. Even though an improvement in civil affairs in Cambodia bodes well for resumption of serious discussions among the riparians concerning the development of the Mekong basin, considerable distrust exists among the parties, and it remains to be seen whether that distrust can be overcome, with planned, sensible, and mutually beneficial development the result. The riparians have been meeting under U.N., E.C., and OPEC sponsorship since 1957. The development of the Mekong by a seven-dam "main stem cascade project" has been agreed to as the main thrust of basin development but, to date, only projects on tributaries have been undertaken. Development is progressing slowly not only because of conflicts of interest but also because of lack of internally available funds, lack of planning coordination or technical ability by institutions, lack of government will, and international donor support priorities in the region.

The riparians not only need to resolve differences, they also must now address development problems that will affect development plans and the efficiency of any interventions. **Catchment degradation** in the lower Mekong is causing increased siltation and wet season flooding in Vietnam's coastal waterways. Clearing of land for agriculture in Cambodia may have already caused a reduction in fish production in the Tonle Sap. **Salinity intrusion** in the delta is occurring as a result of low dry season river flows. **Dry season potable water availability** is a major problem in northeast Thailand and parts of Cambodia, prompting competition between irrigation and domestic supplies. **Resettlement and environment** issues also loom large for the cascade plan. **Changes in fishing** patterns — to primarily reservoir fishing — would be necessary. The development of the cascade plan would also have major effects on **river navigation** in Vietnam and Cambodia.

water yields of surface water sources, and to match the timing of supply with that of demand for irrigation and power generation, storage of water is increasingly needed. Storage is capital intensive, however, and may have deleterious social and environmental effects such as displacement of residents of areas to be inundated or spread of vector-based disease (see Box 4 for an example). There are unfulfilled opportunities for small scale, environmentally benign, multipurpose water development. Small hydropower projects on irrigation canals in India may comprise good examples.

Dealing with water scarcity will require increased use of water-saving features such as water charges that link user costs to water demands, water conservation and management of losses, and the reuse of reclaimed wastewater in controlled ways that are safe.

A common shortcoming of water programs and projects is the omission of water-saving features. Dealing with water scarcity will require increased use of water charges that link user costs to water demands, water conservation and management of losses, and reuse of reclaimed wastewater in controlled ways that are safe. In addition, there is often an erroneous assumption that all available water can be abstracted without regard for the needs of ecological maintenance, wastewater assimilation, and prevention of saline intrusion in coastal areas.

Under conditions of increasing scarcity of capital and other resources, water projects should receive much more careful scrutiny for economic soundness than they typically have been given in the past. Appropriate investment decision-making under conditions of water resource shortage requires that a value be ascribed to water. Issues related to benefits, costs, and the value of water are discussed in Appendix B.

The management of demand to promote the efficient use of water and discourage wastage is an important objective frequently achievable through appropriate pricing. It requires that fees be collected on the basis of measurement of the quantities of water used (in the case of urban water supply, water meters that are maintained and read regularly), and that power used for private well pumps be suitably metered and priced. However, experience shows that in the absence of reliable service delivery and of user motivation for systems to succeed, adequate revenue collection in rural and peri-urban areas is often not possible.

Other measures for managing competition, if the data and regulatory means are in place, are:

- Permitting the operation of markets for water rights (with any necessary controls to protect public and environmental interests)
- Encouraging exchanges of water rights (either by fiat or by market trading) in the interest of overall economy, so that water of the highest quality is used for purposes requiring it
- Encouraging reclamation and reuse of municipal wastewater
- Promoting water conservation through education and price incentives and through such technical measures as water metering improvements, leakage detection and repair, canal lining, and better water application methods
- Bringing together competing interests in order to share information and identify areas where agreement is possible

Box 3 - Examples of Water Reuse in Asia

Japan

Because of Japan's great population density and limited water resources, wastewater reclamation and reuse were begun early. The primary use has been for toilet flushing in multi-family, commercial, and school buildings. Retrofitting of buildings for flush toilets as sewers are installed offers excellent opportunities to install dual systems to carry reclaimed water.

Initially, individual buildings or groups of buildings were provided with reclamation plants. Later, advantage was taken of the economy of scale provided by municipal reclamation of effluents.

As of 1986, about 40 percent of effluents were being reclaimed and distributed through dual systems. In addition to toilet flushing, treated effluents are used for urban irrigation and cleansing. In Tokyo, the use of reclaimed water is mandated in all new buildings with floor areas over 300,000 sq. ft.

Singapore

A portion of the effluent from an activated sludge wastewater treatment plant in western Singapore is reclaimed to serve industrial water needs on the nearby Jurong Industrial Estate. It is also used for toilet flushing in a residential development housing about 25,000 people in 15-story buildings.

Source: Manual - Guidelines for Water Reuse, USEPA and USAID, September 1992.

The application of these measures varies widely and frequently is not fostered by government policies. However, increasing competition will tend to force governments to give them greater attention.

There are important Asian approaches to sustainable water development that can be applied elsewhere in Asia. Japan and Singapore provide successful examples of water reuse, which is an important means of water conservation (see Box 3). Driven by internal economic incentives, many utilities have been able to reduce leakage and, thereby, demands for water. Hong Kong, Singapore, and Bangkok provide examples. The application of appropriate policies, supported by the transfer of suitable technologies, can induce water-saving actions on the part of industries. Such actions and policies are essential if widespread improvements are to be made. Examples of industrial water conservation in the USA are given in Table 4.

The essential redirection of water sector efforts towards demand-side solutions such as conservation and reuse should not obscure the parallel need for new supply-side interventions. Populations, especially the poor, still lack essential water and sanitation services, and new or expanded water and drainage systems will be needed to support increased industrial and food production. Although lack of funds, environmental and social concerns, current low food prices and high energy costs have thrown into question the viability of some major construction projects, this does not mean that infrastructure programs and projects will not still be needed. Seasonal and multi-year water storage, water supply, drainage, flood control, sanitation and wastewater infrastructure facilities, and related institutional improvements, will be needed in the future but must be evaluated much more critically for sustainability than in the past.

Health and Environmental Needs and Effects

Environmental health issues related to water are critical in much of Asia. Such issues include inadequate coverage by potable water supply and sanitation services, water quality degradation, other environmental impacts and social issues. Important effects of water supply and sanitation shortfalls and water pollution include:

- Disease transmission through vector proliferation or ingestion of or contact with contaminated water
- Interference with other potential or actual water uses by pollution of water by domestic and industrial wastes
- Introduction of toxic substances and/or carcinogens into the food chain and biomass
- Eutrophication of lakes by nutrients derived from agricultural runoff and urban wastewater discharges

TABLE 4
Industrial Water Conservation and Cost-Effectiveness: Selected Companies in San Jose, California [a]

Company	Water Use (thousand cubic meters per year)		Water Savings (percent)	Payback Period on Investment (months)
	Before Conservation	After Conservation		
IBM	420	42	90	3.6
California Paperboard	2,473	689	72	2.4
Gangi Bros. Food Processing	568	212	63	10.8
Hewlett-Packard	87	42	52	3.6
Advanced Micro Devices	2,098	1,318	37	7.2
Tandem Computers	12	87	30	12.0
Dyna-Craft Metal Finishing	193	14	27	2.4

(a) Last Oasis: Facing Water Scarcity, S. Postel, 1992, Table 11-1, p. 141.

Other important environmental impacts of water use and development include:

- Waterlogging or salinization of irrigated lands
- Saline intrusion into over-pumped aquifers
- Destruction of wetlands, mangroves and other habitats by flow reduction and resulting salinity increases

- Prevention of fish replenishment due to dam or embankment construction
- Exacerbated flooding extremes due to flood plain restriction

Social acceptability and equity issues include:

- Displacement of resident populations
- Unacceptable intrusion or over-riding of perceived rights (a historical and potential ongoing issue for flood management in Bangladesh)
- Favoring of certain potential beneficiaries over others
- Compensation for damage or inequity
- Lack of real ownership of water systems by users and continued reliance on government-oriented agendas

Water quality is of increasing concern. The volumes and concentrations of urban and industrial wastewater that are creating serious health, economic, amenity and ecological problems urgently need to be reduced.

Water quality is of increasing concern in Asia because of the limitations it imposes on water uses and its impact on health and environment. High population densities, increasing industrialization and the general lack of pollution control facilities have led to very high levels of water pollution, and correspondingly high levels of health risk, in much of Asia. Some specific examples are presented in Box 4.

The volumes and concentrations of urban and industrial wastewater are increasingly creating serious health, economic, amenity, and ecological problems and urgently need to be reduced. Developments intended to provide health and environmental improvements frequently have negative downstream impacts. For example, water supply projects without sanitation improvements may cause sewage ponding and water pollution, and sewerage projects without adequate wastewater treatment or industrial waste minimization or pre-treatment may worsen water pollution.

The discharge of wastewater containing toxic or carcinogenic substances or nutrients into lakes or underground aquifers may seriously impair their value as long-term sources of water.

A fundamental shift towards waste minimization, open access to data and risk-based incentive programs is occurring in industrialized countries, and is urgently needed in developing country pollution control programs as well.

Box 4 - Examples of Water Pollution

India. Of India's 3,119 towns and cities, only eight have complete sewerage and treatment facilities, while 209 have partial sewerage and sewage treatment. On the Ganges alone, 114 cities with 50,000 or more inhabitants dump untreated sewage into the river each day. DDT factories, tanneries, pulp and paper mills, petrochemical and fertilizer complexes, and rubber factories use the river as a sink for their liquid wastes. The Hooghly estuary receives untreated industrial wastes from more than 150 major factories in Calcutta and raw sewage is deposited in the river continuously from 361 outfalls. The Yamuna passing through Delhi receives nearly 200 million liters of untreated sewage each day.

Karachi, Pakistan. The Lyari river which runs through Karachi, Pakistan's largest industrial city, is an open drain for raw sewage and untreated industrial effluents. Most effluents come from an industrial estate with some 300 major industries and almost three times as many small units. Three-fifths of the units are textile mills. Most other industries in Karachi also discharge untreated effluents into the nearest water body.

Shanghai, China. Some 3.4 million cubic meters of industrial and domestic waste pour mostly into the Suzhou creek and the Huangpu river, which flows through the heart of the city. These have become the main (open) sewers for the city. Most of the waste is industrial since few houses possess flush toilets. The Huangpu has essentially been dead since 1980. In all, less than 5 percent of the city's wastewater is treated. The normally high water table also means that a variety of toxins from industrial plants and local rivers find their way into groundwater and contaminate wells that provide the city's water supply.

Peninsular Malaysia. The high levels of pollution evident in many rivers are due largely to organic wastes from sewage and discharges from oil palm and rubber factories. The range and complexity of water pollution problems caused by the discharge of other industrial effluents have increased, especially in centers such as Kuala Lumpur, Petaling Jaya, and Penang. The main sources of pollution are electroplating industries, tanneries, textile mills, food processing industries, distilleries, chloro-alkali plants, sulfuric acid plants, and electronic factories. Many of these industries discharge untreated wastes containing different compounds, including heavy metals, into public water courses. Significant levels of toxic heavy metals have been encountered in the Juru River Basin.

Source: Our Planet, Our Health, Report of the WHO Commission on Health and Environment, WHO, 1992, p. 113.

The experience of the most industrialized countries has demonstrated that pollution prevention is usually more effective and costs less than pollution control. However, many public sector and industrial engineers in developing countries continue to hope that their problems will be solved by "magic bullets" of new technology. A fundamental shift towards waste minimization, open access to data and risk-based incentive programs is occurring in industrialized countries, and is urgently needed in developing country pollution control programs as well.

The Water and Sanitation Decade brought bilateral and multilateral donor funds to bear on the lack of potable water and sanitation facilities in developing countries. During the Decade, 730 million people gained access to potable water and 415 million to sanitation. Nevertheless, the objectives of the Decade (100 percent coverage by 1990) were not met. There was much success in the provision of small community water supplies, especially where appropriate technologies and community participation were key design factors, and in the provision and sustainability of city water systems (and to a very limited extent sewerage systems) when institutional capability enhancement and revenue generation were emphasized. However, very large unmet needs remain, especially in rural and peri-urban areas. In addition, many urban areas that received some degree of coverage during the Decade in fact still have large unserved populations and in some cases receive water that is not continuously available and is at times contaminated. Impacts of inadequate potable water supply and sanitation/sewerage facilities include high incidence of water-borne diseases, high infant mortality rates and poor worker productivity. The key issues in the potable water supply and sanitation subsector are: lack of capital funds; inadequate pricing to recover costs and control demand; attempts to provide services at a level that the users either do not want or cannot pay for; the high cost of providing effective sewerage and sanitation services to urban areas; and inadequate operation and maintenance of facilities that do exist.

Irrigation frequently has unintended downstream consequences such as waterlogging, soil salinization and contamination by pesticides and nutrients. Overpumping of groundwater near the coast can cause long-term impairment of aquifers by saline intrusion. This is a problem in many locations, including parts of India and southwestern Bangladesh.

Social impacts of water projects have thrown into question the viability of some very large investments in the water sector. A well-known example is the Sardar Sarovar Dam in India (see Box 5). Ignoring the effects of water developments such as dams and flood protection facilities on intended beneficiaries and area residents can not only alienate them but also lead to deliberate sabotage of project facilities.

River control works can seriously affect not only human populations but also flora and fauna of ecological and economic importance, by destroying wetlands and impeding fish access. Projects that do not provide for the effects of siltation on river

Box 5 - Narmada: An Example of Social Impacts

Probably the best-known recent example of conflict between water supply development and human welfare is the Sardar Sarovar Dam on the Narmada River in India. Designed to provide 1,200 MW of electric power, supply water to 40 million people, and irrigate 1.8 million ha of land, the proposed reservoir system will submerge 240 sq. km of forest and agricultural land, and displace about 100,000 residents of the Narmada Valley. Many more people will be displaced or adversely impacted by an associated canal system.

Protests by the people affected, and the failure to include provisions for compensation in the project design, have been widely publicized.

storage and training works are not likely to be sustainable.

The management of water quality, the control of water-related disease transmission, and the avoidance or mitigation of other environmental and social impacts of water use and development, are above all else a matter of public policy. Even where governmental agencies are the primary players in water use planning and facility provision, it is important that governments establish and implement policies that will govern the actions of all water users, not least the governmental service providers.

Responsiveness to Change

Most Asian countries clearly need urgent financial and technical assistance to handle the transition from the end of a phase of large capital investments in water that paid little heed to efficiency to a new phase based on efficient and sustainable use of resources. Increasing emphasis will necessarily be placed on managing demand through more efficient use of water and improved system maintenance, and through user empowerment and similar moves towards decentralization, democratization, market processes, and stakeholder involvement in water-related planning and management.

Asian countries have embraced the principles of decentralization, democratization, market processes and stakeholder involvement in water-related planning and management with varying degrees of commitment. Nevertheless, there is a clear recognition among major international donors that the basic principles of democratic institutions and processes, and good governance, are fundamental to effective government policies and programs. For sustainable water sector development, there is an increasing chorus of governments, interest groups, voluntary organizations and participating citizens calling for this approach.

Asian governments are seeing the importance of finding cost-effective, technologically appropriate solutions to urban water and wastewater problems, and involving the beneficiaries in determining the measures to be taken and the costs to be incurred.

The World Bank and the Netherlands are among the first external support agencies to take limited initiatives in this direction. In India, the central and many state governments are realizing the virtue of shrinking the official role in irrigation management and expanding the role of water users associations[1]. The evolving plan for flood control in Bangladesh is an illustration of government recognition that a combination of structural and nonstructural measures, and the participation of beneficiaries in planning, implementation and

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_____, An Approach to Organizational and Procedural Changes in Irrigation Sector, Central Water Commission, New Delhi, September 1992.

management, are necessary to handle an otherwise insurmountable problem[2]. The World Bank and other international agencies, as well as Asian governments themselves, are seeing the importance of finding cost-effective, technologically appropriate solutions to urban water and wastewater problems, and involving the beneficiaries in determining the measures to be taken and the costs to be incurred. An example is the Philippine Government's national strategy for urban sewerage and sanitation improvements, which will follow its recently codified policy of local governance and bottom-up development.

USAID Involvement

The Agency has been involved in the water sector in Asia for many years. Since 1952, a total of $2,909 million has been spent on water projects, including significant water components of other projects. As is indicated in Figure 1, India, Pakistan and Sri Lanka have been the recipients of the greatest amounts of water-related assistance, comprising a combined 62 percent of the total. Irrigation has been the largest focus area, comprising two thirds of the total, as indicated in Figure 2. Water supply and sanitation accounted for 12 percent but was also included in some mixed projects. The types of assistance included a large amount of construction (over a third of the total cost), which in many cases was associated with technical assistance and training. While pure training projects comprised a very small part of the total, training was a component of many projects (63 of the 115 total). A list of the projects and the information on which Figures 1 and 2 are based is provided in Appendix C.

The Agency has supported the International Drinking Water Supply and Sanitation Decade, the provision and improvement of agricultural irrigation, and the improved management of water resources, in all regions including Asia. This has been done through centrally-funded projects serving bureau and mission needs and through mission-initiated bilateral interventions.

The Asia and Near East Bureau and many Asia missions are already engaged in environmentally and institutionally oriented efforts that are specifically directed towards, and showing results in achieving, sustainability in water resource development. The USAID Environmental Support Project is successfully assisting low-cost pollution reduction by electroplating and tanning industries. The U.S.-Asia Environmental Partnership is providing assistance in environmental management through policy reform, institution building, public awareness, and private sector participation.

In Bangladesh, Bureau and Mission assistance has included the preparation and promotion of guidelines for flood control project environmental assessment, the development of guidelines for dealing with flooding when it does occur, and the use of a geographic information system to improve the understanding of the behavior and effects of the country's giant rivers. This assistance has contributed to improved awareness of the need for consult-

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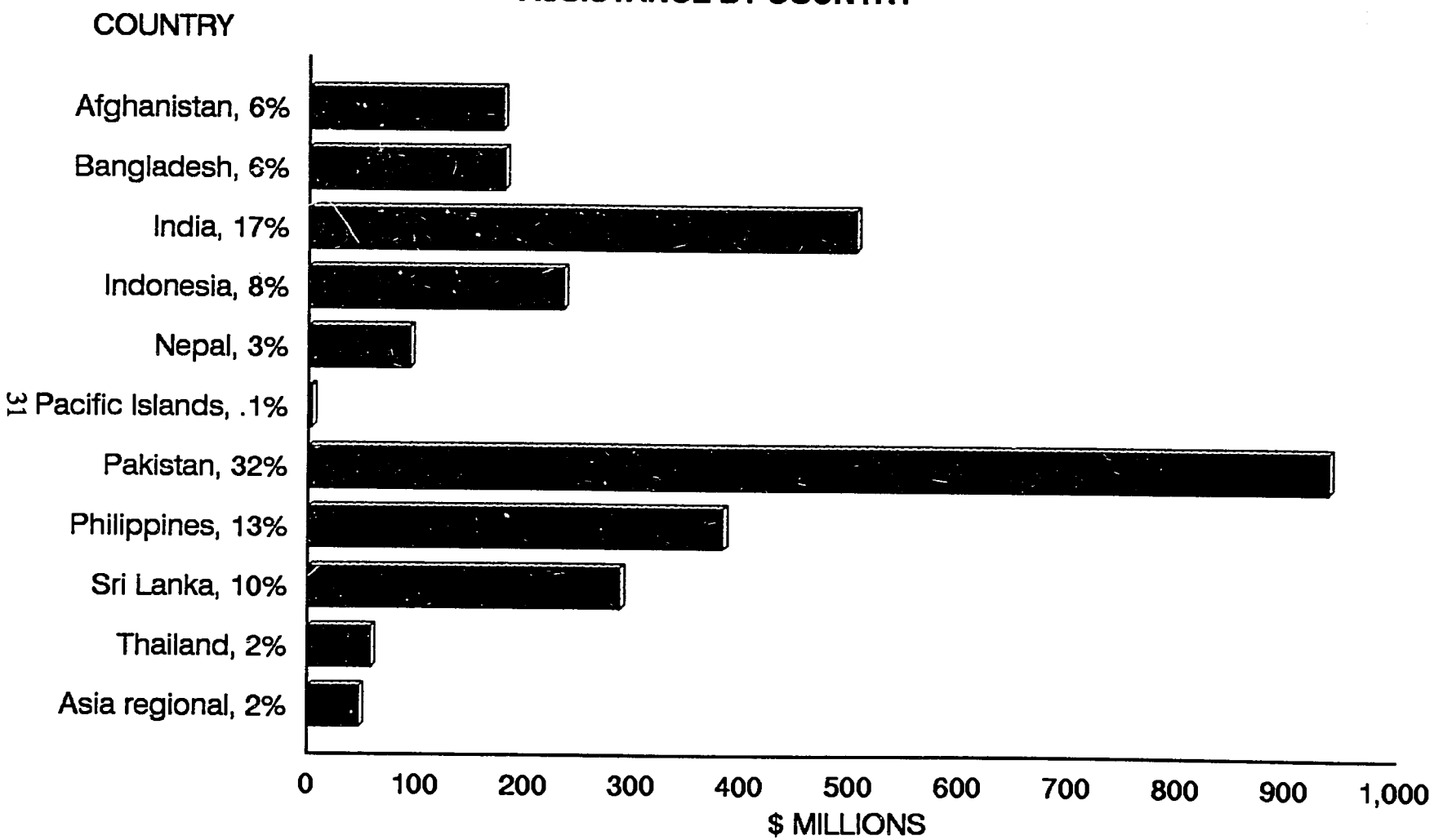
_____, Bangladesh Action Plan for Flood Control: Achievements and Outlook, an Update, Government of Bangladesh and the World Bank, November 1992.

Figure 1
USAID ASSISTANCE TO WATER SECTOR IN ASIA
ASSISTANCE BY COUNTRY

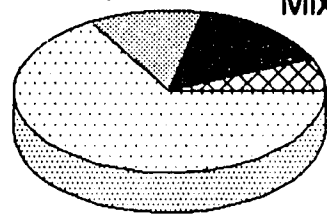


Total Amount $2,909 Million

Figure 2

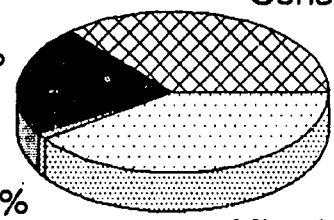
USAID ASSISTANCE TO WATER SECTOR IN ASIA

ASSISTANCE BY FOCUS AND TYPE



FOCUS OF ASSISTANCE

Note: Mixed includes navigation and hydropower generation



TYPE OF ASSISTANCE

Notes: Construction includes any associated technical assistance, training & commodities

Technical assistance & training include associated commodities

Mixed includes pure commodities

Amounts in $ millions, 1952-92
Total $2,871 million

ative planning processes involving the range of stakeholders and of consideration of alternatives to ubiquitous flood control structures of doubtful permanence and effectiveness.

USAID/New Delhi has assisted in the development of a network of water and land management institutes in eleven states of India. These institutes have developed and are providing training programs to upgrade the skills of water resources professionals. In Sri Lanka, USAID involvement in national potable water supply institutional strengthening, and in technical, user participation and other aspects of the massive Mahaweli irrigation scheme, has contributed to the sustainability of those systems.

To move positively and successfully towards sustainability in water use and development will require strenuous and clearly focussed efforts by Asian countries, with key donors playing important roles in providing impetus, guidance and information.

These positive examples constitute no more than a beginning to what will be a very difficult process for countries and for their international donors. They show an understanding on the part of a few important players of the crucial need to start in a new direction towards sustainability in the water sector through good governance and demand management.

Much of Asia is entering a critical period in water development. Important decisions on water development and use will be made in countries where demands are approaching quantities of water available and where water sources are so polluted as to seriously limit their value. The next few years will provide an important window of opportunity to improve the efficiency and sustainability of water use in order to maintain and protect water resources for the future. However, to move positively and successfully towards sustainability in water use and development will require strenuous and clearly focussed effort by individual countries. Movement towards sustainability in water development will be achieved most expeditiously if key donors provide countries with suitable impetus, guidance and information-sharing opportunities. This will be a long and difficult task that is critical to the economic, environmental and social well-being of most Asian countries.

The United States, with its resources and commitment to encourage democratic processes, has a unique opportunity to play a leadership role in orienting and facilitating the essential changes in the water sector.

The United States, because of its resources and commitment to encourage democratic processes as a means of enhancing world stability, has a unique opportunity to play a leadership role in orienting and facilitating the essential changes in the water sector. Its extensive skills in nonstructural aspects of water development enable it to exert considerable beneficial influence.

The next chapter presents a framework for actions by the Bureau and Missions to spearhead such a role in Asia.

Chapter 3. THE WATER SECTOR STRATEGIC FRAMEWORK

Most Asian governments will find it necessary to change the emphasis of their water management and development strategies and policies. This will involve a shift from the direct provision and disposal of water to good governance of both the supply and the demand sides of water management.

Most Asian governments will find it necessary to shift from the direct provision and disposal of water to good governance of both the supply and demand sides of water management.

Strategies and policies will be needed to ensure the sustainability of water development through management of competition, water quality improvement, water-related environmental protection, and institutional upgrading. Strategies will be required to optimize efficiency in water use, and to implement measures to promote water conservation, adjudication and exchanges of water rights, wastewater reuse, and penalties and incentives to control pollution. The necessary large investments and radical changes of approach will require external assistance and provide a corresponding opportunity for USAID and other donors. At the heart of any successful move towards sustainable water development are the concepts of decentralization, democratization, good governance, stakeholder participation and operation of market forces.

The following strategic framework is intended to serve as a guideline for assisting countries to achieve sustainability of their water resources and systems. It takes into account the problems that result from the past separate approaches to such water subsectors as potable water supply, sanitation and sewerage, and irrigation. The framework provides a basis for an integrated approach to promote water resource development and use in ways that are consistent with the economic growth, population and health, environmental, democracy and participatory development objectives of USAID with the UNCED water sector goals as expressed in "Agenda 21," and with the environmental and natural resources strategy of the Bureau.

The strategic framework is a guideline for assisting countries to achieve sustainability of their water resources and systems. It encompasses assistance in establishing policy and institutional arrangements and in resolving issues of competition for water, water quality and the environment.

The Framework

The strategic framework encompasses assistance to governments, private sector organizations and voluntary organizations to (a) establish policy, legal, regulatory and institutional arrangements for water that provide accountability, transparency and balance between economic, environmental, social and other interests, (b) resolve issues of competition for water, and (c) resolve water quality and other water-related health and environmental issues.

The policy and institutional measures to be fostered include democratizing water use planning, greater accountability and transparency, operation of market forces, involving the full range of stakeholders, and basing water management decisions on broad analytical assessments.

The policy and institutional measures to be fostered include:

- Decentralizing and democratizing water use planning and implementation, including through the involvement of private sector and other non-governmental organizations
- Promoting good governance, that is, overall policy making and oversight of the water sector, through greater accountability and transparency and by supporting active citizen participation groups
- Encouraging the operation of market forces subject to such controls as are necessary to optimize water quality and equitable use
- Ensuring the participation of the full range of stakeholders in the formulation and implementation of policies for water development and management
- Basing water management decisions on broad analytical assessments that encompass the full range of relevant hydrological, environmental, socio-economic, institutional and financial considerations.

