Towards a Water Secure Future:

USAID's Obligations In Water Resources Management For FY 2000

In Parts I and II

Prepared by the USAID Water Team

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USAID's Global Water Team was formed to promote integrated water and coastal resources management and support environmentally sound, cross-sectoral approaches to managing, conserving, and sustainably using freshwater and coastal resources. These involve participatory processes that include women, the poor, and marginalized groups; prioritizing and planning for water demand; and strengthening institutional capacity in water resources management.

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There is no substitute for water.

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List of Acronyms

AFR	Bureau for Africa
ANE	Bureau for Asia and the Near East
BEMAMCCOR	Belize-Mexico Alliance for the Management of Common Coastal Resources
BMPs	Best Management Practices
BOT	Buy-Operate-Transfer
CACEDRF	Central America and Caribbean Emergency Disaster Recovery Fund
CAMP	Coastal Aquifer Management Program
CDMP	Caribbean Disaster Mitigation Project
CGIAR	Consultative Group on International Agricultural Research
CITES	Convention on the International Trade in Endangered Species of Wild Fauna and Flora
CRM II	Coastal Resources Management Project (Phase II)
CRSP	Collaborative Research Support Programs
CSD	Child Survival and Disease
CZM	Coastal Zone Management
DA	Development Assistance
DCP	Development Credit Program
DFID	Department for International Development
DFRI	Indo-Pacific Destructive Fishing Reform Initiative
EAPEI	East Asia and Pacific Environmental Initiative
EE	Bureau for Europe and Eurasia
EGAD	Center for Economic Growth and Agricultural Development
EIA	Environmental Impact Assessment
ENSO	El Niño Southern Oscillation
ENV	Center for Environment
EPA	U.S. Environmental Protection Agency
ESF	Economic Support Funds
EVCC	NMS code for global climate change
EVUM	NMS code for urban environmental management
FAO	United Nations Food and Agriculture Organization
FEMA	Federal Emergency Management Agency
FEWS NET	Famine Early Warning System Network
FIRE-D	Financial Institutions Reform and Expansion (Debt Component)
FORWARD	Fostering Resolution of Water Resources Disputes Project
FY	Fiscal Year
G	Global Bureau
GCC	Global Climate Change
GEF	Global Environment Facility
GHG	Greenhouse Gases
GPA	Global Program of Action
GWP	Global Water Partnership
HRPT	High-Resolution Picture Terminal
ICLARM	International Center for Living Aquatic Resources Management
ICM	Integrated Coastal Management
IDA	International Disaster Assistance
IPCC	Intergovernmental Panel on Climate Change
IQC	Indefinite Quantity Contract
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
LAC	Bureau for Latin America and the Caribbean

MAC	Marine Aquarium Council
MACH	Management of Aquatic Ecosystems through Community Husbandry
MERC	Middle East Regional Cooperation Project
NBI	Nile Basin Initiative
NGO	Nongovernmental Organization
NMS	New Management Systems
NOAA	National Oceanic and Atmospheric Administration
OAS	Organization of American States
OFDA	Office of Disaster Assistance
R4	Results Review and Resource Request
RCSA	Regional Center for Southern Africa
SADC	Southern Africa Development Community
SARI	South Asia Regional Energy Initiative
SEED	Support for East European Democracy
SLR	Sea Level Rise
SO	Strategic Objective
SST	Sea Surface Temperature
STWG	Science and Technical Working Group
TCMP	Tanzania Coastal Management Partnership
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
UNPD	United Nations Population Division
URI CRC	University of Rhode Island Coastal Resources Center
USAEP	United States-Asia Environmental Partnership
USAID	United States Agency for International Development
USD	U.S. Dollars
USG	U.S. Government
USGS	U.S. Geological Survey
WHO	World Health Organization
WRI	World Resources Institute
WSSWM	Water Supply, Sanitation, and Wastewater Management

Executive Summary

The world faces an unprecedented crisis in water resources management, with profound implications for global food security, protection of human health, and maintenance of aquatic ecosystems. Water shortages threaten to reduce global food supply while world population grows by 80 million people each year. With current trends, by 2025 one-third of all humans will face severe and chronic water shortages. Industrialization, irrigated agriculture, massive urbanization, rising standards of living, and, of course, more people are pushing the demand for freshwater to new heights.

Water security is an elusive concept, but consensus is beginning to emerge in the world community as to its dimensions, its parameters, and the best approaches for its achievement. As endorsed by the Second World Water Forum Ministerial Declaration (2000), water security simultaneously considers the need for human access to safe and affordable water for health and well-being, the assurance of economic and political stability, the protection of human populations from the risks of water-related hazards, the equitable and cooperative sharing of water resources, the complete and fair valuation of the resource, and the sustainability of ecosystems at all parts of the hydrologic cycle.

Many professionals argue that the water crisis is not one of absolute scarcity but one of poor management and inequitable distribution. Regardless of the cause, we do know that some regions require particularly urgent action. Of the 48 water-short countries (by 2025), 40 are either in the Middle East and North Africa or in sub-Saharan Africa. The 20 countries of the Middle East and North Africa face the worst prospects. Nearly 70% of the United States Agency for International Development's (USAID) total water-related obligations occur in Egypt, Jordan, and West Bank/Gaza—at the center of perhaps the most water-stressed region of the world.

USAID and the global community have come to understand that effective water resources management requires a participatory approach involving users, planners, managers, and policy makers at all levels. By first assessing a country's overall water supply and demand, and through building capacity and a coordinated response at local, national, and international levels, effective water resources management is achievable. The Water Team, within USAID's Global Environment Center, works with USAID Missions and Regional Bureaus worldwide towards that goal. The fundamental role of the Agency's Water Team is to promote the use of integrated water resources management (IWRM) worldwide by providing technical and managerial assistance, education and outreach opportunities, and international leadership through both USAID and other donor programs.

To improve the impact of USAID's water portfolio, the Water Team has undertaken this analysis to examine how and where the Agency invests in water-related activities and to assess the potential for improved effectiveness and efficiency across its portfolio. The results of this analysis are reported in two ways. In Part I, obligations are reported as they occur within activity categories. In Part II, USAID water-related activities are described in terms of the results and solutions they provide to world water security issues faced by the global community in the areas of water scarcity, water quality, resource allocation, and disaster preparedness. In this part, the reader will find a wealth of illustrative examples of Agency programs and field activities making a difference to communities and ecosystems around the world with regard to the sustainable management of water resources.

Current Obligations: Key Findings

This analysis estimated that USAID obligated a total of $406 million to water-related activities in FY 2000 (see Table ES.1). Approximately 75% of these obligations were allocated to Asia and the Near East (ANE) Regional Bureau Missions ($306 million), with lesser amounts obligated for Latin America and the Caribbean (LAC) Regional Bureau Missions ($51 million or 13%), Europe and Eurasia (EE) Regional Bureau Missions ($22 million or 6%), Africa (AFR) Regional Bureau Missions ($11 million or 3%), and Central operating units ($14 million or 3%). This last figure also

includes nearly $2 million invested by the Water Team across all regions.

Major obligations were allocated to four categories across all Bureaus and operating units: Water Supply, Sanitation, and Wastewater Management (WSSWM) ($221 million); Natural Resources Management ($96 million); Economic Development and Food Security ($73 million); and Disaster Preparedness ($17 million). More obligations (54% of the total) were allocated to WSSWM activities than any other major category.

Seven Strategic Objectives (SOs) totaling $237 million (58% of all water-related obligations) were found to be "water" SOs, for which all activities and obligations are allocated to some aspect of water resources management. None of the seven water SOs addressed Disaster Preparedness.

In addition to Agency-wide analysis, this report separately examines the obligations directed to three operating units that account for nearly 66% ($268 million) of USAID's investment in water-related activities in FY 2000: Egypt ($129 million), Jordan ($83 million), and West Bank/Gaza ($56 million). Within the Agency, obligations are somewhat more evenly distributed across activity categories after removing Egypt, Jordan, and West Bank/Gaza from the analysis. WSSWM receives 43% ($60 million) of remaining obligations, Natural Resources Management receives 28% ($39 million), Economic Development and Food Security receives 16% ($22 million), and Disaster Preparedness accounts for 13% (nearly $17 million).

Within regions, different patterns are apparent. In some places, WSSWM obligations predominate. For example, 89% ($20 million) of the total EE water-related portfolio is dedicated to this area. In other regions, different activities emerge as priorities, as in the 44% ($5 million) of AFR obligations allocated to Natural Resources Management, or the 30% ($15 million) of investment in Disaster Preparedness in the LAC region devoted almost entirely to post-reconstruction activities of one extreme event in 1998, Hurricane Mitch.

Water Supply, Sanitation, and Wastewater Management

The WSSWM category addresses the provision of clean, adequate supplies of drinking water to rural and urban communities, and the promotion of practices that protect these supplies from contamination by improper handling of domestic water supplies, household waste, inadequate sanitation, and industrial and urban pollution. WSSWM activities focused on Drinking Water Supply ($81 million), Sanitation ($48 million), Wastewater Treatment ($84 million), and Industrial Pollution Control ($8 million). This category includes most of USAID's work in water-related infrastructure projects. Some 73% ($161 million) of all WSSWM obligations were allocated to Egypt ($93 million), Jordan ($28 million), and West Bank/Gaza ($40 million), while the remaining 27% ($60 million) was allocated to other operating units. Major operating unit recipients of funds (excluding Jordan, Egypt, and West Bank/Gaza) were Kosovo, Bosnia-Herzegovina, US-AEP, South Africa, India, Ecuador, and El Salvador. Refer to Chapters 2 and 3 in Part II for illustrative activity descriptions of these and more.

Natural Resources Management

The Natural Resources Management category comprises a variety of activities aimed at promoting sustainable development in concert with the protection of ecological services in coastal zones, freshwater ecosystems, and whole river basins or watersheds. USAID obligated $96 million for water-related activities in Natural Resources Management, which amounted to 24% of all water-related obligations in FY 2000. Nearly 61% of all obligations for Natural Resources Management were allocated to Egypt ($17 million), Jordan ($28 million), and West Bank/Gaza ($13 million).

Including all operating units, obligations were allocated among subcategories as follows: 66% for Watershed Management and IWRM, 33% for CZM, and 1% for Freshwater Ecosystems Management. Chapters 4 through 9 in Part II provide a wealth of illustrative examples of natural resources management activities occurring in transboundary water issues, CZM and coral reef conservation, and aquatic biodiversity.

Economic Development and Food Security

The Economic Development and Food Security category addresses activities aimed at promoting equitable economic growth. Activities focus on effective means of bringing poor, disadvantaged, and marginalized groups into the mainstream of an expanding economy, and promote the development of capabilities to enable countries to meet their own demands for food supply. USAID obligated $73 million for water-related activities in Economic Development and Food Security during FY 2000. These activities amounted to 18% of all water-related obligations in FY 2000 for Fisheries, Mariculture, and Aquaculture; Irrigation and Agriculture; and Hydropower. The subcategory of Irrigation and Agriculture accounted for most of the obligations in the Economic Development and Food Security category ($55 million). Nearly 69% ($50 million) of all obligations for this category were allocated to Jordan ($28 million), Egypt ($19 million), and West Bank/Gaza ($3 million), while 31% ($22 million) were allocated to other operating units. Major recipients of funds (excluding Jordan, Egypt, and West Bank/Gaza) were Bangladesh, Colombia, the Global Bureau's Center for Economic Growth and Agricultural Development (G/EGAD), the Philippines, Nepal, and Bolivia. Illustrative activities in agricultural development, fisheries, and food security are provided in Chapter 10 of Part II.

Disaster Preparedness

The Disaster Preparedness category includes obligations assigned to the two subcategories of Monitoring and Forecasting and Vulnerability Assessment. Included are activities that support the monitoring of environmental conditions for use in drought and flood prediction, as well as the rebuilding of water delivery systems damaged by natural disasters. The category also includes the transfer of technology and expertise for hydrological monitoring, runoff and storm flow control, and protection of water resources from extreme weather variability and climate change. This category does not include medicinal and food aid delivered in response to droughts, floods, and storms. Emergency funds for providing potable water and for rebuilding irrigation, water, and sanitation systems are included in the appropriate categories in WSSWM and Economic Development and Food Security.

USAID obligated nearly $17 million for water-related activities in Disaster Preparedness during FY 2000. These activities amounted to 4% of all water-related obligations in FY 2000 and included $16 million for Monitoring and Forecasting, and $600,000 for Vulnerability Assessment. These figures include only a small percentage of all disaster-related obligations made in FY 2000. In May 1999, responding to a request to provide assistance in the aftermath of Hurricane Mitch, Congress approved $621 million in supplemental funding for the Central America and Caribbean Emergency Disaster Recovery Fund (CACEDRF) for FY 1999 and 2000. Approximately $15 million of these funds were obligated in FY 2000 for water-related disaster assistance. Chapter 11, the final chapter in Part II, describes USAID's work towards evaluating vulnerability and mitigating the effects of extreme storm, flood, and drought events, as well as global climate change.

USAID Activity and Global Investment Needs in Water Resources Management

Worldwide demand for water tripled during the past century and is presently doubling every 21 years (Green Cross International, 2000). Clearly, such demand is unsustainable in the long term and will require dramatically new approaches to water resources management to avoid the worst of the looming crisis.

Of the 31 countries (with a combined population of 458 million) that faced water scarcity or water stress in 1995, USAID is currently engaged in water-related activities in only 11. Looking towards the future, of the 48 countries (with a combined population of more than 2.8 billion) expected to face water scarcity or water stress in 2025, USAID is currently engaged in water-related activities in only 16. This represents $280 million in USAID water-related assistance to countries with a combined projected 2025 population of 1.8 billion (66% of the population projected to face water scarcity or stress). Worldwide, USAID invested approximately $406 million in water-related activities during FY 2000. Maps 1.1 and 1.2 and

Table 1.9 illustrate these trends in global water scarcity and USAID activities in IWRM.

The USAID obligation figures compare with World Water Council estimates that $70-$80 billion (excluding direct investment by industry) is currently invested each year to provide water services. The largest investors by far are governments, at $50 billion per year, followed by the private sector at around $15 billion (dominated by small vendors servicing municipal utilities). International donors invest roughly $9 billion annually (Cosgrove and Rijsberman, 2000).
There was almost universal agreement at the Second World Water Forum in the Hague that investment in water services must significantly increase to avert a global water crisis. As USAID considers how to best address water resources management in the future, questions will have to be answered related to where we work, what type of activities we undertake, and how water-related work is designed and implemented. Regarding the geographic area of focus, this study has identified many areas of the world where a water crisis is already present or imminent, and where USAID currently has no activities at all in the water sector. Some of these places may present opportunities for USAID to fill a clearly identified need in a way that takes advantage of the Agency's comparative strength. In other places, USAID can effectively engage in a partnership with the private sector, NGOs, academia, and/or other donors to address water quantity or quality problems in an integrated and effective way.

As for technical and sectoral areas of focus, USAID's current portfolio and expenditures reveal that USAID operating units are engaged in the broadest spectrum of water resources management activities spread across all sectors. Every sector in which USAID is engaged clearly indicates the important role that water resources play in fostering economic and agricultural development, human health, ecological sustainability, and conflict prevention.

Finally, and most importantly, USAID shares in the global consensus that the approaches promoted through IWRM offer the best hope for achieving greater effectiveness, efficiency, and sustainability in water resources management. Several IWRM principles emerge as the foundation for greater Agency effectiveness in water resources management, and illustrative examples of these are included throughout this document.

1. An integrated, cross-sectoral, and participatory approach is the preferred strategy for successful water resources management in the long term.
2. Water resources must be managed at the appropriate scale (either basin or sub-basin) and level (international, national, provincial, or local) to ensure ecosystem integrity and international cooperation over shared resources.
3. Greater attention should be focused on the use of sound science to determine the water budget and other water resources available at the basin scale.
4. Participatory planning and transparent decision making should be instilled to enhance political will, self-reliance, and stewardship by relevant stakeholders.
5. Water should be treated as both an economic good *and* a basic human need, with the goal of full cost recovery for water services with targeted subsidies for the poorest of the poor.
6. Countries should be encouraged to adopt the "users and polluters pay principle."
7. Water allocation mechanisms must increasingly encompass environmental and human use values.
8. Infrastructure and water service delivery should be demand-driven and service-oriented, with every opportunity explored for public-private partnerships.

The analysis reveals that activities at all stages of the IWRM planning and implementation cycle are being undertaken by USAID around the world, through the promotion of sound information and analysis, participatory governance, and effective site-based practices. At the same time, many activities focus on water resources management for a single desired end, e.g., human water supply, agricultural production, or the sustainability of ecosystem services. While such activities can be very successful in their own right, they may miss opportunities for integrated and sustainable management that satisfy many human and ecological uses simultaneously, and that enhance the sustainability of them all. Indeed, even where

USAID does not undertake activities directly related to water resources, operating units may find it useful to factor in the role of water resources in their other programs, and adopt integrated planning for activities that may be affected by growing scarcity or declining quality of the resource.

As USAID proceeds into the new millennium, the Water Team will work with operating units in the field and in Washington to advance USAID's collective understanding about the most effective approaches to IWRM at all scales. It is our hope that the present analysis of Agency activities, along with the detailed highlights and thematic discussions provided in Part II of this report, will serve as important inputs to future strategic planning and program design related to water resources for all USAID operating units.

Table ES.1 USAID obligations for water-related activities, FY 2000

USAID Water-Related Obligations, FY 2000, in U.S. Dollars (000s)	AFR	ANE	EE	LAC	Central Operating Units	TOTAL
WSSWM	**4,680**	**173,447**	**19,947**	**17,883**	**4,642**	**220,599**
Drinking Water Supply	1,360	59,532	10,000	7,551	2,209	80,652
Sanitation	2,160	34,832	5,661	3,601	2,209	48,462
Wastewater Treatment (Domestic)	1,160	76,000	4,000	2,416	224	83,800
Other Pollution Control	0	3,083	286	4,316	0	7,685
Natural Resources Management	**4,981**	**68,434**	**2,447**	**13,681**	**6,310**	**95,853**
Watershed Management and IWRM	2,514	44,170	2,447	9,541	4,405	63,076
Coastal Zone Management	1,467	24,264	0	3,943	1,905	31,579
Freshwater Ecosystems Management	1,000	0	0	197	0	1,197
Economic Development and Food Security	**541**	**64,512**	**0**	**4,445**	**3,100**	**72,598**
Irrigation	541	51,512	0	2,653	500	55,206
Fisheries, Mariculture and Aquaculture	0	11,800	0	1,625	2,600	16,025
Hydropower (small-scale)	0	1,200	0	167	0	1,367
Disaster Preparedness	**1,200**	**0**	**0**	**15,331**	**0**	**16,531**
Monitoring/Forecasting	600	0	0	15,331	0	15,931
Vulnerability Assessment	600	0	0	0	0	600
TOTAL WATER	**11,402**	**306,393**	**22,394**	**51,340**	**14,052**	**405,581**

WSSWM = Water Supply, Sanitation, and Wastewater Management

This Report

To improve the impact of USAID's water portfolio, the Water Team[1] has undertaken this analysis to examine how and where the Agency invests in water-related activities, and to assess the potential for improved effectiveness and efficiency across its portfolio. At the center of this effort was a comprehensive and systematic review involving the compilation and analysis of data contained in annual progress reports[2] produced by each of the 101 operating units within USAID (Annex A) for FY 2000.[3] In addition, personal communications with relevant personnel were carried out as necessary to augment and clarify data and information contained in the report. Official confirmation by individual Missions was not attempted.

A total of 475 SOs[4] were examined for water-related obligations.[5] Obligations from DA, CACEDRF, CSD, ESF, IDA, Plan Colombia, SEED, and Title II funds were considered. Reported obligations for water-related activities were first assigned to one of four broad categories that roughly align with Agency development goals: Water Supply, Sanitation, and Wastewater Management; Natural Resources Management; Economic Growth and Food Security; and Disaster Preparedness. Two other more detailed levels of activity categories were also used as part of the three-tiered hierarchy of water-related categories tracked (Annex B).

The results of this analysis are reported in two ways. In Part I, obligations are reported as they occur within the activity categories outlined above. The category designations used in this section are programmatic and reflect the way results are reported in the Agency. The terminology reflects the manner in which USAID is organized along strategic frameworks outlined by Agency strategic objectives and carried out by USAID Bureaus and offices.

In Part II, USAID water-related activities are described in terms of the results and solutions they provide to 10 important world water security issues faced by the global community. In this section, the reader will find a wealth of illustrative examples of Agency programs and field activities making a difference to communities and ecosystems around the world with regard to the sustainable management of water resources. Most of these programs are supported by funds from multiple obligation categories as reported in Part I.

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[1] USAID's Water Team was formed to promote integrated water and coastal resources management and to support environmentally sound, cross-sectoral approaches to managing, conserving, and sustainably using freshwater and coastal resources. These involve participatory processes that include women, the poor, and marginalized groups; prioritizing and planning for water demand; and strengthening institutional capacity in water resources management.

[2] Reports used in the analysis were the Results Review and Resource Request (R4) and the Budget Justification. A more detailed summary of the methodology employed in analyzing budget figures is provided in Annex B.

[3] FY 2000 for USAID ran from October 1, 1999 to September 30, 2000.

[4] SOs are set for each operating unit within the Agency, and are used as guiding principles for the design and management of activities the program implements to achieve results.

[5] The term "obligations," rather than "expenditures," is used throughout this report. It is important to note that *obligations* refer to funds appropriated by Congress and allocated by USAID in a particular fiscal year, while *expenditures* refer only to the proportion of allocated funds that have actually been spent. Expenditures and obligations for the same activity, therefore, may not be the same in any given fiscal year, as funds are only expended after allocations have been made.

Part I

Towards a Water Secure Future

Chapter 1
Agency Obligations in Water-Related Activities for FY 2000

The Global Water Crisis

The world faces an unprecedented crisis in water resources management, with profound implications for global food security, protection of human health, and maintenance of aquatic ecosystems. Water shortages threaten to reduce global food supply while world population grows by 80 million people each year. By 2025 with current trends, one-third of all humans will face severe and chronic water shortages. Reduced flows and poor water quality diminish the health and productivity of both freshwater and marine ecosystems in many parts of the planet. Viewed globally, the water crisis is turning into a classic collision of supply and demand.

The worldwide demand for freshwater is increasing all the time. Industrialization, irrigated agriculture, massive urbanization, rising standards of living, and, of course, more people are pushing the demand for freshwater to new heights. While world population tripled in the past century, water use increased by more than six times (Hinrichsen et al., 1998). Slightly more than one-half of available freshwater supplies are now used for human purposes, and the world water demand is doubling every 20 years (Metcalfe, 2000).

Against this backdrop, food security challenges loom large. As the biggest consumer of freshwater (estimated to be near 70% worldwide), the agricultural sector is targeted for the greatest reductions in water use. Yet, the International Water Management Institute (IWMI) projects that to achieve global food security, irrigated agriculture will require 17% more water in 2025 than is currently used (Seckler et al., 1999). Food security will vary among countries and regions, but studies suggest that India may be the worst hit by water scarcity, with agricultural production falling by 25% in the next two decades. Water-short countries[6] must move quickly to stabilize populations, increase water productivity, or find means to increase food imports if they are to avert tragedy.

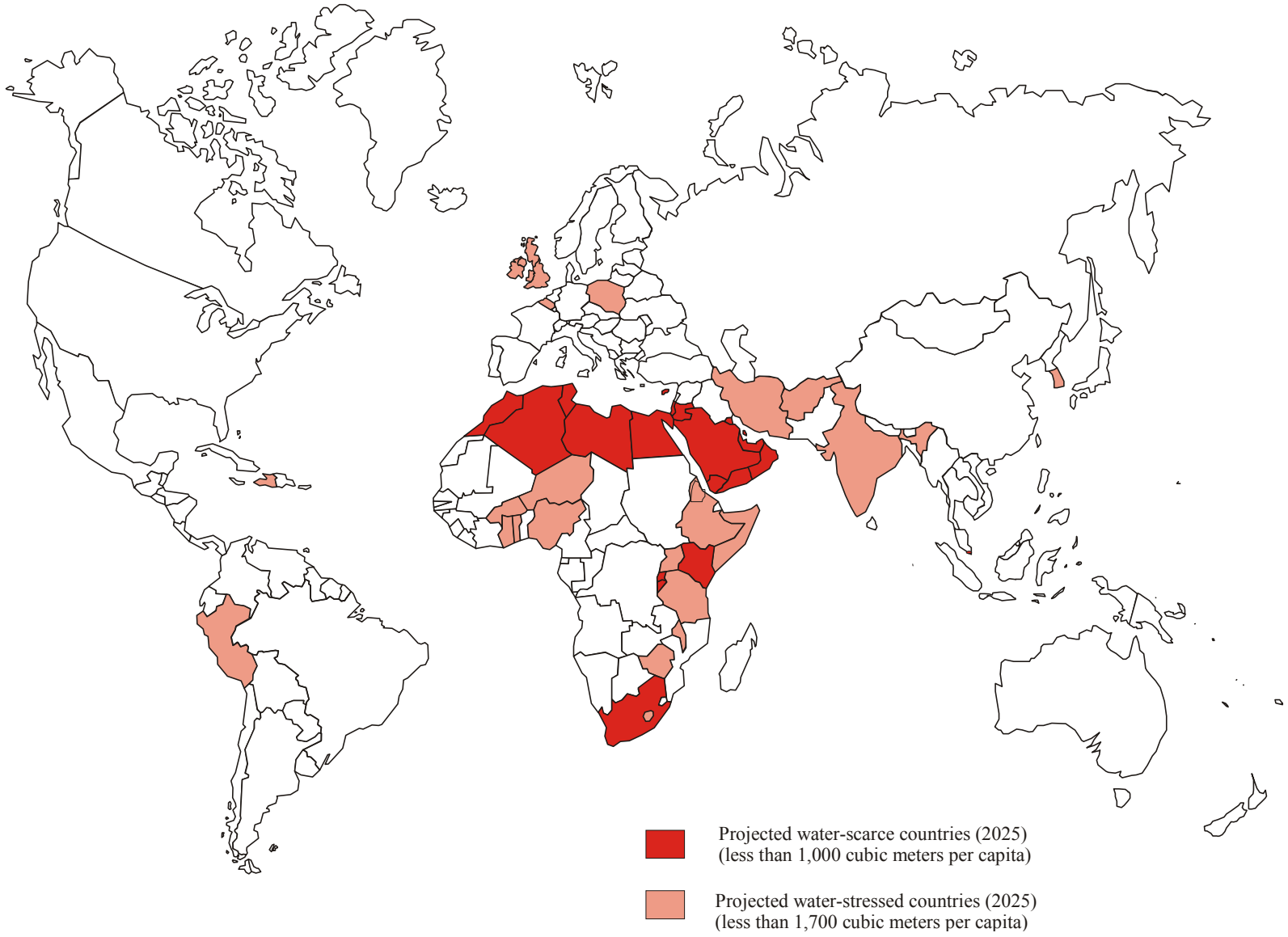
Successful management of freshwater resources is one of the most critical health issues facing humanity. Already, more than 1.2 billion people are at risk of poor health because they lack access to clean water (Hinrichsen et al., 1998). Polluted water, unsanitary living conditions, and water shortages kill more than 12 million people each year (Hinrichsen et al., 1998). Of this figure, 3-4 million people die of waterborne diseases, including more than 2 million children from treatable diarrhea (Cosgrove and Rijsberman, 2000).

