Woodrow Wilson International Center for Scholars
Asia Program

RUNNING ON EMPTY

Pakistan's Water Crisis

Edited by
Michael Kugelman and Robert M. Hathaway

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Essays by:
Samia Altaf
Kaiser Bengali
Anita Chaudhry and Rabia M. Chaudhry
Adrien Couton
Sarah J. Halvorson
Simi Kamal
Feisal Khan
Shams ul Mulk
James L. Wescoat Jr.

Edited by:
Michael Kugelman
Robert M. Hathaway

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Glossary

ACO	Agricultural Census Organization (Pakistan)
bcm	Billion cubic meters
cusecs	Cubic feet per second
EPA	Environmental Protection Agency (Pakistan)
FBS	Federal Bureau of Statistics (Pakistan)
GDP	Gross domestic product
GLOF	Glacial lake outburst flooding
ha	Hectares
IBP	Indus Basin Project
IDEI	International Development Enterprises India
IMF	International Monetary Fund
IRB	Indus River Basin
IRSA	Indus River System Authority
Km	Kilometer
KPT	Karachi Port Trust
KWP	Karachi Water Partnership
KW&SB	Karachi Water and Sewage Board
LBOD	Left Bank Outfall Drain
lpcd	Liters per capita pre day
MAF	Million acre feet
MDG	Millennium Development Goal
MGD	Million-gallons per day
Mgl	Milligrams per liter

MSL	Mean sea level
MW	Megawatt
NWFP	Northwest Frontier Province
O&M	Operations and maintenance
OPP	Orangi Pilot Project (Pakistan)
PCRWR	Pakistan Council of Research in Water Resources
Rs.	Rupees (Pakistan)
SACOSAN	South Asia Conference on Sanitation
SAWUN	South Asian Water Utilities Network
SCARP	Salinity Control and Reclamation Project
TRDP	Thardeep Rural Development Program (Pakistan)
URC	Urban Resources Centre (Pakistan)
USAID	United States Agency for International Development
WAPDA	Water and Power Development Authority (Pakistan)
WASA	Water and Sanitation Authority (Lahore)
WHO	World Health Organization
WWF	World Wildlife Fund

Introduction

Michael Kugelman

"Water shortages," warns the South Asia scholar Anatol Lieven, "present the greatest future threat to the viability of Pakistan as a state and a society."[1] While this assertion may be overblown, one can hardly dispute its underlying premise: Pakistan's water situation is extremely precarious. Water availability has plummeted from about 5,000 cubic meters (m^3) per capita in the early 1950s to less than 1,500 m^3 per capita today. According to 2008 data from the Food and Agriculture Organization, Pakistan's total water availability per capita ranks dead last in a list of 26 Asian countries and the United States.[2] Pakistan is expected to become water-scarce (the designation of a country with annual water availability below 1,000 m^3 per capita) by 2035, though some experts project this may happen as soon as 2020, if not earlier.[3]

SOAKED, SALTY, DIRTY, AND DRY

Today, at least 90 percent of Pakistan's dwindling water resources are allocated to irrigation and other agricultural needs. This is not entirely surprising, given that Pakistan is an overwhelmingly arid country with an agriculture-dependent economy. Unfortunately, however, intensive irrigation regimes and poor drainage practices have caused waterlogging and soil salinity throughout Pakistan's countryside. As a result, vast expanses of the nation's rich agricultural lands are too wet or salty to yield any meaningful harvests.

Michael Kugelman is program associate with the Asia Program at the Woodrow Wilson International Center for Scholars, where he focuses on South and Southeast Asia.

With the lion's share of Pakistan's limited water supplies dedicated to agriculture, less than 10 percent is left for drinking water and sanitation. Predictably, many Pakistanis lack these services. Though estimates vary, it is safe to say that anywhere from around 40 to 55 million Pakistanis—about a quarter to a third of the country's total population—do not have access to safe drinking water. In much of urban Pakistan, water is contaminated and waterborne disease is rife. Nationwide, 630 children die each day from the waterborne illness of diarrhea.[4]

Nonetheless, some of the water crisis's starkest manifestations can be found in the parched regions of Sindh Province, in southern Pakistan. As the country's population has surged, large volumes of water from the Indus River have been diverted upstream to Punjab Province to satisfy soaring demand for agriculture and for consumption in cities. Consequently, downstream in Sindh, the once-mighty Indus has shrunk to a canal, and in some areas shriveled up to little more than a puddle. The river's disappearance throughout much of Sindh has snuffed out livelihoods throughout the river delta, particularly those of fishermen—who are now forced to gather firewood for a living and to buy their water (at high cost) from trucks. One Pakistani environmentalist has lamented how the Indus Delta is suffering through "severe degradation," sparking "coastal poverty, hopelessness, and despair," causing great damage to the delta's mangroves, and destroying entire ecosystems.[5]

WIDENING WATER WOES

Several dramatic demographic shifts are intensifying Pakistan's already-rampant water insecurity. In the spring of 2009, Pakistan's military launched a full-scale assault against the Taliban in the Swat Valley, displacing more than two million people—the largest exodus of Pakistanis since Partition in 1947. These newly displaced Pakistanis, combined with the hundreds of thousands uprooted earlier by war and violence in the country's northwest, suggest that up to three million internally displaced Pakistanis could be without water and sanitation—and, with no end to the fighting in sight as of mid-2009, these numbers seem likely to grow. Additionally, rural laborers are flocking to Pakistan's overcrowded and water-short cities, many of them seeking jobs that water shortages have eliminated back home. And finally, the country has witnessed the return of large numbers of its expatriates from the Middle East, where they have lost their jobs due to the global financial crisis. Such migratory flows—both within and into the country—further threaten the country's stretched-to-the-limit national water supply.

Meanwhile, Islamabad announced in April 2009 that it would make available six million acres of farmland (almost 2.5 million hectares) to foreign investors for crop cultivation—a decision it made one year after allegedly signing away more than 320,000 hectares of land to the United Arab Emirates.[6] Troubling questions have arisen about where the water will come from to support these agriculture-intensive, large-scale farming schemes. As one Pakistani observer points out, the country's water shortage "is making farming, especially in lower Sindh, a precarious occupation. Pakistan's water resources can hardly sustain intensive farming on the scale being planned."[7]

Perhaps the most powerful accelerant of Pakistan's water crisis is global warming. The Indus River Basin—Pakistan's chief water source—obtains its water stocks from the snows and rains of the western Himalayas. However, few—if any—areas of the world are suffering from the effects of climate change as much as this legendary mountain region. Many of its glaciers are already thinning by up to a meter per year. This rapid melting pattern—coupled with another consequence of global warming, high-intensity precipitation—is expected to aggravate river flooding. Once the glaciers have melted, river flows are expected to decrease dramatically. What does this entail for Pakistan? According to the World Bank, it means an exacerbation of the "already serious problems" of flooding and poor drainage in the Indus Basin over the next 50 years, followed by up to a "terrifying" 30–40 percent drop in river flows in 100 years' time.[8]

In essence, Pakistan's water crisis affects both the country's vital agricultural sector and its booming cities; has implications for livelihoods, public health, and the environment; and, because of global warming, will undoubtedly worsen before it abates. On November 20, 2008, the Woodrow Wilson Center's Asia Program, with assistance from the Center's Environmental Change and Security Program and

Comparative Urban Studies Project, and with financial support from the Fellowship Fund for Pakistan, convened a full-day conference to highlight the different facets of Pakistan's water crisis; to examine the rural and urban dimensions of the crisis; and to consider possible responses. This volume comprises the eight papers presented at that event, along with one additional contribution.

In the first essay, the Hisaar Foundation's **Simi Kamal** provides an overview of Pakistan's water challenges. These include agriculturally inefficient irrigation ("Pakistan is using 97 percent of its allocated water resources to support one of the lowest productivities in the world per unit of water"), abysmal urban sanitation facilities, and catastrophic environmental damage (she bemoans the "destruction" of the Indus Delta). Another obstacle is a lack of water laws to define water rights. As a result, land ownership, not water use, has become a "proxy" for water rights—and therefore the rights to water of landless people (especially farmers and women) are "ill-defined." Consequently, Kamal writes, Pakistan's water crisis is as much a "social construct" resulting from inefficiency and "entitlements for the few" as it is a simple case of water shortages. She posits that the "three Es" of economic efficiency, environmental sustainability, and equity offer a useful framework "to reorient water demand and improve water management."

THE DEBATE ON DAMS

Kamal questions the way Islamabad prioritizes and allocates its water expenditures. She calculates that the resources dedicated to water supply and sanitation equal less than 0.2 percent of gross domestic product. (WaterAid has concluded that Islamabad spends a whopping 47 times more on military budgets than on water and sanitation.) By contrast, Islamabad's Annual Development Plans earmark 40 to 50 percent of expenditures to water resources development—which includes the building of dams. "The national discourse," she writes, "continues to be on the need for highly costly investments for the construction of dams." She references the Diamer-Bhasha Dam project, which was approved in November 2008 at an estimated cost of $12.6 billion, and is projected to generate more than eight million acre feet (MAF) of water when it becomes operational in 2016. Kamal, however, is not impressed. She argues that much more water—76 MAF—would be freed up simply by properly repairing and maintaining Pakistan's existing canal systems, which suffer from poor transmission and seepage. "The strategy of putting up dam structures when the downstream distribution structure is so inefficient needs rethinking," she concludes.

This emphasis on dams and other storage-generating engineering projects is the subject of **Kaiser Bengali**'s essay. Bengali, a Pakistan-based economist, warns that Pakistan cannot address its water crisis without a "paradigm shift" in the way Pakistanis think about water management. The traditional paradigm, he observes, is overwhelmingly "technocentric" and emphasizes engineering solutions and water storage. Water is treated as "a mere raw material," and "technical and scientific knowledge" is deployed "to harness it to its fullest capacity." However, he argues that this approach is increasingly unsustainable because of shortfalls, or constraints, both in water supply and in the funds required for operation, maintenance, and investments.