Tactical approaches include leveraging assistance by linkages with other activities, identifying opportunities in which the U.S. has comparative advantage, and promoting water resource and system sustainability through conditions on other assistance.

Tactical approaches include:

1. Utilizing requests for assistance in water development as opportunities to move governments towards sustainable water development and use, decentralization, democratization, good governance, application of market processes, and stakeholder involvement.

2. Leveraging the effects of such assistance by linkages with the Asia and Near East Bureau's democracy and environmental programs and other USAID activities, such as the U.S.-Asia Environmental Partnership, and with similar initiatives by multilateral lenders and other organizations such as the International Irrigation Management Institute.

3. Identifying opportunities in which the U.S. has a comparative advantage as an assistance provider or which have a potential for U.S. trade development. A listing of water-related technologies in which the USA has comparative advantage and/or trade potential is presented as Appendix D.

4. Placing conditions on general assistance by incorporating the philosophy of sustainability of water resources and systems, institutional change, democratization and decentralization into many dealings with governments. It can be expressed as conditions on PL-480, structural adjustment and other general assistance that could, for example, require the taking of measures to open water sector planning issues and processes to public discussion. To give effect to this, it is necessary that Missions inform themselves about water sector conditions in each country in order to identify needs and opportunities for the application of such assistance conditions.

Interventions

The types of intervention that can promote the achievement of the goals of this strategic framework include:

- Policy dialogue
- Conflict resolution
- Coordination with other donors
- Institutional development
- Training and information dissemination

The goals of strategic framework for water in Asia can be promoted through policy dialogue, conflict resolution, coordination with other donors, institutional development, training and information dissemination.

Policy Dialogue

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.

Opportunities should be sought to assist governments to bring together the key proponents and issues on which national water policies will be based, and to provide them with technical and institutional assistance to develop appropriate water sector policies. Among the elements to be considered for such policies would be: accountability, transparency, decentralization, democratization and good governance of planning and decision-making; legal bases for water rights; adjudication procedures; principles of sustainable development and use of water; use of market-based methods of water allocation; conservation principles; responsibilities and principles for pollution reduction incentives and sanctions; increasing investments in potable water supply and sanitation based on demand-driven strategies; and responsibilities for data collection and monitoring.

Some principles that should be considered as potential bases for viable national water policies are presented and discussed in Appendix E.

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 USAID. Because of the vested interests of powerful individuals and agencies in certain aspects of the water sector, effective policy dialogue 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.

Conflict Resolution

Contributions to the resolution of both international and intra-national disputes over water competition and allocations should consist of: assistance in the collection and interpretation of data to support either agreement by the parties or decisions by higher authorities; conducting workshops or other fora for the discussion and informal resolution of disputes; assistance in establishing formal procedures for conflict resolution; and the support of international or regional efforts to establish agreements on the principles for resolution of conflicts over water. An example of such efforts is the guidance and technical support of integrated or internationally coordinated data collection and management in relation to waterways that are subjects of international competition or conflict.

Coordination with Other Donors

Multilateral lenders have the opportunity to influence policy-making and strategy development while preparing to fund capital projects. Missions and the Bureau are in a position to contribute to the discussions and investment decisions of such donors in order to leverage the effects of USAID inputs. Without good coordination between donors, the efforts of those who have serious concerns about water sector sustainability and governance may be undercut by others.

Institutional Development

The range of types of institutional assistance to governments, water basin authorities, water providers and users, system owners and operators, and public interest groups might include:

- Assistance to end users and governments in defining policies and programs for the transfer of management responsibilities and ownership of water systems

  As governments in Asia proceed with plans for the divestiture of management responsibilities and assets of water distribution systems, they will require assistance in formulating and carrying out appropriate policies and programs, particularly through user organizations. USAID's vast experience in participatory development should be made available so that new programs in system turnover and privatization may flourish.

- Improvement of management and financial systems

  Institutional capability improvement assistance should be made available to both governance organizations and to service providers such as municipalities, water or sanitation districts, river basin authorities, and utility organizations. Such assistance would be oriented to improvement of both the performance of the subject entities and the policy and regulatory frameworks in which they operate.

  Assistance may take the form of management advisory inputs or organizational development assistance. Management advisory inputs may include assistance in conducting management audits, diagnosing the causes of management difficulties, preparing organizational and/or procedural recommendations, or developing and implementing management procedures and guidelines. Organizational development assistance may include the conduct of management review workshops including provision of specific resource inputs.

  Assistance could be provided in the identification of organizational, staffing, budgeting, information management, administrative, personnel management, customer relations and related resources needs, and in the planning and implementation of improvement programs.

Many water agencies and utilities have revenue shortfalls that result in either inadequate maintenance or dependence on government operational subsidies. Assistance may be provided in such areas as unaccounted-for water and metering, water loss and wastage reduction programs, water pricing, energy conservation, cost accounting, and financial management.

- Assistance in the preparation and evaluation of water sector or subsector programs, strategies, projects or guidelines

  In the development of policies, programs or strategies for the water sector, or for specific subsectors such as potable water supply, sewerage, sanitation, water pollution control, industrial waste management, agricultural water use, or wastewater reclamation and reuse are needed. Guidelines for the involvement of governmental and other organizations in the oversight, planning and implementation of national, regional, sectoral or subsectoral planning, capital allocation, standard-setting and monitoring can also be established.

  By providing for specialist advice and appropriate contacts between Asian and U.S. industries, USAID could promote the adoption of no-cost and low-cost pollution reduction and by-product recycling through in-factory technological changes.

  USAID can assist governments or other implementers of water programs and projects by providing evaluations that focus on the elements of policy and institutional change, water competition, and health and environmental protection, either as the basis for actions needed in relation to the particular programs or projects or to derive lessons-learned that will guide the preparation or implementation of future programs or projects.

- Environmental assessments and assessment planning

  U.S.-based experience can be the basis for assisting governments in the preparation and adoption of guidelines, having locally relevant focus, for the conduct and evaluation of environmental assessments of water projects. For particular programs of large scale or international importance, USAID may offer assistance in the preparation of environmental assessments.

- Instrumentation, computers and other equipment

  Equipment is needed in areas where the U.S. has a competitive technological edge, such as monitoring and measuring equipment, computers and specialized pollution reduction equipment. Provision of such equipment would have a pronounced leverage effect for relatively small outlays.

- Computer applications

  There are many categories of computer applications in the water sector in which U.S. specialized skills can exert beneficial influence on water resources development that will be very great as compared with the costs. Examples include: data management and decision-support systems; geographical information systems; remote sensing applications; meteorological forecasting; systems control and data analysis; and interactive training systems.

- Emergency assistance and assistance in emergency planning

  In Asia, the water sector has major potential for disasters through such possible results of natural events as dam failures, contamination or failure of potable water systems, and embankment failures. Examples of potential assistance would be in help in developing a flood early warning system or in specifying, procuring and maintaining mobile potable water treatment equipment. Preparedness should be developed to deal with emergencies before they occur.

- Gender analysis and program development

  Women, who have regularly been excluded from water resources development and management efforts, must become partners instead. Their critical role in water-based activities and their requirements must be better understood to improve program effectiveness and sustainability. Assistance in gender-related issues should be an essential part of any participatory development effort.

- Other assistance

  Assistance to Asian basin authorities and water and wastewater utilities in pre-investment planning is an effective way to promote the principles of sustainability based on analysis of the full range of applicable hydrological, environmental, socio-economic, institutional and financial considerations.

  Assistance may include conducting applied and lessons-learned case studies, and disseminating the results, to support NGO, utility and private sector planning in such areas as: effective user/customer involvement in sector decisions and operations; water conservation technologies and management; strategies for drought reduction or catchment stabilization; wastewater reclamation and reuse; low-cost wastewater treatment methods; and assessment of ecosystem water needs, and benefits relative to other water uses.

Training and Information Dissemination

Assistance could be provided to governments, river basin and district water and pollution control agencies, water and wastewater utilities, other water providers and users, and other

water stakeholders including non-governmental organizations, in staff development and training.

This need will increase as the focus of the sector shifts towards conservation, public involvement and transparency. The forms of assistance may include:

- Training programs and delivery

  Assistance in the preparation of training needs assessments, training plans and curricula, and training materials, and in the evaluation of available training resources and the training of trainers

- Twinning and support of interest groups

  Assistance in the establishment of human resources support systems through such means as twinning arrangements. Technical support will also be provided to public interest groups in the water sector.

- Seminars, workshops, and information dissemination

  The design and conduct of seminars and workshops in connection with water program and strategy planning can be a valuable adjunct to national efforts and to those of other donors. Such fora and information dissemination efforts as newsletters and managed technical exchanges between specialist working on related issues in different countries provide an opportunity for the U.S. to foster open water planning and the adoption of appropriate water policies.

Partnership

Sustainability of water development and use in Asia will require policy and planning shifts by most governments towards governance of both supply and demand for water. Policy development and planning to support sustainability will require active promotion and support by external support agencies working in close partnership with governmental or other indigenous entities. The external components may include policy dialogue, technical assistance, information exchanges and/or other interventions. External inputs will in general need to be provided as grant assistance because governments are reluctant to borrow internationally for purposes other than infrastructure construction.

Because of its resources and commitment to encouragement of democratic processes, the United States has a unique leadership opportunity. Donor coordination is critical both for leveraging of U.S. inputs and to prevent undercutting of efforts to improve water sector governance. Donor efforts and coordination should enhance partnership approaches that support host government responsibility for policies, programs and priorities that improve sustainability.

Policy development and planning will require donor grant assistance in partnership with local entities. The U.S. should promote donor coordination and partnership approaches that support national responsibility for sustainability.

APPENDIX A

COUNTRY WATER RESOURCE PROFILES IN ASIA

COUNTRY WATER RESOURCE PROFILES IN ASIA

- **Physical Characteristics:** Topography, climate, rainfall, major rivers and catchments and other features;
- **Prevailing Uses:** Agriculture, municipal and industrial (M&I) supply, navigation, hydroelectricity; and
- **Issues and Problems:** Watershed degradation, municipal and industrial discharges, use conflicts (both regional and international), institutions, financial resource availability, sustainability of capital works, and so forth.

Statistics on country population, economy, and general water use are also presented. These profiles were generated from a literature review and discussions with A.I.D. and World Bank project officers.

Introduction

The following water resource profiles of the 18 Asian countries depicted in the regional map above and the South Pacific island nations provide a "snapshot" of basic information intended to familiarize the reader with the water resource potentials, current uses, and current issues that prevail in these countries. The profiles are brief and are meant only to portray, in broad-brush terms, the complexity of water resource development issues that confront each of these countries today. Each profile is organized in a standard format that includes discussions of:

Asian Water Resource Development

Almost all of the Asian countries profiled are endowed with plentiful renewable freshwater resources. Nevertheless, rapid population growth in most of these countries is exacerbating the need for additional resource development. At the same time, population pressure is having a negative impact on the physical systems that define basin flow characteristics and regimes. The combination of **increased need** for multi-use water supply to serve the growing population and **environmental degradation** has created serious problems that affect not only the future economic development of these

45

Water Resource Development Problems and Issues
in 18 Asian Countries and the South Pacific

	WATER QUANTITY ISSUES			WATER QUALITY ISSUES			INSTITUTIONAL ISSUES	
	International Conflicts Over Uses	Regional Conflicts Over Uses	Overuse Of Groundwater	M&I Caused Water Pollution	Agriculture Caused Degradation	Catchment Degradation/ Siltation	Organization And Policy Issues	Lack of Financial Resources
Afghanistan	minor	minor	0	minor	0	MAJOR	MAJOR	MAJOR
Bangladesh	MAJOR	MAJOR	minor	MAJOR	MAJOR	MAJOR	MAJOR	MAJOR
Bhutan	0	0	0	MAJOR	0	MAJOR	MAJOR	MAJOR
Cambodia	MAJOR	0	0	MAJOR	MAJOR	MAJOR	MAJOR	MAJOR
China	minor	MAJOR	MAJOR	MAJOR	MAJOR	MAJOR	0	minor
India	MAJOR	MAJOR	MAJOR	MAJOR	MAJOR	MAJOR	MAJOR	MAJOR
Indonesia	0	MAJOR	MAJOR	MAJOR	MAJOR	MAJOR	minor	MAJOR
Rep. of Korea	minor	0	0	minor	minor	0	0	0
Laos	MAJOR	0	0	MAJOR	0	MAJOR	MAJOR	MAJOR
Malaysia	0	minor	minor	MAJOR	minor	MAJOR	0	minor
Mongolia	minor	minor	0	minor	minor	minor	minor	minor
Myanmar	minor	0	0	MAJOR	0	MAJOR	MAJOR	MAJOR
Nepal	0	0	0	MAJOR	minor	MAJOR	MAJOR	MAJOR
Pakistan	MAJOR	MAJOR	MAJOR	MAJOR	MAJOR	MAJOR	MAJOR	MAJOR
Philippines	0	minor	MAJOR	MAJOR	minor	MAJOR	minor	MAJOR
Sri Lanka	0	0	0	MAJOR	minor	MAJOR	minor	MAJOR
Thailand	MAJOR	MAJOR	minor	MAJOR	MAJOR	MAJOR	0	minor
Vietnam	MAJOR	minor	0	MAJOR	0	MAJOR	MAJOR	MAJOR
South Pacific Island Nations	0	0	MAJOR	MAJOR	minor	MAJOR	minor	MAJOR

countries, but also the general health and well-being of the country populations as well.

Six of the world's major rivers are located in the Asian countries under review. These are:

- The Mekong;
- The Indus;
- The Ganges;
- The Brahmaputra;
- The Yangtze; and
- The Yellow.

The development of surface water in Asia has a long history. Asian engineers pioneered irrigation system construction more than 2,000 years ago. However, water resource distribution in Asia is uneven. While some areas have access to plentiful supplies, others are water scarce. User demand on

water resources in most Asian countries has been growing in the past 40 years alongside rapidly increasing population, urbanization, and industrialization. As per capita incomes in many countries increase, the demand for increased water resource development for agricultural, municipal, and industrial uses expands.

Of the total 11,986 BCM of estimated annual renewable water resources in the Asian countries reviewed, only an estimated 15 percent of that volume is withdrawn for use. However, utilization of the remaining 85 percent is problematic because the cost of developing these water resources far exceeds that of earlier development initiatives. Agriculture, which accounts for 86 percent of all water withdrawals, remains the predominant use for water resources in Asia today.

Problems and Issues

The table above is a matrix of the countries reviewed according to water resource development problems. The severity of these problems is indicated by a three-level scale: "O" indicates no problem or a problem that still has a manageable solution; "minor" indicates a problem that has negative affects on water resources and their development and requires serious attention and remediation; and "MAJOR" indicates an urgent problem that needs concerted and immediate attention to safeguard future water resource development potential.

Regional conflicts include internal country competition between uses, such as in China, where urban public and industrial water supplies in and around Beijing and Tianjin are competing with agricultural withdrawals, or in Indonesia, where the same issue is a problem on Java.

International conflicts between country water resource riparians are serious in this part of Asia. This is true between India and Pakistan over the development of the Indus and its tributary rivers; and between India and Bangladesh with respect to the Ganges and Brahmaputra development. The development of the Mekong is a major issue for the economic development of its riparian countries Thailand, Laos, Cambodia, and Vietnam.

Catchment degradation — caused by unmanaged logging, the clearing of new land for agriculture, and overgrazing — is the major problem facing the **sustainable** development of water resources in the Asian countries studied. The problem is critical and is the major contributor to:

- Increased downstream wet season flooding;
- Increased downstream dry season low flows;
- Increased soil erosion;
- Increased siltation of coastal waterways;
- Increased siltation of impoundments;
- Increased efficiency losses of capital works, such as hydroelectric, irrigation, and transport facilities;
- Increased changes to weather and rainfall patterns;
- Increased loss of groundwater aquifer recharge; and
- Increased effort and cost to treat water for M&I uses.

Overuse of groundwater is an unsustainable practice that is common in agricultural, municipal, and industrial uses among many of the countries reviewed. Over-pumping of aquifers is also leading to saltwater intrusion in coastal areas. **Untreated municipal and**

industrial waste discharges are polluting surface water in virtually all the countries studied, in both urban and rural areas. Water pollution is especially problematic near the larger cities and is becoming a major public health hazard. In their efforts to manage water resources, many countries in the region are hampered by **inadequate institutions**, both public and private. Other countries have problems maintaining capital facilities. The **sustainability of infrastructure** is essential to support national economic development in each country reviewed. The availability of **financial resources** is an issue for many of the countries whose profiles follow.

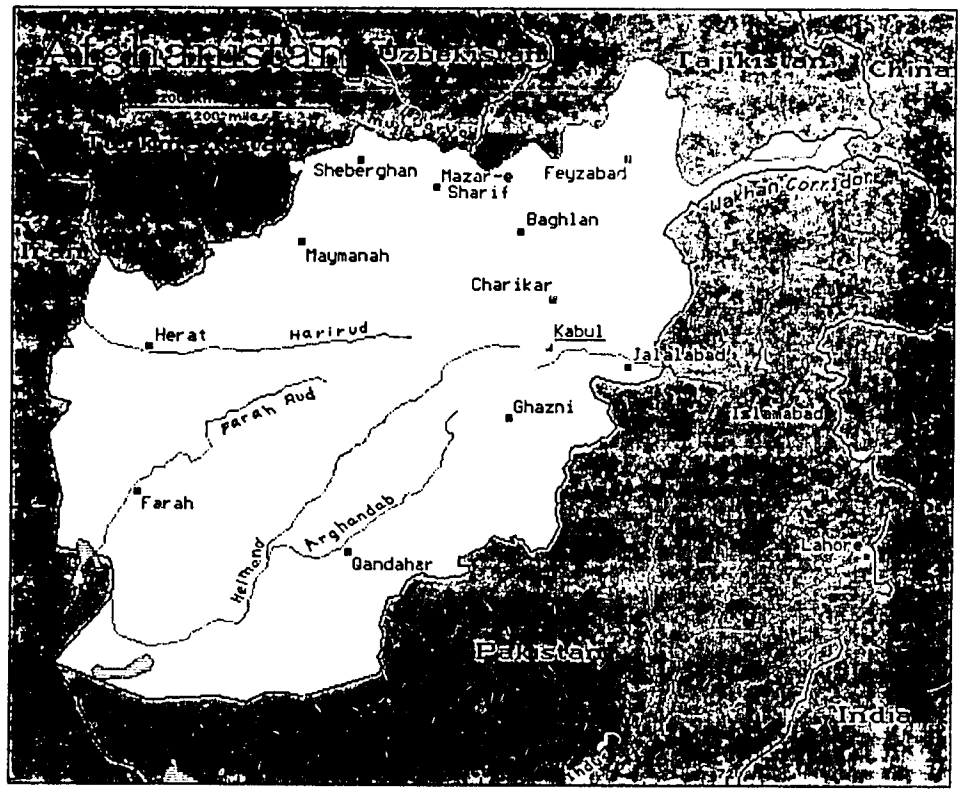
AFGHANISTAN

Population (1990)	N/A
Population Growth Rate (world = 1.8%)	N/A
Urban Population (1965/1990)	9%/N/A
Gross National Product	N/A
Per Capita GNP (1990)	N/A
Land Area (sq. km)	652,090
Potential Water Available (bcm/yr)	50
Developed Water Resources (bcm/yr)	26.1
Total Supply Per Capita (cm)	3,020
Water Use by Sector Ag/Ind/Mun & Dom	99%/0%/1%
Water Resources Originating in a Neighboring Country	N/A
Population Access to Safe Water Urban/Rural	38%/17%
Hydropower:	
Installed capacity (MW)	281
Av. annual generation (GWh)	764
Percent of total power production	67.7

Afghanistan is dominated by the great Hindu Kush mountain range. Lowland areas include the region between the Hindu Kush and the Amu Darya River in the north, the southwest deserts of Sistan and Registan, and the fertile alluvial valleys around Kabul, Bamiyan, and Jalalabad. Annual mean rainfalls average from 150 mm in the north to 300 mm in the east. Rain usually occurs between November and May. There are four major drainage systems in the country. The Amu Darya flows east to west for 1,100 km along the northern border of Afghanistan. The Hari Rud basin originates in the central mountains and flows westward for 650 km into Iran. The Kabul River system is tributary to the Indus River and flows east from the middle of the country along the fertile Kabul valley. The Helmand-Arghandab system drains about 40 percent of the country's land area and has the greatest potential for development. Of the 50 BCM annual renewable water resources, about 26 BCM were withdrawn for all uses before the war. Agriculture accounts for 99 percent of all withdrawals.

Approximately 14 million ha are arable; of this, about 7.8 million ha were cultivated before the war. Because of the low rainfall, irrigation is important. Of the total land cultivated, about 5.3 million ha were irrigated. Irrigation facilities in the highlands are small scale but extensive. As the rivers descend to their alluvial plains, larger public irrigation systems are frequent. The largest system in the south is operated and maintained by the Helmand-Arghandab Valley Authority. Hydroelectric potential is available and two major facilities exist—the first on the Kabul river generating power for Kabul, while the second is located on the Helmand river as part of the multipurpose dam at Kajakai that serves the irrigation system and regulates flows for downstream flood prevention. Groundwater is available in the alluvial plains of each basin and is utilized for domestic, light industrial, and agricultural uses.

Hydropower accounts for over two-thirds of total power generation. A further 260 MW of capacity now under construction will add over 92 percent to the existing capacity. An additional 338 MW of capacity is in the planning stage.



The war, the continuing internecine struggle, and the consequent flight of about one-fifth of the population have seriously affected agriculture and water resource development. Most irrigation infrastructure has been damaged, abandoned, or both. Studies point out a wide range of rehabilitation needs on most systems. Spare parts for all pumping and generating equipment are scarce, affecting public water supplies and small pumped irrigation schemes.

Catchment degradation is occurring as a result of localized population pressure for building materials, intensified need for fuelwood during the winter, and overgrazing. Erosion and siltation are occurring, especially in the Kabul basin. *Flood control* works have been built throughout all the major basins, as disastrous floods can occur anytime between February and July. These will need rehabilitation, also. Although uses are limited, *groundwater mismanagement* is common. Most alluvial aquifers depend on limited replenishment and are closely linked to surface flows variations. *Riparian issues* exist concerning allowable irrigation withdrawals on the Amu Darya. The development of Afghanistan's water resources has been virtually halted for the past 13 years. Physical facilities need to be reconstructed in many cases, and government institutions will also need to be rehabilitated. Major infusions of aid capital will also be needed. The rebuilding of the institutions will be especially difficult, as most surviving skilled engineers and technicians have relocated to third countries.

BANGLADESH

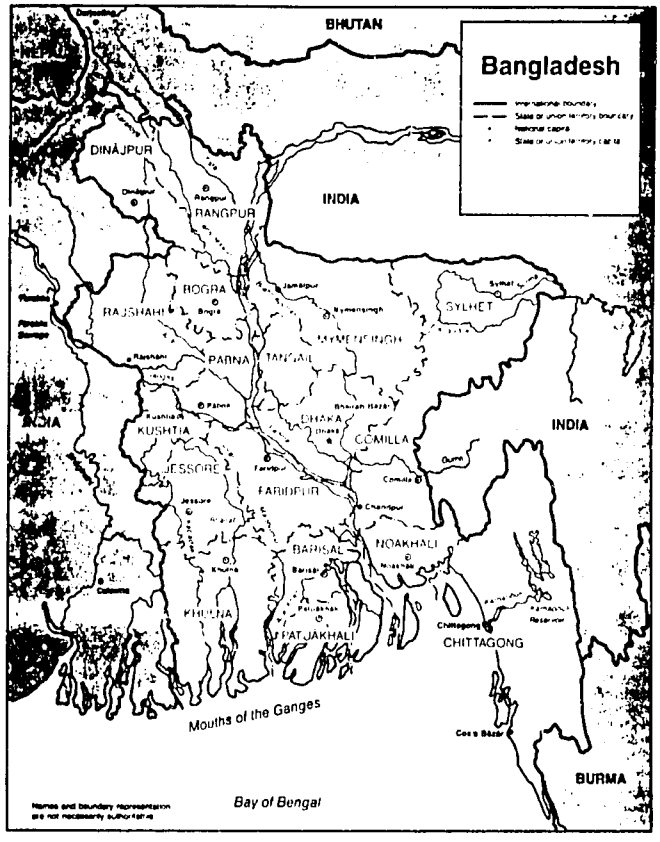
Population (1990)	107 million
Population Growth Rate (world = 1.8%)	2.3%
Urban Population (1965/1990)	6%/16%
Gross National Product (1990)	$18,505 million
Per Capita GNP (1990)	$210
Land Area (sq. km)	130,170
Potential Water Available (bcm/yr)	1,357
Developed Water Resources (bcm/yr)	22.5
Total Supply Per Capita (cm)	11,740
Water Use by Sector Ag/Ind/Mun & Dom (%)	96/1/3
Water Resources Originating in a Neighboring Country (bcm/yr)	1,000
Population Access to Safe Water Urban/Rural	25%/66%
Hydropower:	
Installed capacity (MW)	230
Av. annual production (GWh)	739
Percent of total power production	9.9

Bangladesh, situated in the fertile delta of the rivers Ganges, Meghna and the Bahmaputra, has always been densely settled. Today this low-lying country is one of the most densely populated countries in the world. The three major river systems with a combined average peak discharge of 90K CMS, gives the land the fertile alluvial soils. The majority of Bangladeshis live in rural areas and are engaged in agricultural production. Agriculture accounts for 96 percent of all water resource uses in the country. Water resources play a vital role in the economic development of Bangladesh. The productivity of agriculture which employs 85 percent of the population and produces 51 percent of the Gross Domestic Product, is influenced during the monsoon season, from May to September, when 70 percent of the foodgrain is produced, by flooding and by drought from November to March when irrigation is required. In addition, inland water fisheries produce 70-80 percent of total animal protein consumed in the country.

Bangladesh's water resources consist of three main components, i.e., rainfall, streamflow, and groundwater storage. Average annual rainfall in Bangladesh is among the highest in the world, at more than 1,900 mm per year. 80 to 85 percent of the annual rainfall occurs in the single monsoon season. The abundance of water during monsoon season results in extensive flooding in the delta area. Flooding in normal years is generally not harmful in physical and human terms. Flood waters provide the necessary recharge for the extensive groundwater aquifers that serve as a primary source of tubewell irrigation throughout the country. However, normal flooding also results in the spread of water contaminated by human waste, resulting in high incidents of diarrhea and cholera in many parts of the country.

The Bangladesh Water Development Board (BWDB) and the Water Resources Planning Organization (WARPO) are in charge of water resource programs' design and development. In 1986, a National Water Plan was prepared to maximize agricultural growth and production and contribute to achieving foodgrain self-sufficiency by providing allocation of water, investment strategies, and guidelines. Major development policy

51



issues exist concerning the priority of large- or small-scale projects as the strategy for development.