By 2025, more than 2.8 billion people—35% of the world's projected population—will live in 48 countries facing water stress or water scarcity (Map 1.1). These figures are conservative, as they are based on country-level data and averages that mask significant regional differences in water scarcity due to a variety of natural and human-induced causes. For example, about one-third of the populations of China and India live in regions that should be classified as water scarce, adding 661 million people to the figures above (Seckler et al., 1999).

Moreover, none of the water scarcity data takes into account that finite water resources are becoming increasingly polluted. Inadequately treated wastewater from industries and cities; polluted runoff from agricultural operations; and massive siltation from logging, road construction, and other land use activities are perhaps the largest culprits. As a result, excessive nutrients, pesticides, heavy metals, pathogens, sediments, and other pollutants degrade lakes, rivers, and coastal environments to the detriment of aquatic ecosystems and humans alike. At least 20% of the world's freshwater fish species are already extinct, threatened, or endangered (Revenga et al., 2000). While there are many contributing factors (e.g., habitat loss, freshwater diversions, and climate change), increasingly polluted waters often shift the balance towards

[6] Notwithstanding the compounding problem of water distribution, a country is said to experience water stress when annual water supplies drop below 1,700 cubic meters per capita. When annual water supplies drop below 1,000 cubic meters per capita, the country faces water scarcity. As used in this report, "water-short" countries are those that are either water stressed or water scarce.

Map 1.1 Projected water-short countries (2025). (Data source: Gardner, Outlaw and Engelman, *Sustaining water, easing scarcity: A second update,* Washington, D.C., Population Action International, 1997, as adapted from Hinrichsen et al. 1998 (1) with USAID Water Team Data)



extinction, diminished productivity, and lost ecosystem services.

Some would ask how a planet that has 70% of its surface covered with water could face a water crisis. More than 97% of that water is ocean water. Of the remaining 3%, about three-quarters is locked away in ice caps or glaciers and thus unavailable. In truth, slightly less than one one-hundredth of 1% of the world's total supply of water is easily accessible as lakes, rivers, and shallow groundwater sources that are renewed by snow and rainfall (Hinrichsen et al., 1998). Water scarcity is further compounded by the disparity between where human populations are located and when and where rainfall and runoff occurs. Viewed in this manner, 81% of total global runoff is within geographic reach for human use, but three-quarters of that comes as floodwater and therefore is not accessible on demand (Postel, 1996).

For these and other reasons, many professionals argue that the water crisis is not one of absolute scarcity but one of poor management and inequitable distribution. Regardless of the cause, we do know that some regions require particularly urgent action. Of the 48 water-short countries (by 2025), 40 are either in the Middle East and North Africa or in sub-Saharan Africa. The 20 countries of the Middle East and North Africa face the worst prospects. Jordan and Yemen withdraw 30% more water from groundwater aquifers every year than is replenished, and Israel's annual water use exceeds renewable supply by 15% (Hinrichsen et al., 1998). In fact, the entire Middle East surpassed sustainable water yield in 1972. Since then, the region has withdrawn more water from its rivers and aquifers each year than is being replenished. Nearly 70% of USAID's total water-related obligations occur in Egypt, Jordan, and West Bank/Gaza—at the center of perhaps the most water-stressed region of the world.

Water security is an elusive concept, but consensus is beginning to emerge in the world community as to its dimensions and parameters, as well as to the best approaches to its achievement. As endorsed by the Second World Water Forum Ministerial Declaration (2000), water security simultaneously considers the need for human access to safe and affordable water for health and well-being, the assurance of economic and political stability, the protection of human populations from the risks of water-related hazards, the equitable and cooperative sharing of water resources, the complete and fair valuation of the resource, and the sustainability of ecosystems at all parts of the hydrologic cycle.

Before we can speak about global "water security" in more quantifiable terms, however, considerably more work is needed to integrate data on water supply, consumption, water quality, land use change, human welfare, and ecosystem function at the river basin scale across the globe. The number of variables, including global warming; increased frequency of natural disasters; and growing tensions over shared, transboundary resources, makes the task even more challenging. Along with the world community, we must do more and we must be more efficient and effective in our efforts through integrated approaches to water resources management.

USAID and the global community have come to understand that effective water resources management requires a participatory approach involving users, planners, managers, and policy makers at all levels. By first assessing a country's overall water supply and demand, and through building capacity and a coordinated response at local, national, and international levels, effective water resources management is achievable. The Water Team, within USAID's Global Environment Center, works with USAID Missions worldwide towards that goal.

USAID's Changing Role in Water Resources Management

USAID's early involvement in water and water-related activities began with emphasis on irrigated agriculture, community water supply, and a small handful of large dam construction projects in the pre-1970 era. These early efforts were relatively capital and infrastructure intensive, and included investment in Egypt's Aswan Dam. During the 1970s, the emphasis shifted away from dam construction and towards community water supply and sanitation for health in general, with assistance to water user associations for overall improvement of the water sector. USAID's own environmental regulations and environmental review of multi-donor projects began during this period.

The 1980s saw increasing emphasis on projects related to water for health, in particular for child survival objectives. Watershed management within forestry and/or agricultural contexts received increasing attention, as did industrial pollution prevention. In fact, environmental activities were by then seen as legitimate "development objectives" in and of themselves, and USAID began supporting coastal resources management for the first time. The management of coastal resources continued to increase in the 1990s, as did overall investments in water-related activities.

The Agency's Water Team was launched in 1998 within the Global Environment Center to provide technical assistance on IWRM to USAID Missions worldwide. IWRM is a participatory planning and implementation process, based on sound science, that brings together stakeholders to determine how to meet society's long-term needs for water and coastal resources while maintaining essential ecological services and economic benefits (Box 1.1).

USAID has many goals for assisting people in developing countries, all of which require adequate supplies of clean freshwater. IWRM helps protect the world's environment, foster economic growth and sustainable agricultural development, promote democratic participation in governance, and improve health. The fundamental role of the Agency's Water Team is to promote the use of IWRM worldwide through both USAID and other donor programs. Water Team members work in three central areas:

- provision of technical and managerial assistance to Regional Bureaus, Missions, and partners to incorporate IWRM approaches in field programs and policies;
- provision of education and outreach opportunities to Regional Bureaus, Missions, and partners by producing and distributing information on relevant USAID, USG, and other donor capabilities in IWRM; and
- provision of international leadership and coordination within USAID, and vis-à-vis other USG agencies and donors, through exchange of lessons learned, development of universal guidelines, and adoption of IWRM practices by the wider development community.

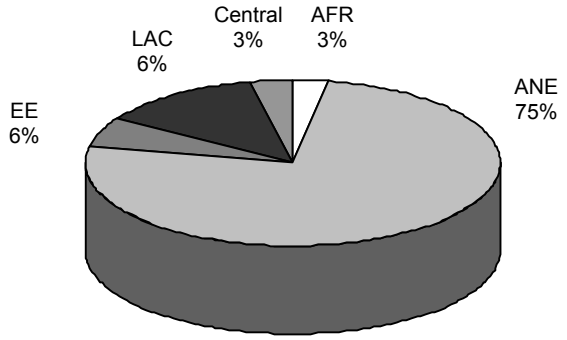
Current Obligations: Key Findings

The analysis estimated that USAID obligated a total of $406 million on water-related activities in FY 2000 (Table ES.1). Approximately 75% of these obligations were allocated to the ANE Bureau ($306 million), with lesser amounts obligated to the Bureau for Latin America and the Caribbean Region (LAC) ($51 million or 13%), the Bureau for Europe and Eurasia (EE) ($23 million or 6%), the Bureau for Africa (AFR) ($11 million or nearly 3%), and Central operating units ($14 million or 3%) (Figure 1.1). This figure also includes nearly $2 million invested by the Water Team across all regions.

Box 1.1
IWRM's Principal Components

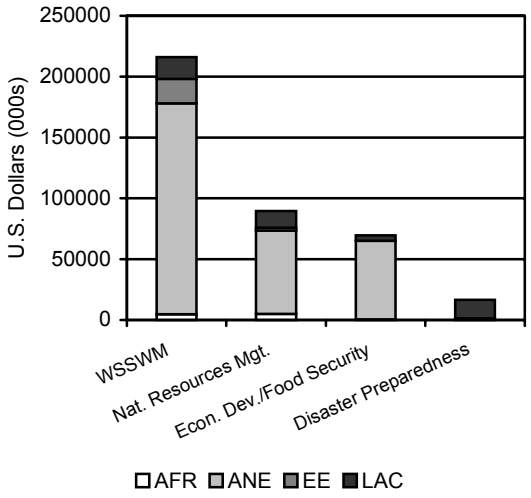
- **Supply optimization,** including assessments of surface and groundwater supplies, water balances, wastewater reuse, and environmental impacts of distribution and use options.
- **Demand management,** including cost-recovery policies, water use efficiency technologies, and decentralized water-management authority.
- **Equitable access** to water resources through participatory and transparent management, including support for effective water users associations, involvement of marginalized groups, and consideration of gender issues.
- **Improved policy, regulatory, and institutional frameworks,** such as the implementation of the polluter-pays principle, water quality norms and standards, and market-based regulatory mechanisms.
- **An intersectoral approach to decision-making**, combining authority with responsibility for managing the water resource.

Figure 1.1
Water-Related Obligations (U.S. Dollars) By Bureau or Operating Unit, FY 2000



Major obligations were allocated to four categories across all Bureaus and operating units: WSSWM ($221 million), Natural Resources Management ($96 million), Economic Development and Food Security ($73 million), and Disaster Preparedness ($17 million) (Figure 1.2). More obligations ($221 million or 54% of the total) were allocated to water resources management activities aimed at protecting human health through WSSWM than any other major category. WSSWM activities addressed Drinking Water Supply ($81 million), Sanitation ($48 million), Wastewater Treatment ($84 million), and Industrial Pollution Control ($8 million).

Figure 1.2
Major Categories of Water-Related Obligations, FY 2000



Of the 475 SOs examined across all operating units, 64 (13%) were determined to contain water-related activities. In terms of absolute numbers, LAC and ANE implemented more water-related SOs than AFR, EE, or Central operating units (Figure 1.3).[7]

Seven SOs were found to be "water" SOs, for which all activities and obligations are allocated to some aspect of water resources management (Box 1.2). These seven totaled $237 million (58% of all water-related obligations) and addressed WSSWM, Natural Resources Management, and Economic Development and Food Security activities (Figure 1.4). None of the seven "water" SOs addressed Disaster Preparedness.

Figure 1.3
Water-Related SOs by Bureau or Operating Unit, FY 2000

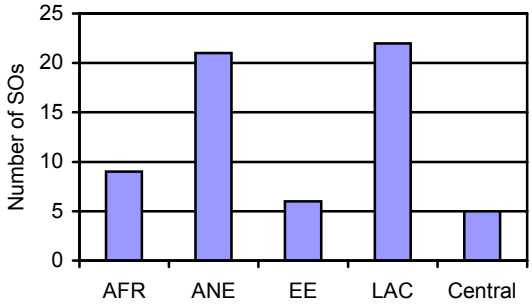
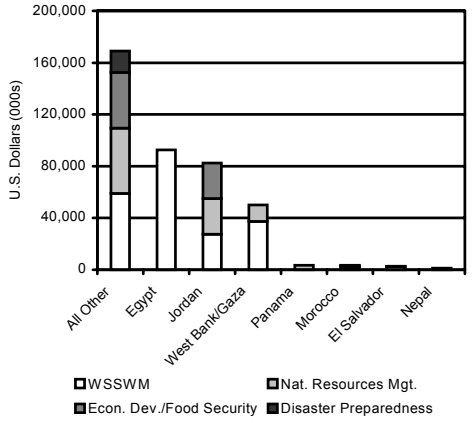


Figure 1.4
Water-Related Obligations for USAID's Seven "Water" SOs, FY 2000



[7] Central operating units include the Agency Water Team; the Center for Economic Growth and Development; the Center for Environment; the Center for Population, Health and Nutrition; and the Office of Foreign Disaster Assistance.

Box 1.2
USAID's Water SOs

Seven SOs obligate 100% of program resources to water resources management, totaling $237 million in USAID's water portfolio for FY 2000.

Asia and Near East

Egypt ($93 million): Improved Delivery of Urban Water Services

Jordan ($83 million): Improved Water Resources Management

West Bank Gaza ($50 million): Greater Access to and More Effective Use of Scarce Water Resources

Morocco ($3.5 million): Improved Water Resources Management in the Souss-Massa River Basin

Nepal ($1 million): Increased Private Sector Participation and Investment in Environmentally and Socially Sound Hydropower

Latin America and Caribbean

Panama ($3.5 million): Sustainable Water Resources Management for Operation of the Panama Canal

El Salvador ($2.7 million): Increased Access by Rural Households to Clean Water

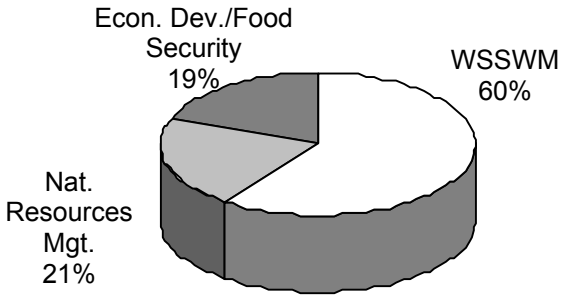
Obligations to Egypt, Jordan, and West Bank/Gaza Operating Units

In addition to Agency-wide analysis, this report separately examines the obligations directed to three operating units that account for nearly 66% ($268 million) of USAID's investment in water-related activities in FY 2000: Egypt ($129 million), Jordan ($83 million), and West Bank/Gaza ($56 million). The dominance of these three programs makes it difficult to appreciate expenditure trends across the other USAID operating units engaged in water-related activities around the world. A disaggregated analysis permits a clearer view of both the geographic location and type of activity in which the majority of Missions and other Agency units are engaged. Figures both with and without obligations for Egypt, Jordan, and West Bank/Gaza will therefore be provided throughout the remainder of this chapter on FY 2000 obligations in each of the four major water-related activity categories (WSSWM, Natural Resources Management, Economic Development and Food Security, and Disaster Preparedness).

Key Findings

Within the three operating units with the most allocations (Egypt, Jordan, and West Bank/Gaza), funds were obligated to WSSWM (60%), Natural Resources Management (21%), and Economic Development and Food Security (19%) activities (Figure 1.5), while no obligations were allocated to the Disaster Preparedness category. While infrastructure-related WSSWM activities dominated in both Egypt and West Bank/Gaza, obligations were more evenly divided across activity areas in Jordan.

Figure 1.5
Water-Related Obligations (U.S. Dollars)
By Major Category
For Egypt, Jordan, and West Bank/Gaza,
FY 2000



In general, obligations from all Bureaus are somewhat more evenly distributed across activity categories after removing Egypt, Jordan, and West Bank/Gaza from the analysis (Figure 1.6). WSSWM receives 44% ($60 million) of remaining obligations, Natural Resources Management receives 28% ($39 million), Economic Development and Food Security receives 16% ($22 million), and Disaster Preparedness accounts for 13% (nearly $17 million).

Within regions, different patterns are apparent after removing Egypt, Jordan, and West Bank/Gaza from the analysis (Figure 1.7). In some places, WSSWM obligations predominate. For example, 89% ($20 million) of the total EE water-related portfolio is dedicated to this area. In other regions, different activities emerge as priorities, as in the 44% ($5 million) of AFR obligations allocated to Natural Resources Management, or the 30% ($15 million) of investment in Disaster Preparedness in the LAC region devoted almost entirely to post-reconstruction activities of one extreme event in 1998, Hurricane Mitch.

Figure 1.6
Water-Related Obligations (U.S. Dollars)
By Major Category, FY 2000
(less Egypt, Jordan, and West Bank/Gaza)

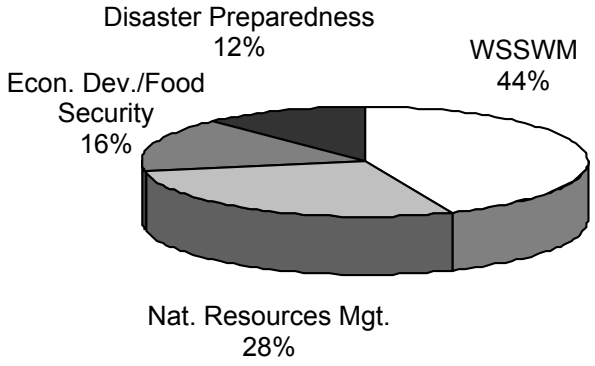
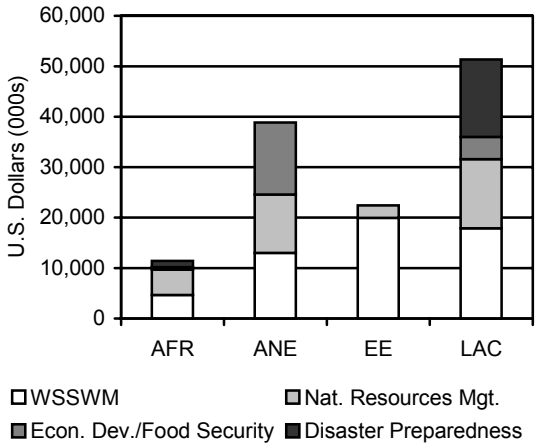


Figure 1.7
Water-Related Obligations by Regional Bureau, FY 2000
(less Egypt, Jordan, and West Bank/Gaza)



Water Supply, Sanitation, and Wastewater Management

The WSSWM category addresses the provision of clean, adequate supplies of drinking water to rural and urban communities, and the promotion of practices that protect these supplies from contamination by improper handling of domestic water supplies, household waste, inadequate sanitation, and industrial and urban pollution. Water-related obligations in WSSWM are assigned to the subcategories of Drinking Water Supply, Sanitation, Wastewater Treatment (Domestic), and (Industrial) Pollution Control.[8]

A large proportion of the activities captured by the WSSWM designation was traditionally assigned to new management systems (NMS) budget codes addressing urban environmental management (under the NMS primary code EVUM and related secondary codes[9] employed by USAID prior to 1999).[10] These activities support the sustainable management of urban areas, including development of housing and municipal finance systems that involve water delivery, building capacity of local governments and private sector entities to deliver potable water and sanitation services, and reducing or minimizing the generation and spread of liquid waste from industrial, municipal, or household sector activities. Water-related activities under WSSWM do not include medical treatment of waterborne disease.

A major distinction between the current categorization used here and the NMS budget coding system concerns water supply and sanitation systems in rural areas. This analysis reports both urban and rural obligations for drinking water supply and sanitation in the same category, while the NMS code EVUM refers to activities in urban areas only.

It is important to note that emergency water and sanitation activities involving the provision of water containers, trucks carrying drinking water, and portable latrines to displaced peoples in temporary settlements are not included in this analysis (e.g., assistance to refugees in Angola under SO1 of the USAID/Angola Strategic Framework). Water and sanitation assistance is, however, included for Bosnia-Herzegovina in this study, since programs help refugees returning to their original homes rebuild water supply and sewerage systems (see Table 1.1 for a detailed description of activities).

[8] See Annex B for the complete three-tiered hierarchy of water-related categories used in this study. Obligations are assigned to only first- and second-level categories.

[9] See Annex C for a comparison of NMS codes and activities relevant to the water-related categories used in this study.

[10] Categories used in this report are compared to the older NMS coding system, since many readers are familiar with how the Agency traditionally categorized activities.

Table 1.1
Illustrative Strategic Objectives associated with major water-related obligations in WSSWM— by operating unit

Operating Unit and Strategic Objective	Water-Related Obligations FY 2000 (in millions USD)
Egypt **SO6*: Increased Access to Sustainable Water and Wastewater Services.** (SO to be phased out in FY 2000; refer to SpO18 in future years.) Primary Activities: Expanded and improved wastewater utilities through improved decentralized utility management, improved systems, and able staff. Also includes legal and regulatory reform for improved autonomy and commercial management of utilities. *(See Box 3.1 – Egypt: Decentralization Enhances Sustainability of Water and Wastewater Services)*	Drinking Water Supply — 31 Sanitation — 31 Domestic Wastewater Treatment — 31
West Bank/Gaza **SO2*: Greater Access to and More Effective Use of Scarce Water Resources.** **SO8: Improved Community Services.** Primary Activities: Construction or development of large-scale production wells, reservoirs, booster stations, force mains, pump stations, and sewer lines; and financing of water distribution systems (related programs: Gaza Wastewater Project and Palestinian-American Friendship Park).	Drinking Water Supply — 25 Domestic Wastewater Treatment — 13 Sanitation — 3
Jordan **SO2*: Improved Water Resources Management.** Primary Activities: Increased capacity to treat wastewater to national standards for irrigation; improvements in wastewater treatment plants; wastewater tariffs; water utility financial counsel; establishment of new management contracts for water and wastewater systems; water or wastewater BOT contracts; improvements in contract process from prequalification to construction; measures introduced to reduce groundwater depletion; rehabilitation of contaminated springs and wells; restructuring/rehabilitation of water networks to decrease leakage.	Domestic Wastewater Treatment — 28
Kosovo **SO3.1: Community Services and Facilities.** **Supplemental SEED appropriation for infrastructure rehabilitation and community development activities.** Primary Activities: Rebuilding municipal water systems.	Drinking Water Supply — 6 Sanitation — 6
Bosnia-Herzegovina **SO3.1: Recovery from Crisis.** Primary Activities: Rebuilding municipal water systems.	Drinking Water Supply — 6
USAEP **SO1: Sustained Impact on the Key People, Institutions, and Forces which Drive the Movement to a Clean Revolution in Asia.** Primary Activities: Improved public policy and environmental regulation; improved urban environmental management; improved corporate governance and environmental management; and increased transfer of U.S. environmental technology, expertise, and practices to Asia through trade and investment.	Drinking Water Supply — 1 Sanitation — 2 Domestic Wastewater Treatment — 2

Operating Unit and Strategic Objective	Water-Related Obligations FY 2000 (in millions USD)
El Salvador **SO3: Sustainable Improvements in Health of Women and Children Achieved.** **SO4*: Increased Access by Rural Households to Clean Water.** Primary Activities: Improved citizen action in the management of local water projects; improved local capacity to manage decentralized water systems and household waste for the protection of water quality. *(See Box 2.2 – Coupling Sanitation with Governance in Small Towns.)*	Drinking Water Supply — 1 Sanitation — 2 Domestic Wastewater Treatment — 2
South Africa **SO6: Increased Access to Environmentally Sustainable Housing and Urban Services for the Historically Disadvantaged Population.** Primary Activities: Improved water and sewerage services, including improved administrative capacity; enhanced public-private partnerships; community participation; and decentralization of utility management. *(See Box 3.4 – South African Municipalities Reap Multiple Benefits from Commercially Viable Water Systems.)*	Drinking Water Supply — 1 Sanitation — 1 Domestic Wastewater Treatment — 1
Ecuador **SpO11: Improvement of Social and Economic Conditions of Ecuador-Peru Border Area Inhabitants.** Primary Activities: Improved delivery of water supply and sanitation services.	Drinking Water Supply — 2 Sanitation — 1
India **SO4: Increased Environmental Protection in Energy, Industry and Cities.** Primary Activities: Municipal bond projects to help finance water and sanitation services; private sector participation in water and sanitation projects with a focus on the urban poor; improvements in the efficient use of water and energy resources while addressing GHG pollution and health issues associated with degraded water supply (related projects are Development Credit Program [DCP]; Financial Institutions Reform and Expansion [FIRE]; and South Asia Regional Initiative on Energy [SARI]). *(See Box 3.3 – India: Project FIRE.)*	Drinking Water Supply — 1 Sanitation — 1 Domestic Wastewater Treatment — 1

* "Water" SO

Key Findings

USAID obligated nearly $221 million for water-related activities in WSSWM (Table 1.3), which amounted to 54% of all water-related obligations in FY 2000. Obligations were allocated among WSSWM subcategories as follows: 37% for Drinking Water Supply ($81 million), 22% for Sanitation ($48 million), 38% for Wastewater Treatment (domestic) ($84 million), and 3% for Pollution Control (other than sewage and domestic wastes, such as from industry) ($8 million) (Figure 1.8).

Some 73% ($161 million) of all WSSWM obligations were allocated to Egypt ($93 million or 43%), Jordan ($28 million or 12%), and West Bank/Gaza ($40 million or 18%) (Figure 1.9), while the remaining 27% ($57 million) were allocated to other operating units. Egypt's SO2, Improved Delivery of Urban Water Services (Table 1.1), received more water-related obligations than any other strategic objective in the Agency,[11] allocating some $93 million to expanded and improved water and wastewater services to municipalities. Related activities included financial reform for the water utility sector, improvements in wastewater treatment, and capacity building for decentralized utility management.

