

CENTER FOR STRATEGIC AND INTERNATIONAL STUDIES  
and SANDIA NATIONAL LABORATORIES



Sandia  
National  
Laboratories

# GLOBAL WATER FUTURES

## Addressing Our Global Water Future

A White Paper by  
The Center for Strategic and International Studies and  
Sandia National Laboratories

Supported by ITT Industries, with additional assistance from the  
Coca Cola Company and Procter & Gamble





# Addressing Our Global Water Future

## EXECUTIVE SUMMARY

This White Paper addresses the growing global challenge of increasing water scarcity and declining water quality. Across the planet, in developing and developed regions alike, poor governance and mismanagement of natural resources coupled with rising population growth, increasing urbanization, and economic development have led to a growing imbalance between water supply and demand. This imbalance is reaching crisis proportions in many regions. The disparity will have even more significant consequences for economic development, stability and security unless there is a more dramatic and urgent international response, effective immediately. Several international forums have arisen to address just this issue. The question remains how the United States could and should engage these forums and formulate a response to the world's freshwater challenges. The goals of this White Paper, therefore, are to (1) make the case for elevating the response to global water challenges as a strategic priority for the United States; (2) identify the most effective responses to global water challenges; and (3) explore U.S. policy options, current and future.

From previous experiences across the planet, it is clear that institutional capacities in governance systems across the world—varied as they are—must all be strengthened to adequately address the magnitude of future challenges involving water. Improving governance will enable and facilitate the development of strategies and responses engaging the full range of available water-related technologies—from high tech, high expense to low tech, low expense. Solutions across this range exist today, and they must be deployed on larger scales and in timely, innovative ways in order to reduce the impacts on public health, economic development, and political stability that result from a lack of adequate clean, safe water for human consumption. Continual effort and investment is needed to develop undiscovered technologies, policy approaches and synergies that could jumpstart new solutions for addressing this growing global crisis in the decades to come. Policy and technology must evolve together to effectively link innovative strategies with innovative technologies. For these reasons, this White Paper emphasizes the development of strategies to address current and future global water challenges with a specific focus on governance and technology and the critical linkages between the two.

This paper is organized into four parts to explore the three goals outlined above. Section One describes the nature and scope of the global water challenges that face the world. Sections Two and Three explore potential areas for innovation and synergy in policy, governance, capacity building, and the application of technologies. The paper culminates in Section Four with an examination of how U.S. departments, agencies and policymakers should integrate and prioritize water as a relatively low-cost, high-impact vector of U.S. foreign policy.

This Executive Summary highlights the analysis in the White Paper by pointing to 14 specific findings, organized by four broad themes that emerged from extensive background research and two major workshops in February and March 2005. Detailed support of the assertions and recommendation made in this Executive Summary are set out in the text of the full paper.

A more detailed description of the overall CSIS-Sandia effort, including multimedia materials from our two workshops, can be found at <http://gsi.csis.org/waterweb/index.html>.

## SECTION ONE

Already at crisis proportions, global water problems could be a source of conflict and instability in the future.

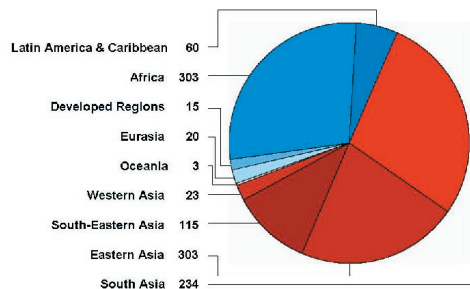
**Finding 1: Water scarcity caused by mismanagement and a growing imbalance between supply and demand is driving us toward a tipping point in human history.** Global trends of increasing population, increasing natural resource consumption, and decreasing natural resource availability—including freshwater—have pushed many human social, economic and political systems to an important tipping point. Poor management of natural resources exacerbates the problem. We face large-scale future dislocations and crises unless significant action is taken now by leaders in developed and developing countries alike.

Increasing human population and continued economic development leading to increasing consumption and decreasing availability of many natural resources have set the world on a collision course with global physical and ecological constraints. Poor management of resources hastens the potential for this collision. Humans already appropriate over half of all accessible freshwater resources, and future water withdrawals and consumption are expected to continue their steady rise. By 2025, over half the world's population will live in water stressed or water scarce countries.

These issues are driven by trends in population growth, urbanization, industrialization, economic development, and climate change. More people will need to be fed by dwindling sources of arable land. Rising food demand will push the expansion of irrigated agriculture—already one of the most inefficient uses of water. Likewise, economic development

### Lack of Access to Safe Drinking Water and Sanitation

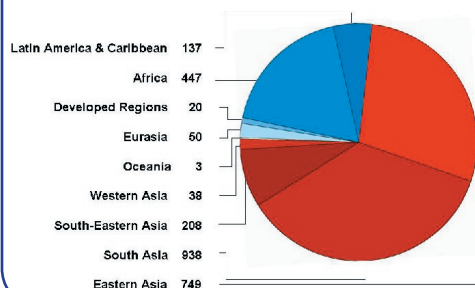
Population without improved drinking water sources by region in 2002 (millions)



1.1 billion people lack access to safe drinking water and 2.6 billion lack access to sanitation.

The majority of those affected live in Asia (see red slices on graph).

Population without improved sanitation by region in 2002 (millions)



The situation is worst in sub-Saharan Africa, where 42 percent of people lack access to safe drinking water and 64 percent lack access to adequate sanitation.

Source: WHO/UNICEF 2004

requires new power plants that use significant amounts of water in cooling towers. Industrialization will also continue to attract water-intensive industries to water-stressed developing countries—China serving as a case in point.

The consequences of over-consumption and mismanagement on human health, economic development and the functioning of regional and global aquatic ecosystems are already dire and can be expected to worsen. Groundwater levels are dropping and rivers, lakes and wetlands are drying up around the world. Billions of people already lack access to safe drinking water or basic sanitation facilities. Water pollution further constrains safe water supplies for people, agriculture, industry, and ecosystems.

In addition, the reach of these challenges is expanding. They apply not only to arid regions and developing nations but also to developed countries. Almost every region of the world is already experiencing—or soon will experience—water shortages and/or water quality challenges. Coordinated and consolidated regional and global efforts will be necessary to accelerate progress and to keep step with the array of forces affecting global water supply and demand.

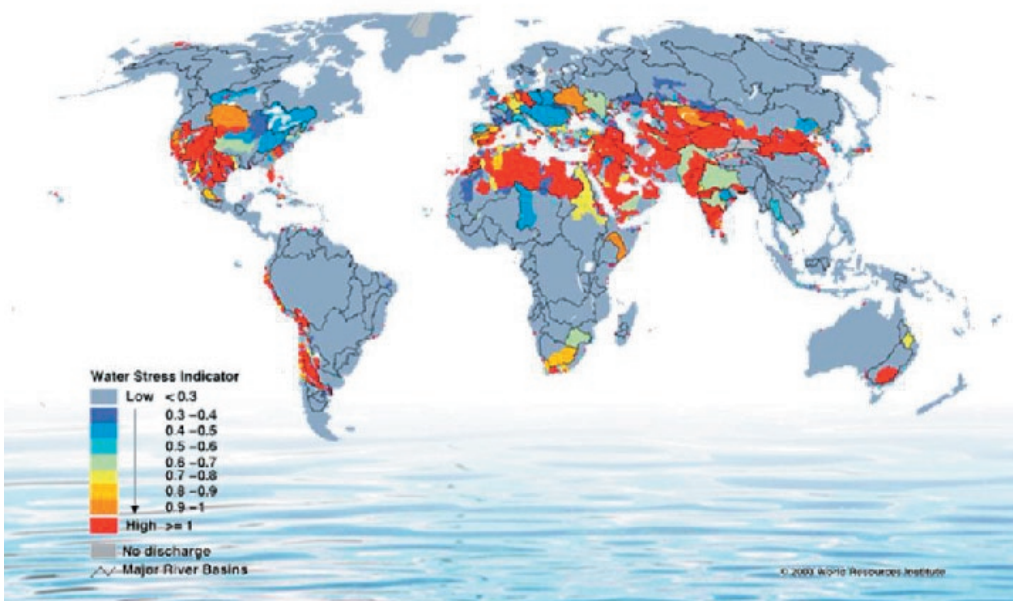
**"We are moving quite rapidly now into what is an unprecedented period of water stress that is not going to ease for some decades..."**

*-Sandra Postel, Global Water Policy Project  
CSIS-SNL Global Water Futures Conference 2005*

#### Did you know...

- The Millennium Ecosystem Assessment (2005) estimates that between 5 and 25 percent of global freshwater use exceeds long-term accessible supplies. Agricultural uses are the biggest concern, with an estimated 15 to 35 percent of irrigation withdrawals in excess of sustainable limits (Millennium Ecosystem Assessment 2005).
- In order to meet growing food needs, the FAO (2003) estimates water withdrawals by 2030 for irrigation must increase by 14 percent in developing countries, many of which are already experiencing water shortages or are badly mismanaging natural resources and irreparably damaging the environment.
- Industrial withdrawals of water are expected to rise by 55 percent out to the year 2025. Currently, water use per unit of output in transition economies is two to three times higher than in OECD countries (Cosgrove and Rijsberman 2000).
- More than 40 percent of growth in electrical production out to the year 2030 will take place in Asia, and will be based principally on coal and natural-gas-fueled plants (ExxonMobil 2004).
- By the year 2050, untreated wastewater could reduce the world's freshwater resources by as much as 18,000 km<sup>3</sup> annually (UNESCO-WWAP 2003). That is the equivalent of over a third of the global annual renewable supply of about 49,000 km<sup>3</sup> (Gleick 1998), or almost four times the annual flow of the Amazon River.