Bangladesh faces several serious water resource issues today. Following the disastrous 1987 and 1988 floods, a major donor funded research and planning effort in water management, entitled the Flood Action Plan (FAP), was initiated. Major river dry season water supplies have declined, and will probably continue to decline, largely as a result of actions undertaken by other basin riparians with consequent dry season impacts to irrigation, navigation, and salinity front intrusion in the lower delta. Water supplies for Dhaka and other cities, depending mainly on deepwells have the potential to be negatively impacted by groundwater levels particularly due to additional deepwells and increased pumping to meet the demands of growing urban populations and industries. Institutional development is also required to ensure that infrastructure for irrigation, flood control, drainage, and public water supply is sustainable, in terms of both operations and maintenance, as well as user ownership and management where applicable.

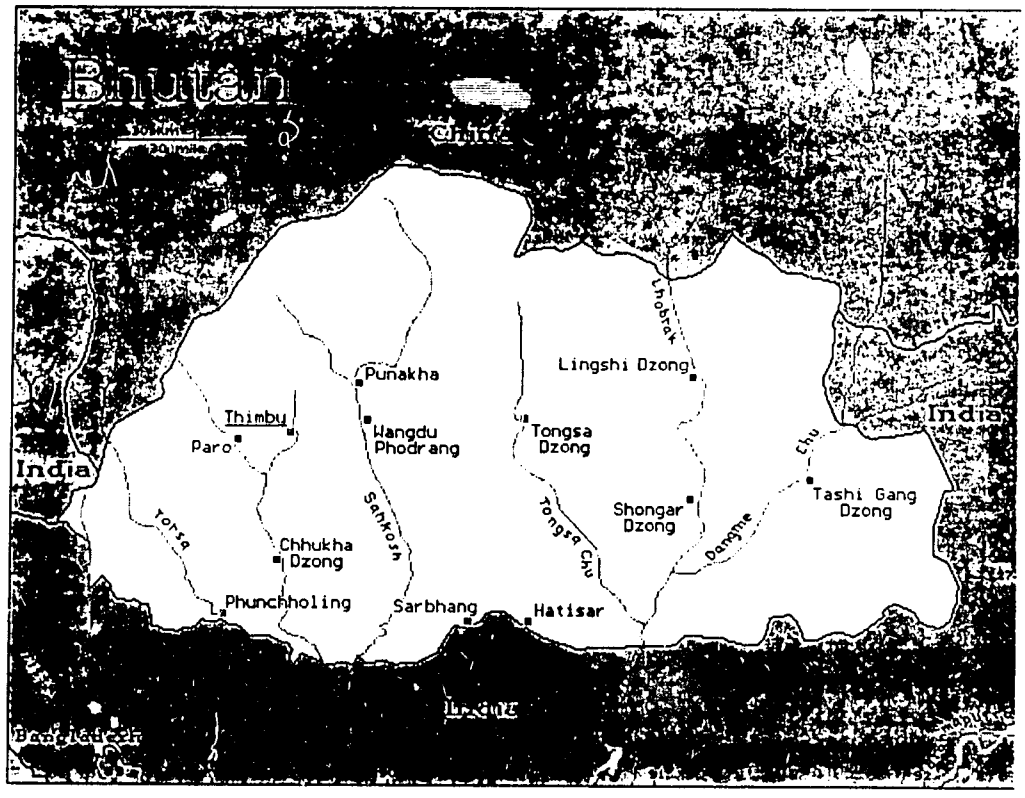
BHUTAN

Population (1990)	1 million
Population Growth Rate (world = 1.8%)	2.1%
Urban Population (1965/1990)	3%/5%
Gross National Product (1990)	$266 million
Per Capita GNP (1990)	$190
Land Area (sq. km)	47,000
Potential Water Available (bcm/yr)	95
Developed Water Resources (bcm/yr)	0.02
Total Supply Per Capita (cm)	62,660
Water Use by Sector Ag/Ind/Mun & Dom	54%/10%/36%
Water Resources Originating in a Neighboring Country	N/A
Population Access to Safe Water Urban/Rural	100%/24%
Hydropower:	
Installed capacity (MW)	230
Av. annual production (GWh)	2,000
Percent of total power production	100

Bhutan can be divided into three regions: the Great Himalayas, the Lesser Himalayas, and the Daur plain. Mountain spurs and deep valleys radiate southward through the Lesser or Inner Himalayas. In the southern foothills, the rivers widen out into deltas that drain toward the Brahmaputra in India. The low-lying Daur plain, subject to excessive rainfalls—averaging 2,000 to 3,000 mm per year—is covered by dense semitropical forests and is largely undeveloped. The seven main river system basins in the country, from east to west, are the Nyera Amara, Dhansiri, Manas (or Gong Ri), Mao (or Aie), San Kosh (or Tsangchu), Raidak (or Wangchu), and Amochu (or Torsa) Jiti. These rivers are characterized by broad alluvial valleys in the lower foothills and by steep gorges as elevations increase into the Himalayas. Average yearly rainfall varies in the country from 600 to 1,000 mm in the east and from 700 to 1,700 mm in the central region. Of the 95 BCM estimated annual renewable water resources, a very small fraction is used (estimated at 0.02 BCM). Agriculture is the largest use, accounting for 54 percent of all uses, followed by domestic supply, at 36 percent.

Groundwater potential exists in all of the valleys to varying extent, and their development is important for agricultural, domestic, and industrial uses. Tremendous hydropower potential (20,000 MW) also exists. One large plant (336 MW) has been commissioned in Chukka and several other micro-plants have been built. Most power is exported to India.

Agricultural land is in short supply, and virtually all arable land—about 16 percent of the total surface area of the country—is under cultivation. Irrigation is practiced in the higher and lower elevations of all valleys, using contour canals, mostly constructed by local farmers. These systems require considerable maintenance each year because of the temporary nature of most structures. Some larger public systems exist close to population centers in the lower foothills. Large-diameter shallow wells and springs also serve as sources to small command areas.



Catchment degradation is occurring, caused by commercial logging, pressure for new agricultural land, and fuelwood. Associated erosion and siltation are also beginning to affect the lower reaches ofriver basins and reservoirs. If this degradation is not checked, the country's hydroelectric development plans will be greatly affected. *Resource development* to alleviate domestic supply shortages is needed. Plans exist to utilize groundwater for these schemes. Groundwater development in the valleys needs to be closely monitored to ensure that utilization does not exceed recharge. *Water pollution* from untreated domestic waste discharges is affecting rivers around and downstream of settlements. Although river gradients afford natural treatment of this mainly organic problem, the health of Bhutan's population is being affected.

CAMBODIA (KAMPUCHEA)

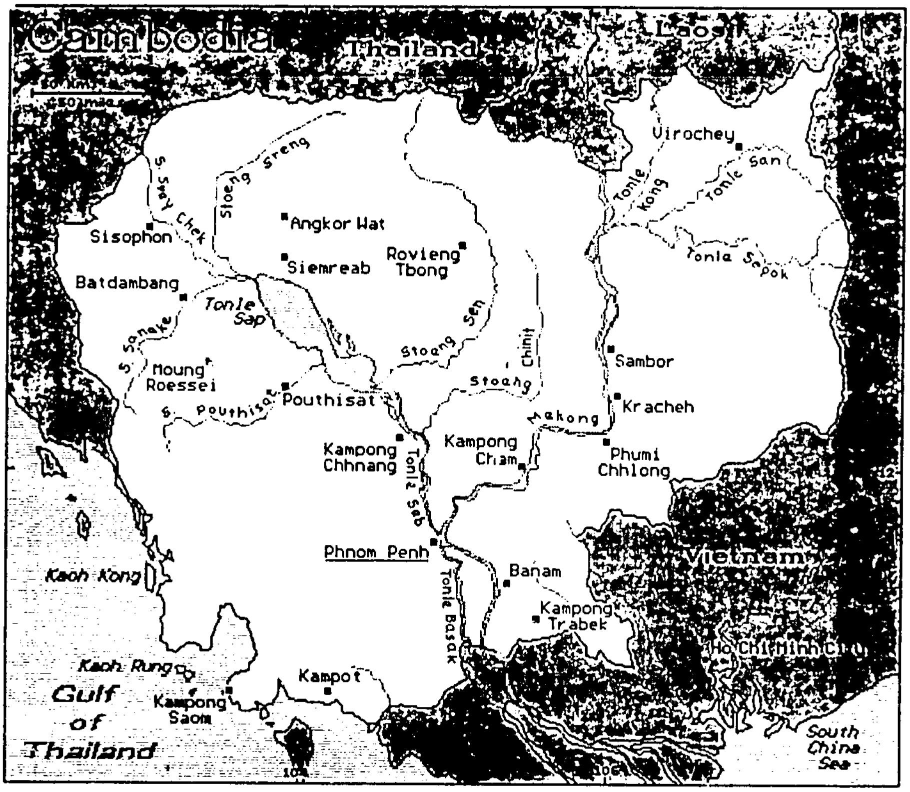
Population (1990)	8 million
Population Growth Rate (world = 1.8%)	2.6%
Urban Population (1965/1990)	11%/12%
Gross National Product (1990)	N/A
Per Capita GNP (1990)	N/A
Land Area (sq. km)	176,520
Potential Water Available (bcm/yr)	88.1
Developed Water Resources (bcm/yr)	0.5
Total Supply Per Capita (cm)	10,680
Water Use by Sector Ag/Ind/Mun & Dom (%)	82%/10%/8%
Water Resources Originating in a Neighboring Country (bcm/yr)	410
Population Access to Safe Water Urban/Rural	NA
Hydropower: Installed capacity (MW)	0

Most of Cambodia's geography is dominated by the large central plain and the Mekong River, which flows south for 315 km through the eastern part of the country. The central plain of the country is rimmed by highlands in the east, northeast, and southwest. Most of the country is drained by the Mekong. The alluvial central plain surrounds the Tonle Sap (Great Lake), which is drained eastward by the 100-km Tonle Sap River to the Mekong. The Stung Streng and the Stung Sen rivers are the two main tributaries to the Tonle Sap basin. The climate in Cambodia is tropical monsoonal, with mean annual rainfall as much as 5,000 mm on the southwest mountain slopes to 2,200 mm in the central plain. The country experiences a hot wet season in May to October because of the southwest monsoon. The cool dry season occurs from November to February. Total annual renewable water resources are estimated at 88 BCM, with only slightly more than 0.5 BCM withdrawn for all uses. Agriculture accounts for 94 percent of all uses.

There is currently no hydropower generation in Cambodia. Technically feasible actual and potential hydropower capacity is 40,000 MW; the economically feasible limit is estimated to be 18,000 MW. A 1 MW plant is under construction and facilities totally 199 MW are planned.

Phnom Penh is situated at the confluence of the Tonle Sap River and the Mekong. From mid-May to early October (the rainy season), the level of the Mekong rises, causing the Tonle Sap River to "reverse flow" and raise the level of the Tonle Sap from a depth of two meters to more than ten. As the water level of the Mekong falls during the dry season, the Tonle Sap drains back into the Mekong. The Tonle Sap is one of the richest sources of freshwater fish in the world.

Cambodia is a member of the Mekong River Development Committee, with Thailand, Laos, and Vietnam. Each Mekong riparian has differing priorities concerning the development of the river. For Cambodia, hydropower benefits could help support the national priorities of agriculture, aquaculture, forest production, and industrial development. However, potential for power generation is much higher than predicted demand in the



country, meaning that successful power-generating projects in Cambodia would have to include purchase agreements with Thailand. The Mekong and the Tonle Sap are also important for their freshwater fish resources and as a means of navigation. Water resource development in Cambodia has been hampered by recent conflicts, a weak and bureaucratic government, ineffectual institutions, and a lack of financial resources to undertake capital development projects.

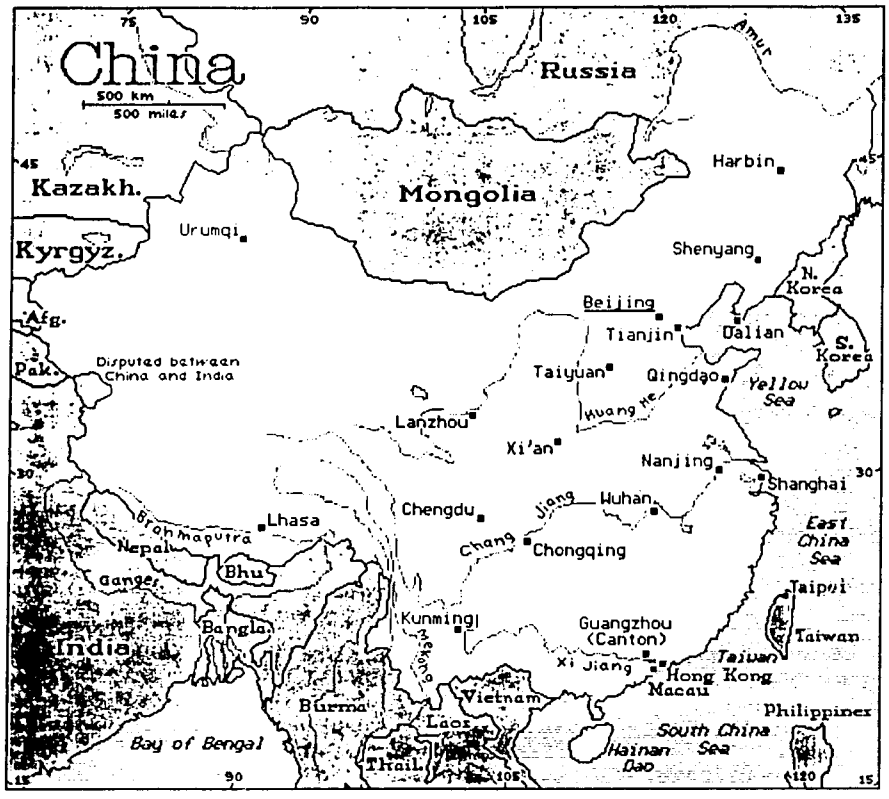
Catchment degradation in Cambodia continues to be a problem. Uncontrolled commercial logging concerns from neighboring Thailand operate in country. The pressure for fuelwood and clearing for agricultural land is also contributing to deforestation. The effects of this deforestation can be seen with increased erosion and siltation in the Tonle Sap, low-lying streams, and reservoirs.

CHINA

Population (1990)	1,134 million
Population Growth Rate (world = 1.8%)	1.4%
Urban Population (1965/1990)	18%/56%
Gross National Product (1990)	$393,006 million
Per Capita GNP (1990)	$370
Land Area (sq. km)	9,364,410
Potential Water Available (bcm/yr)	2,800
Developed Water Resources (bcm/yr)	460
Total Supply Per Capita (cm)	2,470
Water Use by Sector Ag/Ind/Mun & Dom	87%/7%/6%
Water Resources Originating in a Neighboring Country	N/A
Population Access to Safe Water Urban/Rural	87%/66%
Hydropower:	
Installed capacity (MW)	37,880
Av. annual production (GWh)	124,850
Percent of total power production	18.4

The third largest country in the world, China stretches 5,000 km north to south and east to west. Mountains and the high plateau of the Tibetan region constitute more than 25 percent of China's total land area. Elevations are highest in the west, descending gradually to the eastern plains. Ninety percent of the population lives in the eastern part of the country on 15 percent of the total land area. Rainfall patterns vary widely over the country. The large Tibetan plateau in the southwest receives 1,000 mm mean annual rainfall, the extreme south receives more than 2,500 mm, central China receives 400-1,000 mm, and the northwestern half of the country receives less than 400 mm each year. The southeast monsoon, advancing from the south in March and April, greatly influences the rainfall pattern in eastern China. The monsoon reaches the north China plain in June and recedes southward in September and October. Western China does not receive any of the monsoonal rains.

The country is said to have over 50,000 rivers, but only an estimated 1,580 have catchments greater than 1,000 square km, and only seven drain areas greater than 10,000 square km. Rivers in the country can be divided into those with outflows to the ocean (exterior drainage basins) and those with internal drainage basins. The exterior basins account for 64 percent of the land area of China and 96 percent of its run-off. Groundwater is an important localized resource, exploited for agricultural, domestic, and industrial supplies. China has carried out major water resource development activities throughout the country, but mainly in the east, for flood control, irrigation, hydropower, internal navigation, drainage, power generation, and industrial and domestic water supplies. Of the 2,800 BCM annual renewable water resources available, 460 BCM are withdrawn for all uses. Agricultural uses account for 87 percent of the total withdrawals; 49 percent of all China's farmland is irrigated (47 million ha). China has an established system of water user charges for irrigation and other uses. The geographic distribution of total water resources in China is uneven. For example, the pressure posed by the concentrated population in the east is creating conflicts between uses. Transbasin diversions are being studied as a means of relieving the disparate distribution of resources and development.



Technically feasible actual and potential power generation capacity totalls 378,000 MW. Of this, about 290,000 is economically feasible. Large hydropower facilities to produce 20,440 MW are under construction and others for 75,450 MW (including the 17,680 MW three gorges scheme on the Yangtze River) are planned. Small plants (up to 10 MW) in operation total 5,931 MW, with 1,460 MW under construction and 7,000 MW planned. Two-thirds of the potential large hydropower sites are in the southeast, far from the coastal major load centers, requiring long distance transmission over rugged terrain to utilize this enormous potential.

Deforestation and catchment degradation have increased soil erosion and river and canal siltation and have modified run-off regimes. *Unsustainable cultivation practices* in the upper and middle Yellow River basin and the upper Yangtze basin are contributing to severe soil erosion. The controversial *Three Gorges Dam project* is planned for flood control on the Chang Jiang (Yangtze) River. Major dam construction for flood protection is also planned on the Yellow River. *Regional water shortages* on the north China plain, where excessive groundwater overdraft is practiced, will require a reduction in irrigation to alleviate conflicts over uses. Similar problems exist in the Beijing and Tianjin urban areas, where irrigation must be reduced to meet domestic and industrial demand. Of the various *interbasin water transfers* contemplated, the largest would take Yangtze River surpluses to the north China plain. China is also faced with pollution problems because of domestic and industrial discharges. *Wetland development* is practiced as a result of population pressure and because cultivable land—not water—is the limiting factor constraining expanded food production.

58

INDIA

Population (1990)	850 million
Population Growth Rate (world = 1.8%)	2.1%
Urban Population (1965/1990)	19%/27%
Gross National Product (1990)	276,757 million
Per Capita GNP (1990)	$350
Land Area (sq. km)	2,973,190
Potential Water Available (bcm/yr)	1,850
Developed Water Resources (bcm/yr)	380
Total Supply Per Capita (cm)	2,170
Water Use by Sector Ag/Ind/Mun & Dom	93%/4%/3%
Water Resources Originating in a Neighboring Country (bcm/yr)	235
Population Access to Safe Water Urban/Rural	79%/85%
Hydropower:	
Installed capacity (MW)	18,752
Av. annual production (GWh)	71,683
Percent of total power	

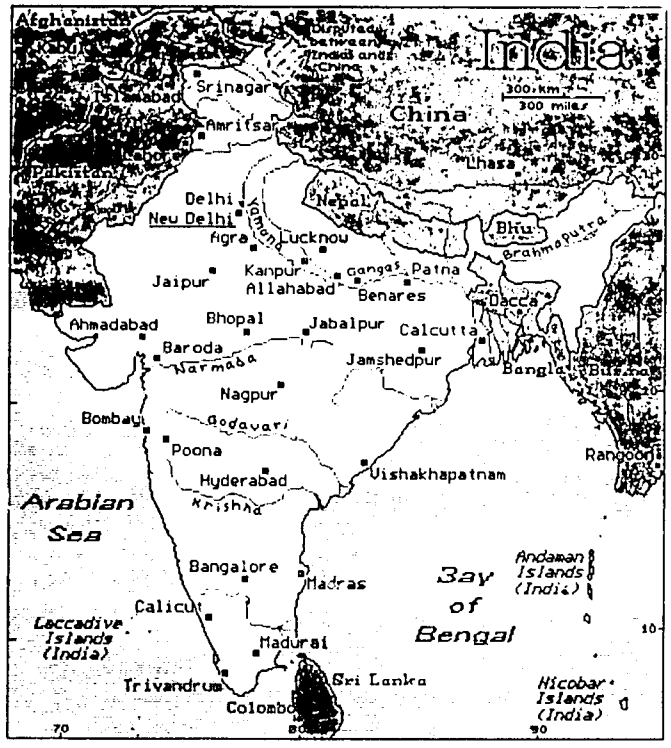
India has a wide variety of geographic and climatological environments ranging from the Himalayas in the north to tropical lowlands in the south, from Thar in the west, a nearly rainless desert, to the east lashed by seasonal monsoonal rains. The northern plain alluvial lowlands extend from PUbjab in the North to Assam in the east and are formed by the river basins of the INdus, Ganges and Brahmaputra rivers.

The east-west Vindhya range separate the northern plain from the rest of the peninsula, dominated by the central Deccan plateau with a narrow strip of coastal lowlands in the west and a broad coastal plain in the east that is crossed by the peninsula's main rivers: Narmada, Cauvery, Krishna, Godavari and Mahanadi. Present agriculture uses 85 percent of India's water. Seventy percent of the population is employed in the agricultural sector. The entire country is criss rossed by 12 major and 46 medium river basis. These contribute over 90 percent of the total run-off.

Of the estimated 4,000 BCM of precipitation, 1,880 BCM is the average annual natural run-off and 1,146 BCM is considered usable. Roughly 50 percent of the usable total is now used. The rivers of the country carry 80 percent of their flow during the monsoon months of June through September, reducing the flow to 20 percent from December to May. This seasonal variation is especially pronounced in the rivers draining peninsular India. Utilizable ground water is estimated at 450 BCM per year.

The water management issues of the river-fed areas (north and west) differ dramatically from those in areas that depend on groundwater, such as the Deccan plateau. The availability of water is highly uneven in both space and time. Floods and drought affect vast areas of the country. About one-third of the country is drought prone. Areas susceptible to flood are about 40 million ha.

Technically feasible actual and potential hydropower capacity in India is 84,000 MW. Facilities with capacity totalling 8,888 are under construction and a further increment of capacity of 17,705 is planned. Small plants (up to 10 MW) totalling 207 MW are in operation and a further 234 MW are under construction.



India has a geographical area of 329 million ha. The cultivable area, net sown area and gross cropped area comprise 186 million ha, 145 ha and 175 ha, respectively. The ultimate irrigation potential is 113 million ha of which 58 million ha is from major and medium schemes and 55 million ha from minor irrigation schemes (major schemes exceed 10,000 ha; medium schemes are in the average of 2,000 to 10,000 ha; minor schemes are smaller than 2,000 ha). Total potential created up to March 1992 is about 81.3 million ha. However, utilization is only 73 million ha giving a gap of 8.3 million ha. So far, more than 3,000 large and medium size dams have been constructed for irrigation purposes. The total live storage capacity of reservoirs completed up to 1989 is about 166 BCM. The production of food grain consequent on creation of irrigation infrastructure coupled with improved agricultural practices has increased from 50 million tons in the 1950s to 178 million tons in 1992-93. India's target is 240 million tons by the year 2,000 to feed its rising population.

The Narmada Valley Development provides for construction of 28 major, 135 medium and about 3,000 minor dams. Four major dams have been completed which another is under construction. The four largest dams will regulate more than two-thirds of the water of the Narmada river. One of these, the Sardar Sarovar dam, is in an advanced stage of construction and is likely to be completed by 1996. Annual irrigation from the lower Narmada project alone will be 4.8 million ha. The installed hydropower capacity will be 3370 MW and Sardar Sarovar will provide drinking water to 17 million people.

Allocating water among nations that share riparian boundaries and among riparian states within India is a major issue. Sharing water resources among competing economic and social sectors is also an important policy problem. In many basins, irrigation, the main user, has driven development in the past and continues to do so today. The national government has now enacted a new water policy which promotes integrated river basin development participatory management.

INDONESIA

Population (1990)	178 million
Population Growth Rate (world = 1.8%)	1.8%
Urban Population (1965/1990)	16%/31%
Gross National Product (1990)	$76,926 million
Per Capita GNP (1990)	$570
Land Area (sq. km)	1,811,570
Potential Water Available (bcm/yr)	2,530
Developed Water Resources (bcm/yr)	16.59
Total Supply Per Capita (cm)	14,020
Water Use by Sector Ag/Ind/Mun & Dom	76%/11%/13%
Water Resources Originating in a Neighboring Country	N/A
Population Access to Safe Water Urban/Rural	41%/37%
Hydropower:	
Installed capacity (MW)	2,062
Av. annual production (GWh)	5,675
Percent of total power production	16.3

Indonesia, the largest country in southeast Asia, comprises more than 13,600 mostly mountainous islands. The largest islands are Kalimantan, Sumatra, and Irian Jaya, which together make up 70 percent of the country's land area. Straddling the equator, the country has a tropical climate. In coastal areas of most islands, mangrove wetlands are common, while tropical rain forests grow in the interior. Java, Lombok, and Bali have wide river valleys and alluvial plains. Average annual rainfall is more than 6,000 mm per year. Total annual renewable water resources are estimated at greater than 2,530 BCM, in Asia second only to China. Of all uses, agricultural withdrawals are greatest, at 76 percent of the 16.6 BCM withdrawn annually. Domestic and industrial water supply uses account for the balance, 24 percent. Groundwater is an important source for agricultural, domestic, and industrial water supplies on Java and in the drier eastern islands. Total withdrawals in this basin for all uses probably exceed 8.75 BCM per year.

Some islands, notably Java, Madura, Bali, and the lesser Sundas, suffer critical basin shortages. These have led to conflicts among users. Watershed degradation in the most populous islands of Java, the Madura inner islands, and Lombok is accelerating due to pressure for new agricultural lands, while the less populous islands suffer from deforestation.

Degradation is localized depending on the population distribution: 62 percent of the nation's people live on 8 percent of the land. Although the outer islands are less populated, they are under pressure from resettlement programs that bring people to new agricultural lands.

On the densely populated islands, hillside erosion is contributing to siltation of lowland streams, irrigation canals, reservoirs, and ports. Stream siltation is causing an increase in lowland flooding, which severely impacts agricultural land. While watershed degradation is occurring, Indonesia has retained a far higher percentage of its land under tree cover than any other large Asian country; 75 percent of the country is protected within Forestry Department boundaries.

Satisfying municipal and industrial demand is crucial to the country's urban and industrial growth; however, in areas experiencing urban growth, demands on basin resources

61

compete with established agriculture. Surface water quality in populated areas is deteriorating because of untreated domestic and industrial discharges. Saltwater intrusion is contaminating fresh water aquifers in low-lying areas because of increased industrial and domestic pumping. As population centers develop along streams and canals, rural water quality may also become problematic.

The technically feasible actual and potential power generation capacity of Indonesia is 75,000 MW. The economically feasible part of this is approximately 35,800 MW. Facilities with 360 MW capacity are under construction and a further increment of 2,592 MW is planned. Small hydro units (up to 10 MW) totalling 50 MW are in operation, with 6 MW under construction and 47 MW planned.