[11] See *Box 3.1, Egypt: Decentralization Enhances Sustainability of Water and Wastewater Services,* for a description of the activities afforded Egypt by these obligations.

Table 1.2
USAID obligations (in thousands of U.S. dollars) for water-related activities in WSSWM, FY 2000

	AFR	ANE	EE	LAC	Central	TOTAL
WSSWM	**4,680**	**173,447**	**19,947**	**17,883**	**4,642**	**220,599**
Drinking Water Supply	1,360	59,532	10,000	7,551	2,209	80,652
Sanitation	2,160	34,832	5,661	3,601	2,209	48,463
Wastewater Treatment (Domestic)	1,160	76,000	4,000	2,416	224	83,800
Other Pollution Control	0	3,083	286	4,316	0	7,685

Figure 1.8
WSSWM Obligations (U.S. Dollars)
By Subcategory, FY 2000
(All Operating Units)

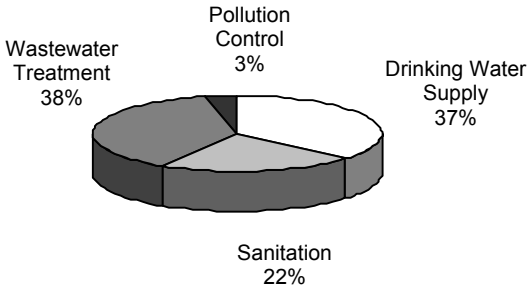
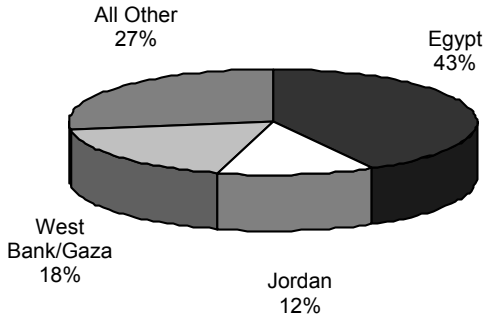


Figure 1.9
WSSWM Obligations (U.S. Dollars)
By Subcategory
For Egypt, Jordan, and West Bank/Gaza, FY 2000



An analysis by Regional Bureau of WSSWM obligations *excluding* Egypt, Jordan, and West Bank/Gaza reveals significant obligations allocated to EE and LAC Bureaus (Figure 1.10 and Table 1.1). Primary recipients of EE health aid were Kosovo ($12 million) and Bosnia-Herzegovina ($6 million) to help rebuild damaged water delivery systems (Figure 1.11). Approximately $5 million were allocated to USAEP to promote the application of U.S. technology and business services in drinking water supply and wastewater treatment to developing Asian countries. Another $5 million were allocated to El Salvador for water supply and sanitation improvement, as well as smaller amounts to South Africa, Ecuador, and India for urban and rural community water services.

Figure 1.10
WSSWM Obligations
By Regional Bureau, FY 2000
(less Egypt, Jordan, and West Bank/Gaza)

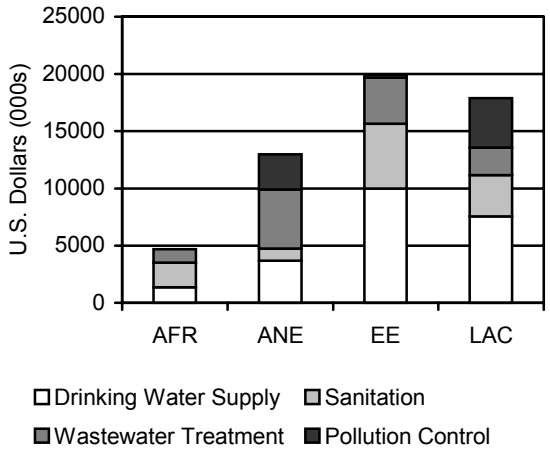
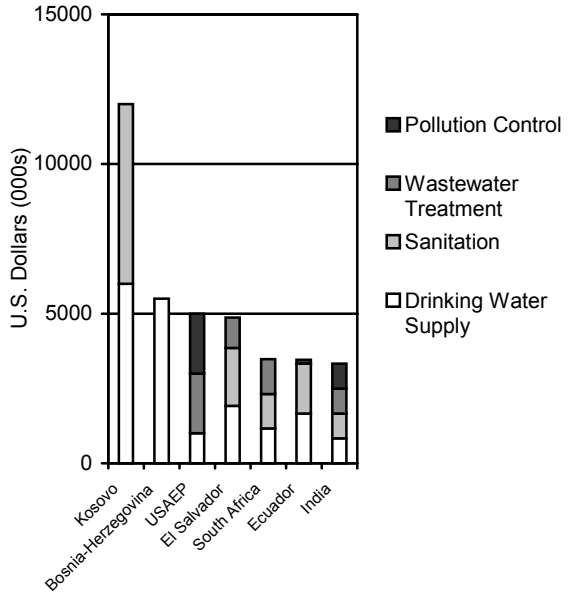


Figure 1.11
Major Recipients of WSSWM Obligations, FY 2000
(after Egypt, Jordan, and West Bank/Gaza)



Natural Resources Management

The Natural Resources Management category addresses a variety of activities aimed at promoting sustainable development in concert with the protection of ecological services in coastal zones, freshwater ecosystems, and whole river basins or watersheds. In coastal zones, these include community participation in the management of local natural resources, biodiversity conservation of coral reefs, ecotourism, marine protected areas, control of pollution and environmental degradation, and related training or capacity building. In freshwater ecosystems activities involve aquatic and wetland protected areas, biodiversity conservation in aquatic habitats, and sustainable management of ecosystem health. Activities in whole basins or watersheds address stakeholder involvement; best management practices for water and land use; transboundary resources management; and related policy development, training, or capacity building. Water-related obligations in Natural Resources Management are assigned to the subcategories of Coastal Zone Management; Freshwater Ecosystems Management; and Watershed Management and IWRM.[12]

Most of these activities have traditionally been assigned to budget codes addressing sustainable natural resources management (NMS primary code EVNR and related secondary codes).[13] Included are activities that support the sustainable use and protection of natural resources, including trees, forests, and non-timber forest products; water, wetlands, coastal, coral reef, and other marine resources; soil and land productivity; and natural habitat and ecosystems. Some activities were traditionally assigned to the primary NMS code EVCB, Conservation of Biological Diversity. Included are activities designed primarily to support the conservation and sustainable use of marine and aquatic biological diversity by identifying needs; by designing, implementing, and monitoring conservation and management actions; through research and training; or through institutional strengthening, policy interventions, and program development.

Key Findings

USAID obligated nearly $96 million for water-related activities in Natural Resources Management (Table 1.3), which amounted to 24% of all water-related obligations in FY 2000. Obligations were allocated among subcategories as follows: 66% for Watershed Management and IWRM ($63 million), 33% for Coastal Zone Management ($32 million), and 1% for Freshwater Ecosystems Management (over $1 million) (Figure 1.12).

Approximately 60% ($58 million)[14] of all obligations for Natural Resources Management were allocated to Egypt ($17 million or 18%), Jordan ($28 million or 29%), and West Bank/Gaza

[12] See Annex B for the complete three-tiered hierarchy of water-related categories used in this study. Obligations are assigned to only first- and second-level categories.

[13] See Annex C for a comparison of NMS codes and activities relevant to the water-related categories used in this study.

[14] This $58 million figure for water obligations in Natural Resources Management does not include $750,000 obligated by the ANE Bureau for the FORWARD Project on conflict resolution for the equitable allocation of scarce water resources in the Middle East. (See Box 3.3, USAID Fosters Stakeholder Involvement through the FORWARD Project).

($13 million or 13%) (Figure 1.13). Although more than half of all water obligations for Natural Resources Management were allocated to three operating units in the Middle East, the funds were used to support very different types of activities in Egypt compared with Jordan and West Bank/Gaza. Obligations supported sustainable management of the Red Sea marine parks and resources for enhanced ecotourism in Egypt, while in Jordan and West Bank/Gaza funds were obligated for best management practices for conservation and IWRM in river basin planning and policy development. This example as well as others discussed in text boxes that occur throughout Part II of this report (see references in Table 1.4) help illustrate the diversity of activities addressed by the Natural Resources Management category designation.

An analysis by Regional Bureau of Natural Resources Management obligations—excluding Egypt, Jordan, and West Bank/Gaza—reveals other obligations allocated to AFR, ANE, EE and LAC Bureaus, primarily in Watershed Management/IWRM and Coastal Zone Management (Figure 1.14). Seven operating units (Indonesia, Center for Economic Growth and Agricultural Development, Panama, Ecuador, the Philippines, the Water Team, and Jamaica) received between $1 and $5 million each for Watershed Management/IWRM and Coastal Zone Management (Figure 1.15). Approximately $1 million was obligated to Uganda for control of the invasive water hyacinth weed in Lake Victoria.

Table 1.3
USAID obligations (in thousands of U.S. dollars) for water-related activities in Natural Resources Management, FY 2000

	AFR	ANE	EE	LAC	Central	TOTAL
Natural Resources Management	**4,981**	**68,434**	**2,447**	**13,681**	**6,310**	**95,853**
Watershed Management and IWRM	2,514	44,170	2,447	9,541	4,405	63,077
Coastal Zone Management	1,467	24,264	0	3,943	1,905	31,579
Freshwater Ecosystems Management	1,000	0	0	197	0	1,197

Table 1.4
Illustrative Strategic Objectives associated with major water-related obligations in Natural Resources Management—by operating unit

Operating Unit and Strategic Objective	Water-Related Obligations FY 2000 (in millions USD)
Jordan **SO2*: Improved Water Resources Management.** Primary Activities: Adoption of wastewater reuse plans; improved NGO capacity to conduct water conservation programs; establishment of water user authorities; enhanced pollution policy. *(See Box 4.3 – Jordan: Integrated Activities Manage Scarce Water Resources for Multiple Sectors and Box 5.4 – Jordan: Slowing Aquifer Depletion through Water Reuse.)*	Watershed Management/IWRM — 28

Operating Unit and Strategic Objective	Water-Related Obligations FY 2000 (in millions USD)
Egypt **SO1: Management of the Environment and Natural Resources in Targeted Sectors Improved.** Primary Activities: Improvements in policies and institutions to guide sustainable tourism growth while protecting the natural resources base of the Red Sea and Gulf of Aqaba; coral reef preservation, mooring installations, and environmental training and awareness for park rangers and tourism developers in EIA regulations.	Coastal Zone Management — 17
West Bank/Gaza **SO 2*: Greater Access to and More Effective Use of Scarce Water Resources.** Primary Activities: Adoption of wastewater reuse plans; improved NGO capacity to conduct water conservation programs; establishment of water user authorities; improvements in understanding management of the principal aquifers via aquifer and well monitoring (related programs: Coastal Aquifer Management Program [CAMP]; Integrated Aquifer Protection Program.) *(See Box 5.2 – West Bank/Gaza: Sharing Data on Groundwater Supply in Regions of Conflict.)*	Watershed Management and IWRM — 13
Indonesia **SO8: Strengthened and Decentralized Natural Resources Management.** Primary Activities: Enhanced community participation in decision making for local management of natural resources; establishment of community-managed parks and reserves; environmental policy development. *(See Box 7.1 – Indonesia: Demonstrating Keys to Success in a Coastal Zone Management Program and Box 8.1 – Community-Based Marine Sanctuaries in Indonesia.)*	Coastal Zone Management — 4
Center for Economic Growth and Agricultural Development **SO2: Improved Food Availability, Economic Growth and Conservation of Natural Resources through Agricultural Development** **SO7: Increased Science and Technology Cooperation among Middle Eastern and Developing Countries, and Utilization of U.S. and Israeli Technical Expertise by Developing Countries** Primary Activities: Implementation of best management practices; coastal zone management and ecotourism of the Red Sea Marine Peace Park.	Watershed Management and IWRM — 3 Coastal Zone Management— 1
Panama **SO1*: Panama Sustainably Manages the Canal Watershed and Buffer Areas.** Primary Activities: Implementation of best management practices in Panama Canal Watershed to protect quantity and quality of water resources used to operate the canal facility. *(See Box 4.2 – Panama: Upper Watershed Management Ensures Proper Function of the Panama Canal.)*	Watershed Management and IWRM — 4
The Philippines **SO4: Environmental Resources Management Improved.** Primary Activities: Fostering community-based, integrated coastal resources management; marine protected areas, awareness campaigns in best management practices; community monitoring for coral reef biodiversity conservation.	Coastal Zone Management — 2
Ecuador **SO1: Biodiversity Conserved in Selected Protected Areas and Their Buffer Zones.** Primary Activities: Improved management of the Galapagos Marine Reserve through improved legislation and strengthened NGOs.	Coastal Zone Management — 2

Operating Unit and Strategic Objective	Water-Related Obligations FY 2000 (in millions USD)
Uganda **SO2: Critical Ecosystems Conserved to Sustain Biological Diversity and to Enhance Benefits to Society.** Primary Activities: Water hyacinth weed removal; introduction of biological control agents to combat infestation; monitoring. *(See Box 9.1 – Uganda: Protecting the Lake Victoria Ecosystem from Aquatic Weeds.)*	Freshwater Ecosystems Management — 1

* "Water" SO

Figure 1.12
Natural Resources Management Obligations
(U.S. Dollars)
By Subcategory, FY 2000
(All Operating Units)

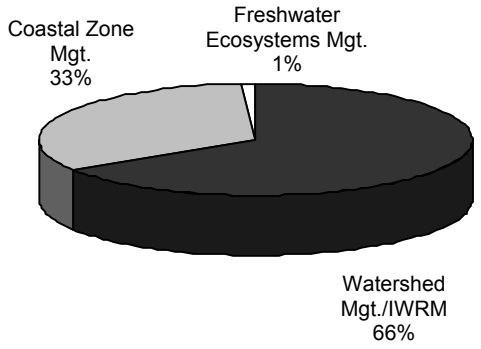


Figure 1.13
Natural Resources Management Obligations
(U.S. Dollars)
By Subcategory, FY 2000
For Egypt, Jordan, and West Bank/Gaza

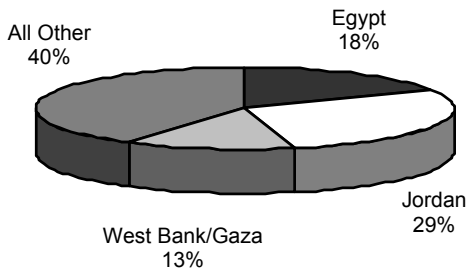


Figure 1.14
Natural Resources Management Obligations
By Regional Bureau, FY 2000
(Less Egypt, Jordan, and West Bank/Gaza)

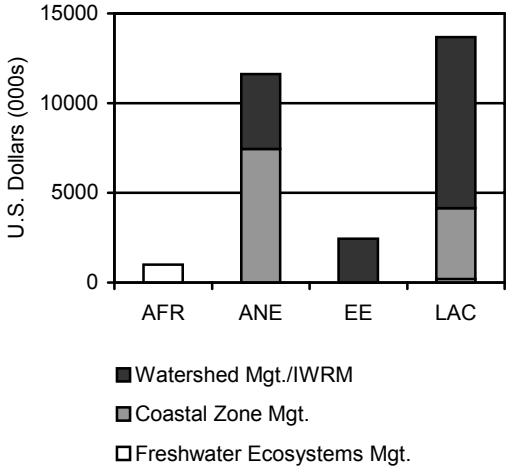
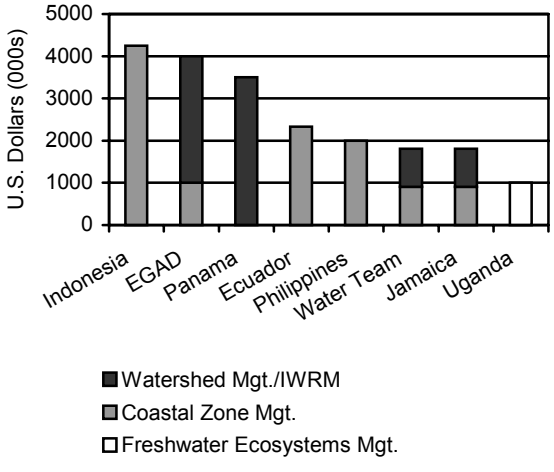


Figure 1.15
Major Recipients of Natural Resources Management Obligations, FY 2000
(After Egypt, Jordan, and West Bank/Gaza)



Economic Development and Food Security

The Economic Development and Food Security category addresses activities aimed at promoting equitable economic growth. Activities focus on effective means of bringing poor, disadvantaged, and marginalized groups into the mainstream of an expanding economy, and promote the development of capabilities to enable countries to meet their own demands for food supply. Water-related obligations in Economic Development and Food Security are assigned to the subcategories of Fisheries, Mariculture, and Aquaculture; Irrigation and Agriculture; and Hydropower (mostly small scale).[15] Most of these activities have traditionally been assigned to NMS budget codes addressing agricultural resources management.[16]

Key Findings

USAID obligated $73 million for water-related activities in Economic Development and Food Security during FY 2000 (Table 1.5), which amounted to 18% of all water-related obligations in FY 2000. Obligations were allocated among subcategories as follows: 22% for Fisheries, Mariculture, and Aquaculture; 76% for Irrigation and Agriculture; and nearly 2% for Hydropower (Figure 1.16). The subcategory of Irrigation and Agriculture accounted for most of the obligations in the Economic Development and Food Security category ($55 million).

Nearly 69% ($50 million) of all obligations for this category were allocated to Jordan ($28 million or nearly 38%), Egypt ($19 million or 27%), and West Bank/Gaza ($3 million or 4%) (Figure 1.17), while 31% ($22 million) were allocated to other operating units. An analysis by Regional Bureau of obligations—excluding Egypt, Jordan, and West Bank/Gaza—reveals other obligations allocated primarily to Missions in ANE and LAC Bureaus (Figure 1.18).

Major recipients of funds (excluding Jordan, Egypt, and West Bank/Gaza) were Bangladesh, Colombia, G/EGAD, the Philippines, Nepal, and Bolivia (Figure 1.19). Approximately $10 million support the Management of Aquatic Ecosystems through Community Husbandry (MACH) Program in Bangladesh for fisheries and aquaculture (Table 1.6). The activities highlighted in Box 10.3, Colombia: Using Aquaculture as an Alternative to Illicit Crop Production, illustrate how water resources management permeates a wide range of USAID programs across a variety of sectors and human assistance needs, not all of which appear to be water related. About $1 million were allocated to Nepal for the development of environmentally and socially sound hydropower, and support activities represented by one of USAID's seven "water" SOs.[17]

[15] See Annex B for the complete three-tiered hierarchy of water-related categories used in this study. Obligations are assigned to only first and second-level categories.

[16] See Annex C for a comparison of NMS codes and activities relevant to the water-related categories used in this study.

[17] Nepal's SO4: Increased private sector participation and investment in environmentally and socially sound hydropower.

Table 1.5
USAID obligations (in thousands of U.S. Dollars) for water-related activities in Economic Development and Food Security, FY 2000

	AFR	ANE	EE	LAC	Central	TOTAL
Economic Development and Food Security	**541**	**64,512**	**0**	**4,445**	**3,100**	**72,598**
Irrigation	541	51,512	0	2,653	500	55,206
Fisheries, Mariculture, and Aquaculture	0	11,800	0	1,625	2,600	16,025
Hydropower (small-scale)	0	1,200	0	167	0	1,367

Figure 1.16
Economic Development/Food Security Obligations (U.S. Dollars) By Sub-Category, FY 2000 (All Operating Units)

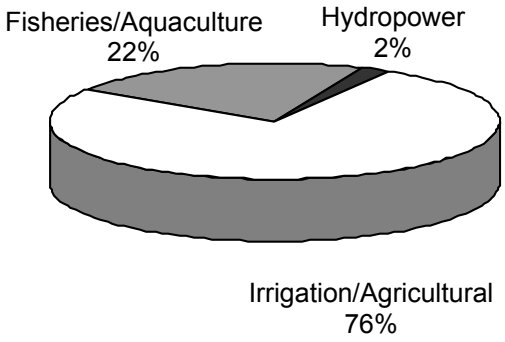


Figure 1.17
Economic Development/Food Security Obligations (U.S. Dollars) By Sub-Category, FY 2000 For Egypt, Jordan, and West Bank/Gaza

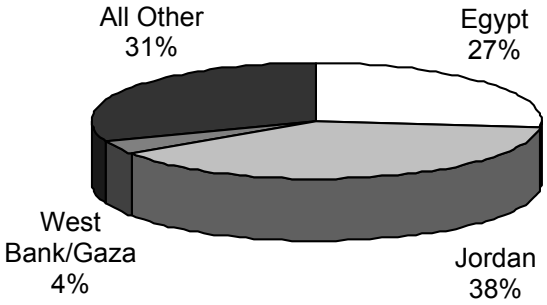


Figure 1.18
Economic Development/Food Security Obligations By Regional Bureau, FY 2000 (Less Egypt, Jordan, and West Bank/Gaza)

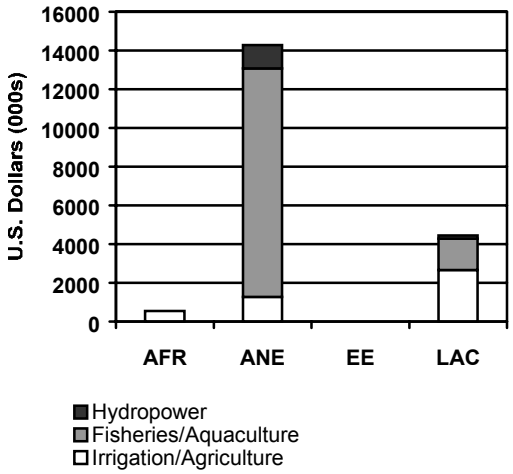


Figure 1.19
Major Recipients of Economic Development/Food Security Obligations, FY 2000 (After Egypt, Jordan, and West Bank/Gaza

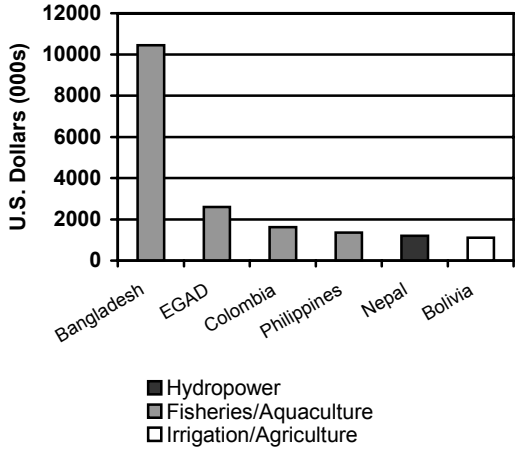


Table 1.6
Illustrative Strategic Objectives associated with major water-related obligations in Economic Development and Food Security—by operating unit

Operating Unit and Strategic Objective	Water-Related Obligations FY 2000 (in millions USD)
Jordan **SO2*: Improved Water Resources Management.** Primary Activities: Sustainable groundwater withdrawal policies; policy to encourage optimized use of treated wastewater for irrigation; irrigation tariffs restructured to reflect differences in quality; increased technical efficiency in irrigation.	Irrigation/Agriculture — 28
Egypt **SO1: Management of the Environment and Natural Resources in Targeted Sectors Improved.** Primary Activities: Improved and/or expanded irrigation practices.	Irrigation/Agriculture — 19
Bangladesh **SO6: Improved Management of Open Water and Tropical Forest Resources.** Primary Activities: Improved fisheries management for food production (related program: Management of Aquatic Ecosystems through Community Husbandry [MACH]).	Fisheries — 10
West Bank/Gaza **SO8: Improved Community Services.** Primary Activities: Improved irrigation systems.	Irrigation/Agriculture — 3
Center for Economic Growth and Development **SO2: Improved Food Availability, Economic Growth, and Conservation of Natural Resources through Agricultural Development.** Primary Activities: Improved aquaculture techniques. *(See Box 10.1 – USAID Supports CGIAR and Box 10.2 – CRSPs Provide Benefits of Cutting-Edge Agricultural Research to Developing Countries.)*	Fisheries — 3
Colombia **SO2: Illicit Crop Production Reduced in Target Areas.** Primary Activities: Promotion of fishpond culture as an alternative source of income for families in target areas. *(See Box 10.3 – Colombia: Using Aquaculture as an Alternative to Illicit Crop Production.)*	Fisheries — 2
The Philippines **SO1: Improved Environmental Resources Management.** Primary Activities: Improvements in best management practices for fisheries as related to the integrated coastal/marine resources management program.	Fisheries — 1
Nepal **SO4*: Increased Private Sector Participation and Investment in Environmentally and Socially Sound Hydropower.** Primary Activities: Institutional strengthening and capacity building in the EIA process for hydropower development.	Hydropower — 1
Bolivia **SO2: Increased Income for Bolivia's Poor with Emphasis on Targeted Communities, Directly or Indirectly Assisted by USAID.** Primary Activities: Title II Program for micro-irrigation to eliminate a critical bottleneck in production and marketing.	Irrigation/Agriculture — 1

* "Water" SO

Disaster Preparedness

The Disaster Preparedness category includes obligations assigned to the two subcategories of Monitoring and Forecasting and Vulnerability Assessment.[18] Most of these activities have traditionally been assigned to budget codes addressing global climate change (NMS primary code EVCC and related secondary codes).[19] Included are activities that support the monitoring of environmental conditions for use in drought and flood prediction, as well as the rebuilding of water delivery systems damaged by natural disasters. The category also includes the transfer of technology and expertise for hydrological monitoring, runoff and storm flow control, and protection of water resources from extreme weather variability and climate change. This category does not include medicinal and food aid delivered in response to droughts, floods, and storms. Emergency funds for provision of potable water and rebuilding irrigation, water, and sanitation systems are included in the appropriate categories in WSSWM and Economic Development and Food Security.