## Water Scarcity and Water Stress



In 1995, over 400 million people lived in countries experiencing water stress or water scarcity.

By 2025, 4 billion people will live in countries where constraints on water supply will give rise to serious social, public health, economic, and environmental problems.

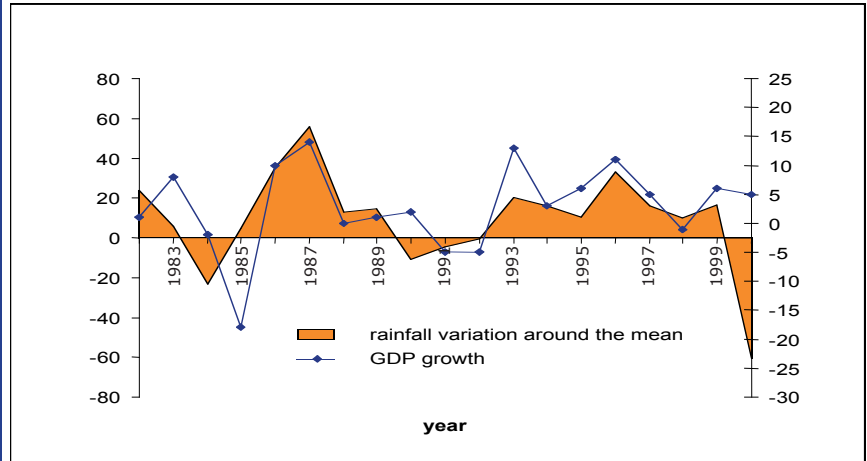
**Finding 2: Water is a foundation for human prosperity.** Adequate, high-quality water supplies provide a basis for the growth and development of human social, economic, cultural and political systems. Conversely, economic stagnation and political instability will persist or worsen in those regions where the quality and reliability of water supplies remain uncertain.

Adequate supplies of freshwater are a cornerstone for human activities at all scales, from daily subsistence needs to higher levels of economic production. Lack of access to safe, clean water for drinking, sanitation, agriculture, or industry is perpetuating cycles of poverty and limiting viable development options in regions around the world.

Without access to a reliable and convenient source of water, family members, most often women and girls, can spend hours each day collecting water. In addition, the water supply is typically unsafe or is stored and transported in ways that ultimately contaminate it. Either situation can result in contraction of life-threatening water-related diseases. Water-related diseases and the requirements of water collection keep children from attending school and keep adults from engaging in productive economic activities. The costs of lost productivity and foregone economic opportunity can be measured in the hundreds of millions of dollars, even in areas of the world where wages may be only a few dollars a day. These concerns are equally relevant for both urban slums and remote rural areas, but the solutions for addressing these challenges differ with each situation.

On a broader scale, countries require a certain level of water infrastructure to support economic activities. Irrigation networks overcome drought and prevent famine; dams and dikes regulate water flows and avoid floods. Countries with adequate infrastructure and institutions to balance low flows and high flows across geographic and temporal barriers are able to protect water quality and capitalize on the productive benefits of water while minimizing the risks of too much or too little water at any given time. For these countries, water represents a net positive force for the economy. In contrast, for countries susceptible to variations in water flow or unable to ensure its quality,

### Variability of Rainfall and GDP in Ethiopia



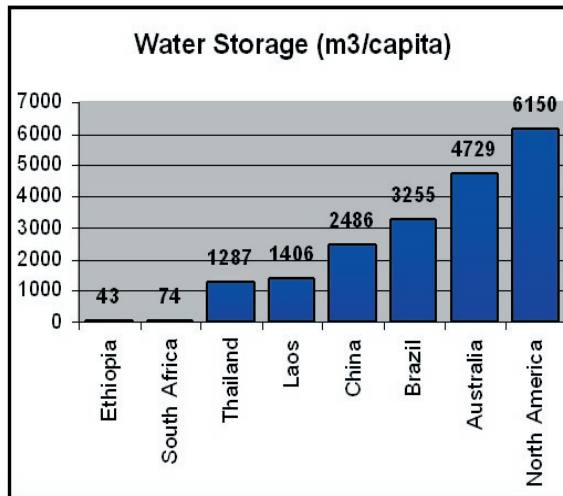
Source: Grey and Sadoff 2005

### Did you know...

- Two million tons of human waste is released into streams and rivers around the world every day (UNESCO-WWAP 2003).
- Eighty percent of people without access to sanitation live in rural areas, totaling 1.3 billion people in rural India and China alone (UNESCO-WWAP 2003). Roughly one third of all people living in rural areas lacks access to improved drinking water sources (CSD 2004a).
- In order to meet the Millennium Development Goals of halving the proportion of people without access to basic sanitation, 1 billion people in urban areas and 900 million people in rural areas will need to be served by 2015 (WHO/UNICEF 2004).
- Five million people die every year as a result of water-borne diseases or water-related illnesses (WHO and UNICEF 2000)
- In Africa, 40 billion working hours are lost each year to carrying water (Cosgrove and Rijsberman 1998). In India, waterborne diseases cost 73 million lost working days and \$600 million in medical treatment and lost production (Lenton and Wright 2004).
- Urban populations in developing countries not connected to a tap often pay ten to twenty times more for water delivered by a truck than water that is delivered to other city residents through a pipe (Cosgrove and Rijsberman 2000).
- In the Tamil Nadu region of India, irrigated districts averaged only 25 percent poverty rates compared to 70 percent in un-irrigated districts. In Kenya, the El Niño flood and subsequent La Niña drought caused estimated damages equivalent to 11 percent and 16 percent of GDP in 1998-99 and 1999-2000 financial years (Grey and Sadoff 2005).

water represents a significant barrier to economic growth. Not only can water hamper economically productive activities, but it also may deter risk averse investors both within the country and from abroad.

Ecosystem degradation caused by water withdrawals, loss of wetlands, and water pollution will also hinder economic development by affecting ecosystem services—purification and delivery of fresh water, decomposition of wastes, generation of soils, pollination of crops, production of wood and fiber, etc.



Water storage capacity is one indicator of water security—the reliable availability of water coupled with an acceptable level of risk that together impact production, livelihoods, and health.

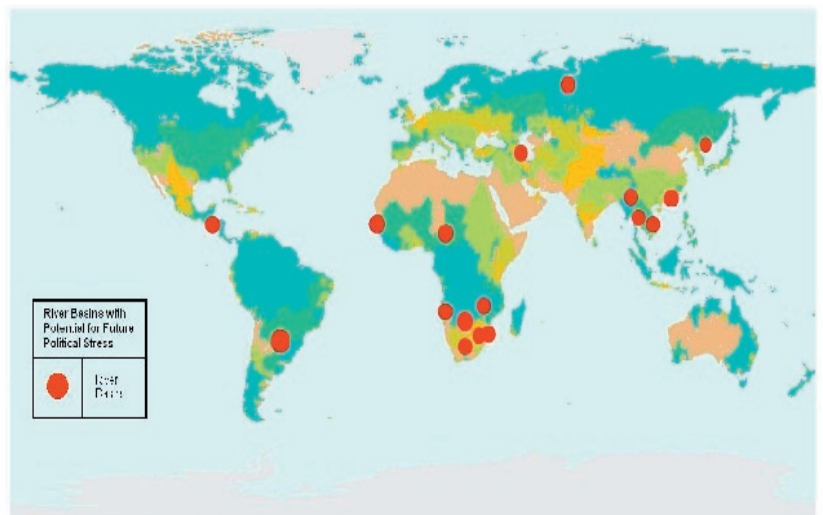
Source: World Bank 2005

**Finding 3: Water problems are geopolitically destabilizing.** *Water scarcity and poor water quality have the potential to destabilize isolated regions within countries, whole countries, or entire regions sharing limited sources of water. There is an increasing likelihood of social strife and even armed conflict resulting from the pressures of water scarcity and mismanagement.*

Water scarcity and poor water quality could lead to increased potential for domestic instability and heightened transnational tensions. History shows that in many regions around the world, water has been a source of considerable cooperation between nations sharing water resources. However, increasing populations and water scarcities may bring about a different future. In the years ahead, instability or conflict related to water supplies will likely take two forms: (1) domestic unrest caused by the inability of governments to meet the food, industrial, and municipal needs of its citizens, and (2) hostility between two or more countries—or regions within a country—possibly leading to greater insecurity or conflict, caused by one party disrupting the water supply of another.