Food self-sufficiency and increased rural economic growth are directly linked to large investments in irrigation infrastructure. While the costs of operations, of maintenance, and of rehabilitation of infrastructure burden Indonesia, many areas of the country are moving from a *water development* to a *water management* and facilities maintenance stage. On the outer islands, irrigation development problems need attention: inadequate command water supply, unforeseen drainage problems, sub-standard construction, and the need to involve farmers with system management, operations, and maintenance.

Indonesian water policy and planning initiatives come from the Directorate General of Water Resources Development. With donor support, the Directorate has taken many of the policy actions required to meet the critical problems of watershed protection, system turnover to farmer organizations and other private entities (balancing industrial, domestic, and agricultural water use), and groundwater contamination.

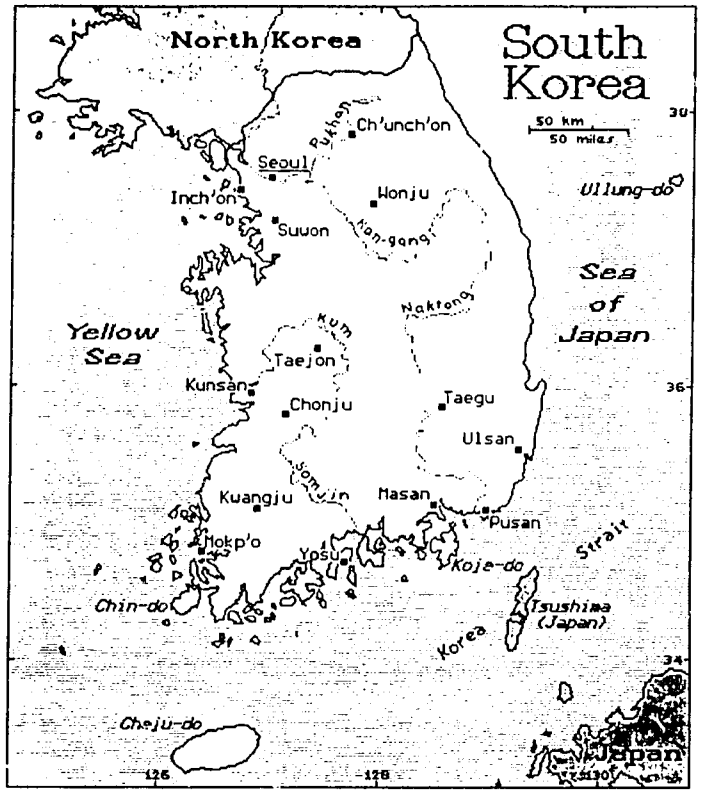
REPUBLIC OF KOREA

Population (1990)	43 million
Population Growth Rate (world = 1.8%)	1.1%
Urban Population (1965/1990)	32%/72%
Gross National Product (1990)	$186,467 million
Per Capita GNP (1990)	$5,400
Land Area (sq. km)	98,730
Potential Water Available (bcm/yr)	63
Developed Water Resources (bcm/yr)	10.7
Total Supply Per Capita (cm)	1,450
Water Use by Sector Ag/Ind/Mun & Dom	75%/14%/11%
Water Resources Originating in a Neighboring Country	N/A
Population Access to Safe Water Urban/Rural	91%/49%
Hydropower:	
Installed capacity (MW)	1,445
Av. annual production (GWh)	3,486
Percent of total power production	2.9

The topography of the Republic of Korea (South Korea) includes the Taebaek-Sonmaek highland range, which runs the length of the peninsula's east coast. The main lowland areas of the south and the west are the areas of maximum agricultural development and population density. The peninsula has a monsoonal climate—cold and dry in the winter and hot and wet in the summer, when 70 percent of the annual rainfall occurs. Mean annual rainfall varies from the north at 600 mm to the south at 1,400 mm. Most of South Korea's rivers flow westward to the Yellow Sea. South Korea's two major river basins are the south Han and the Naktong. A cascade of one multipurpose dam and three primarily hydropower dams has been constructed on the lower reach of the north branch of the Han River. The south and west lowlands, characterized by productive alluvial soils, are the major agricultural regions. Annual renewable water resources are estimated at 63 BCM. An estimated 11 BCM are withdrawn for all uses, with agriculture being the major use, accounting for 75 percent of all withdrawals, followed by industry at 14 percent and domestic uses at 11 percent. Irrigation infrastructure is well maintained and operated. More than 50 percent of the country's population is employed in the agricultural and fisheries sectors.

Technically feasible hydropower capability is about 7,650 GWh/year; the economically feasible portion is about 4,000 GWh/year. Facilities with capacity totally 57 MW are under construction, with a further increment of 169 MW planned. Small hydropower plants (capacities up to 10 MW) with a combined capacity of 29 MW are in operation, with 7 MW under construction and 6 MW planned.

South Korea has among the best water resource management institutions in the region in terms of staff, material resources, and planning capacity. As a result, it has been able to undergo rapid economic development in the last 25 years without the creation of major water resource problems. Complementing the institutions are the political will to make informed planning decisions and the financial resources needed to undertake any capital works required.



Industrialization and urban growth have precipitated local water shortages, and the consequent effluent has caused water pollution problems. Again, these problems have been studied and have been corrected or ameliorated.

The Republic of Korea has a potential riparian water problem in that the upper part of the north Han River basin extends into the Democratic People's Republic of Korea (North Korea). North Korea began construction of a dam on the upper reach of the north Han, and South Korea is concerned that releases from this dam could be used as an environmental weapon. Construction was stopped after South Korea began construction of a downstream dam that would regulate releases made in the north. This riparian problem can be resolved only with continued change—now ongoing—in the political situation.

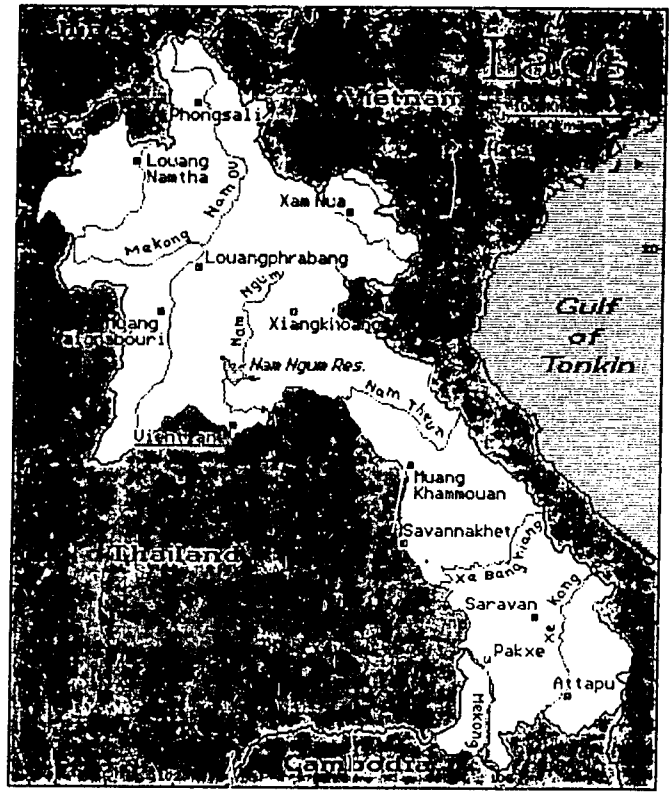
LAOS

Population (1990)	4 million
Population Growth Rate (world = 1.8%)	2.7%
Urban Population (1965/1990)	8%/19%
Gross National Product (1990)	$627 million
Per Capita GNP (1990)	$200
Land Area (sq. km)	230,800
Potential Water Available (bcm/yr)	270
Developed Water Resources (bcm/yr)	0.99
Total Supply Per Capita (cm)	66,320
Water Use by Sector Ag/Ind/Mun & Dom	94%/1%/5%
Water Resources Originating in a Neighboring Country	N/A
Population Access to Safe Water Urban/Rural	61%/17%
Hydropower:	
Installed capacity (MW)	198
Av. annual production (GWh)	885
Percent of total power production	95

Laos is a landlocked country in the center of the Indochinese peninsula, dominated by mountains and rivers. Laos has two physiographic zones: a northern zone that is mountainous and dissected by deep river valleys and a southern zone bordered by the Annamese Mountains on the east and the Mekong River on the west. The Mekong River flows for more than 1,800 km through Laos and is the country's lifeline. In the north, two major basins tributary to the Mekong drain into the Nam Ou and Nam Ngum rivers. More than 80 percent of Laos is drained by the Mekong River. The climate in Laos is tropical monsoonal, affected principally by the southwest monsoon from June to October during the hot wet season. In the north, annual rainfall averages about 3,000 mm, while the south receives an annual mean range of 1,500 to 1,700 mm. Laos has abundant water resources, estimated at 270 BCM on an annual renewable basis. Of this, only about 1 BCM are withdrawn. Agriculture accounts for 82 percent of all uses; 75 percent of the population is involved in agriculture. Gravity irrigation is practiced in the lowlands adjacent to the Mekong. The Mekong is also an important source of freshwater fish and is used for communication and transport.

Technically feasible actual and potential hydropower capacity of Laos is about 20,000 MW. Planned new hydropower plants have a combined capacity of 928 MW. Small hydropower plants (up to 10 MW) totalling 50 MW are in operation, with at least seven power plants being considered along the Mekong River near the Thai border. These have a possible combined capacity of 2,700 MW.

Laos is a member of the Mekong River Development Committee, with Thailand, Cambodia, and Vietnam. Each Mekong riparian has different priorities for the development of the river. For Laos, hydropower benefits from the Mekong could help support national priorities for improved agriculture, forest production, and industrial development. In addition, the Mekong hydropower generation potential far surpasses the predicted domestic demand for Laos. Thus, power-generating projects planned for Laos should include power purchase agreements with neighboring countries. For example, the Government of Laos sells 80 percent of the electricity generated by the Nam Ngum dam to Thailand. Two similar



power-generating projects are now being planned.

Catchment degradation in Laos remains a problem. The commercial harvesting of timber in Laos by Thai logging concerns goes unregulated. Increasing local demand for fuelwood is also contributing to deforestation. The effects of this deforestation are increased erosion and siltation in low-lying streams and reservoirs.Water resource development in Laos has been hampered by a recent history of political conflict, a weak and unwieldy central government, ineffectual institutions for the management of water resources, and a lack of financial resources to undertake capital development projects.

66

MALAYSIA

Population (1990)	18 million
Population Growth Rate (world = 1.8%)	2.6%
Urban Population (1965/1990)	26%/43%
Gross National Product (1990)	$37,005 million
Per Capita GNP (1990)	$2,320
Land Area (sq. km)	328,550
Potential Water Available (bcm/yr)	456
Developed Water Resources (bcm/yr)	9.42
Total Supply Per Capita (cm)	26,300
Water Use by Sector Ag/Ind/Mun & Dom	47%/30%/23%
Water Resources Originating in a Neighboring Country	N/A
Population Access to Safe Water Urban/Rural	92%/68%
Hydropower:	
Installed capacity (MW)	1,581
Av. annual production (GWh)	5,800
Percent of total power production	30.5

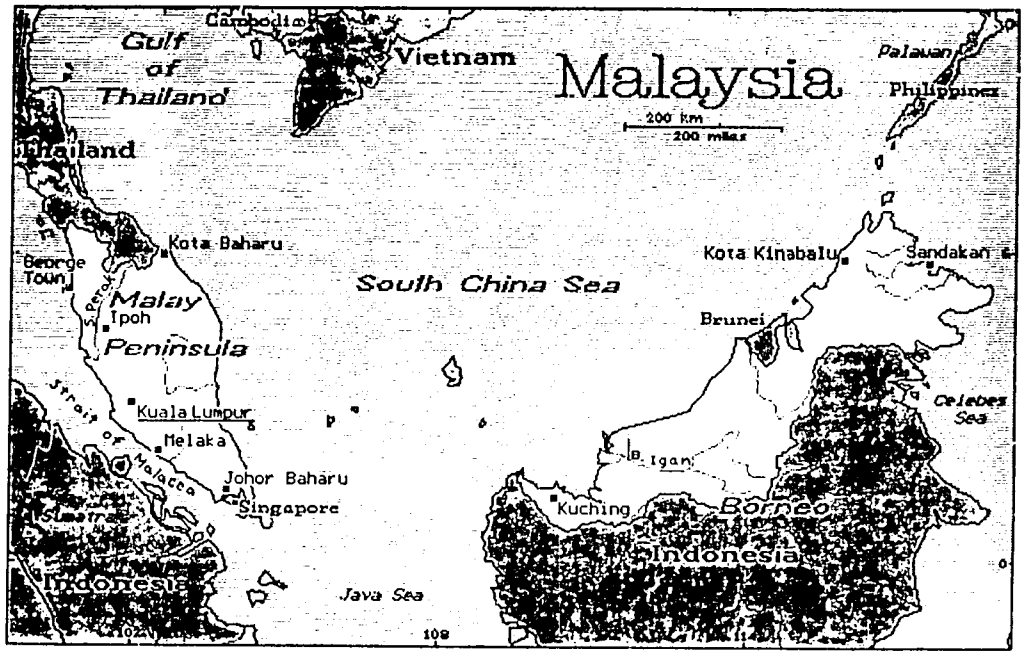
Malaysia is made up of two separate land masses. Peninsular or West Malaysia lies on mainland Southeast Asia between Thailand and Singapore, and East Malaysia (Sarawak and Sabah) lies on the north coast of Borneo, 600 km from West Malaysia. Topographically, both West and East Malaysia are characterized by a series of mountain ridges bordered by narrow coastal plains. Malaysia has a tropical monsoonal climate, and both land masses have abundant water resources.

Malaysia receives rain during the southwest and northeast monsoons. Mean annual rainfall averages range from 2,420 mm on West Malaysia to 2,630 mm on East Malaysia. The Pahang is West Malaysia's main river and the Rajang and Kinabatangan are East Malaysia's. Of the 456 BCM annual renewable water resources, about 10 BCM are withdrawn for use. Agriculture accounts for about 47 percent, industry for about 30 percent, and domestic supplies for 23 percent of the water used in Malaysia.

Uneven rainfall distribution in Malaysia leaves little basin run-off available for use. Storage reservoirs are needed to supplement low river flows during the dry season. In peninsular Malaysia, the west coast is in rain shadow during the period of the northeast monsoon, as is the east coast during the southwest monsoon. However, the best storage sites have already been developed. With large projected increases in industrial and domestic uses, new sites will have to be developed to prevent local *water resource shortages*.

Flood control and drainage also are major concerns in Malaysia, and the government has devoted large expenditures to both. Much of the best agricultural land lies on the coastal plains, which are protected by sea bunds and mangrove strips. Population pressure is increasing the demand for extension of this protection.

Irrigation in Malaysia has served mainly paddy agriculture. In contrast to other countries in the region, Malaysian irrigation system sustainability has less to do with inadequate O&M and resource allocation than with the effects of successful economic development in the country resulting in the rapid growth of non-paddy farm and non-farm incomes. Recent investment in irrigation has



resulted in lower rates of return than expected. *The future of irrigation* in Malaysia depends on reforms in land management, tenure, and market strategies. Investment in both irrigation and hydropower are currently low priorities for the government. Reallocation of water resources from agriculture to other uses or from paddy to other crops may prove Malaysia's best strategy in water use planning.

There is increasing concern about river water quality as pollution from industrial, mining, and municipal discharges is increasing. Malaysia is one of Southeast Asia's economic success stories. Industrial development has created jobs, markets, and wealth. However, one consequence of this development is increased pollution. This effect shows markedly near Penang, Itoh, and Kuala Lumpur.

Catchment degradation due to logging and clearing for settlement is also increasing erosion and siltation. Estuary degradation results from the specific nature of the silt from tin mining operations.

MONGOLIA

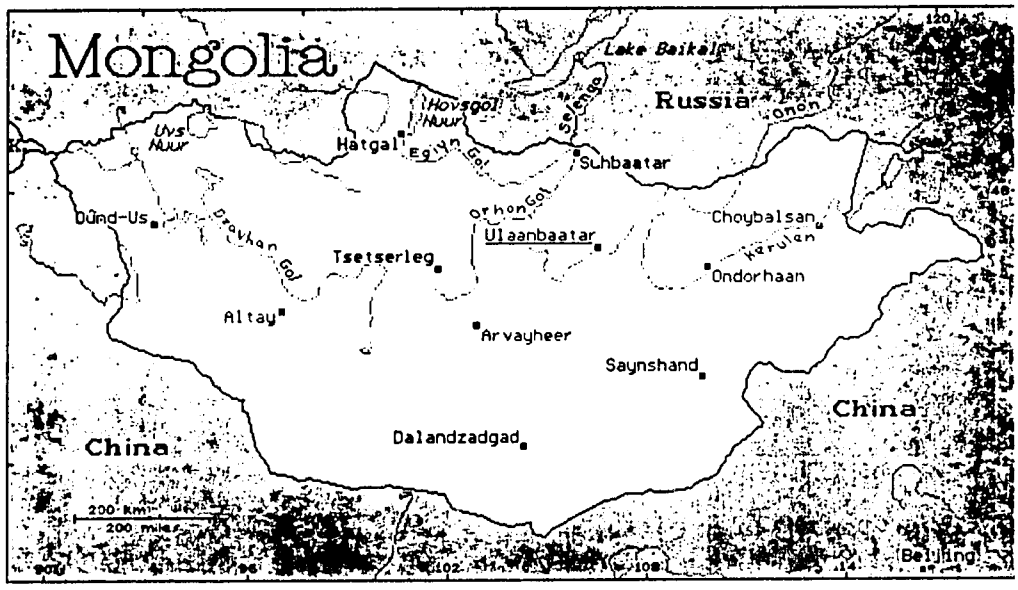
Population (1990)	2 million
Population Growth Rate (world = 1.8%)	2.8%
Urban Population (1965/1990)	42%/52%
Gross National Product (1990)	N/A
Per Capita GNP (1990)	N/A
Land Area (sq. km)	1,566,500
Potential Water Available (bcm/yr)	24.6
Developed Water Resources (bcm/yr)	0.55
Total Supply Per Capita (cm)	1,105
Water Use by Sector Ag/Ind/Mun & Dom	62%/27%/11%
Water Resources Originating in a Neighboring Country	N/A
Population Access to Safe Water Urban/Rural	100%/100%
Hydropower	N/A

The world's largest landlocked country, Mongolia lies on a high plateau with the Altai and Hangayn ranges dominating the north and the northwest parts of the country. A smaller range, the Hentiyn Naruu, rises to the northeast of the capital, Ulanbaatar. Between the Hangayn and Hentiyn ranges lies a large fertile alluvial basin drained by the Selenge, Orthon, and Tuul rivers, all draining into Lake Baykal in Russia. Between the Altai and Hangayn ranges lies the Great Lakes region with over three hundred large deep lakes. The largest is Hovsgol, with a surface area of 2,620 square km and a depth of 240 m at its deepest point. To the south lies the central plateau and then the Gobi Desert. The Kerulen and Onon, Mongolia's other two major rivers, drain the northeast part of the country. The southern and southwest portion of the country is drained by internal rivers that terminate in salt lakes or disappear in the Gobi Desert. Less than one BCM of the total estimated 25 BCM annual renewable water resources is withdrawn for all uses. Agricultural withdrawals account for 62 percent of all uses.

Mongolia experiences a marked continental climate. Annual mean rainfall is estimated from a high of 300 mm in the northwest mountains to a low of 50 mm in the southeast. Rainfall distribution varies widely and occurs mostly in the summer months. Heavy rains in the north cause flooding on occasion. Groundwater potential exists in the alluvial plains in the north, and as Mongolia's urbanization trend has increased in the past 25 years, pressure for domestic and industrial uses is growing. Care needs to be taken to limit extractions, based on recharge availability. Most domestic consumption depends on groundwater.

Diversion irrigation is practiced along all rivers, especially in the north and northeast. The northern rivers have hydropower potential, and there is also geothermal power-generating potential that has begun to be developed. Technical and economic feasibility have been demonstrated for a 220 MW hydropower facility on the Egiin River in north-central Mongolia.

As a result of the changes in Russia, Mongolia is now faced with re-negotiating riparian issues with its northern neighbor.



Also, the development of water resources, once supported by Soviet and COMECON aid, now requires capital and technical assistance from other sources.

As Mongolia has been influenced by the former Soviet Union and COMECON countries, institutions and policy are mostly centralized. Although there is movement to decentralization, assistance could be useful in accelerating the change. There is also a need to train water resource institution staff.

70

MYANMAR

Population (1990)	42 million
Population Growth Rate (world = 1.8%)	2.1%
Urban Population (1965/1990)	21%/25%
Gross National Product (1990)	N/A
Per Capita GNP (1990)	N/A
Land Area (sq. km)	657,540
Potential Water Available (bcm/yr)	1,082
Developed Water Resources (bcm/yr)	3.96
Total Supply Per Capita (cm)	25,960
Water Use by Sector Ag/Ind/Mun & Dom	90%/3%/7%
Water Resources Originating in a Neighboring Country	N/A
Population Access to Safe Water Urban/Rural	38%/28%
Hydropower:	
Installed capacity (MW)	280
Av. annual production (GWh)	N/A
Percent of total power production	N/A

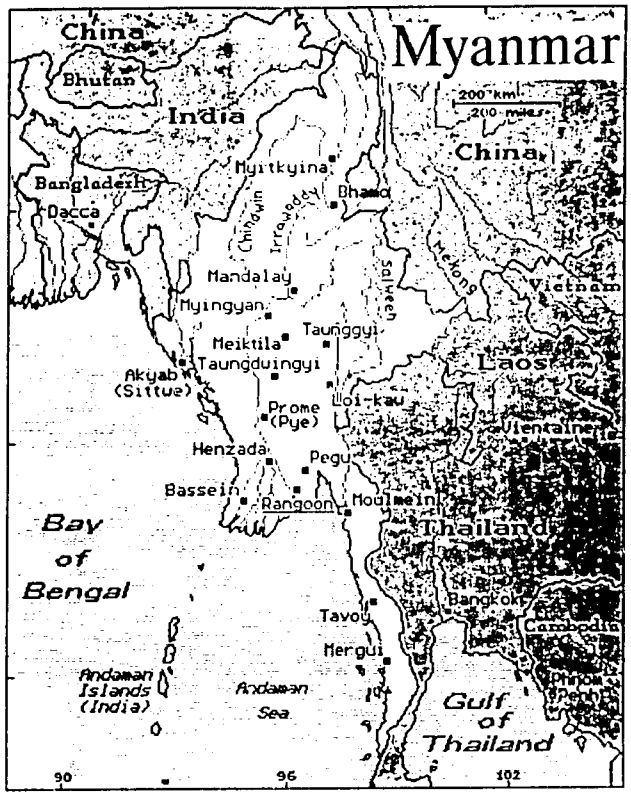
Myanmar is divided into three major topographical regions: the western highland ranges, the central basin dominated by the Irawaddy River basin draining to the Andaman Sea, and the eastern plateau bisected by the Salween River, Myanmar's longest. In the south, the country extends 300 km in a narrow 50-km coastal strip along the Tenasserim peninsula. Myanmar has abundant water resources. Mean annual rainfall exceeds 2,000 mm in most parts of the country and ranges from 6,000 mm in the coastal ranges to lows of 500-1,000 mm in the rain shadows of the coastal highlands. About 40 percent of all Myanmar's run-off is concentrated in the Irawaddy River catchment, measured at the head of the Rangoon delta. This basin constitutes 60 percent of the land area of the country. The Salween River, which rises in China, and the Sitang River also drain the basin.

Only 4 BCM of Myanmar's total annual renewable water resources (1,082 BCM) are withdrawn for use. Ninety percent of water use is for agriculture. Groundwater potential is greatest in the alluvial plains of the central basin rivers and can be exploited through deep well development.

Water resource development in Myanmar has been concentrated in flood control works in the central basin and paddy irrigation. The pace of development has slowed over the past two decades because of the lack of availability of financial resources and, to some extent, security problems in the country.

Myanmar boasts a high level of local participation in the construction of flood control facilities and small-scale irrigation facilities. Sixty-three percent of all irrigated land, over 1 million hectares, was under private management in 1980. Most irrigation depends mainly on river diversion and small storage tanks. There are also major pump-diversion schemes in the central basin. The potential exists for increasing the irrigated land under these pump-diversion systems. However, low rates of return for investments, O&M management requirements, and user cost recovery are constraints to further investment.

In Myanmar's central basin, the government has undertaken medium-scale *multipurpose water projects* that deliver flood control, irrigation, and hydroelectric benefits. Additional projects have been planned, but funding has been problem-



atic, local implementing agencies are lacking in conceptual planning ability, and resettlement and environmental issues are looming. Myanmar has good *hydroelectric power production potential*, estimated at more than 100,000 MW, and this capacity outstrips even the country's medium-term requirement projections. The development of this energy could fuel economic growth. Energy exports to neighboring countries are also possible. Funding for such projects is a major issue. The development of flood control and irrigation infrastructure in the Irawaddy basin and the effects of this development on the Rangoon delta need close monitoring to prevent possible negative changes in the delta drainage patterns and flow regime. In the delta itself, seasonally flooded areas are the site of intensive fishing. *Competition between fishing and land reclamation for paddy production* in the delta needs to be addressed in the overall development of delta water resources.