These constraints, Bengali asserts, illustrate the need for a new "sociocentric" strategy that places greater reliance on indigenous physical and human resource management and is more "resource-efficient and ecologically conducive." What does this mean in practice? Pakistan must move from "a fetish" with the expansion of water supplies through water storage (such as dams) to a new emphasis on the conservation of limited water resources. It must shift away from large-scale capital- and technology-intensive, environmentally degrading solutions to a management-intensive, ecologically balanced approach that relies on indigenous technology.

Bengali only briefly references the merits of the technocentric paradigm, observing how it has, in earlier times, "turned arid lands into green acres." **Shams ul Mulk**, conversely, is an unabashed champion of this water management model. Mulk, a former chair of Pakistan's Water and Power Development Authority (WAPDA), offers a spirited defense of Pakistan's development of the Indus River system. He traces the history of irrigation development in the Indus Basin, with emphasis on the "landmark period" of the 20th century. He describes the Sukkur Barrage (completed in 1932), which was built to serve seven canals and a cultivable area of 3.16 million hectares—"an achievement unparalled in the world." Today, he notes, Pakistan's Indus Basin—with its dams, barrages, canals, and cultivated and irrigated land—is "the world's largest integrated, contiguous irrigated system." Mulk acknowledges the waterlogging and salinity problems spawned by this vast system, and the "major crisis" they had created by the time of Pakistan's independence. However, he believes that the implementation of Salinity Control And Reclamation Projects—which combine groundwater and surface water extraction to increase irrigation, thereby flushing salts below crop root zones—have produced "a clear improvement in the situation" today. He calculates that the percentage of waterlogged land within the Indus Basin has dropped from nearly 40 percent in 1960 to 12 percent in 2008, while saline land areas have fallen from over 50 to 25 percent during the same period.

Mulk also chronicles the proliferation of hydropower projects in the Indus Basin, from the Warsak Hydro Power Station on the Kabul River to the Mangla Dam. He lavishes praise on the "famous" Tarbela Dam, which provides about 54 percent of Pakistan's total hydro capacity and has generated nearly 12 billion cubic meters of additional water for irrigation every year. Constructing this immense dam was "an undertaking of unprecedented size and technical complexity," he writes. When activated for the first time in 1974, a malfunctioning tunnel gate caused major damage to the dam. According to Mulk, however, everything was swiftly repaired, and today "the miracle of Tarbela" lives on, providing Pakistan with agricultural water supplies and affordable power.

Such unqualified support for large hydro facilities is controversial, in Pakistan and elsewhere. Kamal, Bengali, and others in this volume list the disadvantages of such structures (a chief one being their very high costs), and the environmental risks and other dangers of dams are well-documented elsewhere.[9] Furthermore, Mulk does not address the fact that hydroelectric development invariably displaces riparian communities. Pakistan's current minister for water and power has announced that the new Diamer-Bhasha Dam project will "affect" about 28,000 people in the Northwest Frontier Province (NWFP) and in the Northern Areas.[10] Meanwhile, some observers argue that Pakistan's large dams are simply ineffective. According to a *Dawn* story on Pakistan's irrigation problems, Tarbela Dam has lost nearly 30 percent of its storage capacity since the late 1970s, and now retains so little water that irrigation supplies are threatened.[11]

THE WATER CRISIS IN PAKISTAN'S COUNTRYSIDE

Several essays in this collection take a closer look at the water crisis in Pakistan's rural areas, home to about two-thirds of the country's total population. **Feisal Khan** of Hobart and William Smith Colleges describes how bad policies, poor governance, and corruption characterize water management in the hinterland. One ill-advised policy has been "grossly inadequate infrastructure investment" in Pakistan's irrigation system. Insufficient monies are spent on maintenance and repair, leading to neglect and underperformance. The World Bank, Khan writes, characterizes this investment strategy as "Build/Neglect/Rebuild": Basic maintenance is "literally ignored" until the infrastructure "is teetering on collapse." Another misguided policy is Pakistan's "excessive cultivation" of water-intensive crops, such as sugar, which requires nearly seven times more water than is needed by wheat.

Bad governance occurs both within and between Pakistan's four provinces. Khan describes how large landowners—in collaboration with provincial government officials—evade and exploit the rules of *warabandi*, a rotational system used for the equitable allocation of irrigation water among farmers in Pakistan and northern India for more than 130 years. And he has few kind words for the Indus River System Authority (IRSA), a body formed in 1992 to coordinate interprovincial water sharing across Pakistan. IRSA's operations are "disharmonious" and marked by bickering, while provincial governments disagree with—and often ignore—the authority's rulings on water flow. Not surprisingly in this environment of poor governance, corruption—particularly graft—runs rampant. "Like the rest of the Pakistani government," Khan writes, "the water bureaucracy is notoriously corrupt." According to one source with whom Khan has consulted, government irrigation officials in the provinces of Punjab and Sindh are "horribly corrupt, inefficient, and bloody lazy," and farmers freely admit to bribing them.

Khan contends that efforts launched in the 1990s to improve water management through decentralization have failed. He calls instead for improved "professional competence and integrity" in Pakistan's irrigation bureaucracy, an outcome that will require more centralization and "the reassertion of administrative control." However, he is greatly skeptical about any prospects for reform. He points out how recent attempts by the International Monetary Fund to impose an agricultural tax in Pakistan—which could have generated millions of dollars in revenue to fund irrigation repairs—were soundly defeated by Pakistan's powerful agricultural lobby. Consequently, he concludes that Pakistan's water crisis "will surely worsen."

Such a prospect bodes especially poorly for Pakistan's rural women. According to the University of Montana's **Sarah J. Halvorson**, who traces the links between water and gender in rural Pakistan, access to water is of paramount importance for Pakistani women because they bear primary responsibility for obtaining water and completing water-related tasks. The challenges of securing water in parts of rural Pakistan have only grown since the 2005 Kashmir earthquake, which displaced mountain residents and forced them into tent villages. Furthermore, Halvorson writes, the health-related consequences of water scarcity in Pakistan—such as the high numbers of young children suffering from waterborne diseases—deeply affect women, who are largely responsible for caring for sick family members as well as for themselves.

Given these realities on the ground, Halvorson views women's involvement in rural water governance as essential. Traditionally, however, Pakistani women have been shut out of government water-planning and decision-making processes, which operate in realms historically dominated by men. This lack of women's participation can in part be attributed to gender norms and "ideologies of seclusion" that restrict Pakistani women's mobility and freedom. The problem is compounded by abysmal women's literacy rates—as low as 3 percent in certain areas—and poor access to education. Yet despite such constraints, Halvorson highlights some success stories. The Punjab Rural Water Supply and Sanitation Project encourages women's participation in water-sector planning for low-income communities; a radio program, "Water Stories, Women's Issues," injects gender and water themes into public discourse; and Pakistan's National Drinking Water Policy recognizes the need for women's participation in water supply management and acknowledges the "gender differentiated needs" in the drinking water sector. Such examples, she suggests, offer a way forward. Without women's participation in water governance or a recognition of women's vital contributions to water-related work, "Pakistan will remain a long way from reducing water vulnerabilities."

While rural women pay a particularly heavy price for Pakistan's water crisis, small farmers do as well. **Adrien Couton** of the Acumen Fund notes that the number of farms under two hectares in Pakistan has exploded from just over a million in the early 1970s to nearly four million in 2000. Yet Couton laments how Islamabad's water projects mainly benefit large and wealthy farmers, and provide little relief for smallholders. His essay spotlights the Acumen Fund's investments in drip irrigation, a low-cost system geared toward small farmers that conveys a modest but continuous supply of water to plants. The Acumen Fund's drip irrigation initiative in Pakistan is called MicroDrip—a joint venture with the Thardeep Rural Development Program, a Sindh-based nonprofit organization. MicroDrip, he reports, is expected to reach 20,000–30,000 Pakistani farmers over the next few years. According to Couton, these investments underscore the key role of market-based strategies in tackling Pakistan's water crisis.

Couton argues that drip irrigation offers many advantages over conventional flood irrigation, including major water savings, reduced labor, and less soil erosion. Additionally, the system enhances crop productivity, particularly for farmers cultivating crops in semi-arid regions. It also features benefits that he believes are especially attractive for policymakers. For example, drip irrigation brings "massive increases" in water-use efficiency. Additionally, drip irrigation is "granular," meaning that—unlike in the case of a dam—investments can easily be distributed throughout different parts of the country and over time. Finally, water-saving drip irrigation communicates a strong message that water is indeed scarce and precious in Pakistan.

THE WATER CRISIS IN PAKISTAN'S CITIES

One can make a strong argument that the locus of Pakistan's water woes is in the country's rural areas, where desperately needed water for the crucially important agricultural sector is either wasted or running dry—and where water-related livelihoods are disappearing as quickly as the once-raging Indus River. Yet Pakistan's water crisis is also glaringly apparent in its teeming urban centers.

Every year seemingly brings a litany of new research highlighting the grim facts about water in Pakistan's cities. A 2006 study discovered "highly toxic run-off" from plastics factories, cattle pens, slaughterhouses, and sewage in the Fuleli Canal—which supplies drinking water to residents of Hyderabad.[12] In 2007, Rawalpindi's Water and Sanitation Agency announced that 64 percent of the city drinking water supply contained human waste and used water—and that 70 percent of the city's water supply lines were carrying sewage water to consumers. And in 2008, the Pakistan Council for Scientific Research determined that more than two million people in Peshawar drink contaminated water. A major driver of these conditions is the paucity of urban wastewater treatment. In 2006, the World Bank estimated that only 3 out of 100 industries using hazardous chemicals in Lahore treat their wastewater adequately.[13]

The situation in Karachi, Pakistan's largest city, is particularly disturbing. Rivers flowing through the city contain lead, chromium, and cyanide, and more metals have been found in Karachi's harbor than in any other major world harbor. Karachi's own mayor has judged that 400 million gallons of sewage pour into the sea, untreated, every day. Meanwhile, several million gallons of water are estimated to be lost every day due to leaking water conveyance infrastructure.