Over the past five years, several domestic upheavals involving water have erupted across the world. These violent episodes have occurred in countries with varying degrees of economic development and in both rural and urban settings. However, they were all largely the results of the perception or reality of rising imbalances in water availability and the failures of governments to effectively and transparently mediate the concerns and demands of various users.

International River Basins at Risk of Future Conflict



Source: CIESIN et al., 2000; Fekete et al., 1998.  
Projection: Geographic

Source: Wolf et al. 2003

Map produced by the World Resources Institute, 2000.

### Did you know...

- Forty percent of the world's population lives in more than 260 international river basins of major social and economic importance, 13 of which are shared by five or more countries.
- Fifty percent of global population growth is expected to take place in countries already experiencing or expected to experience some form of water stress.
- By 2030, 35 countries will reach water availability thresholds that will require significant food imports.
- The Ganges-Brahmaputra, Han, Incomati, Kunene, Kura-Araks, Lake Chad, La Plata, Lempa, Limpopo, Mekong, Ob (Ertis), Okavango, Orange, Salween, Senegal, Tumen and Zambezi river basins have all been identified as "basins at risk" of international conflict (see map).

Growing water imbalances will also alter international relationships. Changing patterns of food trade caused by water scarcity will influence international alliances. Cross-border relations between riparian countries in water stressed regions will undoubtedly be shaped by water sharing agreements or the lack thereof. Conflicts related to water scarcity will continue to strike hardest in regions already facing geopolitical stress and conflict and will exert enormous pressure on existing transboundary and domestic instabilities.



***"[E]ver increasing demand for the scarce water resources that we have will almost certainly lead to future geopolitical conflicts and we need to find ways to head that off."***

*-Senator Jeff Bingaman  
CSIS-SNL Global Water  
Futures Conference 2005*

**Finding 4: Poor governance and poor economies contribute to and exacerbate water scarcity problems.** *Poor governance and poor economies in regions around the world where water challenges are most severe impair the effective application of either innovative technology or innovative policy. Furthermore, poor governance creates a disincentive to the mobilization of international and domestic financial resources. Solutions to water problems must therefore be linked to improvements in governance.*

There is a general deficit in good governance, strong institutions, adequate financial investment, and political will. These factors are as much a cause of global water imbalances as trends in population growth and economic development—and these shortcomings are cause for more immediate concern.

Specific water governance concerns differ across all nations but can be grouped into three broad categories: (1) institutional and regulatory environments, (2) the tensions between central and periphery management, and (3) governance capacity.

Insufficient or poorly defined regulatory environments create confusion about roles and responsibilities for citizens, government institutions, and the private sector. In addition, a lack of firm regulations and the institutional capacity to enforce those regulations often translates into a lack of incentives for water utilities, whether publicly or privately managed, to expand infrastructure to the poor and maintain water quality.

Increasing local participation in the planning, implementation, and maintenance of water projects would improve sustainability by shoring up regulatory

#### Did you know...

- Participants in a workshop organized by the Asian Development Bank also identified low levels of education, sharp societal divides, bureaucratic impediments, and possible corruption as obstacles for civil society to take on greater roles in the development and management of water infrastructure (Pigram 2001).
- The Global Water Partnership estimates that total spending on water infrastructure (for domestic, commercial, agricultural, and industrial needs) need to increase from current levels of \$75-80 billion per year to \$180 per year from 2000-2025 for a total of \$4.5 trillion.
- Reaching the Millennium Development Goals of reducing by one half the number of people without access to safe drinking water and sanitation will require annual investments of \$5 billion over the next ten years.
- Today, about 65 percent of spending on water services comes from government, 20 percent from the private sector ranging from small water vendors to private municipal and metropolitan utilities, 10 percent from international donors, and the remainder from the international private sector (Cosgrove and Rijsbermin 2000).
- Private sector investment in all types of infrastructure in developing and industrialized countries declined from an all time high of over \$120 billion in 1997 to under \$50 billion in 2002 (Lenton et al. 2005).
- Official development assistance for water dropped from an average of \$3.5 billion between 1996 and 1998 to \$3.1 billion between 1999 and 2001.
- From 2001-2002 less than 16% of total foreign aid to the water sector went to countries where less than 60% of the population had access to an improved water source, including most of the least-developed countries (Lenton et al. 2005).



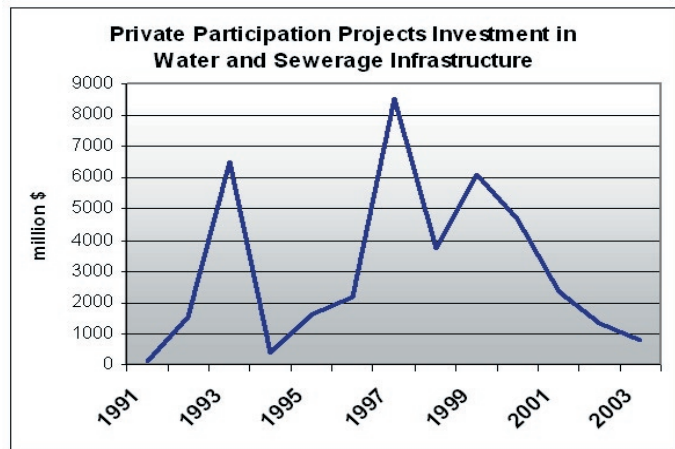
oversight, incorporating local knowledge, better addressing local needs, and creating community buy-in. However, low levels of education, sharp societal divides, bureaucratic impediments, and possible corruption at all levels of governance act as obstacles for civil society to take on the roles that would make decentralized approaches effective. Capacity building across the board in technical, financial, managerial, and social intermediation is necessary.

An absence of incentives and poor governance can also lead to severe gaps in available capital for expanding, maintaining, and improving water infrastructure. Current estimates suggest annual investment in water infrastructure will need to double over the next two decades. Sources of capital for infrastructure development in developing countries have traditionally come from predominantly domestic sources rather than foreign assistance. If official development assistance and private sector spending on infrastructure continues to decline in the future, governments will have to expand their share of infrastructure investment. Poor governance will continue to create obstacles for raising the necessary financing.

World Water Vision Estimates for Required Annual Investment in Water  
(In Billions of US Dollars)

Use	1995	2025
Agriculture	30-35	30
Industry	10-15	75
Water supply & sanitation	30	75
<b>Total</b>	<b>70-80</b>	<b>180</b>

Source: Cosgrove & Rijsberman 2000



Source: World Bank 2004

## SECTION TWO

Institutional capacities must transform and expand in many ways to meet current and future challenges.

**Finding 5: Solutions must be innovative, revolutionary, and self-sustaining.** *Current trajectories for improvement in freshwater availability and quality are inadequate to meet global needs in a timely way. Innovative solutions must be found and employed that replace steady, incremental rates of progress with dramatic, revolutionary changes. These solutions must be designed to be self-sustaining over the long-term.*

Current efforts are inadequate to meet near-term, large-scale crises in strategically important regions of the developing world. These efforts will also fall short of meeting longer-term, large-scale shortfalls in developed regions. In order to meet targets and to make efforts sustainable, the world community must adopt thinking and strategies that do not simply provide “more of the same,” but that actually change the trajectory of current progress. Efforts must yield exponential progress—or “step changes”—rather than linear progress. These new trajectories must be pursued through new policy approaches, new technologies, and new synergies between the two.

Sustainable solutions generally exhibit three characteristics. First, they are strategic. Water is a strategic resource, meaning it is vitally important to human prosperity, economic development, environmental health, and political and geopolitical stability. The most effective solutions will recognize this importance and leverage the different roles water plays in each of these areas. Second, sustainable solutions are innovative. Innovation can stem from not only entirely new solutions, but also new applications and new mixes of past solutions. Finally, sustainable solutions are effective over the long-term. Long-term solutions not only extend the lifespan of solutions implemented today, but also leverage the next generations of innovations and successes in an ever-rising upward spiral. Strategic, innovative, long-term approaches will be necessary to solve the global water challenges of both today and tomorrow.