NEPAL

Population (1990)	19 million
Population Growth Rate (world = 1.8%)	2.6%
Urban Population (1965/1990)	4%/10%
Gross National Product (1990)	$3,069 million
Per Capita GNP (1990)	$170
Land Area (sq. km)	136,800
Potential Water Available (bcm/yr)	170
Developed Water Resources (bcm/yr)	2.68
Total Supply Per Capita (cm)	8,080
Water Use by Sector Ag/Ind/Mun & Dom	95%/1%/4%
Water Resources Originating in a Neighboring Country	N/A
Population Access to Safe Water Urban/Rural	66%/33%
Hydropower:	
Installed capacity (MW)	224
Av. annual production (GWh)	707
Percent of total power production	99.9

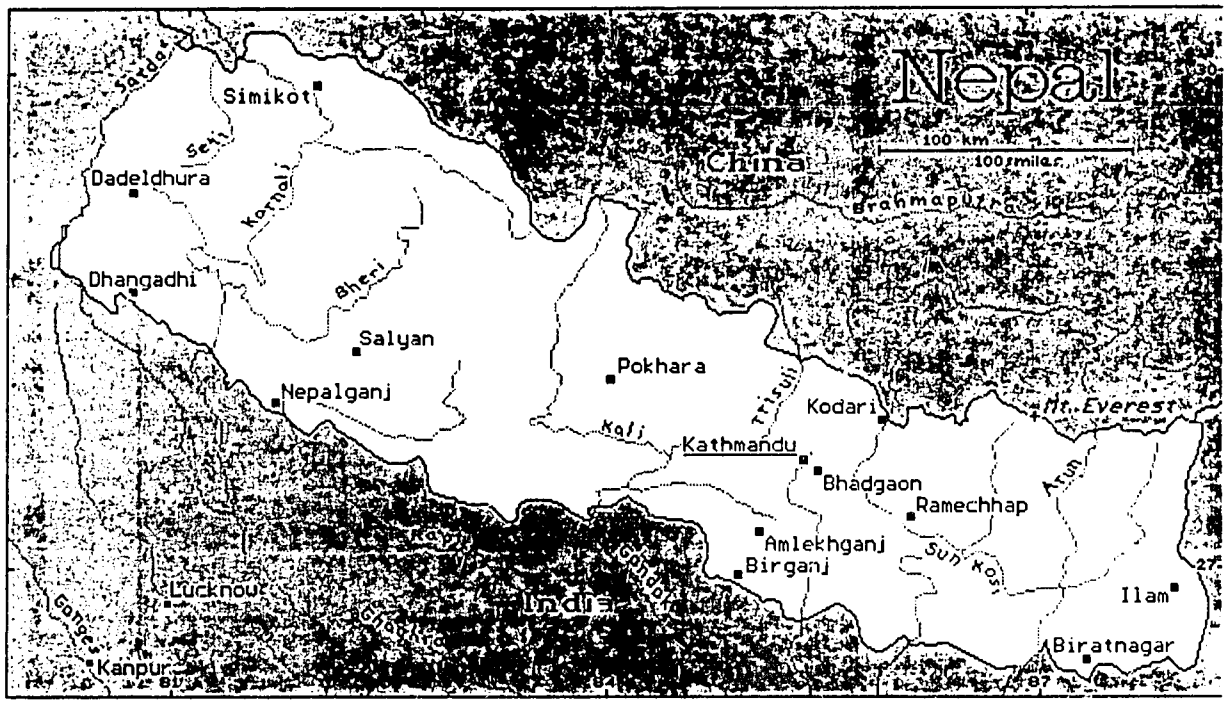
Spanning the northern Gangetic plain and the high Himalayas, Nepal can be divided into three zones. In the south, the Terai, a narrow subtropical lowland plain, includes 80 percent of the country's agricultural land. North of the plain lie the Middle Hills, a series of parallel ranges broken by traverse valleys formed by the Karnali, Gandaki, and Kosi rivers and their tributary systems, all subcatchments of the Ganges River. The Middle Hills rise to the Himalayan massif that separates Nepal from the Tibetan plateau.

Mean annual rainfall in Nepal ranges from 1,200 to 3,000 mm, and the annual renewable water resources are estimated at 170 BCM. Of this amount, only 2.7 BCM per year are withdrawn for all uses, with agriculture accounting for 95 percent of all withdrawals. Seasonal flow in rivers varies greatly as a result of heavy rainfall during the monsoon months, June to September, and snow melt in the high Himalayas. Many of the tributary rivers of the three major systems originate in the Middle Hills and are not charged by snow melt. As a result, these rivers are subject to marked low flows in the dry season. Nepal's groundwater resources are large (estimated at 20 BCM per year), of good quality, and are easily exploited by deep and shallow wells.

About 930,000 ha of Nepal's arable land are irrigated and the potential exists to irrigate an additional 670,000 ha of arable and marginal land through surface water diversion and groundwater development. Currently, irrigation from groundwater sources is minor in comparison to gravity surface diversions. The construction of large reservoirs would help to capture a significant portion of the river flows for dry season use. However, the cost of diversion structures would be high in relation to the potential command area that would be served. Siltation of reservoirs would also limit the benefits of this investment.

Farmers manage 72 percent of all Nepal's irrigation systems, and expansion of the total irrigated area in the country may be better served through smaller system projects, including farmer-managed groundwater development.

Technically feasible actual and potential hydropower generation capacity is 83,000 MW. Of this, about 44,600 is economically feasible. Plants totalling 17.1 MW are under construction, with 492 MW planned.



Development of small hydro projects by the private sector is the primary intended means of relieving power capacity shortage.

Catchment degradation is a major problem in Nepal, caused by commercial deforestation, burgeoning demand for firewood, clearing for new agricultural land, and overgrazing of hill slopes and high pastures. The effects of these activities are soil erosion, increased sediment loads in rivers, and siltation of existing irrigation run-of-the-river intakes and canals. Although the government of Nepal has a master plan to address this problem, the plan requires development of forestry and watershed resource information systems and costly policy and institutional reforms.

Development of multipurpose storage reservoirs is a possible remedy for Nepal's irrigation, power, and flood control requirements. However, there are serious riparian, environmental, and institutional constraints to successful implementation of these projects.

Development of public run-of-the-river irrigation systems continues in Nepal. However, many of the remaining schemes have marginal economic viability because their command areas are too small to warrant large investments in diversion infrastructure. Operation and maintenance problems also exist on the publicly owned irrigation systems, although attempts at modernizing systems and improving operations are under way. Farmer participation in the management of public systems is minimal. Despite government attempts to improve their participation, farmers are slow to accept this responsibility.

Siltation will remain a chronic water management problem for Nepal. In addition, wastewater disposal from the three major townships in the Kathmandu Valley threatens urban drinking water supplies. The government will need to augment the domestic water supply with additional good quality water.

PAKISTAN

Population (1990)	112 million
Population Growth Rate (world = 1.8%)	3.1%
Urban Population (1965/1990)	24%/32%
Gross National Product (1990)	$36,987 million
Per Capita GNP (1990)	$380
Land Area (sq. km)	770,880
Potential Water Available (bcm/yr)	298
Developed Water Resources (bcm/yr)	153.4
Total Supply Per Capita (cm)	2,430
Water Use by Sector Ag/Ind/Mun & Dom	98%/1%/1%
Water Resources Originating in a Neighboring Country (bcm/yr)	170
Population Access to Safe Water Urban/Rural	84%/28%
Hydropower:	
Installed capacity (MW)	2,897
Av. annual production (GWh)	18,305
Percent of total power production	53

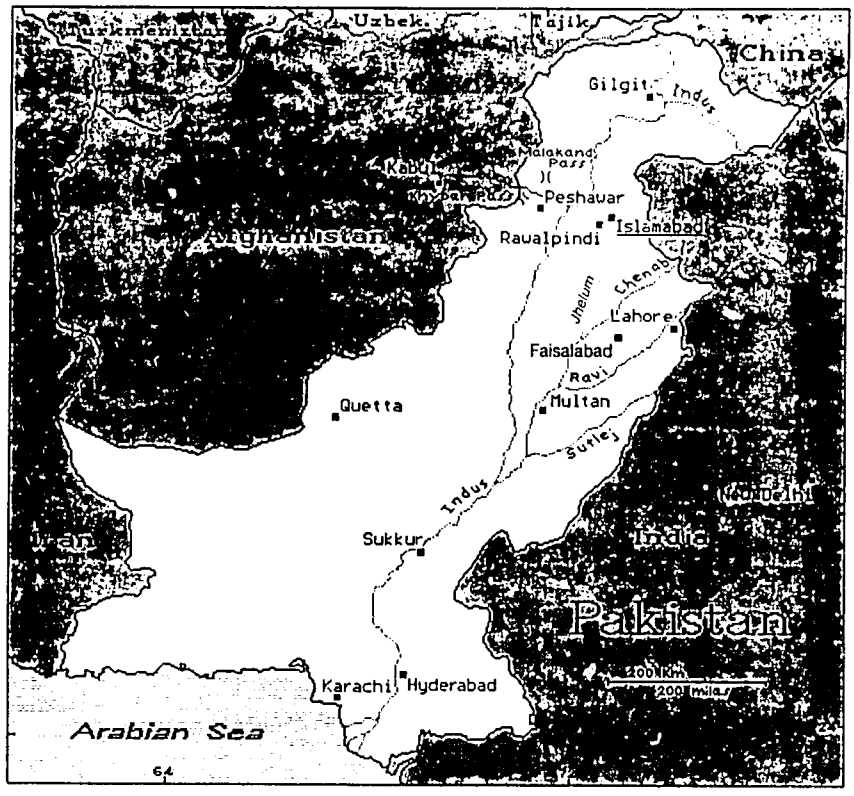
Pakistan is divided into three geographic regions. Mountains dominate the north and northwest. In this area, the Kabul, Swat, Yarkhan, Chitral, and Panjkora rivers flow through deep gorges to narrow alluvial plains before joining the Indus River. The Indus is the country's greatest water resource. The large alluvial plain stretching the length of the country from north to south is crossed by the Indus and its major tributaries, the Jhelum, Chenab, Ravi, Beas, and Sutlej. This plain supports the world's largest contiguous developed irrigation system. The Balochistan plateau is mainly desert and lies in the southwest, and the Thar Desert lies east of the lower Indus. Although classified as tropical monsoonal, the climate has continental characteristics. Rainfall distribution differs widely in the country. The southwest monsoon, from July to October, provides varying rainfall from year to year. Periods of extreme flooding or drought are not uncommon. Mean annual rainfall varies from 150-200 mm on the coast to more than 350 mm in the river valleys and 1,500 mm in the northern mountains. Annual renewable resources are estimated at 298 BCM, with more than 153 BCM withdrawn for all uses.

Agriculture is central to the country's economy, although industrial production now accounts for one-fifth of the country's GNP. Of the total 51 million ha of land cultivated in Pakistan, about 70 percent is irrigated. The cultivated area, 25 percent of the country's total land, largely corresponds to the irrigated Indus basin. Most irrigation water flows through perennial diversion canals, although some small pumping schemes exist, and groundwater is also used. Flood irrigation is practiced in northern and western areas. Dams have been built on the Indus, Jhelum, and Chenab rivers that regulate irrigation waters in the Indus basin. The Tarbela dam on the Indus River is also an important power-generating facility. Other major irrigation infrastructure exists throughout the Indus basin.

Total technically feasible hydropower generation capacity of Pakistan is about 33,000 MW, of which about 24,000 is economically feasible, yielding a potential annual production of 120,000 GWh per year. Facilities totalling 1,928 MW capacity are under construction, with 6,600 MW planned. Small hydro plants (up to 10 MW) total 108 MW in operation with 100 MW planned.

Central planning for water resource development is carried out at Islamabad. However, there is a great degree of decentralized

75



development planning done in each of the four provinces. Institutions at the federal and provincial levels are well developed, with well-trained staff in many positions. The bureaucracies are still dominated by political considerations that tend to distort priorities, such as financial allocations for operations and maintenance. More attention to *sustainability* of existing water resource facilities is needed instead of investing in new works.

Maintenance of the entire irrigation and drainage system is problematic, as insufficient financial allocations are made. Major *salinity and drainage problems* are being addressed, but the magnitude of the problem is large. Sustainability of these programs is still an issue. *User cost recovery* plans for irrigation services have not met with success. Projected *hydroelectric potential* on the northern Indus is greater than projected demand for the country. However, the development of the upper Indus raises serious environmental concerns and would require considerable capital resources. Internal *conflict about use* is occurring near population centers, as the demand for domestic and industrial uses competes with existing irrigation allocations.

Localized water pollution occurs near urban areas as a result of untreated domestic and industrial discharges. Also in urban areas, groundwater is overpumped, and aquifers have declined drastically. *Catchment degradation* is occurring throughout all major drainage basins because of pressure for fuelwood, logging, and overgrazing, resulting in serious soil erosion and siltation of lowland streams and impoundments. *Flood control* is becoming a major problem because of river channelization and increased river flows from watershed degradation. External *riparian conflicts* exist with India over the development of the five major Indus tributaries. The four provinces also compete for common resources.

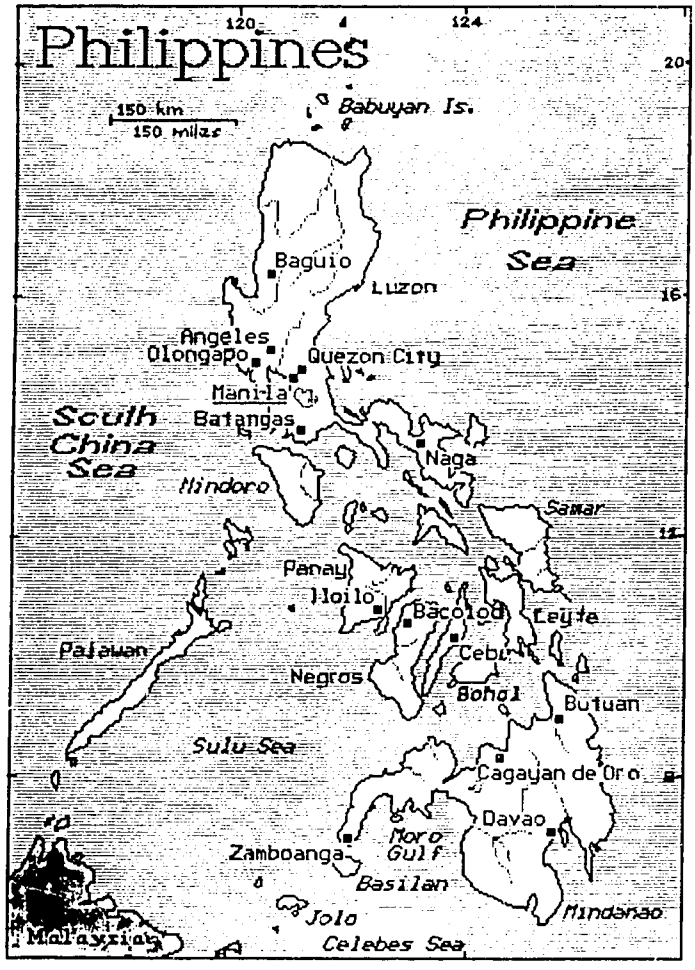
PHILIPPINES

Population (1990)	61 million
Population Growth Rate (world = 1.8%)	2.4%
Urban Population (1965/1990)	32%/43%
Gross National Product (1990)	$37,602 million
Per Capita GNP (1990)	$730
Land Area (sq. km)	298,170
Potential Water Available (bcm/yr)	323
Developed Water Resources (bcm/yr)	29.50
Total Supply Per Capita (cm)	5,180
Water Use by Sector Ag/Ind/Mun & Dom	61%/21%/18%
Water Resources Originating in a Neighboring Country	N/A
Population Access to Safe Water Urban/Rural	81%/68%
Hydropower: Percent of total power generation	25

Comprising 7,107 islands between the Pacific Ocean and the South China Sea, the Philippines is the second largest archipelagic nation in the world. The 11 largest islands constitute 94 percent of the land; 60 percent of the total land mass is made up from the islands of Luzon and Mindanao alone. A mountain range of volcanic origin runs north-south the length of the archipelago. Total country renewable water resources amount to about 325 BCM per year, with about 30 BCM withdrawn for all uses. Ten river systems have drainage basin areas greater than 3,000 square km, and there are more than 400 other rivers and streams with smaller catchments. Good groundwater development potential is found in large areas of Mindanao and Luzon. Most of the country experiences seasonal rainfall that varies from 1,000 mm to 4,000 mm, with mean annual rainfall of 2,360 mm. The northeast monsoons correspond to the wet season from October to March in the east, while it is still dry in the west.

Irrigation is by far the chief use and consumer of surface water, with commands totaling about 1.47 million ha. Of this total, 0.62 million ha are served by publicly owned facilities, 0.7 million ha are covered by communally owned and operated systems, and 0.15 million ha are found under pump schemes. With the exception of three large reservoir systems, most irrigation is fed through run-of-the-river sources that provide adequate water during the wet season and limited service in the dry season. Groundwater development for irrigation has occurred, but not to a major extent. Luzon has a large concentration of privately constructed and owned small-diameter drilled wells that are fed by artesian flow. New large reservoirs are planned, and a number of small storage dams have been constructed. More than 850 impoundments of all sizes for irrigation have been inventoried. Potential hydropower capacity totals over 10,000 MW. Major emphasis is to be placed on development of small hydropower plants.

The only major conflict about water use is between irrigation uses and domestic and industrial uses from the Angat reservoir near metropolitan Manila. In Manila, much of industry draws water from drilled wells, resulting in declining groundwater levels and saltwater intrusion in some areas.



Catchment degradation is occurring because of logging, slash-and-burn agriculture, and poor land management. Increased run-off leads to erosion, and negatively affects aquifer recharge. Sedimentation of water intake diversions, reservoirs, and lowland streams is also occurring. *Irrigation operation and maintenance cost recovery* is proceeding, and 85 percent of costs are recovered from users on publicly owned and managed systems. Water user associations are being encouraged to take further responsibility for system operations to improve system performance, yet insufficient funds are still expended on operation and maintenance.

Most industry and approximately one-sixth of the country's population are located in the Pasig-Laguna de Bay river basin. This concentration of population and industry has caused *severe water pollution* in the three sub-basins and the Angat Lake. Projects are now under way to minimize pollution, reduce nitrogen concentrations, and prevent saltwater intrusion. Future increases in population, industrial capacity, and new land brought under irrigated agriculture will further intensify the problem.

About two thirds of the population have adequate, safe water supplies. Almost 30 percent of the population lack adequate sanitation facilities. Only central Manila and limited parts of four other cities have sewerage systems. Diarrheal diseases rank second among the leading causes of morbidity, showing the effects of the linkage between human excreta, food and water.

78

SOUTH PACIFIC ISLANDS

This profile covers ten countries in the South Pacific. Water is the most critical of all resources on oceanic tropical islands. Defining these island countries by water resource availability and development potential, they can be sorted into three categories:

Continental and High Oceanic Islands: Fiji, Western Samoa, Papua New Guinea, Cook Islands (south), and Solomon Islands. Continental islands, such as Papua New Guinea, Fiji, and the Solomon islands, are large and are characterized by high mountains, high plateaus, and river systems that support some irrigated agriculture, depending on island size.

Papua New Guinea, the largest of these islands, is drained by five main river systems. The island has both surface water and groundwater irrigation facilities, hydropower infrastructure, and domestic and industrial supply systems. The same issues that affect water resource development on mainland Asia—for example, *catchment degradation* and *water pollution* from urban areas—affect development on Papua New Guinea. The island has an estimated 801 BCM annual renewable resources. Fiji, another continental island, is estimated to have just less than 30 BCM annual renewable resources and is characterized by steep gradient rivers. Annual renewable resources are estimated for the Solomon Islands at 45 BCM.

High oceanic islands, such as Samoa and the northern Cook Islands, also have steep gradient rivers with waterfalls. On Samoa, plentiful groundwater potential exists to support the increasing urban population. Large-scale run-off catchment schemes are also planned. Continental and oceanic islands in this group receive plentiful rainfall, averaging 1,000 to 3,500 mm per year. Groundwater is developed on all these islands for domestic and industrial supplies, and access to potable water is generally good from either source. Marine pollution is problematic on these islands in the vicinity of coastal urban development.

Raised Coral Atolls: Tonga, Niue, and Vanuatu. Raised atolls are made up of a submerged volcanic core surrounded and capped by generally thick coral limestone. These islands have few, if any, streams or springs and depend mainly on rainfall catchments and shallow drilled or dug wells for their domestic supplies. Highly permeable limestone or coral-sand soils allows rapid percolation downward. Groundwater extractions from the thin layer of fresh water, or lens, that floats on sea water, must be closely monitored to ensure that the limited resources are not overexploited. Adequate land management on the islands is also important, so as not to disturb percolation and recharge regimes. The thickness of the lens on Niue has been measured at 40 to 80 m in its center, 50 to 170 m below the rim of the atoll. Potential exists for additional withdrawals on Niue; however, financial resources for extraction and distribution are needed. Also, because energy costs are high, the Public Water Department has experimented with windmill-driven pumps.

On Vanuatu, groundwater potential exists to be developed in expanding urban areas and rural areas.

Coral Atolls: Cook Islands (north), Kiribati, and Tuvalu. A coral atoll occurs as a ring-shaped reef appearing as a low, roughly circular, elliptical, or horseshoe-shaped coral island or as a ring of closely spaced coral islets encircling or nearly encircling a shallow lagoon. Thin soils and sparse vegetation prevail on these islands. As in raised atolls, a freshwater lens that floats on sea water is a source of potable water for the residents of these islands, through dug or drilled wells. The factors governing the shape of the freshwater lens are rainfall, periodicity of droughts, tides, seepage, and extraction rates. Development mechanics of this fragile resource on these islands is still under investigation. Rainfall catchment from roofs is the main source of potable water for the residents of these islands.

On the nine coral islands of Tuvalu, the population uses rainwater collected from roofs and stored in home cisterns for drinking and cooking. Water pumped from dug wells is used for bathing, washing, and other non-essential uses. Well water is seasonally saline to some extent.

SRI LANKA

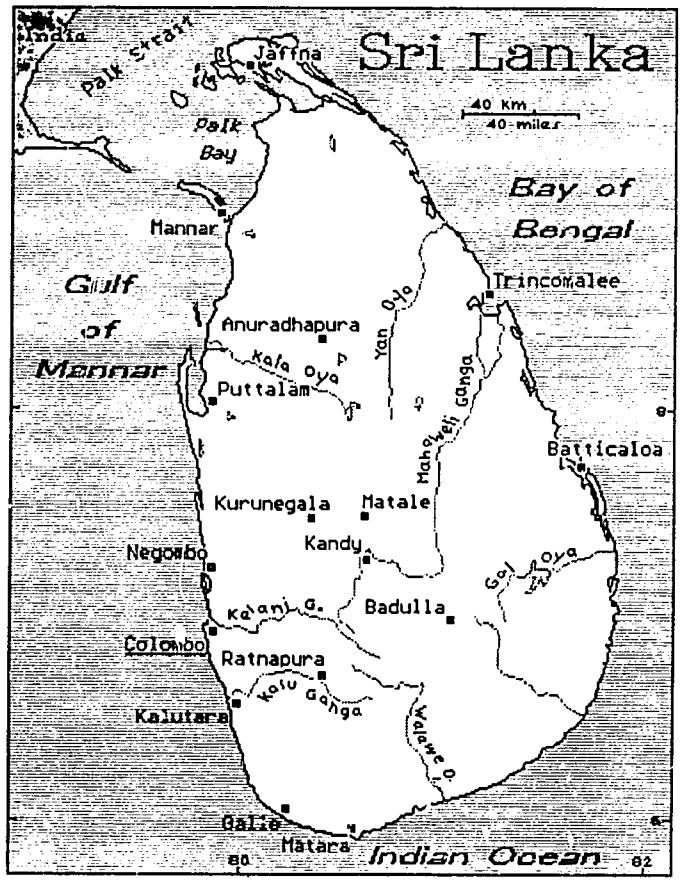
Population (1990)	17 million
Population Growth Rate (world = 1.8%)	1.4%
Urban Population (1965/1990)	20%/21%
Gross National Product (1990)	$6,957 million
Per Capita GNP (1990)	$470
Land Area (sq. km)	64,630
Potential Water Available (bcm/yr)	43.20
Developed Water Resources (bcm/yr)	6.30
Total Supply Per Capita (cm)	2,510
Water Use by Sector Ag/Ind/Mun & Dom	96%/2%/2%
Water Resources Originating in a Neighboring Country	0
Population Access to Safe Water Urban/Rural	82%/35%
Hydropower:	
Installed capacity (MW)	938
Av. annual production (GWh)	2,597
Percent of total power production	92.8

Sri Lanka is divided into three agro-climatic zones: dry, with 1,800-3,000 mm average annual rainfall; intermediate, with 1,200-1,800 mm; and wet, with 1,800-3,000+ mm. Sri Lanka has water resources that are adequate for essential uses, including drinking water. The island nation has two main terrestrial features: a mountainous area in the south central part of the country, and a lowland plain in the north that also surrounds the mountains in the south. Twelve major rivers flow through the three zones with the largest being the Mahaweli Ganga. Total annual run-off on the island is estimated at 43 BCM, with an estimated 6.3 BCM withdrawn for all uses. Agricultural withdrawals account for 96 percent of all abstractive uses. Groundwater withdrawals for village water supply are extensive, although yields in most parts of the island are low. Irrigation using groundwater is limited principally to the northern Jaffna peninsula, but small groundwater-fed high-value crop farming is found throughout the lowlands.

Extensive water resource development for irrigation began 2,000 years ago with storage reservoirs or *tanks* in dry zone catchments and basins, and small-scale diversions on wet zone streams. Rice is the major crop throughout the lowlands. In the last 40 years, substantial development based on the larger rivers and interbasin transfers has occurred and is continuing today. These large programs and projects have culminated in the Mahaweli Accelerated Development Plan (ADP) begun in 1968. It is made up of the construction of five major headworks to command 135,000 ha of currently unirrigated and undeveloped land. Although four dams have been completed, irrigation development has fallen short of original targets. Controversy exists over the macroeconomic, development, and environmental impacts; communal concerns; and cost overruns and delays.

Technically feasible hydropower capacity totals 2,000 MW, with an economically feasible production capability of about 7,300 GWh per year. Plants with a combined capacity of 169 MW are under

81



construction, with a further 392 MW planned.

Sri Lankan water resource institutions are centered in Colombo. However, a movement to decentralize planning and operations and maintenance responsibilities to the provinces is now being considered. Water resource policy is also undergoing transformation. A progressive set of policy reform measures that include significant empowerment and land tenure measures has been proposed that will lead to the sustainable development and maintenance of facilities, if adopted.

Catchment degradation, principally because of clearing land for agricultural development under government-sponsored settlement schemes, is contributing to accelerated siltation of reservoirs, tanks, and lowland streams and drains. *Irrigation development* is slowing, yet large programs, including the next phases of the Mahaweli ADP, are planned, along with interbasin transfer projects. Drainage and flood control facilities are needed in lowland areas. On a positive note, Sri Lanka is planning and addressing irrigation sustainability issues through the *empowerment of user groups*.

Sri Lanka's freshwater resources are impacted by untreated domestic and industrial wastewater discharges near urban ares. Also, agricultural chemical use is causing water quality degradation in major impoundments, reservoirs, tanks, low-lying streams, marshlands, and estuaries. Sustainable agricultural practices are being introduced to protect freshwater resources from non-point source pollution; however, these practices are only beginning and need more support from government.

In the northern peninsula, water resource facilities will need considerable rehabilitation after internecine warfare ends.