Such hardships take a brutal and deadly toll on residents' health. Kamal, who is based in Karachi, has previously estimated that at least 30,000 Karachiites (of whom 20,000 are children) perish each year from unsafe water. In fact, it has been estimated that more people in Karachi die each month from contaminated water than have been killed by India's army since 1947.

While these problems ail all Pakistani cities, some urban areas are affected more than others, and in different ways. **James L. Wescoat Jr.**, of the Massachusetts Institute of Technology, points out that the country's urban water systems operate in very different climates, vary in social and natural terms, and serve different industrial economies "in different municipal and provincial institutional contexts." Little surprise, then, that one city may be suffering flood damages while another faces water shortages or waterborne disease. Nonetheless, the essential facts remain the same: Wescoat states that human drinking water requirements are estimated to be at least 50 liters per capita per day (lcpd), yet some of Pakistan's poorest urban dwellers have access to only 10 lcpd—"and it is all polluted."

Wescoat's essay lays out some water-conserving strategies that Pakistan's cities can adopt to address their water challenges. These include rainwater harvesting and the re-use of washwater (tactics already used in several Pakistani cities), energy-conserving water systems (such as solar climatization systems), and urban plumbing codes. He also pushes for "advanced pond and lagoon treatment systems," an ecologically friendly way of treating wastewater—though he concedes such projects necessitate coordinated water management that is "difficult to attain or sustain." Still, Wescoat is optimistic. Pakistan, he believes, realizes that the provision of basic water needs is fast becoming "a strict obligation of society and the state to all citizens." He asserts that the country "will find that there is sufficient freshwater to fulfill this duty on a national scale." He also notes that Pakistan already boasts some of the world's "most sophisticated" river basin management research, and proposes that the great universities of Pakistan's major cities take the lead in confronting Pakistan's urban water shortages.

Addressing these urban water problems will not be easy, and will prove a particularly formidable challenge in Lahore—a city that relies exclusively on groundwater for drinking water needs, most of which sits 300-600 feet below the surface. The extraction of groundwater, according to **Anita Chaudhry** of California State University-Chico and **Rabia M. Chaudhry** of MWH Americas, Inc., brings only temporary improvements in water access, and occurs "at the expense of future residents." In fact, they note, water tables have already fallen by roughly five feet over the last five years in several parts of Lahore—and by up to 65 feet elsewhere in the city. To make matters worse, Lahore's groundwater is frequently contaminated and very difficult to de-contaminate. According to the Chaudhrys, every sample from a 2006 study of groundwater quality in Lahore was found to contain arsenic beyond permissible levels.

Currently, they explain, Lahore households get water either from public supply agencies or from privately installed groundwater pumps. The former water source is considerably cheaper than the latter. However, public water supply in the city is intermittent, meaning that those residents of Lahore dependent on public water supply—typically the poor—receive less water than wealthier residents with private pumps. For this reason, the writers note, "It is the poor—especially poor women and children—who suffer the most from such public utility shortcomings." So what is required to secure equitable and sustainable access to safe drinking water in Lahore? A first step is more information. "Reliable, useful, and consistent information" on water quality, yields, and depletion rates must be given to water users and managers alike. Pakistanis must also be made aware of the relationships between irrigation water use in Punjab and declining water tables in Lahore. Finally, the Chaudhrys advocate a more intense focus on conservation and on the more efficient use of existing groundwater supplies.

This volume's final essay poses a "deceptively simple question": given that Pakistan has the technology and money to produce clean water, and given that the high costs of insufficient water supplies are well-known, then "why have there been so few positive results?" According to **Samia Altaf**, a physician and public health specialist, the answer is twofold. First, Pakistan lacks a "strong political lobby" to advocate for clean water. In 19th-century Europe, during the heyday of sanitation reform, the wealthy—doctors and businesspersons—used to serve this purpose. Today, however, thanks to bottled water, home filtration, and other technological advances, the rich enjoy clean water and no longer lobby for it. Meanwhile, those still lacking water "rarely have a voice in the political systems of a country like Pakistan." Second, Islamabad is never held accountable for failing to provide clean water. Altaf argues that successful public health crusades of the recent past—such as those against cigarette smoke or for seatbelts—have resulted in safety regulations, legislation, and other tools that ensure accountability.

How can these lessons of the past be applied to Pakistan's present-day water crisis? Altaf outlines a strategy incorporating both Pakistanis and the international donor community. She envisions the creation of "citizen groups," comprised of "people of credibility, standing, and technical expertise," who can "educate" civil society on water issues, and who can institute monitoring mechanisms and other accountability measures. Meanwhile, she recommends that the donor community "lean heavily on the government in Islamabad to deliver results." Accountability, she avers, must be a part of any assistance package. Though she concedes that setting conditions will be unpopular among Pakistan's political elite, she insists that doing so is "both possible and necessary."

ISLAMABAD'S RECORD

Altaf wryly observes that Pakistan "can transport men, tents, shoes, blankets, bread, and bullets to the top of a 20,000-foot glacier." Surely, she concludes, the nation "can transport water to the cities—if it wished to." To be fair, Islamabad has addressed the country's water crisis. It has integrated water-related Millennium Development Goals into its national policies. The government's Planning Commission has called for a national program to monitor water quality and to enforce standards on the discharge of effluents into rivers and lakes. Pakistan has also drafted a National Drinking Water Policy, which Halvorson praises for its embrace of women's roles and community participation. And Couton references a 2007 government initiative to bring drip irrigation to 300,000 acres of land (though he contends the project's benefits will be limited to large, wealthy farmers).

Nonetheless, according to many of this volume's writers, Islamabad has essentially clung to the same limited set of policies, all of which reflect what Bengali calls the "technocentric" paradigm of water management: large dam construction, storage expansion, and the trumpeting of other large, expensive, water supply-enhancing structures. Representative of this mentality is WAPDA's Vision 2025 plan. This ambitious strategy, launched in the early 2000s, envisions the construction of several dozen large water projects (including five dams, three "mega-canals," five hydropower facilities, and two drainage projects), to be undertaken in three different phases and to be completed by 2025.[14]

Unfortunately, some large water structures seem to exist purely for show. Back in 2006, the Karachi Port Trust (KPT) unveiled a "fountain jet" off the city's harbor that was to spew water hundreds of feet up into the air—a height surpassed by few other fountains in the world. The irony was rich: several thousand liters of water were to cascade high above the city, while the city's 15-million-strong population struggled below to obtain clean and affordable water. In 2008, several fountain parts were stolen, rendering the facility inoperable—and reports soon appeared in Pakistan's media suggesting the involvement of KPT officials.[15] The bizarre story of this hapless super-fountain illustrates the extent to which Pakistan emphasizes large-scale water production schemes, and validates Khan's point that where there is water in Pakistan, there is also corruption.

What accounts for this seemingly singular emphasis on a "technocentric" water management strategy? One possible explanation is that Islamabad lacks a true, multifaceted water policy. Kamal notes that the government's National Water Policy is still in draft form, and observes that the country's "water policy framework" consists of a hodgepodge of water strategy plans, frameworks, and visions from different government ministries. "The draft water policy at its current stage," she writes, "reads like a list of actions and has no real vision or comprehensive approach." She adds that there is no national regulatory framework in Pakistan dealing with water use.

Another, more controversial, reason for the country's static water policy could be Pakistan's entrenched agricultural lobby. This political juggernaut—a far different beast from what Altaf has in mind when writing of the need for a "strong political lobby" to promote the delivery of clean water—poses a major obstacle to the crafting of water policy reforms. Many prominent Pakistani politicians are large landowners who benefit from the status quo, and have no desire "to push for a real overhaul of farming practices."[16] The presence of this lobby may also help explain why the government spends such a disproportionate amount on irrigation and other agricultural uses of water.

WATER AND SECURITY

While Islamabad dithers, Pakistan's water pressures are exacerbating the country's rampant instability and volatile security situation.

Farmers and fishermen are launching protests about their lost livelihoods. And the diversion of scarce riverwater upstream from dry Sindh to the more fertile Punjab is stoking ethnic tensions between Sindhis and Punjabis.

In Pakistan's turbulent northwest, Taliban forces in Swat have blown up electricity grids, causing disruptions to area water supply. Additionally, alarm bells sounded across the country in April 2009 when the Taliban pushed southeast of Swat into the Buner district of NWFP. This concern arose not just because of Buner's close proximity to Islamabad, but also because it lies just 60 kilometers northwest of Tarbela Dam. The dam has been targeted before, including a deadly attack on an army base within the Tarbela premises in 2007; the Taliban was fingered as the likely perpetrator.

Meanwhile, Pakistan regularly accuses India, the upper riparian state in the Indus River system, of suppressing the flow of water downstream to Pakistan, the lower riparian state. Soon after the Mumbai terror attacks in 2008, Pakistani military officials began highlighting India's alleged violations of the Indus Waters Treaty—which stipulates how the various waters of the Indus River system are to be divided between the two countries—and suggesting that water issues constitute "a latent cause" of the ongoing conflict in Kashmir.[17] Civilian officials make such insinuations as well: Shujaat Hussain, president of Pakistan's PML-Q party, has warned that the two countries could go to war over water. While one could dismiss such statements as purely rhetorical and for domestic consumption, it is notable that Pakistani President Asif Ali Zardari voiced similar concerns in a *Washington Post* op-ed in January 2009. "The water crisis in Pakistan is directly linked to relations with India," he declared. Failure to resolve the water imbroglio "could fuel the fires of discontent that lead to extremism and terrorism."[18]

The U.S. government has recognized that Pakistan's economic and development challenges—including those of water—are linked to its combustible political and security situation, and that stabilizing the latter will require tackling the former. The proposed Enhanced Partnership with Pakistan Act (known as the Kerry-Lugar bill), which President Barack Obama has promised to sign if passed by Congress, identifies "access to potable water" as a shared "compatible goal" between "the people of Pakistan and the United States." The bill would appropriate U.S. funds toward Pakistan's water infrastructure, including irrigation channels and wells.