**Progress on Attaining Millennium Development Goal 7**  
(Target: Halve the proportion of people without access to improved water sources)

	Achieved	On Track	Lagging	Far Behind	Slipping Back	No Data
Sub-Saharan Africa	1	9	4	9	0	21
East Asia and the Pacific	0	6	1	4	0	8
South Asia	3	4	0	0	0	1
Arab States	0	8	0	3	0	6
Latin America and the Caribbean	1	21	1	2	0	8
Central and East Europe and the CIS	0	8	0	0	0	17
	Number of Countries					

Sub-Saharan Africa is not on track to meet the Millennium Development Goal targets on safe drinking water or sanitation. Many of the countries of East Asia and the Pacific are also falling behind.

Source: UNESCO-WWAP 2003

***“[Y]ou need a management super-structure which is congenial to new technology, and not just the tried-and-true approaches that we heard so much about in the water sector.”***

*-Hank Habicht, GETF*

*CSIS-SNL Global Water Futures Conference 2005*

***“With a little restructuring here and there, I believe this decade can be the start of a whole new program and a whole new process. So that is a world vision. It’s a global vision.”***

*-Ambassador John McDonald, Institute for Multi-Track Diplomacy on the International Decade for Action: Water for Life, 2005-2015*

*CSIS-SNL Global Water Futures Conference 2005*

**Did you know...**

- Over one billion people were connected to safe water supplies during the first International Decade for Clean Drinking Water, from 1981-1990; 1.1 billion people still lack access to safe drinking water today.

On March 22, 2005, World Water Day, the United Nations inaugurated a second international decade for action related to freshwater. The purpose of Water for Life (2005-2015) is to promote efforts to fulfill international commitments made on water and water-related issues in the Millennium Development Goals and at the 2002 World Summit on Sustainable Development in Johannesburg. Innovative, sustainable solutions will be critical in avoiding the need for a third international decade for water. (More information at [www.un.org/waterforlifedecade/index.html](http://www.un.org/waterforlifedecade/index.html))

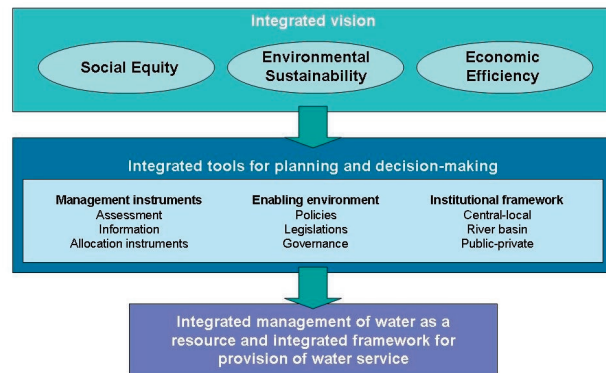
**Finding 6: Participatory principles strengthen sustainable solutions.** *Effective water planning and management at local and regional levels requires a broad and integrated collaboration, including farmers, urban developers, environmentalists, industrialists, policy makers, citizens, and others, all within an open and participatory framework. Water improvement and management projects conducted at local and regional levels that promote the principles of multi-stakeholder processes and open communication can play a dual role as democracy-building projects.*

The foundation for any self-sustaining strategy that addresses water challenges is an open, participatory system that engages all relevant stakeholders—farmers, urban developers, environmentalists, civil society, non-governmental organizations, local to national government representatives, and others. This approach must strike a balance between economic, social and environmental interests.

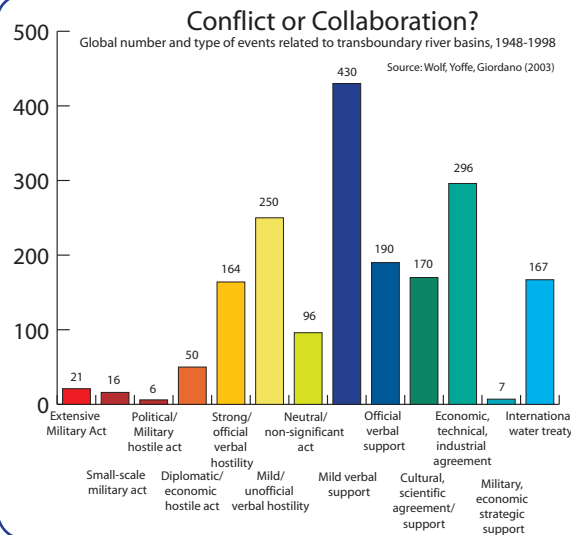
The concept of “integrated water resource management” (IWRM) is heralded as a means to overcome the traditional sectoral treatment of water. IWRM seeks to give consideration to the multiple uses of the resources. IWRM strategies must consider both the physical dimensions of a source of water—location, type, quantity, and quality—as well as the nonphysical—the interests, habits, education levels, cultural predilections, preferences and objectives of the broad array of water users, as well as broader ecological, political and economic goals imposed by society. A framework to move towards effective IWRM must ensure the concurrent development and strengthening of three elements: (1) an enabling political and regulatory environment; (2) appropriate institutional roles for all stakeholders; and (3) practical management tools and approaches drawn from policy, technology and economics and appropriate for the circumstances in which they are applied.

Effective integrated water resource management relies upon community participation. The principles of this approach can be applied at any level and at any scale, depending on the circumstances. As such, participatory, integrated water projects can improve gender equality, foster democratic institutions, and improve tenuous or uncertain cross-border relations.

### Framework for creating an Integrated Water Resource Management Strategy



Source: UNESCO-WWAP 2003



In the past fifty years, water has been a more often unifying than dividing force.

This quality can be leveraged to bring disparate communities, sectors, and countries together.

***“We found that you can get people in urban poor areas from different ethnic groups to work together if everybody understands that they have equal participation. We found that you can get communities and their local government officials to negotiate and talk together about how to do work together to address their water and sanitation issues, especially around extending water lines and making sure that the water is available at a fair price.”***

*-Steven Werner, Water For People  
CSIS-SNL Global Water Futures Conference 2005*

**Finding 7: Sustainable strategies must include diverse and multi-institutional partnerships.** *No single government agency, non-governmental organization, corporation, international organization, or academic institution can provide all the required expertise or coordinate a sufficiently integrated response to meet the nature and scope of global water challenges. Partnerships across social organizations are necessary for both developing and implementing sustainable solutions.*

The varying competencies of government agencies, international organizations, non-governmental organizations, the private sector, and academic institutions can all provide specific expertise to addressing water challenges in situations across the globe; but no single organization can effectively address these challenges without the support and cooperation of the others. In both donor governments and recipient governments, agencies from federal to local levels have specialized knowledge that will deliver optimal solutions only when resources are pooled and collaboration is enhanced. The private sector has increasingly become engaged in issues related to freshwater, lending both expertise and financial resources. Greater coordination and cooperation between the private sector, nongovernmental organizations, governments, international organizations, and academic institutions both within countries and across borders will foster truly innovative and sustainable solutions. Greater cross-sector collaboration must occur to foster more effective resource planning and implementation.

***"[T]he private sector can certainly not do it all. We don't have the knowledge or the capacity that we would need in public health. And for many new interventions, reaching people in the developing world requires a public health intervention and public health education, so partnerships are absolutely necessary."***

*-Greg Allgood, Procter & Gamble  
CSIS-SNL Global Water Futures Conference 2005*

#### **Experts speak...**

- "Partnerships are particularly important in a global world where traditional boundaries between what is seen as public versus private responsibilities have become increasingly blurred, and where challenges such as the management of water resources extend beyond national and political borders" (Dossal and Fanzo 2004).
- "Cooperation in the management and development of international rivers may contribute to political processes and institutional capacities that themselves open the door to other collective actions, enabling cross-border cooperation beyond the water resources" (Sadoff and Grey 2002).

**Finding 8: New ways of investing in, pricing and valuing water can provide powerful solutions.** A serious funding gap exists between projected financial needs and current trends in spending on water projects. International lending institutions and official development assistance should be leveraged to generate more in-country capital. Private-sector involvement offers a largely untapped source of investment, leadership, knowledge, and innovation, and must be mobilized. Difficulties in valuation of water and inadequate economic indicators obfuscate the role sustainable water resources play in economies. A participatory governance structure, strong institutions, clear regulatory frameworks, and better valuation methods will all support the development of new, innovative modes for financing improvements and expansion of water infrastructure.