82

THAILAND

Population (1990)	56 million
Population Growth Rate (world = 1.8%)	1.8%
Urban Population (1965/1990)	13%/23%
Gross National Product (1990)	$54,469 million
Per Capita GNP (1990)	$1,420
Land Area (sq. km)	510,890
Potential Water Available (bcm/yr)	110
Developed Water Resources (bcm/yr)	31.9
Total Supply Per Capita (cm)	1,970
Water Use by Sector Ag/Ind/Mun & Dom	90%/6%/4%
Water Resources Originating in a Neighboring Country (bcm/yr)	69
Population Access to Safe Water Urban/Rural	81%/57%
Hydropower:	
Installed capacity (MW)	2,429
Av. annual production (GWh)	4,412
Percent of total power production	11.2

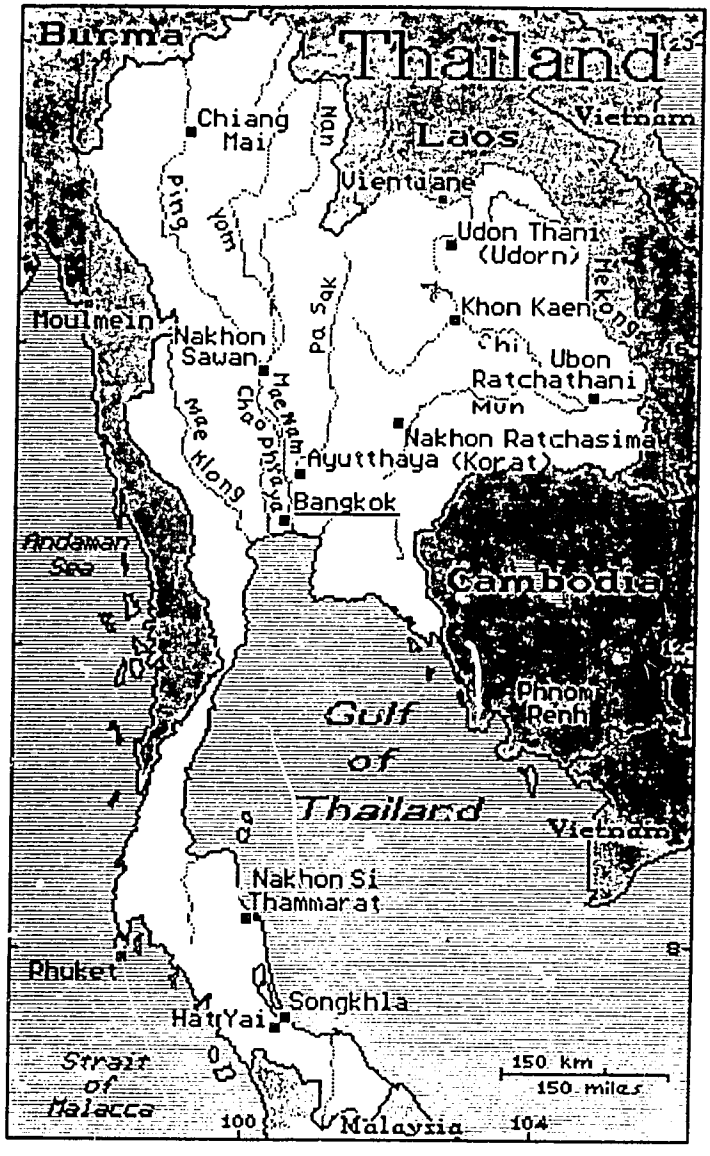
Located in the middle of the Indochina peninsula, Thailand straddles two mountain systems with large alluvial plains between them. It has a tropical monsoon climate. The central plain, about 35 percent of the country's land surface, is drained by the Chao Phraya river basin, whose water flows to the Gulf of Thailand. Twenty-two other rivers drain the remainder of the country, including the Mekong, which empties the large northeast region. Peninsular Thailand is drained by a series of small river systems that flow west to the Andaman Sea or east to the Gulf of Thailand. The northern, northeastern, and central regions receive 85 percent of their rainfall from the southwest monsoon in May through October, with little rain during the rest of the year. Mean annual rainfall ranges from 1,250 mm in the north to more than 2,000 mm in the south. Of the total annual renewable water resources (estimated between 110 and 170 BCM per year), an estimated 32 BCM are currently withdrawn for all uses. Agricultural withdrawals account for 90 percent of all uses. Except in the south, cultivation is not possible in the dry season without irrigation.

Over 3.0 million ha are under irrigation, and large projects, with command areas greater than 20,000 ha, represent 75 percent of the total irrigated land. Groundwater sources do not yet contribute significantly to irrigation. The government has begun to address the sustainability of irrigation systems through system design improvements and through farmer participation in operations and maintenance, including fees for service. Progress has been made, but financial allocations for the operation and maintenance of most systems is too low, and farmers do not pay user fees. Both surface water and groundwater are used for domestic and industrial water supply.

Thailand's total technical hydropower potential is about 10,600 MW, including about 8,150 of economically feasible capacity. Plants totalling 352 MW are under construction and a further 186 MW are planned.

Catchment degradation in Thailand's portion of the Mekong basin has occurred as a result of uncontrolled logging and, to some extent, the creation of new agricultural land. In 1989, logging was

83



banned in Thailand. However, some Thai logging companies now operate in parts of the Mekong basin in Laos and Cambodia. Thailand's development priority for the Mekong basin in northeast Thailand is the construction of multipurpose (irrigation, flood control, and power generation) storages. Objections to all major planned projects in Thailand's Mekong basin development plan have come from Thais along the river and from other Mekong riparians: Laos, Cambodia, and Vietnam. These plans include irrigation in the northeast and transfers to the Chao Phraya basin.

Continued expansion of irrigation facilities in the Chao Phraya basin has overcommitted supplies so that systems in the south receive inadequate dry season flow. Ever-increasing demands in Bangkok have also caused overdraft of groundwater, resulting in land subsidence and drainage problems. Water demands throughout the Chao Phraya basin are increasing. Although there are plans to address the growing scarcity of supply, solutions are controversial and expensive. Water quality in villages and small towns is a problem. In the northeast, there is a scarcity of drinking water in the dry season.

The Royal Irrigation Department sets and implements water policy in the agricultural sector. However, planning and policy for multisectoral water use reside in a multiplicity of agencies, whose agendas often conflict. Resolving this institutional dilemma is one of Thailand's major challenges.

84

VIETNAM

Population (1990)	66 million
Population Growth Rate (world = 1.8%)	2.1%
Urban Population (1965/1990)	16%/22%
Gross National Product (1990)	$14,200 million
Per Capita GNP (1990)	N/A
Land Area (sq. km)	325,490
Potential Water Available (bcm/yr)	376
Developed Water Resources (bcm/yr)	5.07
Total Supply Per Capita (cm)	5,600
Water Use by Sector Ag/Ind/Mun & Dom	78%/9%/13%
Water Resources Originating in a Neighboring Country	N/A
Population Access to Safe Water Urban/Rural	70%/39%
Hydropower:	
Installed capacity (MW)	1,763
Percent of total power generation	70

Vietnam's topography is characterized by mountains and hills of the Annamese range, which extends almost the length of the country. The climate is tropical monsoonal with a marked dry winter season from November to April. The north has more pronounced seasons as it is located at a higher latitude. Mean annual rainfall averages range from 1,000 mm in the south to about 3,000 mm in the center. The country has 15 major catchments, each with an area greater than 3,000 square km. The area in the Mekong River basin accounts for 22 percent of the country's area, 72,300 square km. The second major drainage system is the Red River basin with 60,960 square km. All rivers in Vietnam have low flows during the dry season, and storage is required to sustain dry season irrigation or regulate power generation. Annual renewable water resources are estimated at 376 BCM, and withdrawal for all uses is estimated at just over 5 BCM per year. Agriculture accounts for 70 percent of all uses.

Thirty-two percent of all cultivable land lies in the Mekong delta and 20 percent is drained by the Red River basin. Total area irrigated is estimated at 2.5 million ha, 84 percent of which is under paddy. Irrigation facilities are more highly developed in the Red River basin than in the Mekong. The delta irrigation systems are multipurpose in nature, also serving navigation, flood control, and drainage uses through pumped lifts.

Total potennnntial economically feasible hydropower production in Vietnam is about 6,500 GWh per year. At present, plants totalling 870 MW are under construction and 1,020 MW are planned.

Vietnam is one of four riparian countries that lie within the lower basin of the Mekong River. Each of these countries has differing priorities and water resource development potential for the area of the basin that falls within its boundaries. Implementation of projects by each riparian country will have an impact on the water resource development potential of its neighbors. This is particularly true for Vietnam, lying furthest downstream in the basin. For Vietnam, the main development priority for the Mekong basin is to develop the delta through flood

85

protection, control of saline water ingress, provision of drainage, and increasing of flow to the delta during the dry season. These developments will improve and expand agricultural land. Although the development potential exists, the country does not have the resources required to undertake a comprehensive program. Also, from a planning and implementation standpoint, the cumbersome government bureaucracy needs to be streamlined to manage and coordinate such a program efficiently.

Severe catchment degradation, because of forest clearing, is problematic in the upper catchments of eleven river basins, lying entirely in Vietnam, that drain about 36 percent of the land area. This results in erosion and sedimentation in lowland streams, with consequent ill effects to water resource uses. Degradation of watersheds of the other rivers, including the Mekong, is occurring in riparian countries of the Mekong. At this time there are no international agreements that govern or control the causes of the problem. The development of irrigation systems in the Red River basin and throughout central Vietnam needs to be better planned, with more rigorous attention focused on rates of return for projects.

Urban water pollution is increasing to alarming proportions because of the untreated discharge of domestic wastewater. This is causing severe health problems in the major cities of the country. Little information exists concerning groundwater development potential in the country; however, it is believed that local supplies do exist. A primary interest in exploiting this potential would be to improve domestic water supply quality.

86

APPENDIX B

THE FULL VALUE OF WATER AND WATER-RELATED INVESTMENTS

Appendix B
THE FULL VALUE OF WATER AND WATER-RELATED INVESTMENTS

Long-term welfare of a country, and perhaps even its survival, requires that economic rationality play a part in the decision-making process surrounding the development and use of water resources. Both water itself and the capital to develop and use water efficiently are in short supply. In addition, compared with most commodities, water use is more likely to affect persons other than the direct beneficiaries, sometimes through the physical environment and sometimes through market-exchange processes. An effective water management action plan in Asia must address these issues of scarcity and interdependence as they relate to water and its use.

This appendix outlines the issues pertaining to water management and provides a framework to help decision makers balance the beneficial and adverse effects of water resource development in the complex, often politicized process of selecting specific water-related programs and projects. This appendix is not a handbook for analyzing economic feasibility of projects; in fact, USAID already has handbooks for that purpose. Instead, this material highlights the special characteristics of water and water-related projects, explains why water projects need special analysis, and describes some of the technical, socio-political, and economic considerations of such analysis.

Critical Issues

Shortages

Water. Despite mounting evidence that the availability of water is becoming more and more limited, in many countries in the region it is still treated as a free good. No charge is imposed on users for extracting water from either surface or groundwater sources, and property institutions practically never vest an exchangeable right in users. Although users may pay for the treatment, transport, and even disposal of water, the price paid rarely reflects the true value of water to society. Equally important, the value of water in terms of its opportunity cost or foregone benefits is too rarely considered in water development planning.

Capital. That water-development capital is scarce is a theme that needs little elaboration. In the coming decades, USAID and its host countries in Asia will have to attempt to accomplish water development and management goals with extremely limited budgets. Accordingly, planners must scrutinize proposed expenditures to ensure that the resulting benefits will exceed the direct and indirect costs incurred, thus yielding a satisfactory return on investment.

Interdependencies and Water Use

Water exhibits important economic and physical interdependencies that distinguish it from most other resources and commodities. Economic interdependencies of the water resource exist in the form of linkages between water-based economic activities and the rest of the economy. Purchases in the local economy by water users add employment and income. For example, irrigators receiving new water supplies purchase services and goods locally, thereby boosting the economy in that area.

Physical interdependencies arise from the physical characteristics of water itself. Being liquid, water tends to flow, seep, evaporate, and transpire. This mobility causes a unique, unpredictable interrelationship among its users. For example, in many cases diversionary uses of water from streams and aquifers return up to one-half of the original water diverted. Users who are downstream, or interconnected through an aquifer, are directly affected (positively or negatively) by the quantity, quality, and timing of releases, leaks, or return flows by the upstream users. Such characteristics make it difficult to identify and measure the use of water, thus making it relatively difficult to establish and enforce the exclusive property rights of an exchange economy. Physical interdependencies such as these cause what are known to economists as technological externalities.

Approaches to Classifying and Defining Economic Effects

Comparative evaluation of water-related projects or proposals is based on balancing the positive and negative effects: the desirable or positive effects are called benefits, while the undesirable or negative effects are called costs. All proposed decisions entail some costs since, at the very least, a choice of one course of action implies a decision not to do something else. In general, a commitment of some resources (labor and capital) is also necessary to derive benefits.

Classifying According to Type of Effect

Program evaluation needs to address all the effects, or consequences, of a proposed policy. In addition to the basic distinction between benefits and costs, it is useful to specifically define and classify the range of potential effects.

Real and pecuniary effects. One major type of impact is the distinction between real and pecuniary effects. Real effects are the changes in the actual quantities of goods and services available to the affected parties. In the case of benefits, real effects are additions that in some way aid the final consumers. In the case of costs, they represent the actual value of the resources that have been diverted from alternative uses.

Pecuniary effects result from changes in demand and, hence, from changes in price for various goods and services in the economy. Pecuniary effects are usually regarded as mere

income transfers since increased incomes for some are balanced by increased outlays for others.

Real effects are regarded as the key issue by most economists. At the national level, positive and negative pecuniary effects are usually ignored since they are assumed more or less to offset each other. At the local level, however, pecuniary benefits, even though offset by diffuse national costs, may have a significant effect. Unfortunately, it is not always easy to distinguish between real and pecuniary effects.

Direct and indirect effects. It is also important to distinguish between direct (or primary) and indirect (or secondary) impacts. Direct effects, which can be either benefits or costs, are those that would immediately result once the proposed development project was implemented. Direct benefits represent the value of project goods and services, which is often measured by the willingness of the beneficiary to pay for the project benefits. The value of the resources and services sacrificed to accomplish an investment or program is the direct (opportunity) cost. They are measured by the benefits foregone when a scarce resource is used for one specific purpose rather than for another purpose.

Indirect effects (usually referred to in the economic literature as external spillover costs or benefits) affect third parties and can be beneficial or adverse. In the past, such effects have not been quantified; they have either been ignored or treated lightly. For example, discharge of municipal, industrial, and agricultural waste and effluent into area streams, the effects of which were neither quantified nor well understood, has been a major factor in the deteriorating quality of the region's water resources.

Indirect effects can be classified as either technological or pecuniary. Technological indirect (or external) effects result from interactions among individuals through a physical medium. In the case of water systems, indirect technological effects are often registered as changes in the quantity or quality of water available to third parties. By definition, technological indirect effects are not priced in market exchanges, so some process of imputing values is necessary; this is typically accomplished through shadow pricing.

Pecuniary effects, on the other hand, are uncompensated side effects transmitted through the price system. Backward-linked (or induced) pecuniary effects are those experienced by suppliers of inputs to project beneficiaries. In the case of irrigation, these might be fertilizer, machinery, or fuel suppliers.
Forward-linked (or stemming-from) effects accrue to those who process, store, or transport project outputs.

Economists disagree as to whether indirect pecuniary effects are real—which would require measuring and including them in program appraisals—or merely offsets to indirect costs incurred elsewhere in the economic system. The latter view is typically held in the United States and is currently being applied to cost-recovery studies in Egypt.

Water resources analysts in both the public and private sectors may choose from among a number of dollar-denominated measures to appraise investments. Corporate financial specialists might employ gross revenues, cash flow, net profits, or a number of similar concepts to help them assess the desirability of an investment. In the private sector, profitability is the most appropriate measure. For public water program analysis, monetary measures include gross revenues, value added (payments to primary-factor owners—land, labor, capital, and managements), and net economic benefits (benefits above costs). For the public sector, net benefits, which correspond to profits in the private sector, provide the most rigorous measure of investment desirability and suitability.

Classifying According to Degree of Measurability

Quantitative measurement of positive and negative effects obviously simplifies program appraisal. Unfortunately it is often quite difficult to quantify impacts in the context of water resources planning. One fruitful approach is to consider benefits and costs according to the degree to which they can be measured in monetary terms. The following four categories—free market, market intervention, nonmarket, and nonmonetary—range from the most readily monetized benefits and costs to those which it is impractical to value in monetary terms.

Free market. Market prices exist and the observed prices correctly reflect the values society places on the resources. These are limited to extensively traded commodities whose prices are not influenced by explicit government policies.

Market intervention. Prices can be observed but do not reflect appropriate social values. These include goods and services for which the government intervenes in the marketplace such as the important farm crops of wheat and rice. Examples of inputs include labor or imported capital equipment.

Nonmarket. Market prices do not exist, but the user's willingness to pay can be inferred from one of several recently developed analytic techniques. For example, the quantities of water diverted for irrigation water are typically not priced, but the willingness to pay can be estimated by analyzing farm budgets. In turn, the benefits of improvements in water quality might be estimated in terms of cost savings from the least-cost treatment alternative.

- *Shadow pricing water quantity and quality.* Shadow prices are often employed to estimate the value of specific applications of water that preclude other productive uses. The shadow price reflects the value to others of that fraction of the water used whose use is precluded elsewhere. For example, the diversion of one acre-foot of water to an upstream project may only preclude downstream users from using one half of an acre-foot because much of the water is again available downstream through return flows. If the downstream cost of an acre-foot of water is $1.00, then $.50 (the shadow price) would need to be subtracted from the output value of the upstream project when calculating its net benefits.

Water quality degradation effects should also be included as costs. These can often be estimated as the cost of cleaning up the water so that downstream users can make effective use of it.

- *Environmental effects*. The framework for extending traditional feasibility-analysis procedures to allow for external effects exists as a result of the increasing concern over the past two decades with valuing environmental effects. Quantitative environmental values are used almost routinely at U.S. federal and state levels in evaluating environmental measures. In fact, the U.S. federal government has developed regulatory impact analyses that consider many environmental values in great detail.

  Some of these values could be used appropriately by other countries. In any case, they provide examples of approaches that could be adapted by Missions to address the unique local conditions in each host country.

- *Displacement*. Displacement of people caused by water investments is another indirect effect of increasing concern. It is now generally recognized that these costs entail far more than the values of properties seized by eminent domain. Since the properties of people in their own cultures and milieu are likely to be worth more to them than to those who purchase them, the actual monetary costs of the property and transportation probably understate the negative values of resettlement. Nevertheless, it is possible to quantify the other resettlement values by estimating the varying levels of these negative values.

Nonmonetary. For many impacts, meaningful monetary evaluation is often impractical. Typical examples include maintenance of important ecosystems and preservation of endangered species or archeological treasures. Even in this category, however, guidelines such as the following are available:

- *Ecology*. Ecological effects present perhaps the most complex valuation problems since they are not only difficult to estimate accurately in physical terms, but they are also difficult to value monetarily. However, ecological effects can be described in physical terms and values can be estimated. In fact, over the past decade abundant evidence has been amassed on people's willingness to pay for the preservation of unique vegetative and animal species and other aesthetic values, and this can be used in evaluation.

- *Human health*. Life and health risks can be valued fairly readily when the established dollar value pertains to a statistical life and not to the life of any individual. Expenditures must be limited by the dictates of reasonable prudence. By definition, a well-developed procedure determines the sacrifice, in terms of consumption denied, that people will make to gain an increase in the probability of survival. This determines the prudent level of safety measures or justified expenditure to save a

statistical life. In the West, such procedures have led to statistical values being applied in the range of $2 to $5 million per life. Similar approaches have been developed and are rapidly being refined for valuing morbidity effects.

Effects on free market benefits and costs generally present few measurement problems for economic appraisal. For market intervention and nonmarket situations, some special analytical approaches are necessary to measure and quantify the benefits and costs. In the economic appraisal literature, these approaches—which attempt to replicate the market exchange value that would occur in a hypothetical free market—are usually called shadow pricing. Such nonmarket techniques have been used extensively to value water in streams for uses such as recreation and fishing.

Data Development

The degree of quantification required by the classification system demands large amounts of data and extensive analytical capabilities; naturally, available data and analytical capability vary from country to country. For those host countries in which the amount of data appears inadequate, innovative techniques such as the following are required. The various elements of the proposed intervention can be initially framed using standard USAID feasibility-analysis techniques; each will have a specific set of effects including some that can be readily quantified and some that cannot.

Much of the data can then be collected from available sources. For example, farm budgets essential to valuing such effects as irrigation, flood control, drainage, water-logging, and salt intrusion exist or can be readily created for any country. Most Missions with agricultural programs also have some useful data as do previous USAID project papers, World Bank appraisal reports, and other studies. These can serve as sources of data for hydroelectric plants, sewer and wastewater facilities, and municipal and industrial water supplies, as well as for irrigation. Recent World Bank water resources projects, in particular, have required countries to quantify many of these effects.

After gathering the available data, apply the collective judgments of experienced and knowledgeable professionals to close the data gaps. These experts can estimate the values needed in ranges that reflect the confidence one should place in the estimates to quantify the remaining effects of various choices for decision-making purposes.

The With-Without Principle

The basic purpose of project evaluation is to contrast the situation where the proposed program is in place and operating with the situation that would prevail without the program. When all incremental impacts—positive benefits and negative costs—on the relevant populations have been addressed, this process reflects the with-without principle.

Proper with-without evaluation is not accomplished by merely contrasting conditions before and after the project since many changes in the affected area would have occurred without the project. Such effects need to be identified and eliminated from the project justification.

Area Covered by the Analysis

A project may create benefits, costs, and other impacts on a local area or a larger region; they may even extend nationwide or worldwide. For reasons of simplicity or of political jurisdiction, decision makers limit their recognition of benefits and costs to a specific area. The geographical area or political subdivision within which the decision maker decides to quantify impacts also defines the area for analysis. In order for an appraisal to be valid, all relevant impacts must be addressed. In particular, all significant external costs need to be scrupulously included in the analysis.

Off-Stream Versus In-Stream Benefits of Water Use

Water development is most often defined as capturing and transporting water from natural watercourses to serve some human activity elsewhere: agricultural irrigation, industrial and manufacturing uses, and household consumption and sanitation are prime examples of off-stream usage. Increasingly, however, water is valuable while still in the stream for such purposes as electricity generation, dilution to improve water quality, preservation of wildlife and fishery habitats, and water-based outdoor recreation.

Off-stream uses are consumptive, especially irrigation and water for household and public uses. By contrast, in-stream uses are most often nonconsumptive, meaning that water is not lost to evaporation or transpiration during its usage. Many categories of in-stream use present special difficulties for estimating value both because of the nonconsumptive character of the benefits and because consumers do not compete for their use.

Applying Feasibility Testing

An investment represents the commitment of resources or inputs that have alternative productive uses to a project from which the returns accrue over some future planning period. Applying a feasibility test to water resources projects or programs provides a specific example of the problems encountered when evaluating public programs.

Net Benefit Principle

The general strategy of evaluation is defined by one fundamental principle, supplemented by certain concepts and definitions that should be applied consistently across proposed programs. The basic axiom is this: in any situation requiring choice, select the policy alternative that produces the greatest net benefit. The net benefit principle, as applied in economic evaluation, is based on Paretian welfare economics which is, in turn, rooted in the Utilitarian principle of selecting the greatest good for the greatest number. An investment

is thus said to be economically feasible if its anticipated benefits (B) exceed its anticipated costs (C): a B/C ratio greater than one. The degree of feasibility required can be obtained by setting a cutoff B/C ratio greater than one.

A crucial issue in feasibility appraisal is how to make benefit and cost streams commensurate in time. Typically, benefits occur at different times than costs, with the benefits accruing late in the project's life and costs concentrated in the early years. Benefits accruing early are valued more highly than those received later. Some form of weighting system is needed to make streams of benefits and costs commensurate over the project's life. This task is achieved by the use of a specially defined interest rate, usually called the discount rate; it is selected to reflect the public's assumed time preference between present and future benefits and costs. The term economists use for the process of applying the weighting system is discounting to present value.

Feasibility Formula for Water Resources

A feasibility formula for water resources analysis rests on the axiom of choice just introduced and on the concepts of scarcity and interdependency discussed earlier. It requires that scarcity of capital and water and the prevalence of interdependencies inherent in water management be fully taken into account.

If all benefit and cost expressions are assumed to be in discounted present value terms, employing a consistent planning horizon, interest rate, and price level, the full conditions for economic feasibility of a water project or plan can be expressed as follows: a project is feasible if the willingness to pay of the direct beneficiaries, plus in-direct benefits to off-stream and in-stream water users as well as any pecuniary external benefits to non-water-users exceeds construction costs plus foregone direct benefits plus foregone indirect benefits (opportunity costs) imposed on off-stream and in-stream users as well as foregone external benefits to non-water-users and operation and maintenance costs.

The feasibility test therefore addresses these issues:

- The scarcity of capital is measured by the cutoff rate of interest used to discount benefit and cost streams to present value:
- The value of water in alternative uses is measured by the foregone-benefits terms.
- The interdependencies, both the technological and pecuniary externalities, are reflected in the foregone indirect user and nonuser benefits expressions.

Measuring Effects in Monetary Terms

The basic principle of measuring the real economic impact of water policies, projects, and programs is the willingness of those receiving benefits to pay for them. To be incorporated into economic analysis, beneficial and adverse effects must be expressed in monetary terms. Since project inputs and outputs are generally expressed in physical terms such as tons, kilowatt hours, and cubic meters, these physical measures must be transformed into commensurate value terms by applying the appropriate prices to each input and product.

Whether the prices used in the evaluation are market prices or shadow prices, they must represent willingness to pay for a particular good or service by consumers, producers, or units of government. This approach assumes that individual preferences should form the basis for public policy. If so, individual valuations as reflected by willingness to pay would constitute the measure of value for policy analysis. Willingness to pay is measured by the individual's best offer to obtain a particular good or service.

Intermediate or producer goods. Incremental profitability added by an intermediate good to the business enterprise is the usual basis for valuing intermediate goods. The following approaches are commonly used to estimated this value:

- *Change in net income.* This method equates willingness to pay with the increment in profit attributable to an increment in water supply. Budgets are developed that forecast the project's profit and subtract forecasted profit without the investment. The increment between the profits with the project compared to those expected without the investment is defined as the willingness to pay for the investment.

- *Alternative cost approach.* This technique can be applied in a number of cases where direct willingness to pay is difficult to estimate. Hydroelectric power valuation is its most common application in water resources planning, but the method is also applied to inland waterways transportation and industrial water use. Its name refers to the cost of the alternative method that appears most feasible for supplying project services or goods, but it is applicable only if the alternative is itself economically feasible. In other words, the services do not cost more than the individual is willing to pay.

Consumer goods. In the industrialized countries, techniques for valuing water as a final consumptive good have advanced rapidly during the past decade. The applicability of these techniques to developing nations, however, has not been frequently tested.

Willingness to pay for residential water supplies can sometimes be directly observed. In other cases, data on prices and quantities consumed can be subjected to statistical analysis, or regression analysis can be employed to derive the demand function for water in the sample communities. Residential water valuation is often achieved by the alternative cost test, an approach more likely to succeed in developing nations.

Assigning values for water treated as a public good has presented much more of a challenge for water planners. Such assessments are usually associated with water quality improvement, recreation, and aesthetic enjoyment of water in natural surroundings. Two lines of approach have been attempted, both based on user surveys. The first collects and statistically analyzes data on actual user expenditures and then mathematically derives a willingness-to-pay function from these data.

The other approach asks users directly about their willingness to pay for incremental levels of environmental services for hypothetical proposed policy interventions. This method is called the contingent valuation method (CVM) because it seeks users' valuations on contingent or hypothetical water supply or environmental supply situations. Although the method must overcome some skepticism regarding the reliability of interview responses, careful application of the technique in industrialized countries has yielded valuable information for planning purposes. Some investigation of the applicability of CVM to developing countries is warranted.