RECOMMENDATIONS

Such prospective American aid, particularly if unencumbered by conditionalities, would be welcomed by Islamabad. Nonetheless, given its small size (the bill would authorize only $1.5 billion in non-military assistance per year over a five-year period), this funding would translate into an exceedingly modest contribution.

Much more of a commitment will be required—and not merely one of money, nor simply from Washington or the broader international donor community. Rather, a comprehensive commitment is needed—one of time, funding, and other resources, and one that comes not just from foreign friends and funders, but most importantly from Pakistanis themselves. The essays in this volume offer a variety of recommendations—some of them controversial—to help guide Pakistan's response to its water crisis. Some of the principal ones are listed here, not for purposes of endorsement, but rather to provoke further discussion on the way forward.

1. *Bigger is not always better.* While dams, canals, barrages, and other massive engineering projects have helped establish an extraordinary irrigation system, these structures can be expensive, environmentally unfriendly, and inefficient. Instead of repeatedly building immense new structures that only create more water inefficiency, Pakistan should boost investment in repairing and maintaining existing infrastructure in order to decrease water profligacy—thereby lowering costs and safeguarding precious water supply. More emphasis should also be placed on modest, indigenous technology—such as drip irrigation.

2. *Strike appropriate balances between centralized and decentralized water management.* Improving efficiency and competence in Pakistan's bloated water bureaucracy will require more central oversight over provincial irrigation programs. Additionally,

in Pakistan's cities, one centrally located public water utility may be more cost-effective and beneficial to the poor than several different facilities dispersed throughout the city. At the same time, some of Pakistan's best examples of successful water provision—such as those implemented by the Orangi Pilot Project in Karachi—accentuate community participation and decentralized decision making.

3. *Give more attention to water provision and distribution on local and individual levels.* Provincial water distribution has traditionally dominated debates about how Pakistan's water supplies should be divided up. This broader focus, however, masks the troubling state of water distribution on the micro level. Water allocations among Pakistanis are highly inequitable. The absence of laws on water rights means that, by default, landowners have better-defined rights to water than do the landless, many of whom are highly dependent on water. Also, large, wealthy farmers receive more irrigation water than small, poorer farmers. Meanwhile, in cities, poor households must settle for sporadic public water utility supply, while richer homes can pay for more dependable private groundwater pumps.

4. *Understand the links between agricultural and urban water pressures.* Growing urban drinking water demand contributes to the rapid depletion of water in Pakistan's rural regions. Karachi depends entirely on the Indus River for its drinking water supply, while Lahore must compete with rural Punjab for dwindling groundwater resources. Agricultural water shortages mean higher food costs, and such price spikes affect the incomes and livelihoods of the urban poor. Meanwhile, male laborers escape poverty in the countryside by migrating to cities—which adds to the strain on urban water supplies and exacerbates the challenges rural women left at home face in their struggle to obtain water for their families. Tackling water shortages in Pakistan must not occur in a vacuum; rural and urban sources of the problem must be addressed collectively.

5. *Promote the involvement of the private sector.* The private sector can play a key role in alleviating Pakistan's water crisis. It can work with local partners and the general population to develop environmentally friendly, affordable, water-saving technology. Private investments serve as an alternative to the large, publicly funded water-production facilities that predominate in Pakistan.

6. *Empower the citizenry.* All stakeholders—not just the government or the privileged classes—must be involved in developing Pakistan's water policy and in informing the policy's decision-making process. In particular, women, as those most responsible for water-related work (especially in rural areas), must be included. Members of civil society should serve a public advocacy role. Small farmers should collaborate with private investors and offer feedback on the merits of water-conserving technology. To make Pakistanis better informed about water challenges, to empower them to make wiser decisions about water use, and to enhance popular participation in efforts to tackle water challenges, knowledge gaps about water must be eliminated—and this will entail the expansion of available information about water quality, use, and availability.

7. *Demand more accountability.* Pakistanis and donors should pressure Islamabad for results, and make clear that a failure to bring about improvements will have consequences. Civil society should develop performance measures; implement rigorous monitoring regimes; and establish checks and balances. International funders—whether national governments or international financial institutions—should build accountability measures into their assistance plans.

8. *Conserve, conserve, conserve.* For all the weighty talk about necessary paradigm shifts, there are also straightforward steps Pakistanis can take to tackle the water crisis—all of which reflect the policy of conservation. Farmers can adopt water-

conserving agricultural technology. Agricultural planners can de-emphasize production of water-intensive crops, like sugar, and encourage production of wheat and other staples that require less water. City planners and architects can implement water-conserving urban building design. And citizens can seek alternate, renewable water sources, such as rainwater.

The benefits of conservation extend beyond saving water. Conserving can also bring relief to Pakistan's struggling economy. Large dam projects are foreign-debt financed and have constituted the single-largest allocation in Pakistan's federal public investment budget. By contrast, water-conserving technologies such as drip irrigation are much cheaper and do not eat up monies needed to tackle Pakistan's debts.

Similarly, intensifying the production of less water-intensive crops—such as wheat—can reduce Pakistan's growing dependence on wheat imports and alleviate the country's balance of payments troubles.

9. *Address the structural obstacles.* While the drivers of Pakistan's water crisis include natural factors (such as its highly arid climate), there are also human-generated constraints that hamper attempts to resolve it. Systemic inequality pervades Pakistani society, from the small elite who own the majority of cultivable land to ingrained prejudices against women. Additionally, entrenched political interests (such as powerful landowners and sugar industry lobbies) stand in the way of meaningful agricultural reform. While promoting water conservation policies, launching information campaigns about water, and strengthening public water utilities are important, such efforts will ultimately fall short if the deeper, structural impediments to reform remain unaddressed.

10. *Learn from the success stories.* Some progress is being made in reducing the severity of Pakistan's water crisis. Waterlogging and salinity, while still prevalent, have decreased over the last few decades. Conservation efforts—particularly in terms of individual water consumptions habits and water-saving

technologies—are being implemented in some parts of the country. Some recent government and media initiatives demonstrate an appreciation of the importance of societally inclusive water management models. These examples should be publicized and analyzed further, in the hope that they can be replicated elsewhere.

11. *Immediate action is required.* Despite the success stories, Pakistan's water crisis is still very much a crisis and shows no signs of easing—particularly as the country's population continues to rise and as global warming melts away the ice and snow of the Himalayas, hastening the eventual drying up of the Indus system. Time is of the essence, and now is the time to act.

PAKISTAN'S WATER FUTURE: SPECULATING ABOUT 2025

What might lie in store for Pakistan down the road if it fails to act now? Data projecting Pakistan's water needs in the year 2025 tell a sobering story. By that year, according to one study, Pakistan's total water availability will have barely changed from the current availability of 236 billion cubic meters (bcm). Yet Pakistan's total water demand in 2025 is projected to be about 338 bcm—suggesting a gap of 100 bcm.[19]

To put this projected shortfall in perspective, consider that (according to the figures in Mulk's essay) the total storage capacity for the Indus River system's reservoirs is about 19 bcm. This suggests that by 2025, Pakistan's water shortfall could be five times the amount of water that can presently be stored throughout the vast system's reservoirs. In fact, the 100 bcm gap will comprise almost two thirds of the entire Indus River system's current annual average flow.

Such figures convey a sense of how truly water-scarce Pakistan could be in just a few years. And they underscore the need for immediate action.

Confronted with this data, some will immediately insist on the need to expand the production of more dams and reservoirs (and in fact WAPDA's Vision 2025 plan is already working toward this goal). Others will just as emphatically argue the need to be more judicious with currently available water resources. Both strategies have been described and advocated in these pages. Perhaps the most workable solution lies somewhere in the middle—one, for example, that embraces smaller dams that displace fewer people and are easier to maintain. Ultimately, however, this is not the place to declare which solution is correct. Rather, this volume seeks only to present the scope of Pakistan's water challenges, and to offer multiple ways forward—before it is too late.

After all, while Pakistan's water crisis does not presently threaten the viability of the Pakistani state, it is undeniable that so long as the crisis rages on, essential components of this state—such as the vital agricultural economy, the health and livelihoods of the population, and above all political and economic stability—do lie very much in the balance.

★★★★★★

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Pakistan's Water Challenges: Entitlement, Access, Efficiency, and Equity

Simi Kamal

Pakistan is faced with a growing population, water scarcity, system losses, distribution inequalities, loss of ecosystems, and the generation of effluents. The country is struggling to meet incremental demand for more irrigation water and to fulfill environmental flow requirements; to deal with the disposal of salts and pollutants; and to meet urban, domestic, industrial, and agricultural needs.

Estimates from November 2008 show that Pakistan has a population of 165 million, of which at least 41 million (25 percent) are below the poverty line; 98 million rely on agriculture; 50 million do not have access to safe drinking water; and 74 million have no sanitation.[1]

According to the World Bank,[2] Pakistan became a water-stressed country (1,700 cubic meters per capita per year) around the year 2000. According to a government source,[3] Pakistan reached 1,700 m^3 in 1992 and became a water-short country, and then declined further to 1,500 m^3 in 2002. Water scarcity (1,000 m^3 per capita per year of renewable supply) is expected in about 2035.[4] However, a United Nations Development Programme source gives Pakistan's current water availability as 1,090 m^3 per capita per year.[5] This is because the terms "water shortage" and "water scarcity" are often used interchangeably—while both use the 1,000 m^3 per capita measurement as a benchmark, "shortage" is an absolute term and scarcity is a relative concept.

Simi Kamal is chair of the Hisaar Foundation in Karachi and a member of the Global Water Partnership, a Stockholm-based think tank.