While official development assistance (ODA) for water projects has been declining, ODA constitutes only a small fraction of total spending on water services. Therefore, to effectively address the growing gap between current and still needed investment, new, innova-

***"I certainly would argue that you'd see an improved investment and cost recovery with a regulatory framework [and] market-based pricing."***

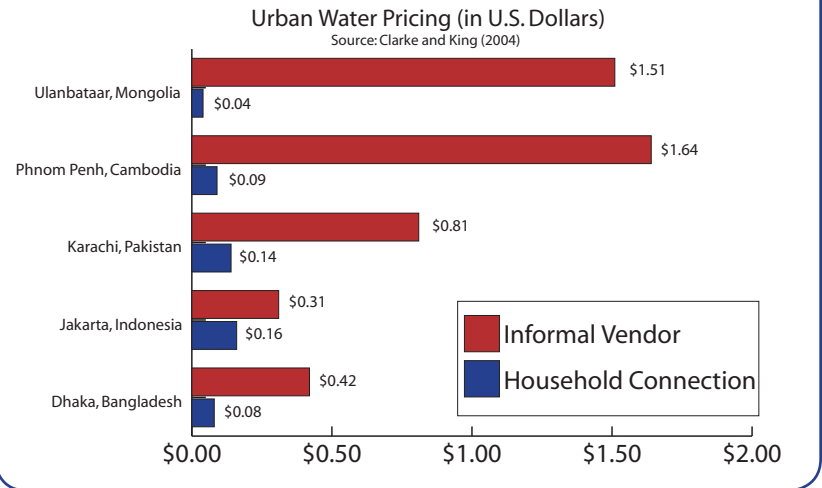
*-Janice Beecher, Michigan State University  
CSIS-SNL Global Water Futures Conference 2005*

tive methods of financing must be made available to governments in developing countries. Creative approaches to finance include municipal bond issuance, public-private partnerships, revolving fund models, and the creation of enterprise development funds focused on water issues.

Expanding investment will help alleviate many of the world's water challenges, but long-term sustainability is contingent on formulating robust water pricing models. New pricing structures based on cost-recovery will be key not only in providing the necessary incentives for investors to make a commitment to water projects, but also to provide the revenue necessary for operation and maintenance of existing systems. Such pricing models will also be necessary to engage the private sector, and in turn reap the benefits of greater efficiencies and improvements in service often realized through privatization.

However, the potential for marginalization of the poor and important cultural values must be recognized. Creating a strong regulatory framework integrated with an open, participatory management structure will support systems in which water prices can be readjusted to better reflect the cost of delivery, and in which the interests of both the water providers and the poorest segments of society are met.

While some critics argue that rationalizing water tariffs will hurt the poor, the poorest segments of society not connected to municipal water supplies are already paying up to 100 times as much for water. Creating incentives for government or private water utilities to service these disconnected populations will require some form of cost-recovery pricing.



### Experts speak...

- "Conceptualizing the provision of safe drinking water and adequate sanitation as a development objective broader than those usually considered as environmental objectives may elevate water infrastructure projects to a greater priority in lending agendas (Rodriguez 2004)."
- Domestic and industrial users often pay over one hundred times as much per unit as agricultural users (Cosgrove and Rijsbermin, 2003).
- "...water needs to be affordable for people while at the same time making certain that water agencies are financially healthy and able to expand service coverage and improve quality (Gleck 2004)."

## SECTION THREE

Policy approaches and technological approaches must be fully integrated.

**Finding 9: Innovations in policy and technology must be tightly linked.** *Innovations in policy can lead to important developments in technology, and, likewise, innovations in technology can lead to important developments in policy. Institutions must realize the synergies made possible by integrating policy and technology.*

A wide gap exists between technology and policymaking at the local, regional and global levels. To bridge this gap, greater communication between those people who set the policies, develop new technologies and implement new solutions must be applied. There is a corresponding need for greater cross-fertilization of ideas and approaches and more integrated planning. Shifts in policy approaches that include new strategies, new funding, new regulations, or new educational campaigns will all benefit from understandings of current and future technologies. Effective and sustainable research, development and implementation of new technologies depend upon policy frameworks informed by current and future technological capabilities. In the case of monitoring and modeling capabilities, for example, technology can be used to directly inform policy and frame water management plans. In order to reach the economies of scale necessary for effectively addressing global water challenges, innovative solutions through the coordination of policy and technology will be necessary.

**Examples of innovative technology solutions:**

- Scientific innovation leading to the creation of new, cutting-edge technologies;
- New combinations and applications of existing technologies;
- New engineering, manufacturing and distribution techniques using knowledge and other resources from across the range of stakeholder interests;
- New approaches for technical capacity building, training, and education that will lead to regional ownership of solutions and the integration of technological and social systems.

**Examples of innovative policy solutions:**

- New financing models for official development assistance and private sector participation for the development of infrastructure;
- Initiatives that would encourage good governance practices;
- Partnerships between governments, private corporations, nongovernmental organizations, international organizations, and local citizens' groups;
- Regulatory frameworks that would encourage efficiency and innovation;
- Programs that would scale-up local approaches proven to be effective;
- Education campaigns that would alter perceptions about the importance of water and sanitation.

**Finding 10. Solutions must be specifically tailored to the socioeconomic, political and geographic conditions of a region.** *Solutions to water scarcity and water quality problems are different for different regions and for different socioeconomic and demographic groups within regions. Solutions must therefore be designed to meet the specific kinds of challenges presented by different socioeconomic, climatic, geographic and geopolitical conditions.*

There is no "silver bullet" for addressing global water scarcity or water quality issues. No two sets of tools, approaches or strategies applied to specific regions will look the same. Strategies must be differentiated to account for a number of factors, including level of economic development, governance structure, cultural attitudes toward water and water utilities, education levels, communication capabilities, the physical environment, and other factors. These factors can and do change from country

***"Bottom line is there are alternatives, and they don't all cost a fortune. They don't all take a lot of time. Some may be short term, some may be long term, but the important factor is to choose the right solution for the right situation that will ultimately be sustainable ... Then other factors can come in later, economic development and so forth."***

*-Joseph Cotruvo, J. Cotruvo and Associates  
CSIS-SNL Global Water Futures Conference 2005*

to country, but also within countries, so that it may not be possible or effective to simply scale up locally successful programs to the national or international level.

The technological scale for expanding water supply spans new village wells and treadle pumps at one end to desalination plants and large-scale infrastructure such as dams at the other. The scale for improving water treatment spans point-of-use household treatment procedures to city-wide treatment facilities. Many technological solutions exist for reducing water demand through improving agricultural, industrial, and domestic efficiencies. Technology can also aid in the management of water supplies through collecting, transmitting, and interpreting data. All of these approaches must be integrated with localized and differentiated policy applications that must contend with the governance and political will pressures examined in other sections of this paper.

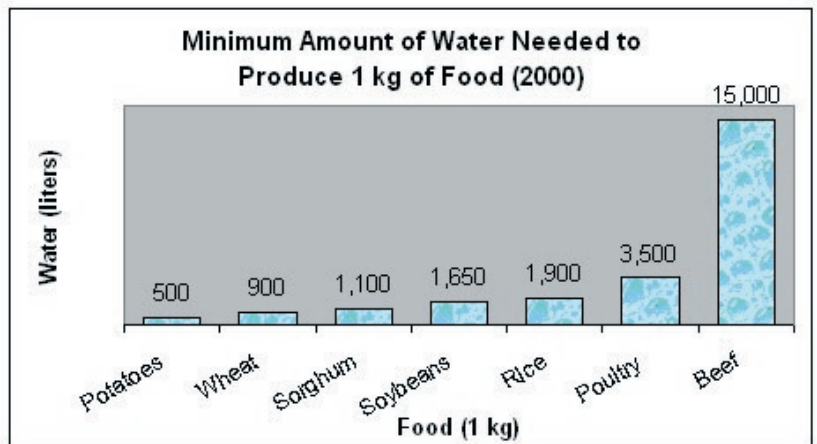
### Did you know...

- An estimated 800,000 dams of all heights and more than 45,000 large dams (greater than 15m in height) have been built around the world for flood control, power generation, water diversions and water storage for irrigation and municipal supply (Postel and Richter 2003).
- The current cost of desalinated water ranges from approximately \$2-3 per thousand gallons for sea water purification and \$1.00 - \$1.50 for brackish and reuse water purification (Hinkebein 2004, Ebensperger and Isley 2005).
- Shifting from conventional surface irrigation approaches (including flood irrigation) to subsurface, drip and low-loss sprinkler technologies can increase overall water productivity by 25 percent to over 200 percent, but only about 1 percent of irrigated farm land worldwide uses precision irrigation (Gleick 2002b, Gleick 2002c).
- Irrigation efficiencies in most developing countries range from 25-45 percent (Rosegrant et al. 2002).
- "Unaccounted for water" (UFW) is the difference between the amount of water sold and the amount of water supplied, expressed as a percentage of the amount of water supplied. Well managed systems achieve UFW values of 10-15 percent. In developing nations, the UFW values range from 39 to 52 percent (Rosegrant et al. 2002).