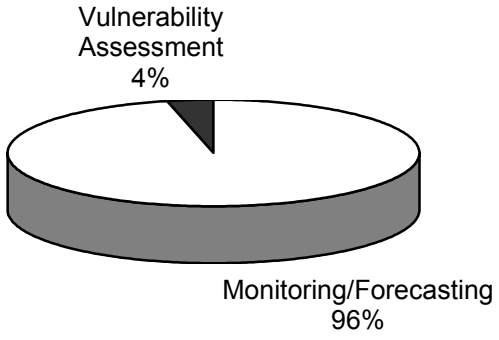
Key Findings

USAID obligated nearly $17 million for water-related activities in Disaster Preparedness during FY 2000 (Table 1.7). These activities amounted to 4% of all water-related obligations in FY 2000 and included $16 million for Monitoring and Forecasting, and $600,000 for Vulnerability Assessment (Figure 1.20). In the aftermath of Hurricane Mitch, in May 1999, Congress approved $621 million in supplemental funding for CACEDRF for FY 1999 and 2000. Approximately $15 million of these funds were obligated in FY 2000 for water-related disaster assistance. In the supplemental, Congress identified specific USG agencies to be involved in the hurricane reconstruction. More than $100 million of the Fund is being implemented with more than a dozen USG agencies through the LAC Regional program.

One of the LAC Regional program objective is to provide hurricane reconstruction service in the LAC region. The majority of assistance is to communities in Honduras, Nicaragua, El Salvador, Guatemala, the Dominican Republic, and Haiti, which are the ultimate customers and beneficiaries of the assistance. Activities focus on disaster mitigation, preparedness and reconstruction, and public health.

Obligations in Disaster Preparedness for FY 2000 support FEWS in the Nile River Basin and throughout sub-Saharan Africa. Substantial allocations have been made to all Bureaus in FY 2001 for hydrological monitoring and forecast systems to support disaster preparedness and natural disaster reconstruction activities in future years of assistance.

Figure 1.20
Disaster Preparedness Obligations
(U.S. Dollars)
By Subcategory, FY 2000
(All Operating Units)



[18] See Annex B for the complete three-tiered hierarchy of water-related categories used in this study. Obligations are assigned to only first- and second-level categories.

[19] See Annex C for a comparison of NMS codes and activities relevant to the water-related categories used in this study.

Table 1.7
USAID obligations (in thousands of U.S. Dollars) for water-related activities in Disaster Preparedness, FY 2000

	AFR	ANE	EE	LAC	Central	TOTAL
Disaster Preparedness	**1,200**	**0**	**0**	**15,331**	**0**	**16,531**
Monitoring and Forecasting	600	0	0	15,331	0	15,931
Vulnerability Assessment	600	0	0	0	0	600

Table 1.8
Illustrative Strategic Objectives associated with major water-related obligations in Disaster Preparedness—by operating unit

Operating Unit and Strategic Objective	Water-Related Obligations FY 2000 (in millions USD)
LAC Regional Bureau **SpO16: Hurricane Reconstruction Services in the LAC Region Provided.** Primary Activities: Help communities reduce vulnerability to flooding and landslides in watershed basins through the establishment of monitoring and early warning systems; improve emergency management systems and response capabilities in vulnerable countries; disease forecasting and prevention.	Monitoring/Forecasting — 15

USAID Activity and Global Investment Needs in Water Resources Management

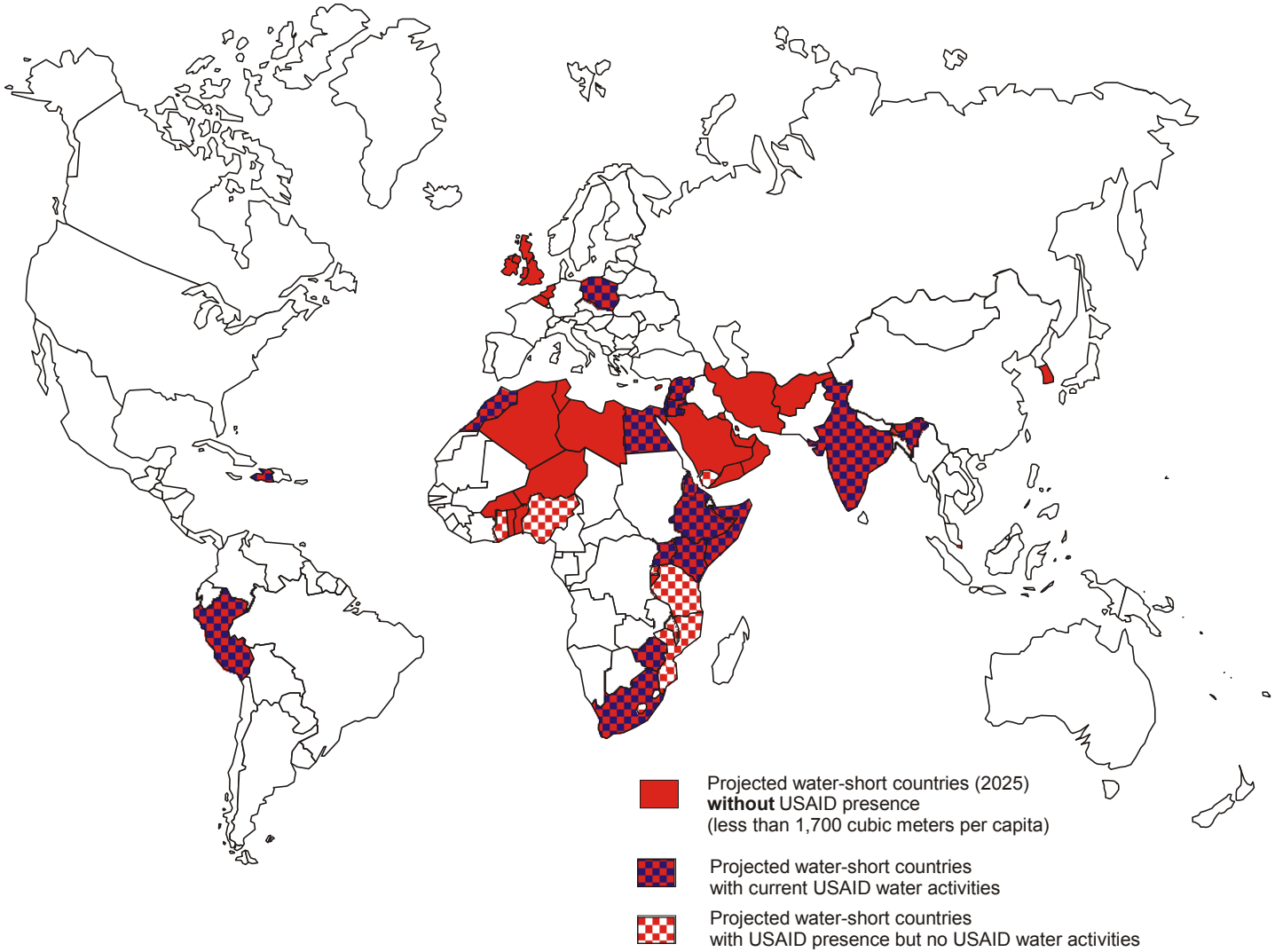
Worldwide demand for water tripled during the past century and is presently doubling every 21 years (Green Cross International, 2000). Clearly, such demand is unsustainable in the long term and will require dramatically new approaches to water resources management to avoid the worst of the looming crisis. Water resource programs typically require 20 years or more to come to fruition, increasing the urgency for building national, regional, and international capacity to anticipate and respond to problems before they reach a crisis state (Seckler et al., 1999).

The alternative scenarios for the future of water resources are driven by many factors, including population growth, economic growth, technological change, social trends, and environmental quality (Cosgrove and Rijsberman, 2000). Economic growth, for example, leads to increased demand for electricity, more industrial output, higher incomes, and greater household use of water. This increased demand can be offset by greater efficiencies—through technological improvement or conservation. However, on a global scale and with all factors combined, increased water demand will overwhelm efficiency gains in the absence of other societal changes, such as the harmonization of cross-sectoral policies and management systems to ensure the most productive use of existing water resources.

The same driving forces behind water scarcity are also causing critical water quality problems in many places. Due to lack of good quality data, most global assessments have not quantified the worldwide water quality crisis, but some experts estimate that at least 90% of all domestic wastewater is discharged without any treatment at all worldwide.

As stated earlier, the pressure on water resources will grow significantly for more than 60% of the world's population, including large areas of Africa, Latin America, and Asia. Of the 31 countries (with a combined population of 458 million) that faced water scarcity or water stress in 1995, USAID is currently engaged in water-related activities in only 11 (Map 1.2). This represents $271 million in USAID water-related assistance to countries with a combined current population of 238 million (52%

Map 1.2 USAID water resources management in projected water-short countries (2025). As their populations grow, more and more countries are facing water shortages. Water-short countries are those with annual water resources less than or equal to 1,700 cubic meters per person. Calculations of water shortage are based on estimates of a country's renewable freshwater supplies and do not include water withdrawn from fossil groundwater. They also do not reflect variations in temporal and spatial distribution of precipitation and water supply that exist in many countries not identifi ed as water-short using this definition. Once a country experiences extreme water scarcity, it can expect chronic shortages of freshwater that threaten food production, hinder economic development, and damage ecosystems. (Data source: Gardner, Outlaw and Engelman, *Sustaining water, easing scarcity: A second update,* Washington, D.C., Population Action International, 1997, as adapted from Hinrichsen et al. 1998 (1) with USAID Water Team Data)



of the 458 million people facing water scarcity or stress).

Looking towards the future, of the 48 countries (with a combined population of more than 2.8 billion) expected to face water scarcity or water stress in 2025, USAID is currently engaged in water-related activities in only 16. This represents $280 million in USAID water-related assistance to countries with a combined projected 2025 population of 1.8 billion (66% of the population projected to face water scarcity or stress). Worldwide, as this report describes, USAID invested more than $406 million in water-related activities during FY 2000.

The above projections for people and countries facing future water shortages are based solely on physical water scarcity, or the per capita availability of water, based on projected population growth and water withdrawal rates. (See Table 1.9, which lists water-short countries in 2025 where USAID currently supports water-related activities, at the end of this chapter.) In addition to these countries, there are many countries that face economic water scarcity.[20] While such countries may have sufficient water resources, they will need to invest in significant storage, treatment, distribution, and other service infrastructure to avoid falling below the water-short threshold.[21]

The USAID obligation figures compare with World Water Council estimates that $70-$80 billion (excluding direct investment by industry) is currently invested each year to provide water services. The largest investors by far are governments at $50 billion per year, followed by the private sector at around $15 billion (dominated by small vendors servicing municipal utilities). International donors invest roughly $9 billion annually (Cosgrove and Rijsberman, 2000).

There was almost universal agreement at the Second World Water Forum in the Hague that investment in water services must be significantly increased to avert a global water crisis. For example, the World Bank estimates that an additional $60-$80 billion per year over today's spending levels is needed to provide basic water supply and sanitation for the world's population. The Global Water Partnership calls for investments of an additional $180 billion per year, or $4.5 trillion over the next 25 years, to achieve global water security in the broadest sense, including water supply and sanitation, reduced risk from floods, increased agricultural water productivity, and health of freshwater ecosystems (Global Water Partnership, 2000).

Increased Effectiveness of Agency Water Programs

As USAID considers how to best address water resources management in the future, questions related to where we work, what type of activities we undertake, and how water-related work is designed and implemented will have to be answered. Regarding the geographic area of focus, this study has identified many areas of the world where a water crisis is already present or imminent, and where USAID currently has no activities at all in the water sector. Some of these places may present opportunities for USAID to fill a clearly identified need in a way that takes advantage of the Agency's comparative strength. In other places USAID can effectively engage in partnerships with the private sector, NGOs, academia, and/or other donors to address water quantity or quality problems in an integrated and effective way.

As for technical and sectoral areas of focus, USAID's current portfolio and expenditures reveal that Agency operating units are engaged in the broadest spectrum of water resources management activities spread across all sectors. USAID activities in every sector manifest the important role that water resources play in fostering Agency goals in economic development, human health, ecological sustainability, and conflict prevention. Further-

[20] Whereas some arid and semi-arid countries face actual (physical) water scarcity, several countries that are relatively more "water-rich" will nevertheless face scarcity too if they cannot find the economic means to develop their water resources to meet growing demand. This situation is known as "economic water scarcity."

[21] Considerable effort has been made to refine projections based on both physical and economic water scarcity, and interested persons are encouraged to refer to the World Water Vision (Cosgrove and Rijsberman, 2000) published by the World Water Council for a view of how such factors play out in different scenarios within varying contexts of technology, economics, private sector involvement, and other societal norms and policies.

more, spending is fairly evenly divided across different sectors of water-related activity within USAID, with WSSWM-related obligations dominating in the three largest programs in the Middle East.

Finally, and most importantly, USAID shares in the global consensus that the approaches promoted through IWRM[22] offer the best hope for achieving greater effectiveness, efficiency, and sustainability in water resources management. Several IWRM principles emerge as the foundation for greater Agency effectiveness in water resources management, and include the following.

- An integrated, cross-sectoral, and participatory approach is the preferred strategy for successful water resources management in the long term.
- Greater attention should be focused on the use of sound science to determine the water budget at the basin scale.
- Water resources must be managed at the appropriate scale (either basin or sub-basin) and level (international, national, provincial, or local) to ensure ecosystem integrity and cooperation over shared resources.
- Participatory planning and transparent decision making should be instilled to enhance political will, self-reliance, and stewardship by relevant stakeholders.
- Water should be treated as both an economic good *and* a basic human need, with the simultaneous goals of full cost recovery for water services and targeted subsidies for the poorest of the poor.
- Countries should be encouraged to adopt the "users and polluters pay principle."
- Water allocation mechanisms must increasingly encompass environmental and human use values.
- Infrastructure and water service delivery should be demand-driven and service-oriented, with every opportunity explored for public-private partnership.

The present analysis of activities shows that USAID operating units are already doing many things right, and are working in line with several IWRM principles. Activities at all stages of the IWRM planning and implementation cycle are being undertaken by USAID around the world, through the promotion of sound information and analysis, participatory governance, and effective site-based practices.[23]

At the same time, the analysis reveals that water resources are still often viewed primarily through the lens of a single sector of use within USAID. Many activities focus on water resources management for a single desired end, e.g., human water supply, agricultural production, or the sustainability of ecosystem services. While such activities can be very successful in their own right, they may miss opportunities for integrated and sustainable management that satisfy many human and ecological uses simultaneously, and enhance the sustainability of them all. Indeed, even where USAID does not undertake activities directly related to water resources, operating units may find it useful to factor in the role of water resources in their other programs, and adopt integrated planning for activities that may be affected by growing scarcity or declining quality of the resource.

As USAID proceeds into the new millennium, the Water Team will work with operating units in the field and in Washington to advance USAID's collective understanding about the most effective approaches to IWRM at all scales. It is our hope that the present analysis of Agency activities, along with the detailed highlights and thematic discussions provided in Part II of this report, will serve as important inputs to future strategic planning and program design related to water resources for all USAID operating units.

[22] As defined by the Water Team, IWRM includes freshwater estuarine, and marine habitats, and the entire range of water quantity, quality, and allocation issues that emerge when human communities place increasing demands on these resources.

[23] See Part II for numerous examples of elements of IWRM in USAID programs.

Table 1.9

Population size and annual renewable freshwater availability (cubic meters per capita) in water-short countries, 1995 and 2025. Countries in **bold** are recipients of USAID assistance in *freshwater* resources management only. Level of obligations (in millions of U.S. dollars) for FY 2000 are indicated in parentheses, where applicable.

Country (with FY 2000 USAID expenditures in water, if applicable)	1995		2025	
	Population (millions)	Water Availability (cubic meters per capita)	Expected Population (millions)	Water Availability (cubic meters per capita)
Malta	0.4	82	0.4	71
Qatar	0.5	91	0.8	64
Kuwait	1.7	95	2.9	55
Libya	5.4	111	12.9	47
Bahrain	0.6	161	0.9	104
Singapore	3.3	180	4.2	142
Barbados	0.3	192	0.3	169
Saudi Arabia	18.3	249	42.4	107
Jordan ($89 million)	**5.4**	**318**	**11.9**	**144**
Yemen	15.0	346	39.6	131
Israel ($56 million in West Bank/Gaza)	**5.5**	**389**	**8.0**	**270**
Tunisia	9.0	434	13.5	288
Algeria	28.1	527	47.3	313
Burundi	6.1	594	12.3	292
Cape Verde ($0.2 million)	**0.4**	**777**	**0.7**	**442**
Oman	2.2	874	6.5	295
United Arab Emirates	2.2	902	3.3	604
Egypt ($110 million)	**62.1**	**936**	**95.8**	**607**
Kenya ($1 million)	**27.2**	**1,112**	**50.2**	**602**
Morocco ($4 million)	**26.5**	**1,131**	**39.9**	**751**
South Africa ($4 mil)	**41.5**	**1,206**	**71.6**	**698**
Cyprus ($3 million)	**0.7**	**1,208**	**1.0**	**947**
Rwanda	5.2	1,215	13.0	485
United Kingdom	58.1	1,222	59.5	1,193
Belgium	10.1	1,234	10.3	1,217
Somalia	9.5	1,422	23.7	570
Poland ($0.2 million)	**38.6**	**1,458**	**40.0**	**1,406**
South Korea	44.9	1,472	52.5	1,258
Haiti ($2 million)	**7.1**	**1,544**	**12.5**	**879**
Comoros	0.6	1,667	1.3	760
Peru ($2 million)	**23.5**	**1,700**	**35.5**	**1,126**
Iran	68.4	1,719	128.3	916
Zimbabwe	11.2	1,787	19.3	1,034
Lebanon ($3 million)	**3.0**	**1,854**	**4.4**	**1,261**
Malawi	9.7	1,933	20.4	917
Ethiopia ($1 million)	**56.4**	**1,950**	**136.3**	**807**
Mauritius	1.1	1,970	1.5	1,485
India ($3 million)	**929.0**	**2,244**	**1,330.2**	**1,567**
Nigeria	111.7	2,506	238.4	1,175
Afghanistan	19.7	2,543	45.3	1,105
Lesotho	2.0	2,565	4.0	1,290
Burkina Faso	10.5	2,672	23.5	1,194
Eritrea (0.3 million)	**3.2**	**2,775**	**6.5**	**1,353**
Togo	4.1	2,938	8.8	1,370
Tanzania	30.0	2,964	62.4	1,425
Ghana	17.3	3,068	36.3	1,464
Uganda ($1 million)	**19.7**	**3,352**	**45.0**	**1,467**
Niger	9.2	3,552	22.4	1,452

Source: Gardner, Outlaw, and Engelman, Sustaining water, easing scarcity: A second update*, Washington, DC, Population Action International, 1997, as adapted from Hinrichsen et al., 1998 (1) with USAID Water Team data.*

Part II

USAID's Response to the Global Challenge of Effective Water and Coastal Resources Management

Chapter 2
Water Supply, Sanitation, and Human Health

Global Trends and Emerging Solutions

The water resources management goal for human health has two dimensions. One is to deliver a clean and adequate water supply, sanitation services, and improved hygiene practices as a package, while ensuring long-term sustainability of both water quantity and quality. Packaging these interventions helps ensure that health objectives will be attained, while at the same time protecting watersheds critical to sustainability supply.

The second human health goal is to ensure that water resources management activities are designed to minimize external impacts on health, such as the proliferation of mosquito breeding sites due to inadequate drainage. Clearly, this objective requires effective management of other issues beyond the scope of water resources management, including solid waste management, vector control, livestock management, and careful control of other aspects of the human built environment.

In this chapter, we focus on the health dimension related to water supply and sanitation. While there are various reasons for investments in water, sanitation, and hygiene, protection of public health is certainly one of the most important and widely accepted. Total mortality and morbidity (sickness) can only be estimated, but more than 4 million people die each year of waterborne diseases, including 2 million children from diarrhea alone (Cosgrove and Rijsberman, 2000).

It is useful to classify water-related diseases according to transmission mechanism, since such a classification will directly inform decisions on intervention design. Table 2.1 summarizes a commonly used approach. For diseases in each of these categories, Table 2.2 summarizes disease burdens. In terms of mortality, diseases transmitted via the fecal-oral pathway have the greatest impact. These include cholera and other diarrheal diseases, typhoid, hepatitis A and E, and intestinal helminthes. Fecal-oral transmission includes direct waterborne transmission and water-washed transmission, which is principally poor hygiene because of inadequate water quantity. The second category of water-washed diseases imposes a large morbidity burden resulting from poor hygiene due to insufficient quantities of water for bathing, and is responsible for skin infections (scabies, body lice, and tropical ulcers) and eye infections (trachoma and conjunctivitis). Water-based disease, such as schistosomiasis and guinea-worm (dracunculiasis), involve parasitic vectors that spend part of their lifecycle in an intermediate, aquatic host organism. Other water-related diseases, including malaria, filariasis, yellow fever, dengue, and river blindness, use insect vectors that require standing water for part of their lifecycles. In terms of disease burden, the most significant of vector-borne diseases is malaria, with the vast majority of the cases occurring in sub-Saharan Africa.

Of growing concern is the contamination of drinking water with a variety of human-made and naturally occurring chemicals and heavy metals. One group of chemicals, the organochlorines, has been linked to genetic, reproductive, and behavioral abnormalities in humans and wildlife (World Resources Institute, 1995). These chemicals are now widely found in well water, lakes, and oceans, and in some areas have contaminated both food supplies, through bioaccumulation, and drinking water. Heavy metal contamination is of considerable local concern in various locations. For example, in Bangladesh, India, and Chile, naturally occurring arsenic in groundwater, exacerbated by aquifer drawdown, is responsible for a wide range of serious health effects stemming from chronic overexposure through drinking water. Meanwhile,

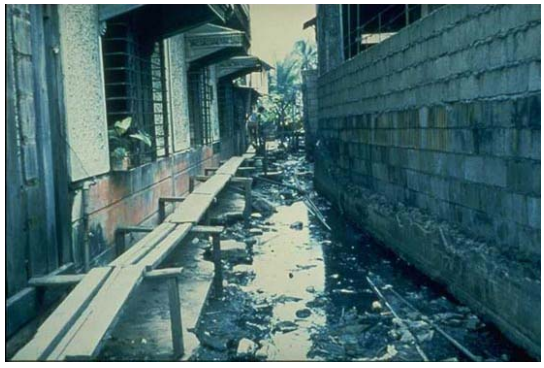


Figure 2.1 *Proper sanitation in urban areas is a major constraint to human health in developing cities.*

exposure to mercury and cyanide from mining discharges to water bodies is a serious but often unrecognized health problem to residents downstream of such operations.

All of these problems—insufficient quantity of water, poor water quality, inadequate sanitation, and bad personal hygiene practices—are compounded for the poor who most often are found settled in low-lying, flood-prone, or swampy land with poor drainage and sanitation conditions.

Table 2.1
Summary of water-related disease

Type of water-related infection	Examples	Water-related control measures
Fecal-oral diseases	Diarrhea, typhoid, hepatitis, cholera	Increase water quantity used; improve water quality and hygiene
Strictly water-washed	Scabies, trachoma, conjunctivitis	Increase water quantity used
Water-based (intermediate host)	Guinea-worm, schistosomiasis	Restrict contact, provide alternative sources
Water-related insect vectors	Malaria, filariasis, river blindness	Focus on insect breeding sites

Source: Adapted from DFID, 1998

Table 2.2
Some orders of magnitude of the worldwide extent of water-related disease

	Morbidity	Mortality/year
Fecal-oral		
Diarrheal disease	1 billion episodes/year	3.3 million
Cholera	>300,000	>3,000
Enteric fevers	>500,000	>25,000
Intestinal Helminths	1.5 billion infected/year	100,000
Roundworm (ascariasis)	20-40% infection rate in developing countries	
Strictly water-washed		
Trachoma	6-9 million blind	
Skin infections	very common; millions	
Water-based intermediate host (parasitic)		
Schistosomiasis	200 million	>200,000
Guinea-worm	1989: 890,000 1996: 35,000 (and still dropping)	
Water-related insect vector		
Malaria	300-500 million cases	1.5-1.7 million
Filariasis	128 million	
Dengue	30-60 million infected/year	20,000

Source: Adapted from DFID, 1998

Table 2.3
Access to sanitation in developing countries by region, 2000

Region and Country	2000 Population (millions)	Percent with Access (%)
Africa	707	60
Latin America/Caribbean	473	86
Asia and Pacific	3,122	48
TOTAL	**4,302**	**34**

Source: WHO and UNICEF, 2000

Clearly, there is still significant unmet need for water supply and sanitation among these most vulnerable groups. One in four people in the developing world presently lacks access to safe and affordable drinking water, and one in two has no access to sanitation (Table 2.3) (WHO and UNICEF, 2000).

USAID Activities

WSSWM activities are the largest category of water-related obligations for USAID.[24] Nearly $221 million were obligated in FY 2000, representing more than half of all water-related activities (see Figure 1.2). Programs address drinking water supply ($81 million), sanitation ($48 million), wastewater treatment ($84 million), and industrial pollution prevention and control (nearly $8 million). Many of these projects are in the ANE region—primarily in Egypt, Jordan, and West Bank/Gaza (see Table 1.1 in Part I)—and provide improved water delivery, sanitation, and wastewater treatment infrastructure systems (see Chapter 3).

Many other activities mentioned in this report address some aspect of water quality and its impact on human health. For example, USAID obligated $96 million for coastal and water resources management[25] to support a variety of programs aimed at the equitable allocation not only of the quantity of water, but also of the quality, helping ensure that stakeholders, including natural systems, have access to water of adequate quality needed for specific uses, all with implications for human health.[26] Many agricultural programs include aquifer recharge or activities to help protect water supplies from agricultural contaminants, such as fertilizers, pesticides, herbicides, organic material, sediments, and/or salts in runoff.