Scarcity can occur at different levels of supply, depending upon demand and other circumstances—such as growing crops in agriculture-based countries or diversion to giant metropolitan areas. Scarcity in Pakistan may have its roots in water shortage, but it is also a social construct—a result of inefficiency, entitlements for the few (and the power that comes from this) and low access for the many. Water scarcity may be controlled by altering water-use behavior, modulating expectations, and introducing regulations. There are, therefore, remedies and options that can be considered and exercised.

It is important to understand the factors other than population growth that are driving Pakistan toward water scarcity. Reductions in the ice and snow areas of the Himalayas mean a lower quantum of annual snowmelts and, therefore, reduced water in the Indus River system. The decline in freshwater additions to surface water bodies has rendered them too saline and polluted for drinking and agricultural purposes. Reduced holding capacity and more rapid runoff (when normal rains and snowfall return) lead to floods and lower reserves of water for drinking and agriculture. The drying up of the Indus Delta has led to losses in the coastal ecosystem and sea intrusion is up to 225 kilometers.[6]

While the realities of water availability, water regime, climate, and delta conditions have changed, the ways of using water have not. This has resulted in large- scale degradation of the resource base. Thirty-eight percent of Pakistan's irrigated lands are waterlogged and 14 percent are saline; there is now saline water intrusion into mined aquifers. There has been a denudation of rangelands and watersheds, a depletion of forest cover and vegetation, a decline in the water table in Baluchistan to alarming levels, and a drastic reduction of sweetwater (fresh drinking water) pockets in the Lower Indus Basin. It is now accepted among many water sector practitioners and professionals in Pakistan that the Indus Basin irrigation system is vulnerable, that greater flexibility is required in the way water systems are envisaged and used, and that there is an urgent need for trust- building among water users and the institutions that control water.

The country as a whole has been engaged in protracted debate over the provincial division of water. Yet this division hides the more critical distribution—the various uses of water. Irrigation and agriculture use up 97 percent of Pakistan's allocated surface water resources,[7] while only 3 percent is left for all other uses, including drinking water for 165 million people, supplies for municipal and industrial uses, and sanitation. In fact, expenditures on water supply and sanitation are typically less than 0.2 percent of gross domestic product (GDP).This low figure is striking given that Annual Development Plans show expenditures of approximately 40–50 percent on water resources development.[8] Apparently, funding priorities lie with water development, and not water supply and sanitation.

The policies, arguments, institutions, and processes that influence access, entitlement, and control over water resources are crucial in determining equity and efficiency. This paper questions the arguments that have defended the status quo in the water sector and calls for radical re-examination.

IRRIGATION INFRASTRUCTURE AND (IN)EFFICIENCY

Ninety-two percent of Pakistan's land area is arid or semi-arid, and cannot be productive without irrigation. The Indus Plain covers about 25 percent of Pakistan's total land area, and 65 percent of Pakistan's population is directly supported by the irrigated agriculture taking place in this area. This irrigated area, which is about 80 percent of the country's total cultivated area, produces 90 percent of Pakistan's food and fiber requirements. About 25 percent of Pakistan's GDP comes from agriculture.

Under the Indus Waters Treaty of 1960, Pakistan is entitled to almost all the waters of the three western rivers of the Indus system (Indus, Jhelum, and Chenab), while India enjoys use of the remaining tributaries.

The average (for the years 1975–2000) rim station inflow (that is, the inflow measurement established at the rim of the river tributaries) of the Indus River and its tributaries is calculated to be approximately 154 million acre feet (MAF) per year, of which 144.9 MAF is available to Pakistan.[9] Another source puts this availability at 140 MAF.[10] However, the inflow of water varies drastically from year to year. The Water Accord of 1991 (an agreement reached between Pakistan's four provinces on how to share the waters of the Indus River) is based on 114.35 MAF per year (plus a 3 MAF estimate for ungauged civil canals, making a total of about 117 MAF). Punjab gets the bulk at 55.94 MAF, while Sindh gets 48.76 MAF.[11] Any supplies over and above this amount are to be distributed on the basis of a predefined formula among the four provinces, with Sindh and Punjab getting equal shares at 37 percent. The remaining water from the average rim station flow (154 MAF–114.35 MAF) is estimated at nearly 40 MAF and often designated as "outflow to sea below Kotri,"[12] but actually includes ungauged canals as well as withdrawals through other small-scale dams and schemes and river losses. The matter of environmental flows (which refer to the amount of water needed in a watercourse to maintain a healthy, natural ecosystem) for the downstream and delta of the Indus is mentioned in the Water Accord at 10 MAF as a demand of Sindh,[13] but these flows have not yet been finalized or included. In recent years, the annual supply of 114.35 MAF as designated by the Accord has not materialized, and is in fact usually lower.

Let us then begin where the bulk of Pakistan's water use lies in terms of the Water Accord. Of the total 114.35 MAF surface water available annually for various uses, 97 percent is earmarked for irrigation to support agriculture.[14] For more than a century, the Indus River irrigation system has been controlled by the construction of dams, weirs, and barrages to feed an extensive canal system that commands 34 million acres for irrigation and is the world's largest contiguous irrigation system.

The storage capacity of this system, however, is very low at only 150 m^3 per capita per year and only 30 days of supply. Meanwhile, existing dams are silting rapidly; both Mangla and Tarbela have lost about 25 percent of their capacity. The canals are not full year round and work on rotation. More importantly, there is no additional water that can be mobilized over and above what is currently used.

Water losses between canal heads and watercourses, and losses within water courses, are generally accepted to equal one-third of the total amount of water delivered.[15] Another 25 percent is lost within the farms. In the context of water infrastructure, there are heavy costs for operation, maintenance and repair (including costs for simple manual drinking water systems), and rehabilitation, but it has so far been quite impossible in Pakistan to make irrigation users pay for water. A recent

World Bank study shows that users pay a very small percentage of operation, maintenance, and excess manpower costs, while Pakistani taxpayers pay the rest of these costs plus the interest, and no one pays for replacements.[16]

In order to improve water charge collection from users, community-based approaches have been tried in some areas. However, participation and user management have delivered few results so far. One reason is the persistent inequalities in water distribution to head, middle, and tail areas of water channels. Poor management and distribution of irrigation water also means that only 45 percent of cultivable land is under cultivation at any given time. Pakistan's crop productivity per unit of water is very low at 0.13 kilograms per cubic meter.[17] What this means is that Pakistan is using 97 percent of its allocated water resources to support one of the lowest productivities in the world per unit of water. This reality does not seem to have sunk in and does not feature in the water discourse of the country.

Dams

The national discourse continues to be on the need for highly costly investments for the construction of dams. The debate is framed such that dams have become a protracted and controversial issue between Punjab and the other three provinces. Given the objections of Sindh to Kalabagh Dam, that project seems to have been shelved for the moment, but the Diamer-Bhasha Dam has now reared its head. In the second week of November 2008, this dam was officially approved at a cost of U.S. $12.6 billion. The dam will be ready by 2016 with a capacity to store 8.1 MAF, generate 45,000 MW of electricity, and, according to official sources, benefit Pakistan to the tune of U.S. $1.5 billion annually in the form of hydropower, and U.S. $600 million annually in the form of water for irrigation.[18] In these days of severe electricity shortages, this looks like good news, and may indeed be a benefit. But few people are asking a crucial question: how much of the 8.1 MAF will actually get to the farm-gate?

The need for dams is argued on four main points: more water for irrigation and agriculture; more storage capacity; more flood control; and more hydroelectric power. If the objective is to meet future water requirements in a way that promotes food security and meets the various uses of water in the context of a growing population, then let us look at each one of these arguments more closely.

In calling for more water for agriculture, there needs to be an objective picture of what is happening to the 114 MAF of sweetwater currently diverted for use in agriculture and other uses. Currently, by the government's own account, two-thirds (approximately 76 MAF) is lost due to poor transmission and seepage in the canal system. This means that about 76 MAF is potentially usable water, if the canal system can be repaired and maintained.

Diamer-Bhasha is projected to produce 8.1 MAF. Of this, two thirds (5.4 MAF) will be lost in the delivery system, and only 2.7 MAF will reach the farms. Thus, the strategy of putting up dam structures when the downstream distribution structure is so inefficient needs rethinking. However, if a quarter of the lost 76 MAF in the irrigation system is saved through better repair and maintenance, it would be over 19 MAF—more than double of what Diamer-Bhasa will produce.

Large reservoirs are ostensibly needed to carry over water from wet months to dry months and from wet years to dry years, and to offset the storage capacity loss in existing dams due to silting. However, a more efficient and maintained distribution system would lead to substantive savings in the total amount of water lost in transmission and thus free at least a reasonable proportion of this water for storage. The needs of lean years could then be met through this source.

If we look at the flood control and mitigation argument for dams, one of the well- known disadvantages of big dams is that they accentuate flood peaks (that is, the highest elevations reached by flood waters during a flood). In any case, much of the flooding in the Indus Basin occurs because levees upstream from barrages are breached to protect the barrages. It would make more sense to improve the strength of barrages in this context.

Because of the preoccupation with the canal irrigation system, there has been much neglect of rain-fed and non-irrigated arid zones, including the entire province of Baluchistan, and very little effort to develop non-flood methods of cultivation. While the world has plentiful examples of dry-land agriculture based on micro-irrigation methods and crop-per-drop technologies (not all of which require heavy doses of electricity), the politics of water in Pakistan are still built around access to river water for traditional methods of irrigation that do not disturb the status quo of feudal land relations.

Groundwater and Conjunctive Use

The Indus Basin has fresh groundwater reserves of about 55 MAF,[19] most of them in Punjab. Groundwater has become a major supplement to canal supplies, especially in the Upper Indus Plain, where groundwater quality is good. There are presently more than 500,000 tubewells in the Indus Basin area. Over the past 40 years, while the unchecked exploitation of groundwater has brought many economic results, there are now clear indications of aquifer mining (which occurs when too much water is pumped from aquifers). Groundwater now accounts for half of all farm irrigation requirements; in other words, it is supplementing the 34 MAF of surface water that reaches farmland. This conjunctive use of surface and groundwater has been hailed as a giant step forward in some quarters, especially because it has enhanced access of both big and small farmers to what is seen as additional water for irrigation. The general distribution of groundwater in the country is well-known and mapped, as it influences options for irrigation and drinking water supplies.