**Finding 11: Planning for and management of water, energy and agriculture must be strongly integrated.** *Important interdependencies exist among water, agriculture and energy production, all of which are critical to human welfare and economic development. Technologies and policies focused on improving efficiencies in food production, power generation, or water use should take into consideration and leverage this interconnectedness for maximum impact.*

Agriculture uses large amounts of energy and water and is a major source of non-point source water pollution. Similarly, large quantities of water are withdrawn, consumed and sometimes impaired for energy production, while water mining and distribution networks require a great deal of energy to operate. The expected rise in global population will drive a corresponding rise in demand for food, energy, and water as well as tighten the interdependencies between the three. Such close linkages also give rise to an increasing possibility of political or economic upheavals stemming from a lack of any one of the key resources.

Many technologies exist to improve efficiencies among agriculture, energy and water—ranging from drip irrigation, to low-flow household appliances, to recycling techniques and recirculating cooling systems—but greater innova-



(Source: Clarke and King 2004)

***"Quite simply, if [the industrial and agricultural] sectors can improve the use of water, there will be more water for others.***

*-Steven R. Loranger, ITT Industries, Inc.  
CSIS-SNL Global Water Futures Conference 2005*

tions to policy, subsidies, regulatory frameworks and other incentives are required. Further exploring the linkages, improving efficiencies, and integrating management plans among the three would serve to expand water supplies and to mitigate water demand. A full understanding of the nexus between water, energy and agriculture is vital to improving the management of all three sectors. This overarching comprehension will serve to secure global energy, food, and water supplies for a growing world, while capitalizing on innovative and sustainable solutions.

#### Did you know...

- Between 2 and 3 percent of the world's energy consumption is used to pump and treat water for urban residents and industry (Alliance to Save Energy 2002).
- By simply improving the way existing pumps work together, the city of Indore, India was able to save \$35,000 within three months without investing a single rupee (Alliance to Save Energy 2002).
- In India, the agricultural/irrigation sector accounts for approximately 80% of total water use and 30% of the total electricity consumed (Malik 2002); however, it provides the smallest fraction of total revenue from electricity generation and distribution. The World Bank estimates that current losses in the Indian power sector amount to approximately \$5 billion per year and are growing rapidly (USAID: India 2003).

**Finding 12: Robust capacity building is essential.** *Results achieved around the world by existing technical aid and infrastructure development programs can be vastly improved with greater efforts to support regional capacity building. These efforts should be aimed at regional education, political and economic innovation and technical expansion sufficient for long-term operation and maintenance by local, indigenous institutions. They must also include both technical and institutional capacity-building.*

Development assistance for improving water conditions must include adequate development of the indigenous technical capacity and knowledge base. Current approaches most often use ODA or international loans to fund U.S. companies as they provide infrastructure and/or services. But these approaches do not explicitly develop the type of robust program in capacity building that could leave indigenous populations with new infrastructure along with the enduring capability to sustain it and to even spread it throughout their region or country.

Technological or financial assistance should be coupled with providing fundamental skills and capabilities required for developing and maintaining sustainable, localized solutions over the long term. These capacities must include not only the development of physical infrastructure, but institutional capacity building—such as training and educational opportunities for regional policymakers, managers, industrialists, bankers, and others—must be pursued to support these projects. All of these efforts must be conducted with the specific needs and circumstances of the country in mind.

***"I believe that a sustainable solution to the problem will only come when society can adequately develop their own resources to sustain their own economy."***

*-Tom Hinkebein, Sandia National Laboratories  
CSIS-SNL Global Water Futures Conference 2005*

#### Experts say...

- Technical capacities to design, implement and maintain new technological solutions will be key in creating sustainable approaches (Lenton et al. 2005).
- The UN Millennium Project (Lenton et al. 2005) proposes the incorporation of "social intermediation professionals" who are trained in listening and incorporating the concerns and suggestions of women, the poor, and other often disenfranchised groups.
- Capacity building must be conducted with the same considerations of local situations and needs as other policy and technology solutions (Pigram 2001).
- Successful examples from other developing countries, such as Brazil, Turkey, and Mexico, should be the model rather than Australia or the United States where the methods may only lead to unachievable goals or outcomes (Pigram 2001).



## SECTION FOUR

The United States should raise international water issues on its list of priorities as a way of enhancing U.S. national security.

**Finding 13: Water can be a powerful and effective foreign policy tool.** *Effective engagement on international water issues can significantly support many U.S. foreign strategic objectives. Strategies to address geopolitical and regional instabilities, economic development, humanitarian concerns and democracy are more likely to succeed by elevating the issue of water.*

Water is a missing element for support of many U.S. strategic pursuits abroad. Enabling and supporting other countries as they establish integrated strategies for managing water supplies is important for maintaining and fostering peace and stability between and within countries. This is particularly true as trends in population and natural resource consumption continue to put pressure on economies and governance structures. Because water is so integral to every aspect of human life and activity, many strategies to promote economic development or humanitarian relief (e.g., poverty reduction or HIV/AIDS relief) cannot be achieved without pronounced attention to water. By fostering inclusive decision-making and management processes at a local scale, water projects can also strengthen democracy-building projects in areas where such projects are not well-received. Water should be a key component in any short-term or long-term regional stabilization and reconstruction effort. Water scarcity, water quality, and water management could both positively and negatively im-

US Foreign Policy Objective	Relationship to Freshwater
Maintaining stability and security	Water-related domestic and cross-border tensions can be expected to increase as water scarcity puts pressure on governments. Cooperative efforts can also be based around water when other areas of agreement are absent.
Democracy building	Participatory approaches to water projects offer the experience of democracy and support institutional capacity building.
Poverty reduction	The need to gather water and exposure to water-borne diseases perpetuate the cycle of poverty through foregone opportunities and lost productivity.
Post-conflict reconstruction	Because water is fundamental to life and economic activity it should be a high priority in post-conflict regions. In addition, most societies have long-standing water management traditions that could be useful in repairing civil society and governing institutions.
Promoting human rights	Participatory water projects empower marginalized populations, particularly women, who often are more effected by the negative impacts of a lack of sanitation and clean water.

pact every major U.S. strategic priority in every key region of the world.

For all of these reasons, water can no longer be regarded exclusively as a function of U.S. humanitarian and foreign assistance policies. It has significant security, political, social, economic and commercial implications for U.S. interests as well. For this reason, there is a strong argument to be made that U.S. policymakers should elevate water on the list of enduring U.S. interests. Water has become a strategic and foundational element of U.S. international interests.

***"The awareness raised by the tsunami can and I hope will be a catalyst for all of us to invest in rehabilitating, developing, and strengthening water and sanitation systems globally, and, in the process, reaffirming and strengthening our commitments as responsible community partners."***

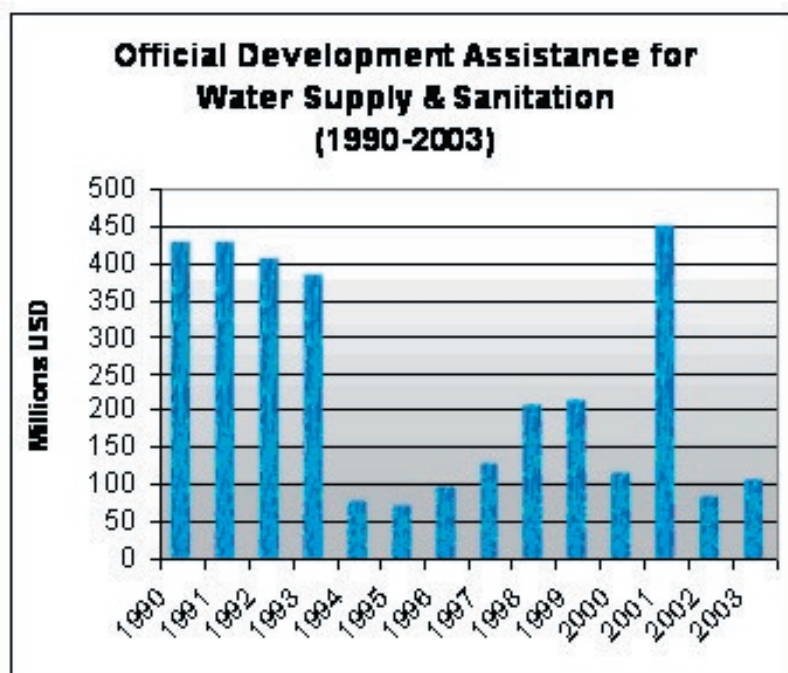
*-Jeff Seabright, The Coca-Cola Company  
CSIS-SNL Global Water Futures Conference 2005*