Conclusion

The case for assisting governments of cooperating countries in Asia region to improve analysis of water use is compelling. Difficulties associated with doing meaningful and comprehensive benefit-cost studies of water use are greatly outweighed by the critical need to establish economically rational priorities for water resource development. Scarcity of water and capital for water resource development as well as issues arising from the transboundary interdependencies inherent in water resources, all make an argument for USAID to use its expertise and resources to help countries in the region maximize the use of their scarce water resources.

APPENDIX C

USAID WATER SECTOR PROJECTS IN ASIA (1952-1993)

USAID WATER SECTOR PROJECTS IN ASIA

APPENDIX C

(1952 - 1993) Source: A.I.D. Projects Database

COUNTRY	PROJECT	FISCAL YEAR	FUNDING $(000)	FOCUS	ASSISTANCE
Afghanistan	National Agriculture Development - Hydrology [306000204]	1952 -1979	11,566	Hydrology, Water Management	Technical Assistance, Training
	Helmand-Arghandab Valley Development [306009001]	1954 -1977	20,185	Water Supply, Irrigation, Conservation	Technical Assistance, Training, Construction
	Special Development Activities - Water Supply [306010301]	1965 - 1975	32	Groundwater, Water Supply	Technical Assistance, Commodities, Construction
	Kajakai Hydroelectric Plant [3060101]	1968 - 1978	17,000	Hydropower	Construction, Training
	HAVA/HACU Equipment [3060102]	1968 - 1976	38,870	Irrigation	Technical Assistance, Training

COUNTRY	PROJECT	FISCAL YEAR	FUNDING $(000)	FOCUS	ASSISTANCE
	Rural Development [3060131]	1974 - 1980	4,362	Irrigation	Construction, Training
	Helmand Valley Soil and Water Survey [3060145]	1975 - 1977	164	Water Resources	Technical Assistance, Training
	Central Helmand Valley Drainage [3060145]	1975 - 1980	1,705	Irrigation, Drainage	Technical Assistance, Construction
	Central Helmand Valley Drainage [3060149]	1977 - 1981	20,004	Water Supply	Technical Assistance, Construction, Training
	Integrated Wheat Development Phase II [3060163]	1977 - 1979	4,378	Irrigation	Technical Assistance
	Agricultural Sector Support [3060204]	1987 - 1992	60,000	Irrigation	Construction
			TOTAL		
			178,266		

COUNTRY	PROJECT	FISCAL YEAR	FUNDING .$(000)	FOCUS	ASSISTANCE
Bangladesh	Agricultural Inputs II [3880015]	1975 - 1978	29,748	Irrigation	Technical Assistance
	Private Voluntary Organizations [3880010]	1975 - 1982	2,286	Water Supply	Technical Assistance
	Project Development Grant I [3880031]	1976 - 1981	3,000	Water Resources	Technical Assistance
	Small Scale Irrigation I [3880019]	1976 - 1982	14,000	Irrigation	Commodities
	Food For Work I [3880017]	1976 - 1984	2,373	Irrigation, Drainage	Construction
	Karnaphuli Third Unit [3880018]	1976-1986	10,200	Hydropower	Construction
	Food For Work II [3880052]	1980 - 1986	3,175	Water Management	Technical Assistance
	PVO Co-Financing II [388004508]	1980 - 1987	6,061	Irrigation, Water Supply	Technical Assistance

COUNTRY	PROJECT	FISCAL YEAR	FUNDING .$(000)	FOCUS	ASSISTANCE
	Rural Electrification II [3880054]	1981 - 1989	61,287	Irrigation	Technical Assistance, Training, Construction, Commodities
	Agricultural Research Phase [3880051]	1981 - 1993	48,213	Water Resources	Technical Assistance, Training
			TOTAL . 180,343		
India	Beas Dam Project [3860233]	1966 - 1974	14, 438	Hydroelectric Power, Irrigation, Water Supply & Management, Floods	Construction
	Soil & Water Management (General) [386036801]	1966 - 1975	4,640	Water Supply, Irrigation, Hydrology	Technical Assistance, Training
	Rural Electrification [3860462]	1979 - 1987	58,000	Irrigation	Technical Assistance, Commodities
	Guyurat Medium Irrigation [3860464]	1978 - 1984	30,000	Irrigation	Technical Assistance, Construction

COUNTRY	PROJECT	FISCAL YEAR	FUNDING .$(000)	FOCUS	ASSISTANCE
	Agricultural Development Credit [3860466]	1980 - 1982	100,000	Groundwater, Irrigation	Technical Assistance
	Rajasthan Medium Irrigation [3860467]	1980 - 1986	36,500	Irrigation, Water Supply	Technical Assistance, Training, Construction
	Maharashtra Irrigation Technology & Management [3860481]	1982 - 1989	47,000	Irrigation	Technical Assistance, Construction, Training
	Madhya Pradesh Minor Irrigation [3860483]	1984 - 1992	51,900	Irrigation, Water Supply	Technical Assistance, Training, Construction
	Irrigation Management & Training [3860484]	1984 - 1990	58,000	Irrigation	Technical Assistance, Training
	Hill Areas- Land & Water Development [3860489]	1984 - 1992	54,000	Water User Associations, Watersheds, Irrigation	Technical Assistance, Construction, Training

COUNTRY	PROJECT	FISCAL YEAR	FUNDING .$(000)	FOCUS	ASSISTANCE
	Maharashtra Minor Irrigation [3860490]	1984 - 1992	50,000	Irrigation	Technical Assistance, Training, Construction
			TOTAL 504478		
Indonesia	Project Development [4970224]	1971 - 1977	4,165	Water Supply	Technical Assistance
	Rural Works [4970240]	1975 - 1980	6,800	Irrigation	Construction
	Seduhara Irrigation & Land Level [4970242]	1975 - 1982	23,700	Irrigation	Technical Assistance, Training
	Citanduy Basin Development [4970245]	1976 - 1984	12,500	Water User Association, Irrigation, Floods	Technical Assistance, Construction, Training
	Indonesia Suraharta Potable Water Project [4970262]	1977 - 1983	6,800	Water Supply, Hydrological Surveys	Technical Assistance, Construction
	Sederhana Irrigation & Land Development II [4970252]	1978 - 1985	36,300	Irrigation	Technical Assistance, Construction, Training

COUNTRY	PROJECT	FISCAL YEAR	FUNDING $(000)	FOCUS	ASSISTANCE
	Rural Works II [4970285]	1979-1985	28,000	Irrigation	Training, Construction
	River Basin Development II [4970281]	1980-1988	27,000	Irrigation, Watersheds	Technical Assistance, Training
	Luwu Area & Transmigration Development [4970244]	1982 - 1983	18,700	Irrigation	Construction
	Upland Agriculture & Conservation Project [4970311]	1984 - 1993	18,900	Watersheds, Water Conservation	Technical Assistance, Training
	Small Scale Irrigation Management [4970347]	1985 - 1993	50,000	Water Supply & Management, Irrigation, Water User Associations	Technical Assistance, Construction, Training
	Private Participation in Urban Services (PURSE) [4970373]	1991 - 1997	2,000	Water Supply & Treatment, Wastewater	Technical Assistance, Training
			TOTAL 234,865		

COUNTRY	PROJECT	FISCAL YEAR	FUNDING .$(000)	FOCUS	ASSISTANCE
Nepal	Food Grain Technology [3670054]	1957 - 1978	4,336	Irrigation	Technical Assistance
	Groundwater Investigation [3670207]	1969 - 1977	1,030	Water Supply, Groundwater	Technical Assistance, Training
	Resource Conservation & Utilization [3670132]	1980 - 1989	27,498	Water Conservation	Technical Assistance
	Rural Area Development - Rapti Zone [3670129]	1980 - 1988	26,700	Water Conservation	Technical Assistance, Training
	Community Based Rural Health Development Program In Nepal [367014402]	1982 - 1988	4,150	Water Supply	Technical Assistance, Training
	Irrigation Management Project [3670153]	1985 - 1994	10,000	Irrigation, Water User Associations, Water Supply	Technical Assistance, Training

COUNTRY	PROJECT	FISCAL YEAR	FUNDING .$(000)	FOCUS	ASSISTANCE
	Rapti Development Project [3670155]	1987 - 1995	18,800	Irrigation	Technical Assistance
			TOTAL 92,514		
Pacific Islands	Rural Water Supply & Sanitation [8790269]	1980 - 1985	600	Oceania, Water Supply & Sanitation	Construction
	Rural Water Supply & Sanitation [4980269]	1982 - 1983	200	Oceania, Water Conservation	Construction
	Small Scale Rural Water Supply & Sanitation Program [879000602]	1985 - 1989	2,800	Sanitation, Water Supply, Oceania	Construction
			TOTAL 3,600		

COUNTRY	PROJECT	FISCAL YEAR	FUNDING .$(000)	FOCUS	ASSISTANCE
Pakistan	Consulting Services & Urban Water Supplies [3910174]	1963 - 1977	2,924	Water Supply	Technical Assistance, Construction
	Karanfuli Hydro-electric Unit III [3910223]	1964-1974	4,850	Hydropower	Construction
	Pakistan-Food for Peace [904031006]	1973 - 1980	1,887	Irrigation	Technical Assistance
	Water Management [3910401]	1974 - 1978	1,728	Water Supply, Irrigation	Technical Assistance
	On-Farm Water Management II [3910413]	1976 - 1987	27,000	Irrigation, Water Supply	Training
	Water Management Research [3910447]	1979 - 1980	900	On-Farm Water Management & Irrigation, Irrigation System Construction	Technical Assistance, Construction, Training

COUNTRY	PROJECT	FISCAL YEAR	FUNDING $(000)	FOCUS	ASSISTANCE
	Irrigation System Management [3910467]	1983 - 1993	205,000	Irrigation, Water Supply, Water User Associations	Technical Assistance, Commodities
	Northwest Frontier Area Development [3910485]	1983 - 1993	63,000	Irrigation	Technical Assistance, Training, Construction
	Baluchistan Area Development [3910479]	1984 - 1990	45,000	Water Supply, Irrigation, Groundwater	Technical Assistance, Training, Construction
	Agricultural Commodities & Equipment [3910468]		565,000	Irrigation	Commodities
	Rural Clean Water [3910406]		21,500	Water Supply, Water-related Disease, Groundwater	Technical Assistance, Training, Construction, Commodities
			TOTAL 938,789		
Philippines	Philippines-Water Resource Management [4920233]	1968 - 1976	646	Irrigation, Water Supply	Technical Assistance

COUNTRY	PROJECT	FISCAL YEAR	FUNDING .$(000)	FOCUS	ASSISTANCE
	Bicol River Basin Development [4920260]	1973 - 1979	2,042	Water Supply	Technical Assistance, Training, Commodities
	Second Feasability Studies Loan [4920264]	1973 - 1976	1,913	Water Resources	Technical Assistance
	Philippines Provincial Water [4920263]	1974 - 1980	14,750	Water Resources	Technical Assistance
	Libmanan Cabusas Integrated Area Development [4920275]	1975 - 1982	3,500	Irrigation	Technical Assistance, Construction, Commodities
	Small Scale Irrigation [490274]	1975 - 1981	7,569	Irrigation	Technical Assistance, Training, Commodities
	Disaster Rehabilitation Didang [4920316]	1976 - 1980	4,991	Water Supply, Floods, Irrigation	Technical Assistance, Commodities
	Local Water Development I [4920309]	1976 - 1983	21,500	Water Supply	Technical Assistance, Training, Construction, Commodities

COUNTRY	PROJECT	FISCAL YEAR	FUNDING $(000)	FOCUS	ASSISTANCE
	Barangay Water [4920291]	1978 - 1982	6,184	Potable Water	Technical Assistance, Training, Construction
	Bicol Integrated Development II [4920310]	1978 - 1985	5,141	Water Supply, Groundwater	Technical Assistance, Training, Construction, Commodities
	Panay Unified Services for Health (PUSH) [4920312]	1978 - 1985	5,950	Water Supply, Groundwater	Technical Assistance, Training, Construction, Commodities
	Small Farmer System [4920301]	1978 - 1981	11,000	Water Management, Irrigation	Technical Assistance, Training
	Agricultural Research II [4920286]	1979 - 1985	10,000	Water Management	Technical Assistance, Training, Commodities
	ASEAN Watershed Project [498025803]	1979 - 1995	16,546	Watersheds, Water Supply	Technical Assistance, Training, Commodities

COUNTRY	PROJECT	FISCAL YEAR	FUNDING $(000)	FOCUS	ASSISTANCE
	Bicol Integrated Health Nutrition & Population Project [4920319]	1979 - 1984	2,500	Water Supply	Technical Assistance
	Barangay Water Project II [4920333]	1980 - 1987	31,713	Water Supply	Training, Construction
	Bicol Integrated Area Development III [4920289]	1980 - 1987	6,843	Water Supply, Irrigation	Technical Assistance, Construction, Commodities
	Elementary School Construction [4920342]	1980 - 1983	18,000	Potable Water	Technical Assistance
	Clark Access & Feeder Roads [4920348]	1981 - 1987	8,000	Water Conservation	Technical Assistance
	Municipal Development Fund [4920361]	1981 - 1990	70,000	Water Supply	Technical Assistance, Training, Construction, Commodities

COUNTRY	PROJECT	FISCAL YEAR	FUNDING $(000)	FOCUS	ASSISTANCE
	Small Farmer Systems II [4920334]	1981 - 1987	9,914	Irrigation	Training, Commodities
	Energy Cooperation in Development [4980272]	1982 - 1987	1,000	Water Supply	Technical Assistance
	Extensive Small Scale Equipment Irrigation [4980265]	1982 - 1986	4,350	Irrigation	Technical Assistance, Training
	Rainfed Resources Development [4920336]	1982 - 1991	44,200	Marine Resources & Fisheries, Water Management	Technical Assistance, Training
	Rural Energy Development [4920375]	1982 - 1990	26,000	Irrigation	Technical Assistance, Training, Commodities
	Accelerated Agricultural Production [4920385]	1986 - 1991	30,000	Irrigation, Water User Associations	Technical Assistance, Training

COUNTRY	PROJECT	FISCAL YEAR	FUNDING .$(000)	FOCUS	ASSISTANCE
	Rural Water Supply & Sanitation [4920401]	1986 - 1990	18,750	Water Supply, Water User Associations	Technical Assistance, Training, Commodities
			TOTAL 383,002		
Sri Lanka	Mahaweli Ganga Irrigation [3830042]	1977 - 1982	6,000	Irrigation	Construction, Commodities
	Market Town Water Supply [3830063]	1980 - 1984	8,000	Water Supply & Treatment	Technical Assistance, Training, Construction, Commodities
	Mahaweli Basin Development Phase II [3830073]	1981 - 1991	110,000	Irrigation, Water Supply	Technical Assistance, Training, Commodities, Construction
	Mahaweli Sector Support [3830078]	1981 - 1985	50,000	Irrigation	Technical Assistance
	Water Supply & Sanitation Sector [3830088]	1984 - 1990	13,505	Water Supply	Technical Assistance, Training, Construction, Commodities

COUNTRY	PROJECT	FISCAL YEAR	FUNDING .$(000)	FOCUS	ASSISTANCE
	Irrigation Systems Management [3830080]	1986 - 1992	18,600	Irrigation, Water Supply, Water User Associations	Technical Assistance, Training, Commodities, Construction
	Mahaweli Agriculture & Rural Development [3830086]	1987 - 1995	14,000	Water Supply, Irrigation, Water User Associations	Technical Assistance
	Mahaweli Downstream Support [3830103]	1987 - 1992	17,976	Irrigation, Water User Associations	Technical Assistance, Construction, Commodities
	Rehabilitation Assistance [3830107]	1988 - 1992	50,000	Irrigation	Construction
	Mahaweli Basin Development [3830117]	1991 - 1995	15,000	Irrigation	Technical Assistance, Construction
			TOTAL 288,081		
Thailand	Mekong Basin Development [4980220]	1959 - 1978	6,152	Water-related Disease	Technical Assistance

COUNTRY	PROJECT	FISCAL YEAR	FUNDING .$(000)	FOCUS	ASSISTANCE
	Rural Health [4930179]	1960 - 1976	6,168	Potable Water	Technical Assistance
	Agricultural Development-Soil & Water [493018005]	1964 - 1979	25,185	Water Conservation	Technical Assistance, Training
	Lam Lam Oon On-Farm Development [4930216]	1967 - 1976	3,306	Irrigation	Technical Assistance
	Labor Intensive Water Development [4930206]	1968 - 1974	1,243	Water Supply	Training, Construction
	Navigation Improvement [4980206]	1971 - 1975	217	Rivers, Inland Water Transportation	Technical Assistance, Construction
	Lam Lam Oon On-Farm Development [493027201]	1977 - 1985	4,600	Irrigation	Technical Assistance, Training
	Energy Cooperation in Development [4980272]	1982 - 1987	1,000	Water Supply	Technical Assistance

COUNTRY	PROJECT	FISCAL YEAR	FUNDING .$(000)	FOCUS	ASSISTANCE
	Extensive Small Scale Equipment Irrigation [4980265]	1982 - 1986	4,350	Irrigation	Technical Assistance, Training
	Provincial Waterworks Authority Institutional [4930331]	1984 - 1989	5,700	Water Supply & Treatment	Technical Assistance, Training, Commodities
			TOTAL 57,921		
Asia Regional	Mekong Basin Development [4980220]	1959 - 1978	6,152	Water-related Disease, Irrigation	Technical Assistance
	Navigation Improvement [4980206]	1971 - 1975	217	Rivers, Inland Water Transports	Technical Assistance, Construction
	ASEAN Watershed Project [498025803]	1979 - 1995	16,546	Watersheds, Water Supply	Technical Assistance, Training, Commodities
	Extensive Small Scale Equipment Irrigation [4980265]	1982 - 1986	4,350	Irrigation	Technical Assistance, Training

COUNTRY	PROJECT	FISCAL YEAR	FUNDING .$(000)	FOCUS	ASSISTANCE
	Rural Water Supply & Sanitation [4980269]	1982 - 1983	200	Oceania, Water Conservation, Supply, & Management	Technical Assistance, Training, Construction
	ISPAN [3980289]	1987 - 1994	20,100	Water Resources, Irrigation, Flood Management, Water Quality	Technical Assistance Training
			TOTAL 47,565		
			GRAND TOTAL 2,909,424		

APPENDIX D

WATER TECHNOLOGIES AVAILABLE FROM THE UNITED STATES

Appendix D
WATER TECHNOLOGIES AVAILABLE FROM THE UNITED STATES

The following lists of technologies are those in which the United States has experience that places it in a potentially competitive situation. US economic competitiveness, which varies depending on local conditions and the extent of any US marketing efforts, was not considered in preparing the lists. Both sophisticated and simpler technologies were included without any prejudgement of sustainability under developing country conditions.

List A (Potential Water Assistance Technologies) includes technologies the input costs of which are likely to be small in relation to total investments in the projects of which they might form part; that is, technologies which could appropriately be drawn upon by USAID in providing international assistance with a pronounced leverage through multilateral donors.

Other technologies, including heavy equipment, are included in List B (Other Water Technologies). While the USA has potential comparative advantage in the listed technologies, other industrialized countries have developed high quality technologies which compete with ours. Consequently, actual trade development is dependent on marketing and aggressive sales campaigns. Some developing countries also manufacture equipment. Here, the US advantage is that of producing equipment or material of superior quality or having a wider range of attributes, for example, high pressure pipe, large volume or high efficiency pump units or corrosion resistant equipment for special applications. In all cases, introduction of US concepts, skills and contacts by USAID at the stage of project development and initiation increases the opportunities for subsequent trade in US-based technologies. In particular, US organizations and individuals have provided, and can continue to provide under USAID sponsorship, intellectual leadership for many water-related "software" applications that can contribute both to sustainable system development in host countries and to US trade opportunities.

The following lists are not exhaustive. They have been prepared from listings made by professional practitioners in various aspects of the water sector but are not based on specific research.

Technologies are constantly changing. Following are some actions that the Agency could take to stay abreast of such changes: (a) assemble a small group of experts to supplement their knowledge with a limited industrial survey of technologies, (b) collate lists prepared by selected experts in various parts of the water sector based on their own knowledge, as was done for this appendix, (c) maintain contacts with relevant professional associations and industry groups, scan technical journals, and possibly attend technical conferences (such organizations and journals could include the American Water Works Association, the Water Environment Federation, the American Society of Agricultural Engineers, the U.S. Committee on Irrigation and Drainage, HazMat World, Waste Tech News, Pollution

Control, Chemical Engineering, Environment Today, and Environmental Business Journal), or (d) commission surveys by commercial market research firms; this would probably be the most thorough approach but it would be expensive.

LIST A - POTENTIAL WATER ASSISTANCE TECHNOLOGIES

Environmental Protection

Technical advisory services in relation to:

- Computer applications
  - Geographical information systems
  - Data management
  - Decision-support systems
- Data needs assessment and collection methods
- Emissions impact estimation/evaluation
- Environmental analysis
  - Impact assessment procedures
  - Impact assessments
- Environmental sciences
  - Air quality and emissions affecting water (acid rain, CO_2, SO_2, particulates)
  - Aquatic ecosystems
  - Environmental monitoring
  - Forestry and land management, land reclamation
  - Fisheries protection
  - Terrestrial ecology
  - Wetlands management
  - Water quality
- Fish passage engineering
- Habitat improvement
- Impacts of agricultural practices on nonpoint sources of pollution
- Risk assessment and risk management
- Standards, analytical procedures, and weights and measures
- Technology transfer and training
- Treatment for removal of volatile organic compounds
- Permitting and enforcement procedures

Equipment:

- Automated sampling equipment
- Computer equipment
- Water quality laboratory equipment

Industrial and Hazardous Wastes

Technical advisory services in relation to:

Computer applications
- Facility control systems
- Supervisory control and data acquisition systems

Flow measurement and sampling
Groundwater contaminant monitoring
Groundwater protection barriers
Industrial wastewater treatment and pre-treatment
Low-cost and no-cost waste minimization and recovery
Process and raw material changes to minimize waste impacts
Process evaluation and selection for large industrial wastewater treatment to include
Site remediation processes
- Soil vapor extraction
- Soil washing
- Bioremediation
- Selenium removal
- Volatile organic compounds and odor issues

Technology transfer

Equipment:

Computer equipment
Water quality laboratory equipment

Irrigation and Land Drainage

Technical advisory services in relation to:

Automated weather stations
Computer applications
- Canal system analysis and management software
- Furrow irrigation system models
- Geographical information systems
- Hydrological and groundwater system modelling
- Irrigation scheduling programs
- Irrigation water application system design software
- Maintenance scheduling and control
- Modelling of irrigation and drainage systems
- Supervisory control and data acquisition systems
- System and facility operations support systems

Contract documents
Dam design
Operation and maintenance

Planning and design of irrigation water application systems (drip/trickle, sprinkler, furrow, surge, graded border, level border)
Planning and design of land drainage systems
Remote sensing data acquisition systems (e.g. re crop changes, waterlogging, salinity)
Technical specifications
Water conservation

Equipment:
Computer equipment
Soil moisture sensors
Transportable flow measurement equipment

Potable Water Supply

Technical advisory services in relation to:
Automated systems for operation of treatment, storage and supply/transmission
Appropriate technologies for drinking water
Bid evaluations
Compact treatment designs using innovative processes
Computer applications
- Construction management systems
- Facility operations support systems
- Geographical information systems for distribution system operations
- Operations management and accounting systems
- Supervisory control and data acquisition systems

Contract documents
Corrosion control
Direct filtration
Emergency action plans
Facility planning and design
Facility startup
Fast-track design
Feasibility studies
Filter technology
Granular activated carbon filtration/adsorption
Groundwater modeling
Leak detection and reduction
Operations planning
Ozonation and other alternatives to chlorination
Prefeasibility studies
Preliminary and final design
Program management and construction management
Rehabilitation engineering
Risk assessment and risk management

Technical specifications
Technology transfer and training
Treatment plant upgrading
Value engineering
Water metering
Water treatment process assessment and application
- Biologically activated carbon filtration
- Membrane filtration

Equipment:
Computer equipment
Leak detection equipment
Transportable flow measurement equipment
Treatment plants for pilot and emergency use
Water quality laboratory equipment

Sewerage and Sanitation

Technical advisory services in relation to:
Appropriate technologies for sanitation and low-cost sewerage
Assessment of volatile organic compound releases from treatment facilities
Bid evaluations
Combined sewer overflow abatement
Compact treatment designs using innovative processes
Computer applications
- Construction management systems
- Facility operations support systems
- Geographical information systems for infrastructure operations
- Supervisory control and data acquisition systems

Contract documents
Energy audits
Facility planning and design
Facility startup
Fast-track design
Feasibility studies
Flow measurement and sampling needs and methods
Oceanography and marine disposal assessment
Operations planning
Prefeasibility studies
Preliminary and final design
Program management and construction management
Residuals management
Wastewater treatment/reclamation
Technical specifications
Technology transfer and training

Static pile and windrow composting of sludge
Value engineering

Equipment:
Computer equipment
Flow measurement equipment
Water quality laboratory equipment

Water Resources and Abstraction

Technical advisory services in relation to:
Computer applications
- Construction management systems
- Geographical information systems
- Groundwater modelling
  - Hydraulic modelling
  - Salt water intrusion modelling
  - Simulations and system modelling
  - Supervisory control and data acquisition systems
  - System and facility operations support systems

Construction management
Dam planning, assessment and design
Dam safety procedures and inspections
Data acquisition
- Photonics
- Satellite Remote Sensing
- Video Imaging

Energy audits
Forecasting:
- Flood forecasting and runoff analysis
- Flood warning systems
- Hydrology
- Snowpack monitoring, runoff, and water availability
- Weather tracking and forecasting

Irrigation water application system analysis and design
Geographic positioning system (and emergency location) applications
Pumped storage
Rainwater harvesting
Regulations, guidelines, permitting, licensing
Rehabilitation engineering
Resource management
River basin management
River basin planning
Techno-economic evaluation and analysis

Technology transfer and training
Wastewater reuse
- Groundwater recharge
- Reclamation for high quality uses
- Wastewater treatment for agricultural reuse

Water sector planning
Watershed management

Equipment:
Computer equipment
Meteorological equipment
Transportable flow measurement equipment
Water quality laboratory equipment
Well monitoring equipment

Technical advisory services in relation to:
Bid evaluations
Construction management services
Contract documents
Dam safety inspections
Emergency action plans
Engineering/technical studies
Environmental assessment/mitigation
Equipment retrofitting
Equipment/services procurement
Operation and maintenance manuals
Operations planning
Performance testing
Plant modernization
Power sales agreements
Pre/feasibility studies
Preliminary and final design
Project rehabilitation
Reconnaissance-level planning
Shop inspections
Technical specifications
Tendering assistance

Equipment:
Communications equipment
Computer hardware and software
Control and protection systems
Electric equipment, auxiliaries
Emergency response notification equipment

Epoxies/polymer repair materials
Fish guidance systems
Geotechnical instrumentation
Index testing equipment
Maintenance/materials management software
Measuring instruments
Microcomputers
Microprocessors
Monitoring equipment, civil
Monitoring equipment, electro-mechanical
Programmable logic controllers
Supervisory control and data acquisition systems
Warning/restraint equipment