USAID's planned Water Management Program for Armenia is another example of an integrated water resources program that uses the single management goal of improved water quality to implicate a wide variety of water resources management improvement activities. These include surface and groundwater pollution prevention through institutional reform; economic instruments (such as pollution abatement incentives); water resources monitoring and forecasting; and management of agricultural and municipal waste in water supplies. The program in Armenia is a newly planned activity, for which results and obligations will begin to be reported in 2001.

USAID's program in El Salvador combines approaches aimed at community participation, better hygiene, and environmental education to protect and/or improve the quality of water supplies in rural areas (see description of SO4 for El Salvador in Table 1.1 of Part I). These activities are included in one of USAID's seven "water" SOs.[27] In Kosovo and Bosnia-Herzegovina, USAID helps war-torn communities rebuild drinking water supplies to safeguard against waterborne disease (see SO3.1 for Kosovo and SO3.1 for Bosnia-Herzegovina in Table 1.1).

[24] See Chapter 1 of this report for a discussion of the WSSWM obligations category.

[25] Included in the obligations category of Natural Resources Management discussed in Chapter 1 (see Tables 1.3 and 1.4).

[26] Uses such as those for urban environments (Chapter 3), groundwater reserves (Chapter 5), coastal zones (Chapter 7), coral reefs (Chapter 8), and freshwater aquatic biodiversity (Chapter 9).

[27] Seven SOs obligate 100% of program funds to water resources management, totaling $237 million in USAID's water portfolio for 2000 (see Box 1.2 in Part I). El Salvador's SO4, *Increased Access by Rural Households to Clean Water*, obligated $2.7 million of these funds.

Box 2.1
Coupled Improvements in Water Quality and Human Health: An Integrated Approach to Armenia's Water Management Program

Armenia, like many of the countries of the former Soviet Union, is characterized by poor environmental conditions. A November 1999 environmental assessment conducted by USAID outlined a number of serious problems, ranging from incomplete environmental legislation, water contamination, and air pollution to overextraction of water from Lake Sevan, unsafe pesticide practices, and nuclear safety issues. While environmental problems in Armenia stretch beyond water management issues, USAID focused on water as the area where the consequences of environmental degradation in Armenia are most severe.

USAID/Armenia's new water management program will be an exploratory effort by the Mission, under which discrete, limited-scope activities will complement other ongoing USAID programs and support broader USG interests in Armenia and the region.

Specifically, the USAID water management program will support initiatives to:

- **Improve the national policy and institutional framework:** USAID will fund efforts to improve legislation on water quantity (rights and distribution) and quality; economic instruments to abate industrial pollution; regulatory opportunities for water pricing and other economic instruments; industrial effluent norms; pollution fees/fines and an environmental fund for water-related remediation projects; the management capacity of national and local institutions; and public support networks for integrated water management.
- **Rehabilitate the water quality and quantity monitoring systems:** USAID will finance the reinforcement of the Armenian Hydrometeorological Institute's (*Armihydromet*) capabilities to collect, manage, and store data on the quantity and quality of surface and groundwater; calculate water balance and forecast changes and ensuing impacts; assess the effect of pollution on water bodies (particularly Lake Sevan); and identify protection and remedial measures.
- **Increase local-level capacity to develop and implement market-based solutions:** USAID will support NGOs, local groups, and governing bodies to test innovative approaches to improving water quality and to confirm/apply data and analysis developed through other components of this initiative. These efforts may include water quality testing; control of industrial or agricultural effluent; small-scale wastewater management/treatment/disposal projects; water protection; and the mitigation or clean-up of specific water pollution problem areas.

Start up of the program began in the Spring of 2000.

Box 2.2
Coupling Sanitation with Governance in Small Towns

In Latin America and the Caribbean, responsibility for the provision of municipal services, including water supply and sanitation, is increasingly devolving to communities. Typically, however, municipalities are not in a position—financially, technically, institutionally, or socially—to adequately provide these services. In response, several USAID Missions in the region have been supporting cities primarily though local governance programs and direct technical assistance for water supply and sanitation in small towns.

Chapter 3
Growing Urbanization Calls for New Approaches and Technologies

Global Trends and Emerging Solutions

Cities account for just 2% of the planet's surface, yet by 2005 they will be home to half of the world's population (Hinkel, 1999). The concentration of people and the increasing rate of urbanization place cities squarely in the center of the global water management challenge. Cities today account for 60% of all water allocated for domestic human use. With political power and money concentrated in the larger metropolitan areas, governments face growing pressures to reallocate water from other sectors (most notably agriculture) to meet growing urban demands (Postel, 1999). In China, farming communities are being cut off from water supplies so that Beijing's domestic, industrial, and tourist demands can be met. Similar competition occurs in and around virtually every city today.

The challenge of urban water management is multifaceted, but includes a lack of freshwater sources within feasible proximity to sustain water demand in many cities, especially the growing number of megacities.[28] The population density and intensity of economic uses of urban water also lead to water quality degradation that is often most critical in urban settings.

For various reasons, including degraded quality, intermittent supply, and the typically higher cost for surface water, many urban areas have come to rely on groundwater as their primary source, putting special pressure on this resource. In fact, nearly one-third of the global population relies on groundwater as the source of drinking water, including residents in many of the world's largest cities, such as Jakarta, Dhaka, Lima, and Mexico City[29] (United Kingdom Department for International Development, 1998). Aquifer depletion rates and pollution, however, threaten to foreclose this option for many cities.

Figure 3.1 *This urban area in Indonesia competes with the natural coastal environment for ample and clean water resources to sustain surrounding tidal creeks, mangroves, coral reefs, and wildlife contained therein.*

The challenge of urban water management often centers on the fact that cities, especially the growing number of megacities, simply do not have large enough recharge areas within feasible proximity to sustain growing water demand.

Poor or nonexistent urban planning and enforcement of existing land use regulation compound water management problems in most cities. Low-lying areas are inappropriate for development and are vulnerable to riverine and storm-surge flooding. Illegal settlements on precarious sites, including floodplains and unstable slopes, are at grave risk from mass land movement and other water-related disasters, and are exceedingly difficult to provide with needed water supply and sanitation services. In addition, oil and gas extraction, combined with over-pumping of aquifers, results in surface subsidence, placing extra stress on building foundations and underground pipelines in all parts of the city. Finally, local

[29] Most of the drinking water supply for Lima and Mexico City is derived from surface water bodies, yet some also comes from groundwater reserves. Given the large populations centered in each of these cities, the number of people that rely on groundwater as a drinking water sources is significant.

government inability to work with stakeholders to provide for integrated management and long-range infrastructure planning to manage solid and liquid waste from household, industrial, and commercial activities jeopardizes the viability of all sources of water for the city.

Integrated planning and water resource management, together with the use of new technologies for water supply, treatment, conservation, and reuse, offer the most viable options for meeting these daunting challenges.

If cities and governments are to make tangible improvements in water management, they must become increasingly proactive and cross-sectoral in their planning and reform. They must, for example, be capable of simultaneously dealing with risks to physical infrastructure, threats to public safety, and sustainability of critical habitats and resources while proceeding with the provision of water supply and sanitation services. Governments and public financing alone cannot be expected to accomplish the needed expansion in such services, but must decentralize the authority and responsibility for service provision and build capacity to design and manage private sector partnerships. The goal of full cost-recovery must be quickly embraced, so that leveraged financing and economic sustainability can become reality. In Bogor, Indonesia, when the water utility installed meters and raised fees in 1988, household water conservation rose dramatically, allowing the utility to connect more families to the system without increasing the amount of water used.

The management of urban water quality, supply, and demand will become more complex and politically charged as the world's urban population doubles to 5 billion by 2025 (Postel, 2000). Integrated planning and water resource management, together with the use of new technologies for water supply, treatment, conservation, and reuse, offer the most viable options for meeting these daunting challenges.

Figure 3.2 *Lack of urban planning and infrastructure renders the provision of water and sanitation services exceedingly difficult.*

USAID Activities

The bulk of USAID assistance in urban environments is focused on water supply, sanitation, wastewater treatment, and industrial pollution prevention and control activities aimed at improving human health. USAID obligated nearly $221 million in FY 2000 for WSSWM projects in more than 30 countries around the world.[30] Most of the obligations were allocated to projects in urban areas; a smaller proportion was devoted to rural activities.

Nearly $93 million were obligated for Egypt alone, primarily to increase access to improved and

[30] As previously reported in Chapters 1 and 2, projects included drinking water supply ($81 million), sanitation ($48 million), wastewater treatment ($84 million), and aquatic pollution control (nearly $8 million) activities.

sustainable potable water under Egypt's SO2.[31] The main objectives of this project are to increase access to water services from 22.3 million Egyptians in 1995 to 23.1 million in 2004, and to increase access to wastewater services in selected urban areas from 18.6 million in 1995 to 21.1 million by 2004. What these numbers mean is that some additional 2.5 million Egyptians will be connected to improved sewerage systems and the one-half million with access to improved water supplies by the time this project phase is expected to be completed in 2004.

Projects in water supply and sanitation in Egypt (Box 3.1) and elsewhere not only involve improvements in infrastructure, but also address the need to decentralize water utility systems. Promoting the autonomy of demand-driven, local utilities helps ensure that communities will be able to meet their water supply and sanitation needs long after USAID's obligations are spent in establishing such systems (Box 3.2).

USAID addresses the impact of the urban environment on natural environments as well, particularly in coastal areas, yet these are not reflected in reported obligations for water resources projects in urban areas. For example, the watershed management program in Jamaica aims at controlling the discharge of untreated wastes from urban and resort areas in order to safeguard water quality in the surrounding coastal area and to protect coral reefs.

USAID has also identified a need to incorporate groundwater considerations into urban project design. In the year reported, however, no agency resources were allocated in emerging areas, including aquifer depletion and saltwater intrusion, urban sprawl impacts on aquifer recharge, or industrial pollution of groundwater sources.

Box 3.1
Egypt: Decentralization Enhances Sustainability of Water and Wastewater Services

USAID assistance is supporting a shift away from central government responsibility for planning, constructing, and financing basic services towards local utility autonomy and responsibility for operating on a commercial basis responsive to consumer needs. The focus of USAID's FY 2000 $93 million program is on achieving sustainability in expanding water and wastewater delivery:

- improved sustainability for selected water and wastewater utilities through the coverage of full operations and maintenance costs by generated revenues;
- improved decentralized utility management, measured by the increases in independent decision making on personnel policy, budget, and revenue retention; and
- improved capacity to deliver utility services through improved systems and qualified staff.

Box 3.2
USAID Promotes Commercial Viability So Cities Can Afford Water Utilities

Through such projects as FIRE in India, USAID has found that commercial viability can help cities afford to build and maintain water infrastructure projects. Such viability requires that water utilities and other investment structures be able to generate adequate revenues from project-specific assets and other general sources, including targeted and sustainable subsidies, to cover project costs. The approach also recognizes other economic returns attributable to improved water infrastructure, including improved public health conditions and environmental quality. Savings can be achieved via efficiency improvements, such as reduction in unaccounted-for water; energy savings in water pumping; demand-driven, private sector participation in systems operation; improved accounting systems; and tariff reforms with incentive-based financing mechanisms.

[31] See description of Egypt's SO2 in Table 1.3 of Chapter 1.

Figure 3.3 *Wastewater Treatment Facility Construction in Morocco.*

Part of the $3 million obligated to Morocco's water resources management project* in FY 2000 helped fast-growing towns and cities achieve improvements in wastewater supply and sanitation facilities, thereby ultimately helping the urban poor. Activities aimed at training municipal officials in financial management and environmental planning also benefited urban residents through better governance and service delivery.

Construction of the sand filter basin, such as the one shown above with synthetic liner and pipes, will help remove organic material from the wastewater once the facility is under operation, thereby improving effluent water quality in a Moroccan community.

These men are laying sand (which acts as a filter medium) over the liner and pipes shown in the previous photo.

*This project is now included in Morocco's SO6, *Improved Water Resources Management in the Souss-Massa River Basin*, one of USAID's seven "water" SOs discussed in Box 1.2 of Chapter 1.

Box 3.3
India: Project FIRE

India is home to four megacities and more than 30 other cities of more than 1 million inhabitants. Rapid urbanization and growth have left an ever-increasing population living in cramped, overcrowded, and unsanitary conditions. The lack of safe drinking water and hygiene is a constant threat to health, which undermines labor productivity and income generation. The consequences of rapid urbanization and inadequate city management affect the entire population, but particularly the 40% of the urban population classified as poor.

Safe, dependable drinking water and effective sanitation services are priority concerns of the urban poor and municipal administrations alike. Existing demand for services has already outstripped the ability of municipalities to mobilize resources and meet water supply and sanitation needs. Improving and expanding services in response to urbanization has proven to be very difficult due to the chronic lack of resources, poor administration and management capabilities, and an inability to develop commercially viable capital investment projects.

USAID's FIRE project has worked to foster the development of commercially viable municipal systems to secure financing for improvements in urban environmental services (water, sewerage, and solid waste). The project is expanding pilot efforts to more cities, and simultaneously working with state governments towards creating a supportive environment for institutionalizing these principles.

Box 3.4
South African Municipalities Reap Multiple Benefits from Commercially Viable Water Systems

USAID obligated $3.5 million in FY 2000 for improvements in South Africa's water supply and wastewater treatment services in urban areas. Part of these funds were provided to implement a joint USAID-Government of South Africa initiative to help municipalities gain access to private capital for utility services infrastructure to their previously disadvantaged communities. The initiative provides grant funding and technical assistance to municipalities for feasibility studies that assess whether a public-public or public-private partnership might provide the private capital they require to build and operate a commercially viable infrastructure system for water services. If the feasibility studies indicate a strong potential for accessing private sector capital, the initiative provides further grant co-funding and technical assistance to procure a water and sanitation concession. In addition to successfully securing water services for the community, the first water concession procured under this project in the Harrismith municipality provided an additional and rather unexpected benefit. The feasibility study produced recommendations for reforming the overall municipal budget structure to stem a rapidly growing deficit that threatened to render the community bankrupt within a year or two, generating an even larger, longer-term benefit than anything the municipality does with its water system.

Chapter 4
Alleviating the Growing Stress on Water Resources through an IWRM Approach

Global Trends and Emerging Solutions

Central to the global water crisis are the increasing human demands and impacts placed on this finite resource. A world population now growing by 80 million people each year (nearly the size of Mexico) drives this collision between supply and demand. To provide food for the expanding population, irrigated agriculture has been developed during the past three decades to an unprecedented degree and now consumes 69% of total water used by humans worldwide. Industry and commerce sectors demand another 23%, leaving a modest 8% of total water supply for domestic use (Hinrichsen et al., 1998). There are wide regional differences in these proportions, but on a global scale, water demand is doubling every 20 years (Metcalfe, 2000).

In the face of such scarcity and degraded quality around the world, approaches to management often focus exclusively on the needs of a single sector, or a reduced geographic area, and emphasize the development of new supplies as the primary management approach. This has led to an overcommitment of finite supplies, conflicts and tensions between upstream and downstream users, an underemphasis on pollution prevention and demand-side strategies, and serious unanticipated consequences for ecosystems that depend on a minimum flow of freshwater. In sum, a fragmented approach has exacerbated unsustainable patterns of use in many places.

***Figure 4.1** An integrated approach to coastal zone management enables communities to operate prawn ponds such as these (foreground) in Indonesia while continuing to maintain a healthy coastal environment for mangrove ecosystems and other stakeholder groups or systems in the area.*

In response, water managers around the world have developed a more integrated philosophy of resources management that addresses issues of water quantity and quality at the basin scale. IWRM is a process that employs sound scientific information about major water quality and quantity trends to make decisions about sustainable water allocation and use, including a thorough understanding of the supply/demand equation (the "water budget") and analysis of ecosystem needs, as well as water use patterns by all stakeholders within a basin.

An integrated approach ensures that scarce resources are allocated equitably and sustainably among the diverse array of users and stakeholders involved.

Representative and democratic governance processes combine with solid information to produce management schemes that ensure the long-term health and welfare of human communities and ecosystems alike. IWRM employs a range of approaches, methods, and tools addressing policies, laws, and regulations, as well as the technical and financial solutions needed to bring about concerted community participation and stewardship of water and coastal resources at the river basin or watershed scale.

USAID Activities

Many of USAID's water and coastal resources management programs embody the global consensus that an integrated approach is key to successful water resources management. An

integrated approach ensures that scarce resources are allocated equitably and sustainably among the diverse array of users and stakeholders involved. In this way, stakeholders take part in management of the resource, increasing the likelihood that key sustainability strategies, technologies, and decision-making processes are accepted and maintained over the long term.

USAID also promotes an integrated approach at the landscape scale, recognizing that both upstream and downstream activities within a river basin or watershed are integrally linked via ecosystem processes. For example, a whole basin or "ridge to reef" approach is the focus of the water resources management program in Jamaica (Box 4.1). Forested uplands in Panama are likewise actively managed to protect the downstream water resources of the Panama Canal water system (Box 4.2).[32] In the Central Asian Republics, an integrated, landscape approach underlies support for snowmelt monitoring and flood forecasting activities (Chapter 6) that USAID promotes through an interagency agreement with the National Oceanic and Atmospheric Administration (NOAA).

USAID obligated $63 million for IWRM activities in FY 2000, amounting to nearly 16% of total water obligations for the year. Approximately $42 million (67%) of IWRM activities were obligated to the Middle East region (primarily for programs in Jordan,[33] [Box 4.3] and West Bank-Gaza),[34] where the focus remains on bringing diverse stakeholders together to equitably and peacefully allocate scarce water resources.

Box 4.1
Jamaica: A Whole Basin, or "Ridge to Reef," Approach

As Jamaica's population and economic activity become increasingly concentrated in urban and coastal areas, the fragile natural habitats and natural resources in these and surrounding areas are placed under increasing threat from deforestation and degradation of upland watersheds (the result of unsustainable agricultural and industrial practices), pollution of coastal water, or degradation of the island's coral reefs (largely the result of inadequate sanitation and sewage treatment systems). USAID obligated $2.7 million to reverse the trend of environmental degradation through a basin-wide approach. Activities to curb deforestation, unsustainable agriculture, and untreated sewage will not only protect the environments in which these problems are generated, but will also protect the ultimate downstream environment: coastal waters and coral reefs.

Central programs obligated $4 million to the Global Bureau Environment Center to promote an integrated approach in freshwater and coastal management programs around the world through technical and managerial assistance to Missions, outreach and communication, and international leadership activities. IWRM programs in Morocco (Box 4.4) and El Salvador (Box 2.2), and a water-energy joint activity proposed in India (Box 4.5), as well as integrated coastal zone management programs in the Philippines and Indonesia (Box 7.1) have also been successfully implemented and are now being expanded and/or replicated in other countries. In addition to these projects, some $770,000 were obligated to the ANE Bureau program FORWARD for IWRM activities (Box 5.3).

Box 4.2
Panama: Upper Watershed Management Ensures Proper Function of the Panama Canal

Numerous studies, including one conducted by USAID, have demonstrated the link between the environmental protection of the Panama Canal Watershed and the effective long-term operation of the Panama Canal itself. Efficient operation of the Panama Canal relies on the freshwater provided by rain across the 326,000-hectare watershed, as each ship passage requires 52 million gallons of freshwater. USAID obligated $2.5 million for sustainable forest management practices in the upper watershed. The maintenance of adequate forest cover wherever possible, as well as water quality monitoring, will help ensure the availability of adequate volumes of water for canal operations by minimizing sedimentation and drainage of contaminants into the Canal.

[32] Panama's SO2, *Sustainable Water Resources Management for Operation of the Panama Canal*, is one of USAID's seven "water" SOs (see Box 1.2 in Chapter 1 of this report).

[33] See Jordan's SO2, *Improved Water Resources Management,* one of USAID's "water" SOs (Box 1.2 in Chapter 1). Approximately $28 million was obligated to watershed management and IWRM activities under the Natural Resources Management category (Table 1.4).

[34] See West Bank/Gaza's SO2, *Greater Access to and More Effective Use of Scarce Water Resources* (also a "water" SO, Box 1.2). Approximately $13 million was obligated to watershed management and IWRM activities under the Natural Resources Management category (defined in Table 1.4).

Box 4.3
Jordan: Integrated Activities Manage Scarce Water Resources for Multiple Sectors

Jordan is located in one of the most water-scarce regions in the world, and the country currently withdraws more water resources than are restored on an annual basis. Through the integrated approach of USAID's program in IWRM, Jordan can help serve the needs of diverse stakeholders that rely on the country's limited water resources. Water sector initiatives are strengthening key private-public partnerships and improving water use efficiency and the quality of treated wastewater so that it can be used for agricultural and industrial purposes, thereby increasing the quantity available for domestic consumption in both rural and urban areas. Three main sets of activities are implemented to:

- build stronger public sector water institutions with the capacity to better manage the country's water resources and finance capital investment in the sector;
- increase water use efficiency by reducing wastage caused by physical leaks, contamination, and inefficient irrigation practices; and
- improve the quality of wastewater to allow greater reuse in agriculture and industry.

Box 4.4
Morocco: Taking an IWRM Approach That Works

The economy of Morocco depends significantly on agriculture, so plans for economic growth and modernization are hostage to rainfall patterns and the way water is managed in aggregate. In addition, inadequate supplies of domestic potable water and lack of sanitation services are major household burdens and a significant cause of disease. To alleviate these constraints to prosperity and social development, USAID/Morocco has worked since 1995 to improve water resources management in the agricultural, urban, and industrial sectors.

Current activities include:

- improving irrigation efficiency through new technologies and stronger management systems, benefiting farmers and the entire water sector;
- improving watershed management through community-based erosion-control programs, benefiting farmers and urban water users downstream;
- improving water quality by treating urban and industrial pollutants, benefiting all downstream water users;
- providing water, sanitation, and municipal services in fast-growing towns and cities, benefiting the urban poor; and
- training municipal officials in financial management and environmental planning, benefiting urban residents through better governance and service delivery.

For more information, see the USAID Water Team Case Study in Integrated Water Resources Management: USAID's IWRM Program in Morocco.

Box 4.5
IWRM Opportunities in India

A new water/energy nexus activity is being designed in India to jointly manage inefficiencies in both the energy and water sectors that have resulted in negative economic, environmental, and social consequences. Issues that are under consideration by the Mission include over-pumping (mining) of aquifers for agricultural irrigation, wasteful water and energy use practices, improved cost recovery and efficiency, and urban and industrial water supply and wastewater treatment.

Chapter 5
Groundwater—Its Use and Abuse

Global Trends and Emerging Solutions

A significant proportion of the global water supply exists as groundwater. Unfortunately, our knowledge of this resource—both its renewable component and its "fossil" reserves—is severely limited both globally and regionally. While most water resource professionals are trained to manage surface water, groundwater is hidden from view and has received relatively little management attention. It is believed, however, that as much as 10% of global annual water consumption may come from depleting groundwater resources (Cosgrove and Rijsberman, 2000). The depletion and pollution of groundwater is identified by many professsionals as the single greatest problem of water resources management for the coming century (Seckler et al., 1999).

***Figure 5.1** At least 1.5 billion people rely on groundwater as their only source of drinking water supply.*

Groundwater is a critical component of supply for cities, industries, and agriculture. Where it exists in accessible quantities, it is often preferred for its reliability in comparison to erratic surface supplies (see Box 5.1 on India). At least 1.5 billion people worldwide rely on groundwater as their only source of drinking water (Revenga et al., 2000). Aquifers supplement surface water for irrigation in many countries and are a large reason for the success of the "green revolution." An explosion during the past three decades in the use of wells and pumps for irrigation, domestic, and industrial water supply is resulting in rapid drawdown of aquifers. As a result, many countries (including China, India, Pakistan, Mexico, and nearly all of the Middle East and North Africa)[35] have enjoyed a temporary "free ride" at the expense of depleting their groundwater resources over the past 20-30 years (Seckler et al., 1999).

The depletion and pollution of groundwater is identified by many professionals as the single greatest problem of water resources management for the coming century.

The magnitude of the aquifer depletion problem has only recently come into focus. Although comprehensive data do not exist, it is believed that global groundwater overpumping (i.e., beyond aquifer recharge rates) totals at least 160 billion cubic meters a year, equal to the annual flow of two Nile rivers (Postel, 1999 and 2000). For example, groundwater extractions in India exceed recharge rates by a factor of two or more, with some water tables now falling by 1-3 meters per year. As a result, India could lose 25% or more of its current crop production during the next 25 years due to unsustainable aquifer usage rates (Seckler et al., 1999). Similarly, Mexico is depleting ground-

[35] Of these countries, USAID obligated nearly $118 million for freshwater resources management programs in India, Eritrea, Morocco, Ethiopia, and Egypt. This includes $500,000 under the Water IQC mechanism for the program assessment and design of integrated activities to address the dwindling groundwater supply in India (see Box 5.1). It does not include the $10 million obligated for coastal zone management and sustainable ecotourism development of Red Sea marine parks in Egypt.

water reserves in some agriculturally important regions at rates exceeding 3 meters per year (Shah et al., 2000). The implications for global food security are enormous. It is estimated that nearly 10% of the global food supply (160 million tons of grain) is currently based on the unsustainable practice of depleting groundwater (Postel, 2000).

Aquifer contamination and waterlogging compound the problem. Waterlogged soils typically occur in large-scale irrigation projects where surface hydrology is substantially altered. While both surface and groundwater irrigation can be problematic, the problem becomes particularly acute when salts leach from soils and become concentrated through continued recycling of groundwater for irrigation. Salinization can make agricultural lands unproductive and leave both groundwater sources and irrigation projects unusable, a prospect troublesome for countries with low-lying agricultural areas, such as Pakistan.
Even more serious from a public health standpoint, contamination of groundwater is also caused by a wide range of pesticides, nutrients, heavy metals, hydrocarbons, and other toxics used in the agricultural, manufacturing, processing, and transportation industries, as well as the by the leaching of such toxics from solid waste dumps (Figure 5.2). Once polluted, groundwater sources are extremely difficult and expensive to clean up.