**Finding 14: An integrated, comprehensive international U.S. water policy is essential.**

*The United States has the technical capacity, knowledge, and wealth to help relieve water scarcity problems in countries and regions around the world. However, a lack of coordination and prioritization among all the different agencies involved in the decision making and policy implementation process has led to a largely ad hoc approach to global water issues. The United States should therefore develop a coherent, comprehensive water strategy for meeting global water challenges in order to maximize its impact and achieve broader U.S. foreign policy objectives.*

The United States is well positioned to take the lead in addressing global water issues. The U.S. already contributes a significant amount of resources to international water issues—an estimated \$3 billion between 2000 and 2004. However, it remains unclear whether these commitments adequately reflect the absolute importance of water to overall foreign policy goals. Official Development Assistance has vacillated significantly in the past decade. The increase in funding by the Bush administration through the "Water for the Poor Initiative" and the commitment made at the World Summit on Sustainable Development are noteworthy, but represent one-time commitments without the accompanying evaluation of needs, priorities, and internal coordination necessary to adequately address the challenges. On the other hand, two attempts have been made by Congress in the past year to elevate the strategic importance of water and to improve coordination—but these risk becoming unfunded mandates.

US official development assistance for water dropped significantly after the end of the first international decade for clean drinking water and has been sporadic since.



(Source: OECD, DAC Database 2003)

At the operational level, nearly every federal agency or research institution has conducted an international water project. Yet each applies this expertise and experience on a limited, ad-hoc basis. Significant research and development is taking place within the United States in an effort to address our own water scarcity and water quality problems, and these efforts can be usefully applied in regions around the world. Furthermore, the majority of official development assistance for water is conducted on a bilateral basis through USAID and does not reach some of the countries with the greatest water needs. Development of an integrated and cohesive international policy on water will be a major step forward in mobilizing and coordinating the vast resources of the U.S. Government already engaged on global water issues. Such a step may also be critical to achieving many U.S. foreign policy goals.

***"We don't have a clear strategy... as to how to proceed and begin to organize an effort to deal with the set of issues that we confront. I don't think we have institutions in place... to bring about the kinds of changes with regard to water use and consumption that is needed."***

*-Senator Jeff Bingaman  
CSIS-SNL Global Water Futures  
Conference 2005*

***"There is no single place in the US Government to get a comprehensive view of water policy and issues. There is no consortium of businesses addressing water needs and opportunities. Water must become a policy priority."***

*-Steven R. Loranger, President and  
CEO, ITT Industries, Inc.  
CSIS-SNL Global Water Futures  
Conference 2005*

### Did you know...

- Interest in water supply and sanitation picked up after the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg. In response, the Bush Administration committed \$970 million over three years through the United States Agency for International Development (USAID) to address the problem with the highly visible Water for the Poor Initiative (WFPI). In the first two years of the WFPI, the United States exceeded the projected three-year budget and spent \$1.2 billion on over 100 activities related to water issues around the globe (USAID 2005).
- According to a recent GAO study, between 2000 and 2004 the United States spent approximately \$3 billion on freshwater programs abroad when desalination, flood control, irrigation, navigation, water dispute management, water conservation, and watershed protection, restoration, and management are included along with figures related to drinking water supply and water treatment projects (GAO 2005).
- One-third of the \$3 billion went to Iraq and Afghanistan during the 2002-2004 period alone. The other \$2 billion was spread "throughout the world," according to the GAO (2005) study.
- Eight agencies accounted for the majority of the \$2 billion spent on freshwater programs abroad—Foreign Agricultural Service (U.S. Department of Agriculture), U.S. Army Corp of Engineers (Department of Defense), Fish and Wildlife Service (Department of Interior), U.S. Department of State, African Development Foundation, National Science Foundation, U.S. Agency for International Development (USAID), and U.S. Trade Development Agency.
- USAID has consistently been the largest spender on freshwater programs abroad, accounting for over \$331 million, or 87.5 percent of total financial support for freshwater programs abroad (excluding Afghanistan and Iraq), in 2004.
- Only \$9 million, or 3 percent, of USAID's 2004 spending on foreign water projects went to Africa, while the majority went to just three countries – Egypt, Jordan, and the West Bank/Gaza.
- USAID officially formed an agency-wide Water Team to "support environmentally sound, cross-sectoral and participatory approaches to managing, conserving, and sustainably using freshwater and coastal resources" (USAID 2002).
- Amidst this new proliferation of U.S. Government activity abroad and the importance of water, both the "Medicine, Health, and Safe Water: A Currency for Peace Act of 2005" and the "Water for the Poor Act of 2005," introduced in the Senate and House respectively, have recognized the need for better central planning and a high-level mandate for addressing water-related activities.



## **CONCLUSIONS and RECOMMENDATIONS**

Natural resource availability and sustainability are precursors to global economic and political stability, which, in turn, are precursors to U.S. national security interests. The findings described above offer the components for a comprehensive and ultimately sustainable approach to managing water resources at the local, regional and global levels. These findings address not only physical water scarcity and water quality issues, but also the capacity-building, policy-making, economic and governance issues that are interwoven with the water challenges.

The implementation of these findings will not only help resolve water scarcity problems, but will also contribute to greater regional and global stability, improved governance, and the greater spread of democratic principles—all of which will strengthen the sustainable management of water and other resources. Water weaves together international goals for human development, economic prosperity, peace and stability, no matter what the region, what the circumstances, or what the goal.

These water challenges present important risks and opportunities for U.S. international strategic interests. Failure to act could lead toward continued economic stagnation. Failure to engage could contribute to domestic and international tensions or unrest, and it could result in further human suffering and death across the planet. Proactive, innovative, and coordinated actions by the United States, on the other hand, will advance every major strategic priority of U.S. foreign policy—most notably economic development and the building of democratic institutions and practices. Water can no longer be regarded solely as a tool or by-product of U.S. development and humanitarian programs. Instead, it should be recognized as a lynchpin for the broader international engagement strategy of the United States. Policies focused on water in regions across the planet must be regarded as a critical element in U.S. national security strategy. Such policies should be part of a broader, comprehensive, and integrated U.S. strategy toward global water challenges.

In the light of these considerations, the CSIS-SNL Global Water Futures project offers the following policy recommendations on how to proceed:

a. The United States is in critical need of a long-range, integrated strategy for international water. In order to develop such a strategy the U.S. government will need to carry out an inventory of existing international water-related policies and projects, identify a lead agency to coordinate the development of an integrated strategy, convene the many departments and agencies in the U.S. Government with established interests and activities relating to water, undertake a global region by region review of resources and needs engaging regional experts, and consult with third-party groups—i.e., the private sector and the NGO community—to get their feedback and input.

b. As a foundation for the development of an integrated strategy for the United States, we must acknowledge that U.S. international water policy has implications that transcend traditional humanitarian and foreign assistance interests. Water is already a critical element in broader U.S. foreign policy and security interests. It will become all the more significant in the future, especially if the dislocations are allowed to become even more acute.

c. The proposed U.S. international water strategy must be informed by a detailed understanding of the potential impacts of emerging, new technologies and the need for a differentiated approach to the deployment of technology in various regions across the world. This implies the development of partnerships—between government, the private sector, and NGOs—in the development of ideas to “match” technologies with conditions on the ground. This technological plan should be informed by an assessment of optimal use of current technology and by the potential impact of emerging new technology.

d. One key characteristic of the proposed U.S. international water strategy is the identification of realistic goals and metrics to gauge progress and to enable periodic and regular assessments of progress. Such indicators are essential to recalibrating goals and approaches, if necessary. This process should include thorough review and analysis of successes and failures associated with previous water projects.

e. The U.S. international water strategy should include the implementation of pilot projects in different regions and at different scales. These will test the approaches and applications described in this White Paper, promote the continued development of better approaches and applications, and inform the development of larger-scale projects. Regions that should be of highest priority are sub-Saharan Africa, where the flow of funds from international donors has been substantially smaller than the objectively-defined needs of water access and water sanitation, and the Middle East, where secure, sustainable water resources are already widely seen as key to political stability.

f. In order to bring such a strategy to fruition, the United States should significantly expand the financial resources it allocates to international water projects. Furthermore, it should redouble its efforts to mobilize public-private partnerships to mobilize resources and deploy technologies. Finally, working with the other G-8 member states and the broader international community, it should intensify its efforts to catalyze international support to address the challenge of water.

g. The strategy should include a strong awareness and education campaign to elevate water as a foreign policy priority.