The quality of groundwater ranges from fresh (salinity less than 1,000 milligrams per liter, or mg/l total dissolved solids [TDS]) near the major rivers to highly saline further away, with salinity more than 3,000 mg/l TDS. Close to the edges of the irrigated lands, fresh groundwater can be found at a depth of 20–50 meters. Large areas of the Lower Indus Basin are underlain with groundwater of poor saline quality, but with lenses of sweetwater on top. Indiscriminate pumping and the heavy use of pesticides have resulted in contamination of the aquifer at many places where the salinity of tubewell water has increased.

Groundwater quality and quantity is going down fast in and around cities and towns in some parts of the country (Baluchistan, Potohar, Thar, Kacho, and parts of Northwest Frontier Province) where groundwater is the only or major source of water for all uses. In and around the city of Quetta, the mining of groundwater has reached a point where predictions are being made that the aquifer will be lost in 5–10 years.

Since much of the groundwater recharge in the Indus Basin is from canal seepage, an integrated approach is required for the "conjunctive" conservation of surface and groundwater. There are some areas where new technologies may be needed for skimming shallow lenses of sweet groundwater.[20] In all other areas, strict groundwater monitoring and regulation are required as soon as possible.

Environmental Repercussions of System Inefficiency

In addition to waterlogging and salinity, the most devastating consequence of the system inefficiency of the Indus waters has been the destruction of the Indus Delta. The historical flow of water into the delta region was over 170 MAF per year. This quantum kept the 17 main creeks[21] and a multitude of minor creeks active, and maintained a balance between seawater and freshwater in the tidal zones. Today, the delta has only 0.50 to 0.70 MAF per year. The sixth biggest mangrove forest in the world has been reduced from 0.6 million to 0.25 million acres. The drying up of the Indus River downstream from Kotri Barrage has permanently damaged the ecosystem and affected livelihoods,[22] limiting the access of local inhabitants to sweetwater sources and making them the direct victims of infrastructure—in terms of both irrigation and drainage.

The problem in the coastal regions of Sindh has been compounded by ill-fated drainage projects designed to remove saline water from irrigated lands, which have increased the danger and damage of tidal action and seawater intrusion. The damage was so severe that the World Bank (the principal funder of the drainage projects) had to call on its inspection panel in response to widespread protests by both government and local people.

Although the 1991 Water Accord recognizes a fixed quantum of environmental flows (39.5 MAF per year), these are not released in a consistent way each year, and this inconsistency is justified on the grounds that there is an "average" over time (when flood flows even out the dry years). What is needed, however, is a regular, controlled minimum flow each year, to be guaranteed through strict regulation and implementation.

URBAN WATER INFRASTRUCTURE AND SEWERAGE SYSTEMS

Already about half the population of the province of Sindh lives in urban areas, and urbanization is on the rise throughout Pakistan. Despite significant efforts to provide a continued gradual improvement in the percentage of people with water connections, figures show that because of population increases, the total number of urban residents without adequate water supply is actually increasing. While most medium-size towns have a water supply system, only 35–45 percent of households are connected.[23] And even where a distribution system is present, low water pressure and the limited period of water supply in pipes meant for 24-hour supply have resulted in cross-contamination from sewers, endangering water quality.

The water scenario in Karachi is an example of the problems associated with urban water. Currently, the water demand of the city (680 million gallons per day, or MGD) is well in excess of the supply (547 MGD). Of the supply, about 40 percent is lost through leakages and theft. At current population growth rates, Karachi will need a new scheme of 100 MGD every five years. But there is no more water to be mobilized from the Indus or Hub river sources.

The Karachi Water and Sewage Board (KW&SB) is the only government utility responsible for supplying water and treating sewage for the entire population of Karachi, currently estimated at 16 million. It is also the policy and regulation hub, overloaded with excess staff, making it hard to govern and deliver. KW&SB is supposed to generate Rs. 16 billion (U.S. $200,000,000) annually, but recovers only Rs. 2 billion—12.5 percent of the amount billed. This imposes a huge financial burden, and KW&SB is unable to pay its electricity bills or keep the system in better repair.

As in the case of agricultural water, the emphasis in urban areas is also on supply- side solutions, and little effort is made in the direction of demand reduction for water through conservation; realistic charges for the conveyance of water; regulation; fines; or citizens' action. Because water charges are so low, those who get piped water feel free to waste and overuse, while others (mostly women and children) have to queue up for hours at public taps and privately supplied tankers to get a few containers of drinking water. Cities regularly experience riots because of the non-availability of water, and venders supply water to many areas at costs up to 12 times what regular customers pay.

Only 2 percent of urban areas with populations over 10,000 have sewerage facilities. Yet even in cities with treatment facilities, less than 30 percent of wastewater is treated. At present there are only five sewage treatment plants in all of Pakistan. Of these five, three are located in Karachi—and only two of these three are functional. The total sewerage generated by Karachi is 315 MGD, and of this amount only 90 MGD is being treated so far. The optimum designed capacity of sewerage treatment plants is 151 MGD, and the shortfall is 164 MGD.[24]

The environmental consequences are enormous. In Pakistan, 250,000 children die each year from waterborne diseases, and most of them live in urban areas. At present there is little public or government attention directed to the health and environmental consequences of poor drainage and sewerage, and no thinking in terms of sewerage as a water resource.

WATER DISTRIBUTION, ENTITLEMENT, AND RIGHTS

Pakistan does not have a comprehensive set of water laws that define water rights, uses, value, principles of pricing, subsidies, conservation, or polluter penalties. Instead, the concepts of rights and entitlements are dominated by a disproportionate emphasis on and preoccupation with water distribution among provinces, currently modulated by the 1991 Water Accord. While the accord defines a set percentage of water for downstream environmental flow, data show variation from year to year. This environmental flow is a major source of contention between Punjab and Sindh, with the former calling for more water for irrigation and the latter for an increase in environmental flow. These protracted positions, along with Kalabagh Dam, have fed many a political campaign for decades, in spite of the lack of coherent positions on water in the manifestos of political parties. While government has attempted to show that there is "equity" in provincial water distribution, the mighty Indus River has no water downstream from Kotri Barrage for 10 months of the year and the Indus Delta has effectively been destroyed.

The principles of entitlement to common resources are better established in shamilat laws, by precedent and custom. Some serious analytical work has been done on the idea of "environmental entitlements," including water.[25] In terms of gender equity in Pakistan, this work shows clearly how women are consistently more disadvantaged than men when it comes to claiming entitlements, even though women's use of common property resources has been crucial in maintaining household water and food security. In the case of groups that depend on common resources, the access of women to land (for grazing, gathering, and periodic planting) and to water (for drinking, watering animals, and watering of small-scale cultivation) does not seem to be significantly less than those of men from the same group. The ownership of land remains a proxy for water rights—especially in agricultural areas. This excludes all landless people, including landless farmers who are responsible for managing irrigation water. Given that few women own or manage agricultural lands, and usually do not control such lands even if owned, their "rights" to water are ill-defined.

While at first glance it is difficult to see how demand for more irrigation water should be balanced with the need for conservation and environmental flows, and how entitlements and rights should be rationalized, it is actually not that hard. Every river in the world has a "punjab" and a "sindh"—an upper and lower riparian part of the river. This is not a situation peculiar to the Indus River in Pakistan. Other countries manage their water resources between upper and lower riparian parts of the river, and so can Pakistan. There are many models that can be studied, such as the experience of the Murray Darling Basin in Australia, South African river water sharing, the Mekong River experience, and management of the Nile River. As long as the principles of special safeguards for lower riparian areas are incorporated, solutions are possible.

WATER POLICY AND WATER SECTOR REFORMS

Pakistan's draft National Water Policy is a general policy on water and has been through several iterations, but has yet to be finalized. Pakistan's water policy framework can be said to include the following:

- National Water Policy (latest draft 2006)
- Medium Term Development Framework (MTDF, 2005-10)
- Poverty Reduction Strategy Paper (PRSP, 2004)
- The Pakistan Water Resources Strategy (Ministry of Water and Power, 2002)
- Ten Year Perspective Plan (Planning Commission, 2001)
- Vision 2025 (Water and Power Development Authority, 2001)
- Vision and Framework for Action (Pakistan Water Partnership, 2000)
- Pakistan Water Strategy (Ministry of Water and Power, 2000)
- The Water Accord of 1991

Water reforms imply changes in policy, governance, institutions, laws, regulations, and processes that impact on the way water is used, shared, conserved, and valued. The draft water policy[26] at its current stage reads like a list of actions and has no real vision or comprehensive approach. The Indus River System Authority (IRSA) operates at the federal level, as do the Ministry of Water and Power and the Water and Power Development Authority. Additionally, the provinces have irrigation and public health departments. Since devolution, districts, towns, and union councils have taken over water supply and sanitation. Currently, farmer organizations are also being established. A who's who of water institutions[27] is now produced and describes 10 public sector institutions, 28 national organizations, and 19 academic and research institutions covering the water sector. While there are laws to govern water distribution at different levels, there is little effective regulation, penalties, or conservation guidelines. To date, Pakistan does not have a single national regulatory framework dealing with the use of water.

Large parts of the Indus Basin in southern Punjab and upper Sindh are characterized by big landholdings that have managed to evade successive half-hearted land reforms and have appropriated water entitlements on the strength of the size of their holdings. The frequent cry for more water is orchestrated by this class of people, and their representatives fill the assemblies of the country.