LIST B - OTHER WATER TECHNOLOGIES (HAVING INTERNATIONAL TRADE POTENTIAL)

Environmental Protection

Electronic sensors for identification of contaminants in water
Field measurements regarding the adverse environmental impacts of agricultural practices
Satellite-based monitoring of industrial wastewater-producing operations
Water quality instrumentation and on-line sensors

Industrial and Hazardous Wastes

Computer-aided engineering and operations:
- Three-dimensional design modeling and simulation
- Connectivity and communications

Industrial wastewater treatment equipment:
- Anion exchange resins for organic chemical scavenging
- Biological treatment of chemically contaminated wastewaters
- Carbon adsorption equipment for removal of organic and inorganic contaminants from water
- Ceramic membrane technology for ultra-high purification
- Crystallization technology for wastewaters with inorganic salts
- Electrodialysis reversal technology for water purification
- Ion exchange systems for removal of metal contaminants from wastewater
- Macroreticular anion exchange resins for removing colloids and metal oxides
- Magnetic water conditioning technology for lime scale and other problems
- Oil-water separation equipment
- Photocatalytic (titanium dioxide/ultraviolet light/peroxide/ultrasound) treatment of wastewater
- Reverse osmosis systems for contaminant removal
- Solvent recovery systems for water contaminated with organic solvents
- Ultrafiltration, microfiltration, and nanofiltration technologies for contaminant removal
- Wet air oxidation of wastewaters contaminated with toxic organic compounds

Monitoring and analytical instrumentation for cleanup of contaminated aquifers

Specialized site cleanup technologies:
- Bioremediation
- Slurry trench technology
- Soil vapor extraction
- Soil washing

Waste reduction processes, equipment and materials:
- Brine concentrator equipment that produces pure water
- Integrated zero discharge systems using multiple technologies
- Non-hazardous additives for cooling and boiler waters to inhibit scaling, corrosion and biological fouling

Non-toxic, biodegradable, aqueous solvents and cleaners as alternatives to traditional synthetic organic chemicals

Irrigation and Land Drainage

Cablegation irrigation hardware
Control systems (computers, telemetry, valves) for remote operation of irrigation facilities
Drip irrigation technologies:
- Automatic control systems
- Buried drip systems
- Emitters
- Filters
- Low-head bubbler irrigation equipment
- Micro-jet irrigation

Equipment for injecting fertilizers and chemical into pressurized irrigation systems
Laser-controlled equipment for land leveling
Pumps and motors for irrigation applications
Sprinkler irrigation equipment:
- Center pivot systems
- Linear move systems

Surge irrigation equipment (timers, pipes and valves)
Training videos

Potable Water Supply

Chlorination equipment
Computer-aided engineering and operations:
- Connectivity and communications
- Expert systems
- Three-dimensional design modeling and simulation

Electrodialysis membranes and systems
Electronic mass flowmeters
Filter bottoms
Ozone treatment equipment, controls, process design
Reverse osmosis and ultrafiltration membranes and systems
System and treatment plant control hardware and software
Training videos
Ultra-violet treatment equipment, controls, process design

Sewerage and Sanitation

Aeration systems (incl. aerators, compressors, diffusers)
Chemical scrubbers and other means of odor control
Computer-aided engineering and operations:

- Connectivity and communications
- Expert systems
- Three-dimensional design modeling and simulation

Electronic mass flowmeters
High efficiency pumps
Sludge reduction and/or destruction processes and equipment:
- Belt filter presses
- Deep well wet oxidation
- Electrostatic precipitators for sludge incinerators
- Fluid bed incineration
- Gravity belt thickeners
- High thermal efficiency volatile organic compound and odor control incinerators
- In-vessel composting
- NOx control air pollution control processes for sludge incinerators
- Supercritical oxidation
- Solids thickening and dewatering centrifuge
- Wet oxidation

Specialty chemicals (incl. polymers for sludge conditioning and dewatering)
System and treatment plant control software
Training videos
Wastewater treatment processes and equipment:
- Biological nitrogen and phosphorus removal
- Denitrifying filters
- Grit removal systems
- Sludge collection equipment
- Wastewater mechanical screens

Wetlands treatment (natural and artificial)

Water Resources and Abstraction

Computer hardware
Communications equipment:
- Fiber optics
- Meteor burst telemetry

Data acquisition:
- Satellite-based searches for water resources
- Satellite-based evaluations of ground surface contours

Geotextiles
Training videos

Hydroelectric Power Generation

- Actuators
- Build, operate and transfer services

Bus, busbars and busducts
Cleaning equipment
Coatings/lining materials
Construction equipment
Cranes, hoists
Dredges
Fabricated penstocks
Gates
Governors and valves
Prefabricated powerhouses
Pump-turbines
Surge tanks
Switchgear and control
Transformers and substations
Turbines and generators

APPENDIX E

SOME NATIONAL WATER POLICY OPTIONS

Appendix E
SOME NATIONAL WATER POLICY OPTIONS

This appendix sets out some principles which could form the basis of potentially viable host country policies and, where appropriate, for USAID assistance in policy and strategy development.

A policy is a precept and outline course of action to guide present and future decision-making in the achievement of an objective. The implementation of a policy generally requires a series of legislative, administrative, financial and monitoring steps based upon an implementation strategy. The setting of a viable policy implies that such strategic implementation options have been evaluated adequately to give reasonable assurance that the policy can be implemented.

Once the policy is adopted, detailed strategy development, action planning and actual implementation are based on the policy. A viable policy is based on clearly understood objectives and takes into account the existing conditions that govern the implementability of the policy and the results of its implementation.

Examples of principles on the basis of which government water policies could validly be based, and in relation to which USAID could usefully provide guidance, are set out below. They do not necessarily have fixed and universal applicability. Some of the issues of relevance and implementability are discussed in relation to each principle.

A. Principles for Policy Options to Improve Institutional Arrangements and Management

- *To provide for accountability, transparency, democratization and decentralization in the governance of the sector*

  Water sector governance in many Asian countries is not conducted according to well disseminated laws or codes. It frequently involves ad hoc decisions made behind closed doors in a location to which those affected have no access, and the decision-makers are often not accountable to the citizenry. The implications of governance decisions for water users are often not made known to them until it is too late for them to make any effort to influence the outcome.

  Such principles of good governance as accountability, transparency and democratization in the water sector can be implemented through the adoption and implementation of such policies as: holding public meetings for the scoping of environmental impact assessments and for the acceptance and discussion of the results; solicitation and consideration of public comments on proposed

regulations and on decision that would have the effect of limiting public access to or use of water; advising affected parties and groups of pending important water-related decisions; presentation and review of the technical and cost details of public works projects at public meetings with intended beneficiaries and payers of the costs; and briefing and support of organizations representing user and citizen groups.

Furthermore, initiatives for development of resources, and for public expenditures that would be supported by user fees or local taxes, should be taken at as low (decentralized) a level as possible, ideally at the level of government at which the intended user/payers comprise the electoral constituency (with review at the level at which all stakeholders comprise the constituency). Such effective decentralization and bottom-up initiative are fostered by policies that require or encourage local government responsibility for local resource development and infrastructure and that include financial provisions to make local implementation possible. Such a policy is demonstrated by the Philippine Local Government Code, which among many other provisions makes infrastructure development a local government responsibility and provides for revenue sharing from the central government's general income.

- *To provide for cost recovery or cost sharing in governmental and/or municipal provision of water and wastewater and hydroelectric systems and facilities*

Services and facilities that are provided at no cost to their users are not valued by them. Such water-related services and facilities tend to be abused by the users and their maintenance is fully dependent on the original provider (generally government) for both annual funding without end and for resources and organization. Even when well conceived and established, they tend to disintegrate and are generally not sustainable. In addition, they constitute a sérious financial burden for governments. Systems lacking user-based revenues are generally poorly operated (for example water disinfectants and other treatment chemicals tend not to be provided), lack maintenance (for example, large irrigation systems in South Asia that receive no maintenance and depend for longevity on expensive rehabilitation that may not be affordable or economically justifiable), and are not likely to be "bankable" as new investment projects.

The recovery of operating costs, and usually part of the capital debt service cost, is generally feasible for urban water supply and hydroelectric projects because of economic circumstances in urban areas that generally permit cross-subsidization between classes of user through stepped tariff schedules, and because of the possibility of cutting off service for non-payment. However, if the level of service is such that the costs exceed users' willingness to pay (as can be the case for urban sewerage and wastewater treatment systems) and if

enforceable mechanisms for regular fee collection are missing (as is often the case for irrigation systems), cost recovery becomes very difficult. In addition, where facilities have been provided on a central grant basis, the owning/operating organization may not be able to incorporate any part of capital recovery in any user fees. Lack of internal financial management capability may prevent adequate revenue generation or self-support.

Policy options to deal with these conditions include: limiting levels of service to match user willingness to pay; providing government equity to a level that corresponds with general benefit to society (such as for example from high levels of treatment of urban wastewater to protect downstream water quality); and demonstrating equity in the sharing of costs (for example basing sharing of between geographically separated blocks of users on the basis of related costs and between individual users of piped water on the basis of measured flows).

- *To separate governance from service provision in the organization of the water sector*

Governance, in relation to the water sector, is the establishment and application of policies, laws, adjudication processes, incentives and penalties regarding the use and abuse of water. Service provision includes: the abstraction, treatment, supply and distribution of water; the collection, treatment and disposal of drainage and/or wastewater; hydroelectric power generation and distribution; and the provision and maintenance of flood protection facilities. Public sector water organizations in many countries combine governance and service provision functions, to the detriment of both. Equitable and efficient governance must respect the interests of all stakeholder groups across the whole water sector and the interfaces between water and other sectors (including the energy, environmental, industrial, urban development, transportation and other sectors). The provision of water services, on the other hand, creates a provider/constituency relationship that is specific to a subsector and is incompatible with equitable sector-wide governance. Water service providers that are subject to direction by governments may be unable to resist pressure to provide services for which they are forbidden to collect the full cost.

In addition, where subsector service needs have been met directly by governments through the creation of large service organizations, they have tended to distort policy-making and investment planning in directions that owe more to the needs of the institutions than to accountability to meet people's and environmental needs related to water. Such combinations of function in large governmental organizations tend to obstruct sustainable water development and impede economic development. Services should wherever possible be decentralized and should be provided by entities that are administratively separate from water resource and environmental policy and oversight organizations. While not all governments will be ready to accept this principle

immediately, it is a sound starting point for discussion of future institutional directions.

- *To promote private sector investment in development of hydroelectric energy potential.*

Institutional arrangements in the energy sectors of developing countries are often characterized by (1) widespread ad hoc government involvement in most aspects of the management of energy supply enterprises and the sector as a whole; (2) rivalry and inadequate coordination among sector institutions and with other agencies; and (3) weak accountabiilty of sector managers to both supervising ministries and their consumers. As a result, with a few exceptions, the energy sector suffers from a combination of poor pricing, investment and regulatory policies, and inefficient operating and maintenance practices, resulting in returns on investment that are insufficient to attract private debt or equity.

Fundamental changes in the institutional structure often will be required to effect changes in performance and enable this ector to meet its growing financial requirements. A new social compact between the state and consumers and producers is required, one which relies more on the state as a regulator and less as an owner of the means of production.

Under favorable resource and policy condtions, economic private generation options can include the development and utilization of hydroelectric energy potential either as a primary or secondary aspect of water resource development projects. Private development involves the financing and construction of hydropower projects by a private developer. After its construction, the project may be owned by the developer or transferred to the utility. If the developer continues to own the facility, it may operate the facility and sell the energy produced to the utility in accordance with previously negotiated terms of sale.

Private sector investment and development of hydroelectric energy potential brings an alternative source of financing enabling critically needed projects (including multi-purpose water resource projects) to move forward. Private enterprise brings a business approach and operationqal efficiency to the venture. Decisive actions by private entrepreneurs can shorten lead times as compared with public sector development. Private development based on competition brings incentives to minimize cost.

Governments should encourage private entrepreneurial interest in small-scale hydropower developments. Small-scale hydropower projects are potentially more readily financed, and more quickly implemented, than other energy projects because:

(1) They require smaller capital expenditures for the individuals projects;

(2) They are less likely to pose environmental and social problems;

(3) They can be constructed and put into operation in a shorter time frame both because of scale and because of private sector management;

(4) They use a renewable energy source and not a potentially imported fuel;

(5) They enable energy generation centers to be located near to demand centers;

(6) They can be constructed by joint ventures of local and foreign contractors, providing potential US exports and hastening the development of experienced local contractors.

Clearly, the determination of governments to encourage private sector development needs to be expressed in policies and programs that (1) recognize the private development of hydropower; (2) place the licensing and regulation of projects under a single umbrella ministry; (3) provide the private sector with opportunities to bid competitively on hydroelectric development opportunities based on well-conducted site screenings and feasibility assessments.

- *To provide for major water allocation, development and investment decisions to be based on system-wide data collection and analysis including evaluation of sustainability*

Major decisions on water development, even for large scale systems, are too often made on the basis of inadequate data and analyses that address only selected issues in artificially limited temporal and spacial frameworks.

Among the types of pre-program and pre-investment studies that should be considered are multiobjective analyses (that consider the extent to which alternative courses of action meet the range of potential economic, environmental, social and other objectives, taking into account linkages across the full hydrological cycle, between the various actual and potential water interests, between the water and other sectors, and between present and future conditions and stakeholders), risk analyses (that synthesize the likelihood of complete or partial system failure or of unacceptable environmental effects from all causes, including from possible extreme events), and feasibility studies (that provide short term economic, financial, social and institutional soundness analysis).

Governments should establish procedures and criteria to determine the scope and scale of pre-program and pre-project data collection and analysis and to achieve compliance with them by water developers. While holistic evaluation is a general objective, the scale, cost and time-requirements of studies that are justifiable are related to the potential impacts on decisions that may be made. This requires a combination of establishment of guidelines and criteria and providing for decisions to be made based on judgement as to what level of analysis will be required case by case. Such studies may also be needed where no specific development program or project is proposed, for example when serious questions are raised about the equity of existing water allocations or the abuse of water rights or lack of enforcement of available sanctions. As a matter of policy, such studies should be broad enough to encompass all potentially relevant issues.

- *To require public participation as a basic policy principle of all water sector development*

  Public participation is a mechanism to obtain diverse opinion about planned water resource developments from the full range of users. Failure to actively seek public involvement at an early stage runs risks, so that services provided may not match users' needs, expected user-based revenues may be unrealistic, and human and settlement issues may be ignored. Improvements to existing irrigation systems should be made with the involvement of users because farmers know best about what works and what doesn't work in an established system. Likewise, there are many examples of potable water systems that are unused because of poor water quality (such as high iron content) or inconvenience to women who must carry water to the home. For potential hydroelectric power schemes also, user input and involvement is important, especially where existing supply is so limited, or costs have been so highly subsidized, that past demands may not adequately guide forward planning. Thus, planners should seek user input regarding facility designs, costs, and fees for both new systems and changes in existing systems. Participatory processes help establish the connection between users and the system. This is supportive of better maintenance. It also may facilitate public/private sharing of operational costs, and eventual turnover of responsibilities. As a matter of policy, full information dissemination should be provided and public meetings held prior to undertaking any new water resource development.

- *To legalize and encourage the formation of water user associations to operate and maintain tertiary irrigation and rural potable water supply and hydroelectric systems*

  Water user associations (WUAs) are community-based institutions for water management. Working with government employees, WUA members perform systems operations and maintenance. Responsibilities are directed downward to

water users, instead of upward to the government. The change of direction of the reporting responsibility is a means of obtaining better water service.

Experience in Asia and elsewhere has shown that irrigation user organizations commonly cease to function after the rehabilitation or construction of on-farm systems. For these entities to be effective, members must perceive that the organization is beneficial to them. In only few cases are WUAs currently legally sanctioned which means that they have no official status to deal with government representatives. An option that may show some promise is for WUAs to go beyond irrigation or electricity supply services to encompass functions such as acquiring agricultural inputs or marketing of agricultural produce or energy services, but they should not lose sight of their core responsibilities.

Government policies can link funding for water system and hydroelectric improvements to requirements to formally incorporate WUAs. In Pakistan, watercourse improvement projects require that WUAs be formed and that they share costs of the improvement works. Governments can facilitate WUA formation by offering training in by-laws or financial management. Formal training should be offered to WUAs in operations and maintenance. Also, governments can contract with WUAs to carry out some aspects of construction or to perform maintenance functions.

- *To facilitate the turnover of irrigation and rural potable water supply and hydroelectric systems to the user/owners for operation*

Turnover is the transfer of responsibility for water system operations and maintenance from public agencies to organized groups of water users. It is relevant for irrigation systems, small potable water supply systems and small hydroelectric power systems. Turnover places management of the facilities and operations in the hands of individuals or groups who are directly responsible for water. Turnover helps relieve governments of heavy subsidies to the water sector where collection of fees from users is difficult. Transfer can greatly improve the quality of maintenance and the longevity of facilities. It may allow governments to refocus from irrigation or rural-water supply to new functions and priorities, such as the environment or management of public lands and waters. Turnover is part of an evolution of institutional responsibilities from construction, to operations and maintenance, to stewardship.

The two institutional parties must agree if turnover is to occur. Not only must the user groups be ready to accept responsibility but government agencies must undertake procedural and operational changes which reflect the increased responsibilities for water users.

Water facilities must be in a good state of repair before systems can be transferred. Governments should make provision for turnover a part of basic planning for new water systems and use water system rehabilitation as an opportunity to concurrently arrange for the turnover of water facilities to users. Before turnover occurs, governments must have in place a legal framework by which water users have equitable access to water.

B. Principles for Policy Options to Reduce Competition for Water

- *To encourage, and where necessary require, conservation of water*

  Water conservation needs vary from country to country. Where water for agriculture is relatively scarce and where there are large urban concentrations of demand, conservation is of the greatest importance. Potential conservation measures include technological measures (such as the use of water conserving devices in potable and irrigation water systems, metering and leak reduction) and administrative controls (such as limitations on abstraction rights, prohibition of unofficial connections, and related monitoring and enforcement) that will induce water users and distributors to apply conservation measures. Policies could include requirements for loss and wastage evaluation, and/or for ceilings on unit water demands, in pre-investment studies for public system expansion and applications for government-supported or foreign loan funding.

- *To require that water uses reflect its economic value*

  Quite apart from its cost recovery aspect, water pricing can be a key component of the management of demand for water. This can be expressed through the inclusion in the water pricing of a component that reflects the economic value of the water on the basis of its opportunity cost. However, the feasibility of doing this in practice is subject to having both a basis for the calculation of the opportunity cost and an effective means for charging and collecting the price. Effective implementation is likely to depend, among other factors, on popular understanding of the basis for the policy and recognition of its equity, and hence on an open and proactive introductory process. In some countries such a policy will not be practicable. Where this is the case, other means should be found to ensure that water use is commensurate with the economic return on its use. For public facilities, these could include a requirement that the economic value of water be counted as a cost in benefit/cost analyses at the pre-investment planning stage of water supply projects (or as a benefit of water reclamation projects).

- *To encourage reclamation and appropriate reuse of water*

In most countries the principle of multiple health protection barriers governs policies on the reuse of wastewater. In most cases this precludes direct reuse of treated wastewater for domestic supply but some countries permit urban use of groundwater that has been supplemented by recharge with treated and reclaimed wastewater. The policies that govern agricultural and industrial reuse of water vary on the basis of local conditions and, sometimes, cultural values. Where there is strong competition for water, the value of used water should be recognized and policies for its reuse should be such as to bring about the highest available economic return, subject to health, environmental and social acceptability. This may require, for example, the establishment of criteria for the scope, performance, performer qualifications, and evaluation, of economic, environmental and other studies required to justify significant changes in water use or allocation, and for inclusion in those criteria of requirements for consideration of the economic returns to water and of possible reuse.

- *To codify, and permit trading of, water rights in the interest of equity and efficiency of water use*

Achieving the highest economic value of water, taking into account all relevant costs and benefits, should be the primary basis for water allocations between competing uses. To the extent that market forces represent such costs and benefits, they should be the principal determinant of water allocations and reallocations. However, consideration of external costs and benefits may require that mechanisms be put in place to internalize them.

Examples of internalization of external costs include the application of economically-based permitting fees and fines for polluting discharges and the application of charges for water withdrawal that reflect seasonal water availability.

Socially and ecologically necessary limitations on the operation of market forces may include recognition of pre-existing rights in water use, or requirements for the maintenance of specified minimum low flows for downstream users. Limited operation of market forces may also be provided for by a policy of treating only water reclaimed or conserved as subject to sale or lease. Impact assessments for new water uses can also be required.

Some governments insist on retaining the right to allocate use but not ownership of water. This may reflect an intent that water allocation support socially rather than economically oriented goals, such as maintenance of farm incomes or provision of water for the urban poor. It can also have other objectives which may or may not be able to be met through modifications of market systems for water. Even where rights are to be allocated on a case by case basis and relate

only to use, rather than ownership, of water, the principles of such allocation should be codified in clear regulations.

C. Principles for Policy Options to Improve Water Quality and Protect the Environment

- *To require the preparation and evaluation of environmental impact assessments for all major water development activities and significant changes of water use*

  A valuable tool for rational evaluation and mitigation of potential environmental impacts is the environmental impact assessment (EIA). The main objective of EIAs is to identify and quantify environmental impacts of proposed plans, programs and projects, thus assisting decision-makers and their constituents in making informed decisions on project developments and resource allocations. The EIA should be an integral part of the resource planning process, and is especially important in the water sector. The EIA process includes evaluation of the physical, biochemical, social and ecological effects of proposed projects, developments and water uses.

  Policies for EIA implementation should cover screening-level environmental evaluations for use at the pre-feasibility stage, criteria and procedures for defining the level of environmental analysis needed at the feasibility analysis and detailed design stages, and processes to facilitate public discussion of the environmental aspects of major proposed developments. The end results of the EIA processes are go/no-go decisions and environmental mitigation and enhancement of development plans and proposals. Policies should include the basis for issuance of permits and other governmental approvals of water developments and uses.

- *To encourage waste prevention or minimization in lieu of end-of-pipe wastewater treatment of industrial wastewaters*

  It is often technically feasible and economically advantageous to make changes within industrial and agricultural systems to reduce waste production rather than removing polluting materials from wastewater. The techniques involved include changing to processes that use less-polluting raw materials, making process changes to increase efficiency and reduce materials wastage, keeping in-factory waste streams separate and recovering usable materials from them, and the use of countercurrent wash systems that reuse slightly contaminated wastewater flows. In agriculture, avoidance of over-fertilization and overuse of pesticides can be both cost-effective and environmentally beneficial.

  Such methods are often economically beneficial in themselves, but they also reduce the costs of industrial wastewater pretreatment (before discharge to

sewers) or treatment (before discharge to receiving waters), and of treatment of municipal wastewater that includes industrial wastes. A major benefit can be avoidance of the need to safely dispose of industrial sludges with high contents of toxic substances such as heavy metals.

Experience in U.S. industries generally indicates that one quarter to one half of the economic benefits of waste reduction projects are not related to regulatory compliance. These benefits derive from reducing raw material costs, improving overall efficiencies, reducing energy use, improving yields and product quality, and generally increasing the use of environmentally friendly technologies which increase competitiveness. Pollution prevention technologies can also generate safer occupational environments for workers, reduced health care costs, and improved labor productivity.

It makes both economic and environmental sense to supplement governmental regulation with technical assistance and informational programs that foster the use of no-cost and low-cost waste minimization. This is especially important where enforcement of environmental regulations is weak for economic or administrative reasons.

Governments can identify opportunities to incorporate pollution prevention principles and programs in new and current environmental, water resources, and economic development efforts. U.S. industrial and pollution reduction experience provides a very important resource that is available to support such programs in Asia.

Policies to support these principles could include such measures as requirements for evaluation of waste prevention and pollution avoidance in all applications for industrial permits to operate and the provision of pollution minimization information and technology-transfer extension services to industry as part of governmental pollution control programs.

Measuring positive progress in pollution prevention is a key ingredient for sustaining programs, justifying new ones, and seeking assistance from international lending institutions. Monitoring of progress in industrial and agricultural pollution prevention requires decentralized programs of data collection and management that go far beyond traditional pollution monitoring approaches. It requires the mobilization of industrial, agricultural and other non-governmental groups, which is an important policy component.

- *To extend potable water supply, hydroelectric power supply and sanitation or sewerage services (a) to the maximum possible number of persons, (b) using technologies that are functionally and economically appropriate, and (c) through programs and systems that are sustainable.*

Extending services to the maximum number of persons requires the implementation of policies to, for example: increase investments in the subsector; mobilize local (user and local government) capital to minimize needs for national government and international grant funding; concentrate grant funding on wastewater treatment and disposal rather than on water supply, sanitation or sewage collection; recover recurrent costs from the users; and encourage and facilitate local provision of such service extension through program promotion, health education, technical assistance, local institutional strengthening, and loan funding from higher levels of government.

Use of functionally and economically appropriate technologies requires policies to: evaluate what users want and are willing to pay for; provide education on health and other benefits and costs of the technological options; establish demonstration projects and monitor their effectiveness and sustainability; and developing/improving private sector capabilities to perform planning, willingness-to-pay survey, feasibility study, environmental impact assessment, design, construction oversight, financial planning, operation/maintenance planning and possibly other services.

Assuring program and facility sustainability requires policies that will: decentralize the planning and implementation of individual projects; strengthen the capabilities of both service providers and private sector support organizations; involve users, especially women, in decision-making; increase the involvement of the private sector and voluntary organizations in programmatic and implementation activities; and provide central guidelines, incentives and support for projects to be developed, implemented and operated at the local level.

- *To control the quality of wastewater discharges through programs that (a) prioritize the problems and objectives and (b) include a coordinated strategy to apply such measures as sanctions, incentives, technical assistance, monitoring, data collection and data management.*

Achievement of early benefits from pollution reduction in countries where little progress has been made to date requires that choices be made and that priorities be set. Targeting of priority areas for improvement allows the focussing of limited resources to yield economically and environmentally worthwhile benefits in a relatively short time. The setting of nation-wide effluent or receiving water standards is administratively easy, and many countries have done it, but by itself it achieves nothing. Data collection, monitoring and active application of sanctions and incentives should all be focussed on the achievement of the priority objectives which may, for example, cover selected potable water sources

with high public health significance or water pollution that has tourist and economic impacts, where cost-effective improvements can be made.

While receiving-water standards are technologically attractive they give inadequate support to the application of sanctions. Systems of effluent permits with appropriate application and maintenance fees, and fines for non-compliance, can both raise revenues to cover program administrative costs and provide financial incentives for dischargers to reduce their pollution loads. Tax exclusions for pollution reduction investments are also effectively applied in some countries. Decision-support systems, such as that developed by USAID assisting four Danube River riparian countries, can help in determining effective but not overly burdensome levels of sanctions on urban and industrial wastewater discharges. Policies should provide for the rational establishment, support with focussed data collection, and application, of incentives and controls to reduce polluting wastewater discharges. Such policies must be supported by action plans and budgets.