## WORKS CITED

- Alliance to Save Energy. 2002. Watergy: taking advantage of untapped energy and water efficiency opportunities in municipal water systems. Alliance to Save Energy and USAID, Washington, D.C.
- Commission on Sustainable Development (CSD). 2004a. Freshwater management: Policy options and possible actions to expedite implementation. UN Economic and Social Council, New York.
- Cosgrove, W. J., and F. R. Rijsberman. 2000. World water vision: making water everybody's business. World Water Council. Earthscan, Ltd.: London.
- Clarke, R. and J. King. 2004. The water atlas. The New Press, New York, N.Y.
- Dossal, A. and M. Fanzo. 2004. Partnerships for a better world: working together to preserve the planet. Natural Resources Forum 28(4): 333-337.
- Ebensperger, U. and P. Isley. 2005. Review of the current state of desalinization: Water Policy Working Paper Series 2005-008. Environmental Policy Program, Georgia State University, Atlanta, Georgia. <http://epp.gsu.edu/waterpolworking.htm>
- ExxonMobil. 2004. The outlook for energy: a 2030 view. The Exxon Mobil Corporation. Available online. <[http://www.exxonmobil.com/Corporate/Citizenship/Corp\\_citizenship\\_energy\\_outlook.asp](http://www.exxonmobil.com/Corporate/Citizenship/Corp_citizenship_energy_outlook.asp)> Accessed 22 August 2005.
- Food and Agriculture Organization (FAO). 2003. Food, water, and agriculture. Food and Agriculture Organization of the United Nations.
- Gleick, P. H. 1998. The world's water, 1998-1999: the biennial report on freshwater resources. Island Press, Washington, D.C.
- Gleick, P.H. 2002b. The world's water: biennial report on freshwater resources 2002-2003. Island Press, Washington.
- Gleick, P.H. 2002c. Soft water paths. Nature 418, 25 July, 2002.
- Gleick, P.H., 2004. The world's water 2004-2005: the biennial report on freshwater resources. Island Press, Washington, D.C.
- Government Accountability Office (GAO). 2005. Freshwater Programs: Federal Agencies' Funding in the United States and Abroad. GAO-05-253.
- Grey, D. and C. Sadoff. 2005. Water Resources, Growth and Development. A Working Paper for Discussion at the U.N. Commission on Sustainable Development, Panel of Finance Ministers. The World Bank.
- Hinkebein, T. 2004. Desalination: Limitations and challenges. In P. Norling, F. Wood-Black, T. Masciangioli, editors. Water and sustainable development: opportunities for the chemical sciences, pp. 27-39. Workshop Report to the Chemical Sciences Roundtable, National Research Council of the National Academies. National Academy Press, 2004.
- Lenton, R. and C. Wright. 2004. Interim Report of Task Force 7 on Water and Sanitation. UN Millennium Development Project Task Force on Water and Sanitation.
- Lenton, R., A.M. Wright, K. Lewis. 2005. Health, Dignity, and Development: What Will it Take? UN Millennium Development Project Task Force on Water and Sanitation. Earthscan, London.
- Malik, R.P.S. 2002. Water-energy nexus in resource poor economies: the Indian experience. International Journal of Water Resource Development 18(1): 47-58.

- Millennium Ecosystem Assessment. 2005. Ecosystems and human well-being: synthesis. Island Press, Washington, D.C.
- Pigram, J.J. 2001. Opportunities and Constraints in the Transfer of Water Technology and Experience between Countries and Regions. *Water Resources Development*. 17(4): 563-579.
- Postel, S., and B. Richter. 2003. *Rivers for life: managing water for people and nature*. Island Press, Washington D.C.
- Rodriguez, R. 2004. The debate on privatization of water utilities: a commentary. *Water Resources Development* 20(1): 107-112.
- Rosegrant, M. W, X. Cai, and S. A. Cline. 2002. *World water and food to 2025*. International Food Policy Research Institute, Washington, D.C.
- Sadoff, C. W. and D. Grey. 2002. Beyond the river: the benefits of cooperation on international rivers. *Water Policy* 4: 389-403.
- UNESCO-World Water Assessment Program (UNESCO-WWAP). 2003. *Water for people, water for life: the UN world water development report*. UNESCO and Berghahn Books, Barcelona.
- United States Agency for International Development (USAID). 2005. USAID Presidential Initiatives: Water for the Poor Initiative. Website. <[http://www.usaid.gov/about\\_usaid/presidential\\_initiative/waterforpoor.html](http://www.usaid.gov/about_usaid/presidential_initiative/waterforpoor.html)> Accessed 22 August 2005.
- USAID: India. "Strategic Objective 4: Improved Access to Clean Energy and Water in Selected States." 2003-2007. [http://www.usaid.gov/in/our\\_work/strategy/strategy7.htm](http://www.usaid.gov/in/our_work/strategy/strategy7.htm)
- USAID Water Team. 2002. *Integrated Water Resources Management: A Framework for Action in Freshwater and Coastal Systems*. <[http://www.usaid.gov/our\\_work/environment/water/booklets.broch/iwrm.framework.booklet.pdf](http://www.usaid.gov/our_work/environment/water/booklets.broch/iwrm.framework.booklet.pdf)> Accessed 10 February 2005.
- World Bank. 2004. *Snapshot of Private Participation in Infrastructure - Water and sewerage*. Private Infrastructure Projects Database. Available online. << <http://ppi.worldbank.org/PPI2/Reports/Data/4sector.html>>> Accessed 5 August 2005.
- WHO and UNICEF Joint Monitoring Programme for Water Supply and Sanitation (WHO/UNICEF). 2000. *Global water supply and sanitation assessment, 2000 report*. New York: World Health Organization and United Nations Children's Fund.
- WHO and UNICEF Joint Monitoring Programme for Water Supply and Sanitation (WHO/UNICEF). 2004. *Meeting the MDG drinking water and sanitation target: a mid-term assessment of progress*. New York and Geneva: World Health Organization and United Nations Children's Fund.
- Wolf, A. T., S.B. Yoffe, and M. Giordano. 2003. *International waters: Identifying Basins at Risk*. *Water Policy*. 5(1): 29-60.
- World Bank. 2004. *Snapshot of Private Participation in Infrastructure - Water and sewerage*. Private Infrastructure Projects Database. Available online. << <http://ppi.worldbank.org/PPI2/Reports/Data/4sector.html>>> Accessed 5 August 2005.
- World Bank. 2005. *World development indicators*. International Bank for Reconstruction and Development/THE WORLD BANK, United States.

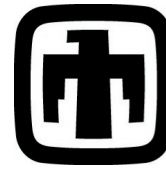


## About CSIS

For four decades, the Center for Strategic and International Studies (CSIS) has been dedicated to providing world leaders with strategic insights on – and policy solutions to – current and emerging global issues. CSIS is led by John J. Hamre, former U.S. deputy secretary of defense. It is guided by a board of trustees chaired by former U.S. senator Sam Nunn and consisting of prominent individuals from both the public and private sectors.

The CSIS staff of over 200 researchers and support staff focus primarily on three subject areas. First, CSIS addresses the full spectrum of new challenges to national and international security. Second, it maintains resident experts on all of the world's major geographical regions. Third, it is committed to helping to develop new methods of governance for the global age; to this end, CSIS has programs on technology and public policy, international trade and finance, energy and global aging.

Headquartered in Washington, D.C., CSIS is private, bipartisan, and tax-exempt.



**Sandia  
National  
Laboratories**

## About SNL

Since 1949, Sandia National Laboratories has developed science-based technologies that support our national security. Today, over 272 million Americans depend on Sandia's technology solutions to solve national and global threats to peace and freedom.

Through science and technology, people, infrastructure, and partnerships, Sandia's mission is to meet national needs in five key areas:

- Nuclear Weapons — ensuring the stockpile is safe, secure, reliable, and can support the United States' deterrence policy
- Nonproliferation and Assessments — reducing the proliferation of weapons of mass destruction, the threat of nuclear accidents, and the potential for damage to the environment
- Military Technologies and Applications — addressing new threats to national security
- Energy and Infrastructure Assurance — enhancing the surety of energy and other critical infrastructures
- Homeland Security — helping to protect our nation against terrorism

Sandia is a government-owned/contractor operated (GOCO) facility. Lockheed Martin manages Sandia for the U.S. Department of Energy's National Nuclear Security Administration. We seek collaborative partnerships on emerging technologies that support our mission.