Box 5.1
India: The Energy-Water Connection in Groundwater Management

Approximately 50% of irrigation consumption across the country is extracted from groundwater sources. The pressure on groundwater reserves is compounded by the unreliability of electricity provision to farmers for pumping. Unreliable grid electricity and fluctuating voltage make it difficult for the farmer to efficiently manage his irrigation schedule and the amount of water he releases to his fields. The farmer copes with irregular energy supply by buying oversized pump motors to ensure maximum water withdrawal during limited periods of power availability and to protect his motor from burnout caused by irregular voltages. Further, the farmer leaves his pumps running 24 hours a day due to the inconvenient timing of electricity availability, thereby indiscriminately pumping water whenever the electricity comes on, often far in excess of what is needed.

Since energy and water are subsidized in the agricultural sector, farmers face little not no marginal electricity cost when pumping and therefore have little financial incentive for efficient water or energy use. As wasteful behavior proceeds, aquifers are depleted, so that farmers must purchase even larger capacity motors to pump water from deeper and deeper wells, thus exacerbating the energy-water waste cycle. In addition, depleted water supplies contribute to lowered agricultural productivity as well as ground and surface water contamination, all with potential health and economic impacts.

USAID/India and the Water Team collaborated in designing an activity to respond directly to the vicious cycle between energy and water management that leads to waste, inefficiency, environmental abuse, and public health consequences within and across the agricultural, urban, and industrial sectors. A major element of the design focuses on improving the quality, reliability, and delivery of power to reduce groundwater abstraction and wasteful consumption in the agricultural sector.

Most solutions involve some combination of increased recharge rate, reduced pumpage rate, overall efficiency gains, and reduced or eliminated contaminant sources.

While the problems and causes of aquifer depletion and contamination are clear, immediate solutions are not. Water professionals agree, however, that active aquifer management must be undertaken in the wider context of watershed management. Most solutions involve some combination of increased recharge rate, reduced consumption rate, overall efficiency gains, and reduced or eliminated contaminant sources (Shah et al., 2000). For example, reducing the velocity of runoff and pro-

Figure 5.2 *Improper disposal of domestic as well as industrial wastes can lead to groundwater contamination.*

viding time for recharge could enhance groundwater supplies significantly and at the same time reduce land-based sources of pollution to receiving waters. Reducing pumpage rates, on the other hand, may involve a close look at linkages with the energy sector and other root causes of overpumping (see Box 5.2). Sustainable groundwater management will also require looking at larger management questions, including the development of alternative surface water supplies, reallocation among economic uses of water, and regulatory limits on abstraction. As with other water resources management issues, all elements of active aquifer management must be undertaken through stakeholder participation and whole basin analysis based on projected demand (see Chapter 4).

USAID Activities

Activities aimed at protecting groundwater supplies are varied in form, and fall under the obligations categories of WSSWM and Natural Resources Management. They are often difficult to disaggregate from activities that benefit both surface and groundwater sources. For example, USAID obligated nearly $8 million for industrial pollution control activities around the world (included in the WSSWM category), which will ultimately help protect both groundwater and surface water quality. Most of these activities were aimed at policy reform measures to provide incentives for industry to adopt cleaner production methods and facilitate the transfer of cleaner production technologies.[36] Many of the $132 million wastewater treatment facility and sanitation improvement projects undertaken by USAID in 2000 are coupled with solid waste management improvements as well.[37]

Many of USAID's obligations for IWRM programs, such as those in Morocco ($3.5 million, Box 4.4), Haiti ($2 million), Jordan ($83 million, Box 5.4), and West Bank/Gaza ($56 million, Box 5.2) include an aquifer management component. In Haiti, for example, sustainable aquifer management is critical to safeguarding the principal water supply for Port-au-Prince, Haiti's capital and home to more than 2.5 million people. The USAID/Haiti mission has incorporated aquifer management objectives into the $2 million it obligated in 2000 for a basin-wide watershed management program, for which additional objectives are also implemented to reduce soil loss and other land-based sources of pollution to the marine environment.

Box 5.2
West Bank/Gaza: Sharing Data on Groundwater Supply in Regions of Conflict

In addressing the critical shortage and economic use of water, USAID plays a crucial role in helping implement the water resources articles of Palestinian-Israeli agreements. Palestinian per capita water consumption rates are well below the WHO's minimum standard. The inadequate supply of water limits both agricultural and industrial development, and only 25% of households are connected to sewage networks. Parts of the agreements focus on sharing data and information on aquifer levels and groundwater supply between Palestinian and Israeli monitoring groups. The ANE Bureau's CAMP has been instrumental in facilitating data sharing in this region.

[36] Many of these technology transfer initiatives were implemented under the Agency's Global Climate Change Initiative, thereby underscoring the added value of cross-linkages in Agency programs described in Chapter 4 on the benefits of an integrated approach to water resources management.

[37] Wastewater treatment and sanitation projects comprise one of the largest water expenditures of the agency, representing more than 32% of all obligations in FY 2000.

Box 5.3
USAID Fosters Stakeholder Involvement through the FORWARD Project

USAID obligated $1.5 million for the FORWARD project to help governments and key stakeholders in the Near East reach agreement on equitable and sustainable strategies, policies, and plans for managing scarce water resources. Since underground reserves of water supply exist in aquifers throughout the world that are largely unmapped or extend across international boundaries, disputes often arise over groundwater withdrawal of supplies commonly used by more than one country or stakeholder group. FORWARD has proved to be a viable means to foster equitable water allocation in such instances.

The absence of effective mechanisms to resolve water disputes collaboratively is a key reason for many environmental, economic, and social problems across Asia and the Near East. FORWARD is a significant departure from traditional water resource projects that consider water problems to be quantity or quality issues. FORWARD provides a mechanism to resolve water disputes between parties with divergent or competing interests in water resources.

The primary beneficiaries of FORWARD are the actual parties to the disputes, including urban and rural water users, farmers, commercial and industrial entities, and government institutions. The wider local, national, and international communities also benefit from the resolution of water issues, which have historically blocked better water planning, development, and management. While its initial focus was on West Bank/Gaza, Jordan, and Egypt, FORWARD is now developing programs for Lebanon and Morocco.

Box 5.4
Jordan: Slowing Aquifer Depletion through Water Reuse

Existing aquifers are being depleted at a rapid rate, and water rationing is a fact of life for most Jordanians. Annual water demand in Jordan is projected to increase to 1.2 billion cubic meters by 2001, far above the current 750 million cubic meters now available on a sustainable basis. As part of USAID's *Water Policy Implementation Program*, efforts are focused on reducing groundwater depletion by optimizing the reuse of treated wastewater. The project has also implemented a Water Information System that involves groundwater monitoring. The data helps Jordan develop appropriate water policies based on available water supplies in order to make the best use of this scarce resource.

Jordan's water program is the second largest in the agency, surpassed only by Egypt. These two countries are among the most water scarce in the world.

Chapter 6
Transboundary Waters: A New Concern for Global Security

Global Trends and Emerging Solutions

The global water management challenge is complicated by the fact that nearly half of the world's population lives within some 300 river basins shared by two or more countries. In the face of growing demand and increasing water scarcity, dependence on shared river basins and aquifers highlights the need for international agreements on the management and allocation of these shared resources. Water ignores political boundaries, and whole basin management based on ecosystem principles is the most viable path to achieving regional cooperation and security. Upriver and downriver riparians must work together to find equitable ways to manage both the quantity and the quality of their shared water resources.

Water ignores political boundaries, and even where a watercourse serves to delineate sovereign states we must work to promote whole basin management based on ecosystem principles.

There are plenty of examples to illustrate how transboundary water resources can be the source of both tension and cooperation among riparians. India and Bangladesh have quarreled over allocation rights for the Ganges, but the two countries have signed an agreement on water sharing. India has also concluded significant agreements with neighboring states of Nepal and Pakistan regarding the Mahakali and the Indus basins, respectively (Salman, 1998). Egypt fears overuse of the Nile by upstream Sudan and Ethiopia, and Turkey's damming and irrigation schemes on the Tigris and Euphrates threaten to deprive Syria and Iraq downstream. At the same time, the Jordan basin plays a huge role in peace talks between Israel and the Palestinians. In Southern Africa as well, riparians in many river basins have embraced a cooperative approach to managing their transboundary river basins, including the Okavango, the Zambezi, and the Limpopo. In sum, a growing body of experience suggests that cooperation rather than conflict is the norm in transboundary basins, and that the building of trust and confidence among sovereignties is central to managing conflict.

Transboundary river issues are prevalent in every region of the world. More than 90% of Middle East water resources are transboundary, while Africa alone contains more than 60 international rivers (Green Cross International, 2000). Every major river is transboundary in Southern Africa, a region where at least four countries will face serious water shortages within 30 years (Development Alternatives, Inc., 1998).

As seen above, there have been many important developments in recent years in the bilateral, regional, and international management of transboundary water resources. However, the absence of a comprehensive set of international legal norms has not simplified the task. In 1997, the UN General Assembly ratified the Convention on the Non-navigational Uses of International Water-

Figure 6.1 *Due to recent efforts by SADC nations in transboundary water resources management (Box 6.4), these children in Southern Africa have a better chance of enjoying future water resources cooperatively managed with neighbors in other SADC countries.*

Box 6.1
The Global Alliance for Water Security in the 21st Century

In recognition of Earth Day 2000, Secretary of State Madeleine Albright presented a speech focused on the need for integrated resources management in helping address growing water shortages and regional security concerns in some parts of the globe. The Secretary specifically called for a "global alliance" of countries working together to ensure "water security in the 21st century." In response, USAID and the U.S. Department of State co-hosted a 2-day meeting in Washington, DC, to address transboundary water resources management with other donors. Representatives of 14 donor countries as well as the European Union, the World Bank, the Global Environment Facility (GEF), UNDP, and UNEP met in June 2000 to discuss regional activities, successes and failures, and how to promote better integration and coordination of diplomatic and technical efforts.

courses, but the general legal principles it contains offer few practical guidelines for how to approach water allocation among riparians, the central issue in most water conflicts (Wolf, 1999).

Competing demand between sovereign states typically calls for the establishment of a basin commission tasked with planning and management authority and composed of multiple parties and stakeholders. While water quantity is often the major issue, it has often been more politically successful to focus early attention on water quality and ecosystem management issues for which consensus may be easier. Effective commissions work to ensure that members develop a common understanding of the basin's historical, present, and projected future hydrology, while recognizing that land and water resource management must go hand in hand. The goal is to develop a multi-sectoral, integrated planning system based on sound science, information sharing, transparency, and decision-making rules that are clear and explicitly understood by all parties (Green Cross International, 2000).

USAID Activities

USAID obligated more than $3 million in FY 2000 for the transboundary management of coastal areas and river basins in four main regions around the world: the Central Asian Republics,[38] Southern Africa, the Belize-Mexico Border, and the Caribbean. Future effort is expected to grow in this area of water resources management for USAID as new projects are currently under planning and consideration. For example, a design team planned a transboundary water management activity in the Trans-Caucasus Region, including Georgia, Armenia, and Azerbaijan, to begin in 2001. The activity will focus on sharing information and building capacity for water management in the Aras and Kura river basins. In addition to obligations directed at specific regions around the world, USAID is a world leader in representing trans-boundary issues at major international forums with other donor countries and institutions (see Boxes 6.2, 6.3, 6.4, and 6.5).

***Figure 6.2** The Syr Darya River and its tributaries wind their way through the Central Asian Republics of Kyrgyzstan, Tajikistan, Kazakhstan, and Uzbekistan.*

Box 6.2
USAID Helps Raise Awareness and Commitment to Transboundary Water Resources Management at the Second World Water Forum

The looming water crisis faced by many regions of the world underscores the urgency to focus increased attention on water resources management at all levels of society and government. These issues, including trans-boundary resources management, were addressed at the Second World Water Forum and Ministerial Conference in The Hague, Netherlands, in March 2000. Hosted by the World Commission on Water for the 21st Century and the Dutch Government, the conference brought together high-ranking government officials, water professionals, the business community, NGOs, and international organizations from more than 140 countries to discuss the key elements of a World Water Vision and a Framework for Action. Transboundary river basin management was a central area of attention for the U.S. government delegation, and the U.S. chaired a panel on this topic with contributions from Mikhail Gorbachev and Simon Perez.

[38] The Central Asian Republics addressed by USAID include Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan.

Box 6.3
Transboundary Coastal Management on the Mexico/Belize Border

USAID has helped support the newly created Belize-Mexico Alliance for the Management of Common Coastal Resources (BEMAMCCOR). This consortium of NGOs, universities, research institutions, and management reserves in Belize and Mexico was formed to support more effective and integrated management of the shared ocean and bay coasts of the Meso-American Barrier Reef System.

Box 6.4
Transboundary Natural Resources Management in Southern Africa

USAID obligated $3 million in FY 2000 for the Initiative for Southern Africa, USAID's regional approach to helping the 11 countries in the southern African region (Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe) achieve equitable, sustainable economic growth and successful democracies. Approximately one-half of these obligations were directed at water resources management. USAID addresses regional transboundary water resources issues by helping 1) develop a cadre of national experts who understand transboundary issues and are able to negotiate conflicts over competing management scenarios in international forums; 2) developing models for improved transboundary natural resource management; and 3) strengthening regional institutional capacity.

Efforts are focused so that those countries and groups that have the most to lose from poor regional management decisions, and who historically have had limited voices in these discussions, are encouraged to participate in the decision-making process. In addition to this initiative, the RCSA Mission worked during 2000 to prepare a multi-year transboundary water resources management activity in the Limpopo River Basin, to be launched during FY 2001.

Figure 6.3 *The magnificent Tis-Abbay Falls in Ethiopia on the headwaters of the Blue Nile River. Waters from the Falls spill from the uplands of Ethiopia into the Nile River, and travel northward through the Sudan and Egypt before emptying its diminished and polluted contents in the Mediterranean Sea. Through the U.S. Department of State Nile Basin Initiative, USAID obligated $1.5 million to work with the World Bank, GEF, and UNDP to develop a strategic action program for sustainable use of water resources by Ethiopia, the Sudan, and Egypt throughout the entire Nile River Basin. The USAID role included an evaluation of environmental issues and consequences of water resources development within the river basin and downstream in the receiving waters of the coastal zone.*

Box 6.5
Central Asian Republics Collaborate on Water Resources Management in the Aral Sea Basin

USAID obligated $1.4 million in FY 2000 for the improvement of environmental management capacity to promote sustainable economic growth focusing on reduction in regional economic and political tensions generated by transboundary environmental issues in the Aral Sea Basin. Activities concentrate on the management of Aral Sea tributaries, global climate change, and the protection of the Caspian Sea environment from petroleum sector exploration. A regional approach has been adopted because the most acute environmental issues are transboundary in nature, are a source of political tension and economic rivalry among the Central Asian Republics, and defy resolution at the national level. USAID provides assistance to establish Water User Associations and to improve water pricing and privatization of local water use rights, water quality, waste management guidelines, pollution fines systems, and multipurpose (power vs. irrigation) management of dams (including water sharing).

Accomplishments over the past year include:

- establishment and training of an experts' group on water resource modeling for optimal water resource use decision making in the Aral Sea basin;
- training of water officials in developing systems to assess, calculate, and recover operation and maintenance costs for hydroelectric facilities;
- formation of an initial working group to assist in the development of water quality standards; and
- assessments of the strength of Water User Associations and the state of legal and regulatory legislation in each republic and the development of plans on how best to privatize and further develop the associations.

Box 6.6
The U.S. Government Nile Basin Initiative

The absence of a general water allocation agreement among Egypt, the Sudan, Ethiopia, and Uganda over water resources in the Nile River Basin has deprived Ethiopia and Uganda of much-needed investment in irrigation and hydropower, and has made Egypt increasingly vulnerable to unilateral water diversions upstream. In 1998, the U.S. government approved an interagency strategy for engagement in water resources management and development to prevent conflict in the Nile Basin. This strategy recognizes that the U.S. has good relations with both Egypt and Ethiopia and the Nile Basin offers enormous potential for infrastructure, environmental technologies, and agricultural products.

USAID's Africa, ANE, and Global Bureaus have worked together on various activities that support this Nile Basin initiative. One of the major projects has involved the application of a modeling and baseline simulation experience developed by NOAA for Egypt to riparian countries in the Upper Nile Basin to assess the potential impacts of various water use scenarios on Nile system water flow and availability. The results will be used to help manage allocation issues and plan future development and water demand as a means of conflict prevention.

Box 6.7
Transboundary Water Pollution Reduction Program in Slovakia, Hungary, and Romania

Between September 1995 and March 2001, USAID has obligated a total of $6,500,000 to the Transboundary Water Pollution Reduction Initiative in Europe. The project aimed at improving water quality and reducing pollution transfer across three international boundaries: Slovakia/Ukraine, Hungary/Slovakia, and Hungary/Romania. Project activities included:

- **sponsored municipal wastewater treatment improvements** at Oradea in Romania and at Kosice in Slovakia;
- **establishment of four automatic water quality monitoring stations** along three international boundaries;
- **assistance to government agencies** in developing the institutional capacity and communications network to warn downstream users when pollution may threaten them;
- **assistance to six Romanian industries** in adopting cleaner production techniques and in developing and implementing environmental management programs; and
- **providing industrial wastewater treatment improvements** at industries in Romania.

Reduction in pollution and human exposure to toxic substances has been achieved by reducing direct and indirect discharges of toxics from the industries, reducing discharges of toxics and pathogens from municipal water treatment systems, and developing the capability to monitor and respond to period spikes of contamination in potable and irrigational water uses. The program will now serve as an implementation model for similar environmental improvement activities to be undertaken in 17 countries of the Danube River Basin as part of the Environmental Program for the Danube River Basin through the International Commission for Protection of the Danube River in Vienna, Austria.

Chapter 7
Increasingly Degraded Coastal Zones Undermine Options for Sustainable Development

Global Trends and Emerging Solutions

It is no coincidence that more than half of the world's population lives and works in a coastal strip just 200 km wide. Moreover, a full two-thirds—four billion people—are found within 400 km of a coast (Hinrichsen, 1998). Coasts contain some of the planet's most biologically productive habitat, and in turn support a disproportionate amount of economic output per unit area. Of the world's 15 largest cities, all but two are located on the coast.

Coasts provide free ecological services, such a storm surge protection, water filtration, waste discharge and dispersal, and industrial and power plant cooling.

Coasts are at the center of huge energy transfers, as waves pound shorelines and freshwater from land races to mix with salt water to form estuaries. The resulting upwelling and distribution of energy and nutrients lead to enormous production of biomass and free ecological services. The majority of commercially important marine fish and shellfish species spend at least a part of their lifecycles within estuaries. Oceanic systems yield 80 million tons of seafood per year valued at $50-$100 billion (Bryant et al., 1998). Globally, the marine catch accounts for 16 percent of animal-protein consumed and is a particularly important source of protein and income within developing countries (Brown et al., 1994).

Figure 7.1 *Coastal ecosystems support a diversity of life and habitat types.*

Yet, the value of coastal resources is much greater than that represented by the seafood industry alone. Maritime commerce, oil and gas production, aquaculture, pharmaceutical and industrial biotechnology, tourism, and recreation are but a few of the manifold human uses of the coastal zone whose values are not easily quantified. Add to these the myriad of free ecological services—storm surge protection, water filtration, waste discharge and dispersal, and industrial and power plant cooling, to name but a few—and the socioeconomic and one can see that the ecological importance of the coastal zone is virtually unparalleled. In groundbreaking economic valuation research, Costanza et al. (1997) place the annual value of coastal services and natural capital (even excluding that of open ocean) ahead of all other ecosystem categories at $12.6 trillion.

As stewards of the earth's coastal zone, we undermine our own efforts at conservation with widespread habitat degradation and loss, overharvesting, and destructive fishing. Half of the world's wetlands were destroyed in the 20th century, and 25% of coral reefs have now perished. The global oceanic fishing fleet is today 40% larger than what the oceans can sustain. As testimony to this fact, of the 200 major fish stocks accounting for 77% of world marine landings, 35% are currently classified as overfished or at their biological limit (Costanza et al., 2000). Meanwhile, the use of dynamite, cyanide, and other destructive fishing practices may very well be the final "nail in the coffin" for marine ecosystems and economies in some locales. It is estimated that Indonesia forfeits more than $10 million a year in lost productivity,

coastal protection, and other benefits through large-scale poison fishing alone (Bryant et al., 1998).

The timing, volume, and quality of freshwater inflow to estuarine environments are additional factors in coastal productivity that are often undervalued or poorly understood. Freshwater inflow establishes the critical salinity gradient to which estuarine species are adapted for part of their lifecycle. With the proper timing and salinity gradient, juveniles of these species are largely protected from marine predators and parasites that can otherwise spell disaster for a given year-class. With increased water diversions for human use, a growing number of rivers today no longer reach the sea (e.g., the Yellow River in China; the Colorado River in the U.S.). Add to this the many problems associated with the degradation of water quality, and it becomes easy to appreciate that successful management of water resources is clearly central to the long-term, sustainable use of coastal resources.

During the past three decades, integrated coastal management (ICM) has gained considerable momentum across the globe, as a complementary approach to broader IWRM practices. As a field, ICM has provided leadership and developed resources management that can be widely drawn on in all aspects of water resources management. Although there have been mixed results and challenging struggles along the way, consensus has emerged that without diligent attention to the appropriate policy framework, laws, institutions, and decision-making processes, chances for sustainable success are exceedingly low.

Successful ICM and IWRM are as much processes in participatory planning and community stewardship as they are strategies to achieve tangible environmental improvement in the short term (Box 7.1). They are equally directed to creating stakeholder voice and ownership in a governance process (Box 7.2) that builds political will as they are to placing certain areas and resources under protected status. The best programs incorporate both regulatory and nonregulatory controls and incentives, and they establish a central role for science in the identification and assessment of priority needs, and formulation of strategy. Successful ICM is tackled at the ecosystem scale, with strong emphasis on water resources management. It is ultimately about forging the right balance between competing human uses of water and natural resources, while ensuring that environmental health and productivity are not compromised in the long term.

Successful integrated coastal management is ultimately about forging the right balance between competing human uses of water and natural resources, while ensuring that environmental health and productivity are not compromised in the long term.

Box 7.1
Indonesia: Demonstrating Keys to Success in a Coastal Zone Management Program

When USAID and the Government of Indonesia first agreed to include East Kalimantan's Balikpapan Bay and its watershed within the coastal resources management project known locally as *Proyek Pesisir*, it was the first initiative in Indonesia to overtly seek to link coastal land and water management using a bay-centered approach. Through its focus on multisectoral interests and the many interconnections between these and the natural environment, as well as implications for future development in the area, the project now serves as a model for achieving sustainable coastal zone management in other USAID projects, both within Indonesia and throughout the rest of the world.

The coastal city of Balikpapan hosts a population of around 450,000 and is rapidly growing at an annual rate of 3% (a rate slightly above the national average). Land use near the city and within the bay watershed is also changing dramatically. Sixty percent of the original primary forests have been cleared (and the remainder is regularly burned), large-scale oil palm and rubber plantations have been established, shrimp and fish ponds are being developed, and new settlements have been built to accommodate rural development. Most of this development has occurred without regard to the ecological or aesthetic values of the bay, home to some 56 rivers and creeks, as well as 17,000 hectares of mangroves that provide a vital habitat to fish and birds.

Residents have therefore begun to take an interest in protecting the coastal environment in Balikpapan, and USAID is helping guide them through a process of governance reform whereby communities can engage in equitable and inclusive approaches to development planning. Local governments are also seizing the opportunity to devise more responsive development programs funded with an increased share of revenues retained locally under new decentralization laws. This is, in essence, the beginning of a governance reform that presumes increasingly localized management of resources will result in improved social, economic, and ecological outcomes for local communities.

What general principles of the ICM approach were key to Balikpapan's success?

- **Establish continuous links among the many sectoral interests and among the different levels of governance, from village to national levels.** This has been implemented through several measures, including establishment of formal and informal working groups at the local level, and provision of regular policy and coordinating inputs to provincial and national forums. For example, *Proyek Pesisir* has established a "walk-in" reference and meeting center in Balikpapan to encourage interaction between stakeholders and project staff in a neutral setting.
- **Build local capacity to concurrently (rather than sequentially) develop, implement, and sustain a bay plan.** *Proyek Pesisir* has sponsored international study tours, numerous training programs, and a wide range of technical assistance to support local partners. Typical of the training given to local NGOs and community partners are skills in low-technology monitoring and evaluation of community-based marine protected areas.
- **Develop understanding and awareness of the importance of aquatic resources, including the nature of interactions between land and water use.** For most East Kalimantan residents, as is common in most urban coastal communities throughout the world, land resources are of primary importance. Relatively few have a direct interest in marine resources and equally few have been concerned with the ecological consequences of their activities. Educating bay residents and building a constituency for improved management is thus fundamental to long-term success and is being undertaken via a range of strategies (Dutton, 2000a).
- **Develop a plan that both has popular support and can be implemented by all parties without the need for external support.** By emphasizing the importance of local ownership and the benefits of an integrated approach to land and water management, it is hoped that the political/administrative and financial support necessary to achieve the objectives of the plan will be ensured.

For more information, see the USAID Water Team Case Study in IWRM: Integrated Management of Balikpapan Bay and Watershed in Indonesia.

Box 7.2
The Role of Governance in ICM

CRM II demonstrations of coastal management practice promote a system of checks and balances and collaborative action within central government -- a key element to successful participatory democracy. These programs have typically created interministerial commissions, usually at the presidential or prime minister level, that come together to analyze significant coastal management issues, negotiate a common agenda and, thereby, set national policy. At the local level, CRM II programs are promoting decision making processes that demonstrate the practice of participatory democracy in a tangible way by holding public meetings, openly negotiating development priorities and teaching conflict mediation techniques. Consensual "user agreements" which hold stakeholders responsible for management of coastal resources, are the foundation for effective, participatory governance that creates stewardship and local accountability for maintaining ecosystem qualities.