While it is partially recognized in Pakistan that water does have "value," common perceptions do not include an awareness that irrigation water is currently provided far below its economic value. The very low irrigation service charges in Pakistan are usually justified as benefiting the poor. In fact, the organization of production remains heavily dominated by sharecropping arrangements in which the tenants are insecure.[28] In this arrangement, the benefits of irrigation infrastructure and rehabilitation—including increases in land values of 30 percent over the past decade—have directly enriched landowners. Unless the tenancy position of the sharecropping farmers is improved through reforms in Pakistan's tenancy laws, landowners are likely to continue to receive the lion's share of the benefits of low water charges and infrastructure improvement, a substantial part of which is subsidized by the government.

The issue of clout emanating from land ownership comes to the forefront again when attempting to develop local participatory frameworks for improved local water management. Medium-size and small farmers, as well as haris (sharecroppers) or wage laborers, may be members, but there is a propensity for the big landowners to appropriate leadership.[29] Since women do not have a clearly defined right over land as a proxy for water rights, their interest in participatory water management is not too high.

In the meantime, carrying water continues to be defined as "women's work," and remains the main focus of gender interventions, given that women expend much time, effort, and energy in this crucial domestic responsibility. Within these realities, the potential offered by gender mainstreaming strategies and engendered statements in water policy will not be realized very easily.

CONCLUSIONS

Keeping in view the water-related Millennium Development Goals, as well as Pakistan's growing population, water scarcity, and increasing demands on water resources, we have to ask the question: Can Pakistan meet its challenges through a continuation of conventional reforms and interventions?

The answer is that yes, Pakistan can meet the challenges, but not through business as usual. A paradigm shift will be required to reframe the whole discourse on water, and to address the fundamental issues of rights, access to water, design policy, and reform with more inclusive and comprehensive perspectives. The focus needs to shift from provincial distribution to uses and users of water—in terms of both rights and responsibilities—and away from the Sindh-Punjab debate and toward a discussion of better-managed water for all of Pakistan.

Most importantly, a shift is needed from management of water supply to management of water demand. The entire edifice of the argument for more irrigation infrastructure is based on an uncritical capitulation to the demand for more irrigation water for agriculture. There is a need to unpack this demand—who exactly is making this demand, and why should this demand be considered when agriculture already absorbs 97 percent of the total mobilized surface water, and almost all the groundwater, for supporting one of the lowest agricultural productivities in the world per unit of water and land? Can this demand for more water for agriculture be reduced by producing more with less water? The answer is yes. During the drought of 1999–2000, when water availability was drastically reduced, one would have expected lower production. Instead, there was a bumper wheat crop, proving that higher yields are possible with less water.

In terms of the Sindh-Punjab debate, it needs to be recognized publicly that not everyone in Punjab has excess, or even adequate, water and not everyone in Sindh is deprived of water. Both provinces face the same issues in terms of equitable distribution among users. This means the water discourse needs to be redefined in terms of head, middle, and tail farmlands in irrigated areas and in terms of other ways of water resources management in non-irrigated rain-fed and arid areas.

Integrated water resources management approaches, with their three Es of economic efficiency, environmental sustainability, and equity, may provide a useful framework to reorient water demand and improve water management. From this perspective, Pakistan is not entirely without traditions and options. However flawed it may be, there is a system of water entitlements within the irrigated areas. There are options for increasing water supply from within the system without investing huge amounts in new infrastructure. One such option would be repairing and priming the canal system. Additionally, there is tremendous scope for increasing water productivity.

In situations where land ownership determines water rights, it is land ownership that needs to be tackled effectively. In cases where a right to water is determined by type of use, tradition, or legal entitlement, water reform will need to ensure that all those that are entitled are clearly defined as such.

Irrigation and agriculture reforms can generate significant outcomes if some or all of the following conditions are created:

- Land holdings of more or less the same size (and not skewed between some huge farms and many tiny ones)
- Socioeconomic homogeneity among farmers (i.e., all hold land titles rather than some owning land while the others are landless and caught in a system of sharecropping)
- Incentives for better managing service delivery and quality
- Farmers pay for water based on satisfactory service delivery (i.e., service providers are made accountable)
- Irrigation schemes and programs specifically designed to benefit the poor through clearly stated conditions for investments, repairs, and rehabilitation of water infrastructure

Given that Pakistan has millions of farmers both land-owning and landless, and millions of people who have direct environmental entitlements, it would be extremely challenging, if not impossible, to recognize individual water rights. In the Pakistani context, the arguments for secure rights to land are much more compelling than water rights.

To be relevant and comprehensive, Pakistan's ongoing water policy exercise needs to do some scenario-building in light of climate change; develop the concept of agro-climatic zoning; and divide up the Indus Basin into its sub-regions and come up with targeted long-term water strategies and programming for each. This will mean different actions in different zones to get maximum leverage in managing water for all its uses. The guiding principles should include making the greatest savings where there is the greatest amount of use. This means rationalizing the use of water in agriculture; encouraging more crop-per-drop processes; and reducing the use of precious riverwater in cities by encouraging urban desalination, recycling, and reuse. Introducing water quality standards; aggressively promoting conservation across the board; keeping all natural water bodies replete with water; taking measures to rehabilitate the freshwater–seawater interface on the coasts; adaptation to climate change—these would all be essential elements of a revamped Pakistani water policy.

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Water Management under Constraints: The Need for a Paradigm Shift

Kaiser Bengali

The Indus River is Pakistan's lifeline. The country receives just 250 millimeters (mm) of rainfall per year—far less than the world average. In Sindh Province, where rainfall is a meager 127 mm per year and groundwater is generally brackish, the Indus is the only source of water for irrigation as well as human consumption. Baluchistan Province, which lies largely outside the Indus Basin, receives less than 100 mm of rainfall per year.

The economy of the country depends heavily on the productivity of its resources, and water in particular. The agricultural sector uses up to 90 percent of Pakistan's total water resources, produces one-fifth of gross domestic product (GDP), contributes to more than half of exports, and employs half the labor force. The agricultural economy is predominantly irrigated. Of the total land area of 80 million hectares (ha), 21 million ha are cultivated—of which 18 million ha are irrigated. About 12 million ha of Pakistan's irrigated land lies within the Indus River system.

Pakistan began its life as an independent state with a life-threatening water crisis. The emergence of two independent states—Pakistan and India—divided the Indus River system, and India became the upper riparian state. The boundary between the two countries was drawn such that it placed India in control of many of the canal headworks—locations where water flows are diverted and controlled and where water supply is regulated. Taking advantage of the situation, India shut off water flow from the Dipalpur Canal and the Bahawalpur

Kaiser Bengali is an economist and former national coordinator of the Benazir Income Support Programme in Pakistan.

Tributary to Pakistan on April 1, 1948. The shut-off, timed with the sowing of the wheat crop, affected 1.7 million acres of cultivable land in Pakistan, threatening the loss of about one million tons of wheat output. The wheat crop was saved only after Pakistan accepted, under duress, India's terms for the resumption of water flow. Apart from underlining the security threat from India, the crisis also highlighted the imperative of managing water resources within the country.

The water management paradigm that emerged was overwhelmingly technocentric in nature and based on two facets: engineering solutions and water storage. This paradigm was partly inherited from the British colonial era. Beginning with the construction of the Sindhani project on the Ravi River (now in India) in 1886, a range of large, highly capital-intensive projects have been built to date. During the 1960s and 1970s, a large portion of investment in the water sector was directed at gigantic Indus Basin projects: the Mangla Dam, the Tarbela Dam, five barrages, one siphon, and eight link canals. Most recently, the U.S. $500 million Greater Thal Canal has been laid in southern Punjab, while the U.S. $1.2 billion 500- kilometer (km) Kacchi Canal, passing through Punjab and Baluchistan, is under construction. In Pakistan today, the Indus River system consists of the Indus River and its tributaries, 3 major reservoirs, 19 barrages, 2 headworks, 43 canal commands, and 12 link canals, running into 56,000 km of canals and 1.6 million km of water courses and field channels. There are 550,000 tubewells.

The obsession with engineering/civil works projects has been so all-encompassing that little or no attention has been accorded to an alternative sociocentric paradigm that would incorporate elements of development, management, and conservation of water resources.

Crucially, the technocentric paradigm is under stress from two binding constraints. One is physical—the growing shortfall in water supplies—and the other is fiscal—the growing paucity of available funds for investment, operation, and maintenance.

THE WATER CONSTRAINT

In Pakistan, water demand exceeds supply, leading to a crisis-like situation almost every year. On an annual basis, the demand for water has led to maximum withdrawals from reservoirs, causing the Mangla and Tarbela dams to reach dead-level every single year. (Dead-level refers to cases in which water discharge from dams must cease because the minimum-required level of water has been reached.) From 2000 to 2004, Tarbela Dam remained at dead-level for an average of 22 days per year, and in 2000 and 2004 the dam reached dead-level for 41 and 46 days, respectively. The fact that dams have to be taken down to dead-level is indicative of water shortage.

The quantum of water flowing in the Indus and its tributaries varies widely from year to year, depending on snowfall in the Himalayan and Karakoram ranges and rainfall in the catchment

Table 1: Annual Western River Flows

Maximum flow in 1977-78	172.10 MAF
Minimum flow in 2001-02	97.13 MAF
Annual average flow	
1978-2008	140.00 MAF
1998-2008	128.52 MAF
"4 out of 5 years" annual average flow	
1978-2008	135.60 MAF
1998-2008	123.00 MAF

Note: MAF=Million Acre Feet

Source: Estimated from data obtained from government of Pakistan, Water and Power Development Authority, Lahore.

areas. Declining water availability is indicated in Table 1. Super floods occur approximately once every five years, which has raised the average flow to 140 million acre feet (MAF) over the past 30 years. In the remaining four years, average water availability has been 135.60 MAF. A comparison of water availability statistics between the last 30 and 10 years points toward declining water flows. While average flows for 1978-2008 equal 140 MAF, the same for 1998-2008 is 128.52. In years without super floods (noted as "4 out of 5 years" in Table 1), average flows have declined from 135.6 MAF during 1978-2008 to 123 MAF during 1998-2008. The highest river inflow in the last three decades was 172.10 MAF in 1977-78; the highest inflow post-1998 has been 152.69 MAF in 2006-07.