USAID Activities

USAID obligated nearly $32 million to activities in coastal zone management in FY 2000. Many of these were implemented under the Coastal Resources Management II (CRM II) cooperative agreement with the University of Rhode Island (Box 7.3).[39] Projects largely promote improved processes of governance, participation, and stewardship toward the management of multi-sectoral activities within the coastal zone and surrounding watershed. The ideal management unit is the entire river basin adjacent to a coastal area, as in Jamaica's "ridge to reef" program (Box 4.1). In addition to Jamaica, projects of wide-ranging scope in CZM activities occur in the Dominican Republic, Indonesia[40] (Box 7.1), Egypt,[41] the Philippines,[42] and Tanzania (Box 7.4). Smaller levels of obligations for projects were devoted to Mexico and El Salvador. Obligations for larger projects are anticipated for Kenya and Mexico in FY 2001.

Box 7.3
The CRM II Cooperative Agreement

The Coastal Resources Management II (CRM II) project is a partnership between USAID and the Coastal Resources Center of the University of Rhode Island. This cooperative agreement strengthens the capacity of public and private institutions to manage coastal resources more effectively on a sustainable basis through integrated approaches to coastal planning and development. Services offered include information dissemination on effective coastal management and support for field demonstration programs to develop and document effective techniques to address coastal management issues in diverse social, political, and economic settings.

The program is in its sixth year of operation, and obligated nearly $6 million in FY 2000 for ICM programs in Mexico, Indonesia, Kenya, and Tanzania. Previous activities were carried out in the Philippines, Thailand, and Ecuador.

Given the broad scope of its CZM projects, USAID accomplishes an impressively wide range of results from its relatively small investment in coastal management. Activities serve in effect to link results across other programs in IWRM (Chapter 4), pollution control (Chapter 2), urban management (Chapter 3), and coral reef conservation activities (Chapter 8) described elsewhere in this report. Groundwater issues (Chapter 5) also have the potential to benefit from future USAID projects in coastal zones.

Figure 7.2 *Prawn harvest in Indonesia. USAID recognizes that in many countries where the capacity for effective resources management is small, the greatest tangible progress may be made initially through community-based projects.*

[39] For more information, see the URI Coastal Resources Center public Web site at http://www.crc.uri.edu or the USAID internal (restricted access) CRM II Web site at http://www.genv.org/enr/water/CRM2/crm2.asp.

[40] Included in Indonesia's SO8, *Strengthened and Decentralized Natural Resources Management,* described in Table 1.4 and Figure 1.17 of Chapter 1.

[41] Included in Egypt's SO1, *Management of the Environment and Natural Resources in Targeted Sectors Improved*, described in Table 1.4 of Chapter 1.

[42] Included in the Philippines' SO4, *Environmental Resources Management Improved,* described in Table 1.4 and Figure 1.17 of Chapter 1.

Box 7.4
Tanzania: Using Science for Management

Marine science and its contribution to resource management is an important aspect of the significant and successful investment that USAID has made in ICM in Tanzania. Through the Tanzania Coastal Management Partnership (TCMP), USAID has been working with managers and scientists to shift the paradigm from a fragmented to an integrated approach, to improved communication and partnering, to an identification and understanding of forces at play in marine resource management, and to creating and disseminating user-friendly scientific information.

In 1998, TCMP created the Science and Technical Working Group (STWG) and has supported it ever since. The Group's membership includes the leading marine scientists in Tanzania. This group was an integral part of developing the national policy on ICM. As the policy moves into action, this group will serve as a scientific advisory board to the coastal management team. Activities to date have included the following.

- **Directory of Marine Scientists Working in Tanzania.** It is the expectation of TCMP that the directory will serve as an essential communication tool between scientists and managers and will enhance the exchange of information for both local and foreign research groups.
- **Annotated Bibliography and Reference Location Guide for Marine Science Literature in Tanzania.** This document contains the most complete list of references available on marine science literature in Tanzania in six thematic areas: shoreline erosion, water quality and pollution, marine fisheries, coral reefs, mangroves, and other living marine resources. The bibliography also includes a comprehensive collection of marine science gray literature in Tanzania.
- **Syntheses of the Current State of Scientific Knowledge of Marine Sciences in Tanzania.** Comprehensive syntheses have been completed on the present status of scientific knowledge in marine issues related to Tanzania. Each synthesis reviews data and information available on the theme, research methodologies applied, reliability of the information, main results, information gaps, and scientific/management recommendations. These documents are particularly useful for marine scientists, university graduate students, and resource managers who require an in-depth understanding of marine science topics.
- **Coastal Ecosystem Profiles of Tanzania.** The findings of the syntheses have been summarized and presented in a format that is brief, direct, and comprehensible to a nonscientific audience. The profiles communicate information on the condition and trends of coastal resources, and are considered by the STWG as particularly valuable for raising the awareness and understanding of resource managers and the public on coastal resource condition and the important role that science needs to play in coastal management.
- **State of the Coast Report and Report Card**. Currently, the STWG is working to complete an assessment that will document status and trends of coastal resources and people, and provide a baseline from which to measure change.

For additional information on other aspects of Tanzania's coastal management program, see the USAID Water Team Case Study in IWRM: Sustainable Mariculture Development in Tanzania.

Chapter 8
Coral Reefs—Critical for Food Security and Economic Development

Global Trends and Emerging Solutions

Coral reefs play a critical but often underalued role in the sustainable development options for coastal residents throughout the world. Coastal protection from waves and storm surges, alternative livelihoods based on tourism, and significant contributions to food security are but a few of the many ecological services and values of coral reefs. It is estimated that, if properly managed, reefs can yield an annual average of 15 tons of fish and seafood per square kilometer. Coral reefs contribute an average of one-quarter of the total fish catch in developing countries, providing food for 1 billion people in Asia alone (Bryant et al., 1998). Reefs are renown for their biodiversity, sheltering more than 4,000 species of fishes, as well as crustaceans, mollusks, and other edible invertebrates. The beauty and diversity of coral reefs are contributing to one of the fastest growing sectors of the global economy—coastal tourism. More than 100 countries could benefit from the sustainable management of coral reefs for the tourist trade.

Figure 8.1 *Sustainable management of the coastal environment is essential to maintain healthy coral reef systems in the Red Sea and the Gulf of Aqaba that benefit local economies as popular tourist destinations.*

However, corals are becoming increasingly vulnerable to a combination of direct human impact and the effects of global warming. By late 2000, 27% of the world's reefs had been "effectively lost," a 16% increase in just two years (Wilkinson, 2000). Multiple human threats are to blame, including poorly planned or sited coastal development, destructive fishing (e.g., blast fishing, fish poisoning, muro ami, and trawling), overharvesting (for the aquarium and curio trades, construction material, and lime), overfishing, and land-based sources of marine pollution (most notably sediments and nutrients). Land-based sources of pollution account for 80% of all marine pollution worldwide, and wreak havoc on reefs through siltation, eutrophication (which stimulates the growth of smothering algae), and alterations to associated flora and fauna. The loss of mangrove forests, seagrass meadows, and fish communities—all of which are ecologically connected to coral reefs—also pose significant threats to reefs.

By late 2000, 27% of the world's reefs had been "effectively lost."

Reef degradation comes with a heavy price. Indonesia, for example, forfeits more than $10 million annually in lost seafood productivity, coastal protection, and other benefits as a result of large-scale fish poisoning that also kills coral. One study concludes that through more careful management, those degraded reefs could support a $320 million fishing industry employing 10,000 Indonesians (Bryant et al., 1998). In the Philippines, overfishing and reef degradation has resulted in a significant decrease in protein in the average person's diet, 67% of which is supplied by fish (White and Cruz-Trinidad, 1998).

More recently, forces beyond the direct control of coastal nations have conspired to place reefs at unprecedented risk. Elevated sea surface temperature (SST) resulting from global warming has caused "bleaching" of significant portions of reefs in all regions and seas to varying degrees of severity. As SST increases by as little as 1-2 ºC above normal summer maxima, the coral polyps lose their symbiotic algae (zooanthellae), which supply the corals with color and nourishment. Once the algae have left the coral, the white calcareous skeleton becomes clearly visible, giving the coral a "bleached" appearance. Where elevated SST is short-lived and bleaching is not too extensive, corals and reefs may recover.

However, with half of the world's population now living within 200 km of the coast and with global warming and elevated SST (especially during severe El Niño events), the prognosis for the world's reefs is not good. Researchers now project that, unless urgent management actions are immediately taken, 40% of the world's reefs will be lost by 2010, increasing to as much as 60% by 2030 (Wilkinson, 2000).

Successful management requires long-term commitment to ICM and IWRM and the process of establishing effective governance by coastal residents and nations over their coastal resources. The ultimate objective is to achieve meaningful "co-management" of the resource, whereby governments and individuals, acting through their communities, collaborate on the identification of priority needs and the design and implementation of successful management solutions. When such integrated and participatory planning is undertaken at the ecosystem scale, chances are dramatically improved that individual and collective behavior and decisions concerning future development will unfold based on principles of resource "stewardship."

The development and adoption of relevant policy, legal, and institutional tools are also an important component of ICM, as are improved monitoring and evaluation to provide feedback and sound, scientific information to guide future action. For example, the legal establishment of a series of ecological "no-take" reserves and/or multi-purpose marine protected areas can result in early and sustained management dividends for the system as a whole. No-take reserves improve fishery yields and help build and maintain healthy fish populations that, in turn, are integral to the health of coral reefs. Such tools, when coupled with ongoing education, enforcement, and alternative livelihood schemes, offer the best hope for reducing or eliminating stress on coral reefs, increasing the odds that they can withstand the next bleaching event.

USAID Activities

USAID is engaged in a wide variety of coral reef and mangrove forest conservation activities in many countries throughout the world. The Agency places high priority on the establishment of marine sanctuaries and reserves, for example, many of which are community-managed (Box 8.1). Many of these reserves and the management issues they entail extend across country boundaries and require transboundary resources planning and management (Chapter 6), as well as the development of regional initiatives or programs.

The establishment of a series of "no-take" reserves and/or multipurpose marine protected areas can result in early and sustained management dividends.

Figure 8.2 *Mining live coral rock for use in construction is responsible for a great deal of coral reef degradation throughout the world.*

Box 8.1
Community-Based Marine Sanctuaries in Indonesia

Community-based marine sanctuaries in the Philippines and South Pacific have proven to be effective in conserving coral reef ecosystems, as well as increasing fish biomass and production. Efforts have been underway to reproduce these successful conservation areas in Indonesia under the ICM project *Proyek Pesisir* in North Sulawesi. These community-based marine sanctuaries are small areas of subtidal marine environment, primarily coral reef habitat, where all extractive and destructive activities are permanently prohibited. They were developed with widespread support and participation of the local community and government, established by formal village ordinance, and are managed by local community groups. Household surveys in Blongko village conducted in 2000 have shown that 61% of respondents have participated in project activities. Approximately 86 percent of respondents were also aware of the management plan developed for the marine sanctuary.

Planning and preliminary implementation activities have resulted in a number of quality of life changes for the village community. These include improved drinking water supply, sanitation improvements from latrine construction, improved understanding by local residents of coastal management issues and their consequences, and greater capacity for participatory community planning and project implementation. With respect to the sanctuary specifically, signboards indicating the rules and promoting marine conservation have been installed in the village. Marker buoys have also been deployed and the community itself is undertaking surveillance and enforcement activities. Local fishers have reported that they believe fish abundance in and around the sanctuary is increasing.

These results confirm that community-based marine sanctuaries can be an effective means of coral reef conservation in Indonesia. By applying a participatory planning and implementation process, they can also provide concrete democratization benefits to local communities.

Other activities involve ecotourism, promoting sustainable fisheries and appropriate mariculture, reducing destructive fishing practices, seaweed mariculture, and reducing the negative impacts of trade in coral reef animals. USAID also contributes technically and programmatically to the Global Program of Action (GPA) for the control of Land-Based Sources of Marine Pollution, the Meso-American Barrier Reef Initiative, the East Asia and Pacific Environmental Initiative, the Middle East Regional Cooperation (MERC) project of the Middle East Peace Process, the Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES), and other regional and global efforts contributing to the conservation and sustainable use of coral reefs and other marine resources. USAID is a strong promoter and supporter of a major global partnership aimed at coral reef conservation and ICM, the International Coral Reef Initiative.

Box 8.2
USAID Works to Eliminate Destructive Reef Fishing

The ultimate goal of the Indo-Pacific Destructive Fishing Reform Initiative (DFRI) is to eradicate the use of cyanide and other destructive practices employed in the live reef fish trade, and to transform the trade into a vehicle for sustainable and equitable coastal development. The live reef fish trade typically targets pristine and isolated reef complexes far from reefs damaged by other stressors, such as siltation, coral mining, and land-based sources of pollution. Gathering live fish for the marine aquarium trade from the world's remaining and most pristine reef areas can be a grave threat to these systems.

EAPEI (see Box 8.3) also provides support to the Marine Aquarium Council (MAC), which brings together stakeholders interested in the future of the marine ornamentals industry and the successful management of the marine organisms and reef habitats it is based on. The network includes the ornamentals industry, hobbyists, conservation organizations, government agencies, public aquariums, scientists, and others. The goal of MAC is to develop an international system of certification and labeling for quality and sustainability in the marine ornamentals trade. This includes establishing standards for quality products and sustainable fishing practices; providing a system to document compliance with these standards and label the results; and creating consumer demand and confidence for certification and labeling.

Box 8.3
What Is EAPEI?

The East Asia and Pacific Environmental Initiative (EAPEI) was established in FY 1999 to continue U.S. Government assistance for fire and haze preparedness and prevention in order to establish broader, long-term efforts focused on other key regional environmental problems in the East Asia and Pacific region. The program is implemented through grants and agreements with U.S. federal agencies, including USAID, U.S. the Department of State, and NOAA, as well as international organizations, universities, and NGOs. In addition to better forest management and climate-impact forecasting techniques, EAPEI supports improved coastal resources management. Some $1.2 million were obligated in FY 2000 for programs to address the conservation of coral reef ecosystems and marine fish biodiversity through the prevention of destructive fishing and the establishment of certification programs for marine ornamental aquarium fish (Box 8.2), as well as for community monitoring and awareness programs (Box 8.1).

Chapter 9
Freshwater Aquatic Biodiversity and Its Unprecedented Losses

Global Trends and Emerging Solutions

The world's freshwater ecosystems—lakes, rivers, and wetlands—are showing signs of pollution and overexploitation, and freshwater diversity is suffering unprecedented loss as a result. Humans already use more than half of all available freshwater supplies for agriculture, industry, and domestic purposes. But that figure is growing, and it is estimated that by 2025 human use of the planet's total available surface freshwater may exceed 70% (Postel, 1998). Growing human demand often means less freshwater to sustain instream flows needed to support healthy biota.

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Water withdrawal and storage for human use plays a large role in the status of aquatic species. Dams, diversions, or canals fragment almost 60% of the world's largest rivers, and the number of large dams has increased sevenfold in number since 1950 (Revenga et al., 2000). It is estimated that there are more than 800,000 large and small dams worldwide (Shah et al., 2000). The cumulative effect of dams and other diversions is the loss of freshwater ecosystem services, the decline of fisheries, and the extinction of aquatic species. Since Egypt's Aswan Dam began operation in 1970, for example, the number of commercially harvested fish species on the Nile has declined by two-thirds, and the sardine catch in the Mediterranean has plummeted by more than 80% (Worldwatch Institute, 1997).

Figure 9.1 *Freshwater habitat diversity is suffering unprecedented losses.*

Other threats to aquatic biodiversity include habitat destruction, pollution, overexploitation, and the introduction of non-native species. Half of the world's wetlands were destroyed during the 20th century. Wetlands are increasingly recognized for the services they provide in cleansing water, recycling nutrients, recharging aquifers, mitigating storm surge and flooding, and supporting fish and wildlife. Pollution effects from industrial, agricultural, and urban discharge and runoff are troublesome, yet largely unstudied for most river basins. Siltation, overenrichment of nutrients, and toxic chemicals destroy spawning and nursery habitats, alter biological communities, and result in morbidity and mortality effects.

Overexploitation has endangered sturgeon in the Caspian Sea and its tributaries, while a boom in frog leg exports from Bangladesh in the 1970s and 1980s led to steep declines in frog populations, and the subsequent steep increase in agricultural pests and waterborne diseases. By 1989, the country was spending three times as much on pesticide imports as it was earning from frog exports (Abramovitz, 1999). For all of these reasons, plus the intentional or accidental introduction of non-native species, scientists believe that future extinction rates for freshwater species will be as much as five times higher than that for terrestrial species (Revenga et al., 2000).

***Figure 9.2** Half of the world's wetlands were destroyed during the 20th century.*

It is believed that 20% of the world's 10,000 known freshwater fish species are already extinct, endangered, or threatened (Revenga et al., 2000). In East Africa, for example, 40% of Lake Victoria's 350 endemic fish species are at risk, with 60% already extinct (Abramovitz, 1999). Pollution and non-native species (especially water hyacinth) are largely to blame (Box 9.1).

The World Wildlife Fund identifies 53 freshwater "ecoregions" across the globe, and estimates that some 300 new freshwater species are identified each year (Revenga et al., 2000). But overall, freshwater biodiversity has not been well studied, and it is likely that many species are being lost without our knowledge of their existence. In fact, basic information on freshwater species is lacking for many developed nations and most of the developing world, making trend analysis impossible. The general lack of knowledge about aquatic systems is both a cause and effect of the little attention conservation of aquatic biodiversity receives on the development agenda.

Management efforts must focus on recognizing and sustaining freshwater ecosystem values and services as the foundation for further sustainable development. The global value of freshwater ecosystem services is enormous. These systems provide for many human uses, including fish catch, irrigation, transportation, power supply (cooling and hydroelectric), flooding and storm surge protection, water filtration, and as a waste sink for industries and cities situated near receiving waters. Aquatic ecosystems provide maximum ecological service when their full complement of natural habitat and biota is intact.

Box 9.1
Uganda: Protecting the Lake Victoria Ecosystem from Aquatic Weeds

The invasive weed water hyacinth (*Eichhornia crassipes*) was unintentionally introduced into Lake Victoria, the world's second largest freshwater lake, probably during the 1950s. The weed now covers more than 40,000 hectares of the lake and its watershed. This infestation threatens both the ecological health of the lake, and the livelihoods of lakeshore communities that depend for their income on lacustrine resources, such as fish. Large-scale business and trade was also negatively affected when the port areas became inaccessible and water intake pipes for dams were blocked. Some port towns on the lake have recorded as much as a 70% decline in economic activity because the hyacinth has choked landing facilities and fishing grounds.

USAID obligated approximately $1 million in FY 2000 to Uganda's natural resources management program to mitigate the environmental and economic impact of the water hyacinth infestation. The program supports three key areas of intervention: technical coordination, regional consensus and capacity building, and operational support for water hyacinth control. Aggressive mechanical removal has been implemented in key locations, such as the Owens Falls Dam and municipal water supply intakes. Two species of weevils that feed on the water hyacinth have also been released into the lake, accounting for localized reductions in water hyacinth vigor. The program has also trained scientists and technicians in Rwanda and Burundi in the rearing and use of weevils in biological control, and a release program is planned for 2000 in the Kagera River, a key source of infestation that drains to the lake. USAID will continue to support measures to combat the water hyacinth menace in Lake Victoria, and is examining the prospects for implementing elements of the program in other threatened watersheds.

As human demand for freshwater and the quantity of wastewater increases, it is therefore critical that the allocation and quality of freshwater for environmental purpose is not lost from the discussion. Opportunities to restore and rehabilitate freshwater systems must be explored, while decisions must be based on sound science, and

Opportunities to restore and rehabilitate freshwater systems must be explored, while decisions must be based on sound science, and include meaningful analysis of costs and benefits.

include meaningful analysis of costs and benefits. An IWRM approach involving multiple stakeholders will help ensure that aquatic biodiversity and its many values and services will have a voice in such decision making.

USAID Activities

USAID obligated nearly $2 million in FY 2000 to manage critically threatened aquatic wetlands and ecosystems around the world. Approximately $1 million alone were obligated to protect Lake Victoria in Eastern Africa from water hyacinth infestation (Box 9.1). USAID's approach towards sustainable development and aquatic biodiversity is largely focused on the conservation of aquatic habitats, thereby protecting all of the species residing within the ecosystem. In the case of Lake Victoria, this principle is extended to include the control of an invasive, non-native plant species in order to enhance species richness of the lake community.[43]

The geographic scope and breadth of USAID's activities in freshwater aquatic biodiversity is relatively limited. There remains great potential to further address threatened and endangered species and aquatic ecosystems through expanded environmental management programs in many developing countries where USAID works.

Box 9.2
The *Pantanal*

The *Pantanal*, a unique wetland ecosystem found south of the Amazon forests in Brazil, spans 150,000 square miles in the basin of the Paraguay River and contains many unique species found nowhere else in the world. USAID obligated some $200,000 in FY 2000 for work with Conservation International to build capacity for park management and protection in both Brazil and Paraguay. USAID is also working to build a consensus for a biological corridor to connect two anchor sites, the Natural Park of the *Pantanal* in the west and Emas National Park in the east, thereby extending protected habitat for many species found within the reserve.

[43] Included in Uganda's SO2, *Critical Ecosystems Conserved to Sustain Biological Diversity and to Enhance Benefits to Society,* described in Table 1.4 and Figure 1.17 of Chapter 1 in this report.

Chapter 10
World Food Security Threatened by Growing Water Demands

Global Trends and Emerging Solutions

The ability to feed the world's growing population will be severely challenged in coming decades by competition over increasingly limited water resources. Since the advent of the "green revolution" more than 30 years ago, the world has by and large managed to keep food production in pace with population growth. That situation is changing, however, with growth in world grain production markedly slowed since 1990. While reasons for the decline are complex and manifold, concern is mounting over the central role that irrigation plays in global food security, and the realization that achieving increased supply of irrigation water may become exceedingly difficult. On a global scale, irrigated agriculture accounts for just 17% of the total cropland area, yields 40% of agricultural output, and consumes nearly 70% of total developed water supply (Postel, 1998).

On a global scale, irrigated agriculture accounts for just 17% of the total cropland area, yields 40% of agricultural output, and consumes nearly 70% of total developed water supply.

Water shortages threaten to reduce global food supply by more than 10% in the next 25 years (Brown and Halweil, 1998). Aquifer depletion, salinization of soils, and the reallocation of agricultural water to other sectors and users will combine to limit irrigated crop production. China's projected grain shortfall alone (conservatively estimated at 175 million tons per year by 2025) would result in steep price increases and disruption of world grain markets, the brunt of which would be felt by the world's poorest nations (Brown and Halweil, 1998).

Exactly how much water will be needed to meet projected food demand is not well understood, but studies suggest that at least 20% more irrigation water will be needed by 2025 (Postel, 1997). Falling investments in new dams and irrigation, combined with unsustainable aquifer depletion rates, dim the prospects for substantially increased irrigation even if it were desirable. Water demand competition is also growing among other stakeholders, including those of industry, expanding urban centers, and aquatic ecosystems. Assuming for a moment, however, that the 2025 global crop water requirement is met entirely by irrigation, an additional 2,050 km^3 would be needed yearly—equivalent to the annual flow of 24 Nile Rivers or 110 Colorado Rivers (Postel, 1998).

The animal protein component of the global food supply also has significant linkages with water resources management. The world relies heavily on oceans and rangelands for animal protein, but since 1990 both of these systems have been approaching their productive limits. Oceanic systems yield 80 million tons of seafood per year, a particularly important protein source in developing countries that accounts for one-fifth of animal protein consumed worldwide (Worldwatch Institute, 1994, and Bryant et al., 1998). Little or no growth can be expected in oceanic fish catch, however, as all 17 of the world's major fishing areas have either reached or exceeded their natural limits (Postel, 1998). Beef production

***Figure 10.1** Water shortages threaten to reduce global food supply by more than 10% in the next 25 years.*

***Figure 10.2** Competition for water resources is growing among a diverse group of stakeholders, including those of industry, expanding urban centers, and aquatic ecosystems.*

has also peaked, due at least in part to declining soil fertility of more than 20% of the world's pasture and rangeland (Postel, 1998). Meanwhile, aquaculture has become the fastest growing sector of the world food economy, and is now poised to overtake cattle ranching as a food source by 2010 (Brown, 2000).

Water quantity and quality are integral to the health and productivity of ocean, freshwater, and rangeland systems. The timing and volume of freshwater inflow is exponentially correlated with biomass production in estuarine environments, where 60%-75% of all commercially important oceanic species spend part of their lifecycles. The world's 1.3 billion cattle are likewise a significant component of the water-for-food budget, requiring 7 kg of grain for every 1 kg of live weight. (As a rule of thumb, 1,000 tons of water is required to produce 1 ton of grain.) In contrast, fish require on average 2 kg of grain to add 1 kg of live weight, and are therefore more "water efficient" as an animal protein source. Aquaculture presents both costs and benefits, producing "water efficient" fish while exacting a heavy toll on habitat and water quality, and increasing evaporative losses from freshwater ponds. Clearly, these tradeoffs have important implications for evolving food and water management policy.

While calculating water needs for global food security is a difficult and inexact science, we are beginning to understand just how limited options are for expanding current food production. A major determinant is "water-use efficiency," which in turn depends on several factors, including climate, evapotranspiration rates, soil fertility, choice of crops, and the genetic potential of those crops (Postel, 1998). Assuming that we can successfully optimize each of those variables, we must still contend with the water supply issue—both quantity and quality—and the efficiency by which that water becomes subsurface soil moisture for crop production. Managers must keep in mind the fact that due mainly to evaporative dissipation and subsoil infiltration along transport pathways, less than half the water removed from rivers and aquifers for irrigation actually benefits a crop (Postel, 2000).

Achieving global food security will require both effective water resources management and reform of food policy. Many actions needed are straightforward and should be instituted wherever feasible without delay. In this category, perhaps the most needed are actions to ensure that the best rain-fed agricultural lands remain in production. Improvements in soil and water conservation practices should likewise be immediately implemented, including small-scale water harvesting, terracing, and other means to channel and store water to increase soil moisture content (Postel, 1998). The ultimate goal is to produce more "crop per drop" and more sustainable livelihoods per unit of water, to ensure that water shortages do not turn into food shortages for the world's poor.

USAID Activities

USAID obligated $73 million for water activities related to food production in agriculture and aquaculture

***Figure 10.3** Aquaculture has become the fastest growing sector of the world food economy.*

Box 10.1
USAID Supports CGIAR

The Global Bureau's Center for Economic Growth and Agricultural Development obligated $46 million in FY 2000 for "improved food availability, economic growth, and conservation of natural resources through agricultural development." One approach through which it achieves this objective is membership in the Consultative Group on International Agricultural Research (CGIAR). The World Bank, FAO, and UNDP are co-sponsors of the CGIAR. The research undertaken by CGIAR centers contributes to environmentally sustainable improvements in the productivity of agriculture, forestry, and fisheries in developing countries. Through individual Missions and Bureaus, USAID annually contributes approximately $30-$40 million to the CGIAR. This included $650,000 to the International Center for Living Aquatic Resources Management (ICLARM) and $750,000 to the International Water Management Institute (IWMI) in FY 2000.

This includes funds used to support IWRM activities of the Consultative Group on International Agricultural Research (see Box 10.1) and CRSPS (see Box 10.2).

Although 93% ($51 million) of obligations for irrigation were spent in the ANE region (primarily in Jordan, Egypt, Lebanon, Nepal, and Morocco), irrigation activities are actually funded throughout the world, including countries in sub-Saharan Africa, Latin America, and the Caribbean. Some activities include the transfer of technology for highly efficient water delivery systems, such as the use of laser level basin irrigation technology in Morocco.

The agricultural sector also derives benefit from many USAID programs aimed at improving the overall efficiency in consumption, delivery, and conservation of water supplies that are not categorized as "irrigation projects." For example, as part of USAID's $83 million water policy implementation program in Jordan,[44] efforts are focused on reducing groundwater depletion by optimizing the reuse of treated wastewater for irrigation (see Chapter 5, Box 5.4). Similar efforts are under way in Egypt[45] and West Bank/Gaza.[46] The USAID/India Mission is also considering activities to strengthen linkages between the energy and water sectors in that country through enhanced water conservation for agriculture (see Chapter 5, Box 5.1).

It should be noted that millions of dollars were obligated at the end of FY 1999 for the reconstruction of irrigation systems damaged by Hurricane Mitch throughout Latin America and the Caribbean and are therefore not reflected in this year's budget reporting. Although funds were obligated during the previous fiscal year, substantial activities to rebuild and strengthen irrigation systems against future disasters are still under way in El Salvador, Guatemala, Nicaragua, and Honduras.

USAID operates programs that foster best management practices (BMPs) aimed at environmental protection in agricultural areas in many countries, including Guinea, Cyprus, the Dominican Republic, Haiti, El Salvador, Guatemala, Honduras, Jamaica, Panama, and Morocco (Figure 10.4). The frequent occurrence of destructive mudslides on steep agricultural hillsides after hurricane events has repeatedly demonstrated the value and utility of employing BMPs in Latin America and the Caribbean region.

***Figure 10.4** Best management practices are an integral part of USAID's sustainable agriculture program in Morocco. The project constructed check dams along this ravine to prevent erosion, thereby enhancing soil and water conservation.*

[44] Included in Jordan's water SO2, *Improved Water Resources Management,* described in Table 1.4 of Chapter 1 in this report.

[45] Included in Egypt's SO1, *Management of the Environment and Natural Resources in Targeted Sectors Improved* (Table 1.4).

[46] Included in West Bank-Gaza's SO8, *Improved Community Services* (Table 1.1).

Box 10.2
CRSPs Provide Benefits of Cutting-Edge Agricultural Research to Developing Countries

Collaborative research support programs, implemented by the U.S. land grant university system, complement the work of the international research system by engaging American and developing-country scientists in research that returns benefits to countries in the area of food security and related environmental challenges. Research and implementation on growing high-value food products (e.g., livestock, fish, and a wide range of crops) in developing countries, as well as value-added BMPs to ensure sustainable food production with minimal damage to the environment, are all part of USAID's water-related portfolio. CRSPs promote erosion and nutrient control measures, as well as water quality monitoring that safeguards aquatic environments and groundwater supplies from agricultural and fishpond nutrients and pesticides in many countries throughout the world.

G/EGAD/AFS provided $20 millioin to the CRSPs in FY 2000. In addition, various CRSPs received a total of about $5 million from other USAID sources (Missions, etc.). Of the nearly $26 million obligated to CRSPs, approximately $2.6 million was allocated for Fisheries and Aquaculture activities ($1.95 million to the Pond Dynamics/Aquaculture Collaborative Research Support Program [PD/A CRSP]). Approximately $3 million was obligated to the Watershed Management and IWRM category ($2.25 million to the Sustainable Agriculture and Natural Resource Management CRSP.

USAID obligated more than $13 million for fisheries and aquaculture activities in such countries as Bangladesh, the Philippines, Kenya, and Colombia (Box 10.3). These programs promote a variety of methods to enhance food security via sustainable production of fish and shellfish, such as fishpond maintenance, fish yield prediction, and nutrient control. Reported obligations (while numerically reported as only 4% of FY 2000 obligations) actually underestimate the level of resources allocated for fisheries and aquaculture, given that these activities are often included in other broader activity portfolios. For example, a portion of the $5.6 million obligated to the CZM programs in Indonesia (Box 7.1) and Tanzania (Box 7.4) include mariculture components to enhance sustainable production of algae and shrimp. Likewise, nearly all of the $1 million obligated to control the water hyacinth weed problem in Lake Victoria, Uganda, directly benefited local fishermen as weed control reopened fishing boat access to areas previously restricted by weed infestation (Box 9.1).

Box 10.3
Colombia: Using Aquaculture as an Alternative to Illicit Crop Production

USAID adds a new dimension to the meaning of food security in Colombia, as it provides fish pond culture as an alternative means of production and income to coca and poppy farmers. Aquaculture activities thereby contribute to the agency goal of eliminating 7,000 hectares of poppy and 40,000 hectares of coca in the region, while providing rural families with a viable source of income and high quality food supply.

Solutions may require greater time and may involve technology transfers and consensus building through participatory planning. IWRM can substantially assist politically charged reforms, such as eliminating water subsidies or instilling competition in the water sector to enhance efficiencies.

Chapter 11
Natural Disasters, Climate Variability, and Climate Change

Global Trends and Emerging Solutions

The gradual warming of the earth's atmosphere may mean that we are entering a period of increased frequency and severity of climate-related disasters, such as drought, flooding, and catastrophic storms. Record losses from weather-related disasters were set in 1998, when more than $90 billion in economic losses resulted from storms, floods, droughts, and fires worldwide, exceeding the $55 billion in losses for the entire decade of the 1980s (Abramovitz, 1999). The climate variability and extremes of 1998 were associated with a particularly strong El Niño Southern Oscillation (ENSO) pattern during 1997 and 1998. These enormous losses were almost repeated the next year, with $67 billion in losses recorded worldwide in 1999 (USAID, 2000). The dual forces of global warming and poor human management choices regarding land and water resources combine to cause such "natural" disasters, and poor planning and preparation exacerbate the level of damage experienced.

Short-term, human exploitation of natural resources weakens the ability of natural systems to mitigate the effects of weather-related events, and places ecosystems and water resources at greater vulnerability.

Forests and wetlands are needed to absorb and slow floodwaters, yet on a global scale these resources are disappearing at alarming rates. One study suggests that if just half of the upper Mississippi River Basin's lost wetlands were still in place during the 1993 flood disaster, the $16 billion in losses could have been reduced (Worldwatch Institute, 1997). Deforested areas can worsen droughts and floods, increase soil loss, represent lost habitat for birds and insects that pollinate crops and control pests, and result in the loss of carbon sinks. Human exploitation of natural resources weakens the ability of natural systems to mitigate the effects of weather-related events and places more people at greater risk in the short term, and places ecosystems and water resources at greater vulnerability.

The health and productivity of ecosystems are fundamental to sustainable development, but they may face increasing threats from global warming in the coming decades. Climate change will potentially affect the geographic location of ecosystems and the structure and function of biological communities, thus influencing their ability to provide ecological goods and services. Many scientists believe that climate change will occur at a rapid rate relative to the speed at which ecosystems can adapt and reestablish themselves (IPCC, 2000). Ecosystem changes in either inland aquatic or coastal systems can have major negative effects on freshwater supplies, biodiversity, fisheries, and important foreign revenue earning industries, such as tourism.

Such change could have equally serious implications for future water supply in some regions. It is predicted that climate change will increase the frequency and magnitude of droughts, floods, and destructive storms in specific regions (IPCC, 2000). Floods are likely to become more problematic in many temperate and humid regions,

Figure 11.1 *Global warming will place stress on coastal wetlands as they begin to "migrate" inland.*

***Figure 11.2** While scientific evidence is still uncertain, some investigators believe that greenhouse gas emissions may exacerbate the problem of increasing frequency of weather extremes and climate variability associated with disaster events.*

necessitating advanced planning, flood forecasting, and even greater attention to well-developed emergency response networks to avoid significant loss of life and property. Some semi-arid regions are in turn likely to become more vulnerable to drought and/or flood-drought cycles that will similarly necessitate stepped-up efforts at integrated water resource management at the river basin scale. Although increasing human demand for freshwater is the largest challenge facing water resource managers, substantially altered hydrological cycles as a result of future global warming can make their task even more difficult.

Water resources managers must begin work on many fronts to ensure that the economic and land-use policies and conditions are in place to guide appropriate private sector investment and resource use patterns.

Climate warming that results in sea level rise (SLR) will likewise place additional, significant stress on coastal systems. Humans are directly responsible for the elimination of half of the world's wetlands during the last century, and SLR will place stress on coastal wetlands as they "migrate" inland. SLR may put two-thirds of the world's largest cities at risk during the next century. Further loss of mangroves and coral reefs could subject tens of millions of people to additional flooding and property damage from storm surges (USAID, 2000). The value of mangroves for flood control alone has been estimated at $300,000 per linear kilometer along some coasts in Malaysia, which represents the cost of building rock walls to protect coastal infrastructure (Worldwatch Institute, 2000). Planning for and adapting to projected SLR is least costly when done before land-use options are foreclosed. A one-meter increase in sea level (the top range of various scenarios projected by the IPCC[47] for 2100), would displace tens of millions in Bangladesh alone in the absence of adaptation measures (IPCC, 2000).

To adapt to and mitigate natural disasters, climate variability, and global climate change, water resources managers must begin work on many fronts to ensure that economic and land-use policies and conditions are in place to guide appropriate private sector investment and resource use patterns. Inappropriate land-use zoning and perverse subsidies for disaster insurance (as well as water and other resources) must be replaced with measures and incentives that promote risk and vulnerability reduction and the restoration of healthy ecosystems. The long-term environmental consequences of resource use must also be addressed with integrated planning that involves people responsible for disaster response and water resources management. A "least-cost" approach will necessarily be proactive rather than reactive, and will make full use of science and the wide range of tools, methods, and technologies now available to aid in disaster forecasting and mitigation.

Application of U.S. government expertise in forecasting and monitoring has the potential to save billions of dollars both domestically and abroad, resources that would otherwise be lost in natural disasters or result from disrupted economies, human health problems, or ecological breakdown due to extreme storm and flood events. For example, studies in the U.S. have shown that advanced warning can dramatically reduce storm and flood damages, and has a benefit-cost ratio

[47] Intergovernmental Panel on Climate Change

anywhere from 2 to 100 times the investment in hydrological monitoring technologies and warning systems. In just one case, a warning system reduced damages by 27% in a flooded area of 650 homes (personal communication, NOAA, 2000). On the other hand, reactive approaches to disasters have proven to be costly; USAID mobilized emergency funds[48] totaling $20 million to flood and storm victims and $11 million to drought victims in FY 2000.

USAID Activities

Agency obligations related to disasters can be sorted into two broad categories: those dealing with forecasting, prediction, preparation and mitigation of disasters, and those dealing with response after the fact. To some extent, reconstruction associated with the response phase often seeks to build in better response to future disasters.

Although important, not all of USAID's disaster response activities have been included in this analysis. Of a total of $174 million obligated under USAID's International Disaster Assistance (IDA) Fund in FY 2000,[49] some $20 million were used for the emergency provision of drinking water and sanitation facilities to disaster victims. Such obligations are an essential element of USAID's international assistance program, but are not considered as part of the agency's portfolio in *sustainable* water resources management.

USAID obligated more than $16 million in FY 2000 for the monitoring and forecasting of water-related extreme events. These activities also included vulnerability assessments and the formulation of mitigation plans aimed at saving lives and money in the face of future drought and storm events. In May 1999, Congress approved $621 million in supplemental funding for CACEDRF for FY 1999 and 2000. In the supplemental, Congress identified specific USG agencies to be involved in the hurricane reconstruction and more than $20 million of the Fund is being implemented through the EPA, the USGS, NOAA, and FEMA. The majority of assistance is to communities in Honduras, Nicaragua, El Salvador, Guatemala, the Dominican Republic, and Haiti, which are the ultimate customers and beneficiaries of the assistance. Activities include the reconstruction of irrigation, water supply, and wastewater treatment systems, and hillside stabilization. Through storm vulnerability assessment, newly reconstructed facilities are being designed and built to better withstand the stresses associated with flood and storm events. Similar post-reconstruction activities are under way in Mozambique (supported by $25 million in FY 2000 and $135 million FY 2001) following the severe flooding experienced in 2000. Efforts to mitigate storm effects are also reflected in many of the combined $94 million activities in coastal zone and watershed management, and BMP implementation discussed earlier in this report.

Nearly all of the funds obligated in Latin America and the Caribbean for disaster monitoring, forecasting, and vulnerability assessment in both FY 1999 and FY 2001 were generated *in reaction* to large-scale disasters, such as Hurricanes Mitch and Georges. In contrast, activities planned in Europe and Eurasia, as well as those throughout sub-Saharan Africa via the FEWS NET program (Box 11.1), are designed as preventive measures to mitigate the impacts of future possible disasters. Through successful efforts to avert famine via

***Figure 11.3** Flooding from severe storm events causes millions of dollars in damage to infrastructure every year.*

[48] USAID's Office of Disaster Assistance (OFDA) in the Bureau of Humanitarian Response can administer emergency aid to countries in need from the International Disaster Assistance (IDA) fund without Congressional approval in order to serve the needs of disaster victims throughout the world.

[49] IDA funds address both natural (storms and floods) and man-made (catastrophic toxic spills and warfare) disasters.

FEWS forecasting, such *mitigation planning* has proven to be cost effective, saving lives and dollars as resources can be reallocated to areas expected to be affected by drought, flooding, or storm events.

Although not originally designed to address the effects of global climate change, many of the activities described here actually contribute to climate change adaptation and mitigation as well. The $16 million USAID obligated for monitoring, forecasting (see Box 11.2), and vulnerability assessments in FY 2000 are also useful adaptation measures to address the potential impacts of climate change. Monitoring and forecasting for food security, as part of the $1.2 million obligated to FEWS NET for water resources management in FY 2000 (Box 11.1), directly assesses vulnerability to drought and famine, and improves capacity to adapt to future climate change.

The $8 million obligated for efforts to control aquatic pollution via cleaner production technologies in the industrial sector also help mitigate the effects of climate change. Further, efforts to enhance coral reef conservation seek the same results, whether degradation results from overfishing, water pollution, coastal zone damage, increased ocean temperature, or global warming. Therefore, vulnerability assessments and mitigation planning are increasingly regarded as proactive, cost-effective measures to protect our water resources threatened by changes in climate (see Box 11.3). They also ensure the sustainable development of a wide variety of water resources and the economic sectors that depend on water availability for their viability.

Box 11.1
FEWS NET:
Drought Monitoring Helps Avert Famine in Africa

USAID obligated nearly $3 million in FY 2000 for the Famine Early Warning System Network (FEWS NET), an information system designed to help decision makers prevent famine in 17 drought-prone countries of sub-Saharan Africa. Approximately $1.2 million of these funds were directly attributed to water-related activities. FEWS NET specialists in the U.S. and Africa assess remotely sensed data and ground-based meteorological, crop, and rangeland conditions for early indications of potential famine. Other factors affecting local food availability and access are also carefully evaluated to identify vulnerable population groups requiring assistance. These assessments are continually updated and disseminated to provide decision makers with the most timely and accurate information available. By helping anticipate potential famine conditions and lessen vulnerability, FEWS NET helps save lives, while also promoting a more efficient use of limited financial resources.

Box 11.2
Central Asian Republics: River and Snow Pack Monitoring Planned

USAID and NOAA are cooperating on providing snow-monitoring and river-forecasting assistance to Central Asian Hydrometeorological Services, known as Glavgidromets. The high-resolution picture terminal (HRPT) will track NOAA polar-orbiting satellites and download imagery that the satellites collect over Central Asia. This imagery will be used by the Glavgidromets to monitor the extent of the snow pack in the Himalayan Mountains, which is the source of most of the water that flows through the Amu Darya and Syr Darya Rivers. NOAA also is working with Glavgidromets to determine whether there are sufficient historical and real-time hydrometeorological data to undertake river forecasting in high-altitude sub-basins for which the snow pack is the principal source of river discharge. Training and developing the technical capacity of the Glavgidromets are important parts of this technical assistance program. Although obligations for this activity were made in FY 2001, efforts to plan the project were carried out in FY 2000.

Box 11.3
The Caribbean Disaster Mitigation Project

Implemented by the Organization of American States (OAS) Unit of Sustainable Development and Environment for the USAID Office of Foreign Disaster Assistance and the Caribbean Regional Program, the CDMP is a coordinated effort to promote the adoption of natural disaster preparedness and loss reduction practices by both the public and private sectors through a program of regional, national, and local activities. Activities target the following six major themes.

- ***Facilitation of Community-Based Disaster Preparedness and Prevention***
  The CDMP recognizes the vital role communities play in assisting government efforts in preparing for natural disasters and mitigating their effects. The project seeks to promote public-private sector disaster mitigation and preparedness initiatives and to carry out pilot projects in specific communities. The final aim is to put in place community-based, sustainable disaster preparedness and prevention programs.
- ***Natural Hazard Assessments and Risk Mapping***
  The CDMP derives hazard and risk information from descriptions of past events, existing topographic and thematic maps, satellite imagery, and other specialized sources. This information is presented in traditional and computer-based, single- and multi-hazard maps for selected study areas. These maps are designed to support incorporation of hazard mitigation in planning and locating physical development, improved emergency management and evacuation planning, and more accurate determination of natural hazard risk by insurance and lending institutions.
- ***Promotion of Hazard-Resistant Building Practices and Standards***
  Large and small contractors, artisans, and others working in the formal and informal building sectors are assisted in adopting effective natural hazard vulnerability reduction measures, and project area governments are assisted in adopting development regulations and building codes that promote vulnerability reduction.
- ***Vulnerability and Risk Audits for Loss Reduction in Lifelines and Critical Facilities***
  Successful performance of lifeline systems (electrical power and communications, water and sewage, transportation, gas, and liquid fuels) is vital for prevention of severe human and economic losses during natural disasters. The CDMP is designed to enable participating institutions to conduct risk audits for utilities and other infrastructure, and to help implement their recommendations.
- ***Promotion of Loss Reduction Incentives and Hazard Mitigation in the Property Insurance Industry***
  The CDMP is working with the Caribbean insurance industry on various actions aimed at easing the property insurance crisis in the region. Among these actions are:
  - ► supporting national insurance associations in organizing technical conferences and in disseminating hazard and risk information;
  - ► producing hazard and risk maps and information to promote safer location of development; and
  - ► promoting loss reduction initiatives on the part of the insurance industry.
- ***Incorporation of Hazard Mitigation into Post-Disaster Recovery***
  While the preferred mode for providing technical assistance in disaster mitigation is to incorporate vulnerability reduction measures into all aspects of development projects, the reality is that often a disaster may strike before there exists sufficient institutional and technical interest in mitigating against future losses. For this purpose, the OAS/CDMP has developed a Post-Disaster Mitigation Strategy, which enables disaster-affected OAS member states to have access to a wide pool of technical specialists to assist in the design of mitigation activities and their incorporation into reconstruction plans and projects.

References

Abramovitz, J. 1996. Imperiled Waters, Impoverished Future: The Decline of Freshwater Ecosystems. Worldwatch Paper 128. Worldwatch Institute, Washington, DC.

Abramovitz, J. 1999. Disasters in the Making. World Watch (July/August).

Brown, L.R. 2000a. Population Growth Sentencing Millions to Hydrological Poverty. Worldwatch Issue Alert (June). Washington, DC, Worldwatch Institute.

Brown, L.R. 2000b. Fish Farming May Soon Overtake Cattle Ranching as a Food Source. Worldwatch Issue Alert (October). Worldwatch Institute, Washington, DC.

Brown, L.R. and B. Halweil. 1998. China's Water Shortage Could Shake World Food Security. Worldwatch Institute (July/August).

Bryant, D., L. Burke, J. McManus, and M. Spalding. 1998. Reefs at Risk. World Resources Institute, Washington, DC.

Cairncross and Feachem. 1993.

Cosgrove, W.J. and F.R. Rijsberman. 2000. World Water Vision: Making Water Everybody's Business. Report prepared for the World Water Council. Earthscan Publications, Ltd. London, U.K

Costanza, R., *et al.* 2000. Principles for Sustainable Governance of the Oceans. *Science*. 28(5374):198.

Costanza, R. 1997. The Value of the World's Ecosystem Services and Natural Capital. *Nature* 387 (15 May).

Development Alternatives, Inc. 1999. Management of Transboundary Water Resources Training Course Manual (July).

Gleick, P.H. 1998. The World's Water 1998-1999: The Biennial Report on Freshwater Resources. Island Press. Washington, DC. *Also available at* http://www.worldwater.org/theBook1999.htm.

Gleick. P.H. 1996. Basic Water Requirements for Human Activities: Meeting Basic Needs. International Water Resources Association. *Water International* 21:83-92.

Global Water Partnership (GWP). 2000. Framework for Action: Responding to the Forum. Global Water Partnership. Stockholm, Sweden. *Also available at* http://www.worldwaterforum.net/index2.html.

Green Cross International. 2000. National Sovereignty and International Watercourses. Presented at the 2nd World Water Forum, The Hague (March).

Hinkel. R. 1999. Coastal Megacities and Sea-Level Rise. Trends and Future Challenges for U.S. National Ocean and Coastal Policy (January 22). Washington, DC.

Hinrichsen, D. 1998. Coastal Waters of the World: Trends, Threats, and Strategies. Island Press. Washington, DC.

Hinrichsen, D., Robey, B., and U.D. Upadhyay. 1998. Solutions for a Water-Short World. Population Reports, Series M, No. 14. Johns Hopkins University School of Public Health, Population Information Program. Baltimore, MD.

IPCC (Intergovernmental Panel on Climate Change). 2000. Special Report on the Regional Impacts of Climate Change: An Assessment of Vulnerability. *Also available at* http://www.grida.no/climate/ipcc/regional/index.htm.

Metcalfe, E. 2000. Nor Any Drop to Drink. The Ecologist (July/August).

Postel, S. 1996. Dividing the Waters: Food Security, Ecosystem Health and the New Politics of Scarcity. Worldwatch Institute. Washington, DC. *Also available at* http://www.techreview.com/articles/apr97/postel.html.

Postel, S. 1997. Last Oasis: Facing Water Scarcity. Norton & Co., New York, NY.

Postel, S. 1998. Water for Food Production: Will There Be Enough in 2025? *BioScience* 48(8):629-637.

Postel, S. 1999. Pillar of Sand: Can the Irrigation Miracle Last? Norton & Co. New York, NY.

Postel, S. 2000. Troubled Waters. Utne Reader (July/August).

Revenga, C., J. Brunner, N. Henninger, K. Kassem, and R. Payne. 2000. World Pilot Analysis of Global Ecosystems. Resources Institute, Washington, DC.

Salman, S.M.A., and L.B. de Chazournes (eds.). 1998. International Watercourses: Enhancing Cooperation and Managing Conflict. World Bank Technical Paper 414. World Bank, Washington, DC.

Sampat, P. 2000. Deep Trouble: The Hidden Threat of Groundwater Pollution. Worldwatch (January/February).

Seckler, D., D. Molden, and R. Barker. 1999. Water Scarcity in the Twenty-First Century. International Water Management Institute. Water Brief No. 1.

Shah, T., D. Molden, R. Sakthivadivel, and D. Seckler. 2000. The Global Situation of Groundwater. International Water Management Institute.

United Kingdom Department for International Development. 1998. Guidance Manual on Water Supply and Sanitation Programmes. Department for International Development, United Kingdom.

UNPD (United Nations Population Division). 1998. World Population Prospects: The 1998 Revision. 1. United Nations Population Division, New York, NY.

USAID (U.S. Agency for International Development). 2000. Climate Change Initiative Report. U.S. Agency for International Development, Washington, DC.

White, A.T. and A. Cruz-Trinidad. 1998. The Value of Philippine Coastal Resources: Why Protection and Management are Critical. Coastal Resources Management Project, Cebu City, Philippines.

WHO/UNICEF (World Health Organization/United Nations Children's Fund). 2000. Global Water Supply and Sanitation Assessments 2000 Report. *Also available at* http://www.who/int/water_sanitation_health/Globassessment/GlobalTOC.htm.

Wilkinson, C. (ed.). 2000. Status of Coral Reefs of the World: 2000, Report of the Global Coral Reef Monitoring Network. Australian Institute of Marine Science. Cape Ferguson, Queensland.

Wolf, A.T. 1999. Water and Human Security. *Aviso* 3(June), Global Environmental Change and Human Security Project, Woodrow Wilson Center. Washington, DC.

Worldwatch Institute. 1994. State of the World Report. Washington, DC,.

Worldwatch Institute. 1997. Damage to Nature Now Causing Widespread "Natural" Disasters, Economic Hardship. Worldwatch Press Briefing (February 11).

WRI (World Resources Institute). 1995. Threats from Environmental Estrogens. World Resources Institute, Washington, DC.