The problem of water scarcity is compounded by unscheduled disruptions in water supplies due to unilateral actions by India, the Indus River system's upper riparian. Reference was made earlier to the shut-off in water flow by India in April 1948. This crisis was followed by the comprehensive Indus Waters Treaty of 1960 between Pakistan and India (mediated by the World Bank), which regulated water relations between the two countries. The treaty allocated the entire Chenab River to Pakistan—suggesting that India is not entitled to draw any water, except for specified limited purposes, from the portion of the Chenab River flowing through territory under India's control. The treaty ensures a minimum flow of 55,000 cubic feet per second (cusecs) of water in the Chenab River across the de facto Pakistan-India boundary line in Kashmir. In August-September 2008, however, India began to fill the Baglihar Hydroelectric Power Plant reservoir on the Chenab. As a result, river flows declined to 48,000 cusecs on August 25 and to 25,000 cusecs on September 4 (see Table 2). Though the matter is still under discussion between the two countries (and remains unresolved, as of this writing), Pakistan has lost about 2 MAF of water, and Pakistan's wheat crop has been adversely affected.

Table 2: Chenab River Flow at Marala Rim Station (August 19-September 4, 2008)

Date	Hour	Cusecs
August 19	1300	51,000
August 20	0300	51,000
August 21	1800	20,000
August 22	0400	20,000
August 23	0100	41,500
August 24	0500	55,000
August 25	2100	48,000
August 26	1400	45,000
August 27	1400	47,000
August 28	1400	36,000
August 29	0600	37,000
August 30	0100	35,000
August 31	1000	38,000
September 01	1400	31,000
September 02	1200	28,000
September 03	0700	28,000
September 04	0700	25,000

Source: Government of Pakistan, Ministry of Water and Power.

DEALING WITH WATER SCARCITY

There are two opinions about how to deal with the problem of water scarcity, and each advises doing so in a diametrically opposite way. One set of opinion favors the construction of more storage capacity (e.g., dams). This is the technocentric approach. The other opinion opposes the construction of new dams on grounds of water availability and instead calls for a more sociocentric approach. This debate has in recent years been centered on the Kalabagh Dam, and has been highly politically charged and contentious. The Kalabagh issue continues to simmer, despite the formal announcement of the dam's abandonment and despite the announcement of the construction of a dam at an alternative site upstream of Tarbela at Daimer-Bhasha. A review of the two positions is, therefore, in order.

The Case for Kalabagh Dam

Proponents of the dam have claimed that, during super floods, as much as 100 billion cubic meters of water flow downstream of Kotri Barrage—the last man-made barrier on the Indus River—into the Arabian Sea. This flow is termed a waste and, thereby, demonstrates the need for a third storage dam on the Indus.

The dam is also considered justified on the grounds that existing dams are fast losing their storage capacity due to the build-up of silt deposits in their reservoirs—which has reduced water supply at a time when demand is increasing. Dam proponents reveal a frightening scenario. There will be a shortfall in renewable water availability of 108 MAF by 2013. The corresponding shortfall in food grains alone is likely to be 12 million tons.

This, it is stated, will put a three-fold burden on Pakistan's meager foreign exchange resources. First, additional foreign exchange will have to be allocated for the importation of food grains. Second, a drop in the production of export commodities such as rice, cotton, and textiles will mean the loss of foreign exchange earnings.

Third, dam supporters argue that the scale of the emerging water shortage will adversely affect power generation and supply as well. Power shortages of over 5,000 megawatts (MW) per year have been predicted by 2010, resulting in power outages and hampering industrial and agricultural production. The induction of thermal power plants can resolve the situation; however, thermal power plants run on imported fuel, further burdening scarce foreign exchange resources.

The Case against Kalabagh Dam

Opponents of Kalabagh Dam advance several arguments. They reject terming the flow downstream of Kotri as a waste, and assert that the flow is essential for the health of the Indus Delta regime. The construction of the Tarbela Dam reduced the flow downstream of Kotri Barrage by 30 percent annually and by 40 percent during the pre-monsoon season, reducing the mangrove cover in the delta from 500,000 ha in 1958 to 86,000 ha in 2005. They opine that earlier dams led to serious degradation of the Indus River ecosystem, and that another dam would cause irreparable damage.

Dam opponents also base their case on the arithmetic of water availability. It is claimed that for rivers in general, the average river inflow is transitory, and that perpetual and expensive projects like the Kalabagh Dam cannot be based on transitory data. Internationally accepted criteria suggest using the annual average quantum of water available in four out of five years, excluding the year of the highest flow.

The internationally accepted legal precept for water availability calculation is explained by the United States Supreme Court, which has had to adjudicate on some extremely complex interstate water disputes. In the case of *Wyoming v. Colorado* (1922), the state of Wyoming sought to prevent the state of Colorado and two Colorado corporations from diverting the waters of the interstate Laramie River. When the state of Colorado presented annual average flow figures as the measure of available supply of water, the court pronounced thus: "To be available in a practical sense, the supply must be fairly continuous and dependable . . . Crops cannot be grown on expectations of average flows which do not come, nor on recollections of unusual flows which have passed down the stream in prior years. Only when the water is actually applied does the soil respond" (259 U.S. 471, 476). The Supreme Court adopted neither the average, nor the minimum, over a long period, but instead the lowest average of any two successive years, excluding the years of exceptionally low flow.

In Pakistan, opponents of the Kalabagh Dam interpret the U.S. Supreme Court decision thus: "To be available in a practical sense, the supply must be fairly continuous and dependable . . . ." Storage dams cannot be filled "on expectations of average flows which do not come, nor on recollections of unusual flows which have passed down the stream in prior years." The criteria for filling the exorbitantly costly U.S. $8–10 billion Kalabagh Dam should be the "lowest average of any two successive years, excluding the years of exceptionally low flow."

Before attempting the arithmetic of water availability, it is pertinent to introduce the element of system losses due to percolation in the riverbeds. In this respect, annual average system losses are estimated at 15.19 MAF. The arithmetic of water availability in the three western rivers of the Indus River system is shown in Table 3.

This calculation does not include system losses that would occur due to evaporation and vertical and horizontal seepage from the water mass in the Kalabagh reservoir. The previous experience of reservoir-induced average annual system losses for Tarbela Dam is:

- Post-Mangla, Pre-Tarbela (1966-1977), 6.9 MAF
- Post-Tarbela (1976-1987), 16.2 MAF

In other words, the inclusion of Tarbela Dam in the Indus River system increased system losses by 9.3 MAF. Inevitably, the Kalabagh Dam will also add its share to system losses.

Table 3: Indus River System Estimates

Water requirement	**139.54 MAF**
Allocation to the four provinces (as per 1991 Water Accord)	**114.35 MAF**
System losses	**15.19 MAF**
Release below Kotri for outflow to the sea (essential for the eco-health of the Indus delta)	**10.00 MAF**
Water availability	**135.60 MAF**
Balance	**-3.94 MAF**

Source: Kazi (1998). Updated based on data from government of Pakistan, Ministry of Water and Power.

The arithmetic outlined above means that the total annual available water normally in the three western rivers of the Indus River system has to be at least 140 MAF to justify the construction of a third storage dam on the Indus. If evaporation and seepage losses at Kalabagh are factored in, this minimum requirement rises to more than 150 MAF. Clearly, in the opinion of opponents, Kalabagh Dam does not qualify even if the average water availability of 140 MAF is accepted.

WATER MANAGEMENT PARADIGMS: TECHNOCENTRIC APPROACH

Proponents of the technocentric approach have a penchant for large, capital-intensive, foreign debt-funded water infrastructure projects. The technocentric paradigm induces policymakers to look almost exclusively toward engineering solutions. This approach treats water as a mere raw material and attempts to use technical and scientific knowledge to harness it to its fullest capacity.

The technocentric paradigm does have its merits and has, in the past, turned arid lands into green acres. However, it has its limitations too. There are limits to working against nature. Planners embracing this paradigm have traditionally stressed enhanced water use, but left it to nature to handle water disposal. Massive investments have been made in irrigation extension through one water storage and diversion project after another, without consideration as to how this water was to be drained. The system has provided more water than the land has been able to drain, causing waterlogging and salinity on a vast scale.

Waterlogging

The construction of the Mangla and Tarbela dams, with the concomitant additional water flow to the newly constructed canal commands, contributed to an increased recharge of groundwater, as well as to a rise in the water table—an indication that sub-soil water is not draining adequately. The rise in the water table above a certain level not only "drowns" plant roots, but also brings up sub-soil saline elements, which renders the soil unfit for cultivation. The additional conveyance losses due to Tarbela alone added 10 percent to the overall recharge of groundwater, raising the estimated recharge to groundwater in the Indus Basin to 56 billion cubic meters. The rate of recharge has been so high that a new freshwater aquifer in the Chashma Right Bank Canal command area has been created.

A 1979 survey, conducted by Pakistan's Water and Power Development Authority (WAPDA), indicated that the post-Tarbela water table in 42 percent of the Indus Basin was less than three meters below the surface and was classified as waterlogged. In 22 percent of the basin area, the water table was less than two meters below the surface. In Sindh, about 57 percent of the province had a water table at less than three meters below the surface and was affected by waterlogging (see Table 4).

Although groundwater use has increased significantly over the last two decades, mostly in Punjab, waterlogging still affects large tracts of land, and about 22 percent of the Indus Basin command area has

Table 4: Water Table Depths and Areas Affected: Indus Plain, Trends by Province

Province	Total Area (mha)	Percent Area under Water Table (Depth in Meters)				
		<1	1–2	2–3	<3	>3
Punjab	10.17	7	11	17	35	63
Sindh	5.57	6	24	27	57	40
Baluchistan	0.35	1	6	9	16	84
NWFP	0.62	6	12	6	24	66
Total	16.71	7	15	20	42	55

Note: mha=million hectares

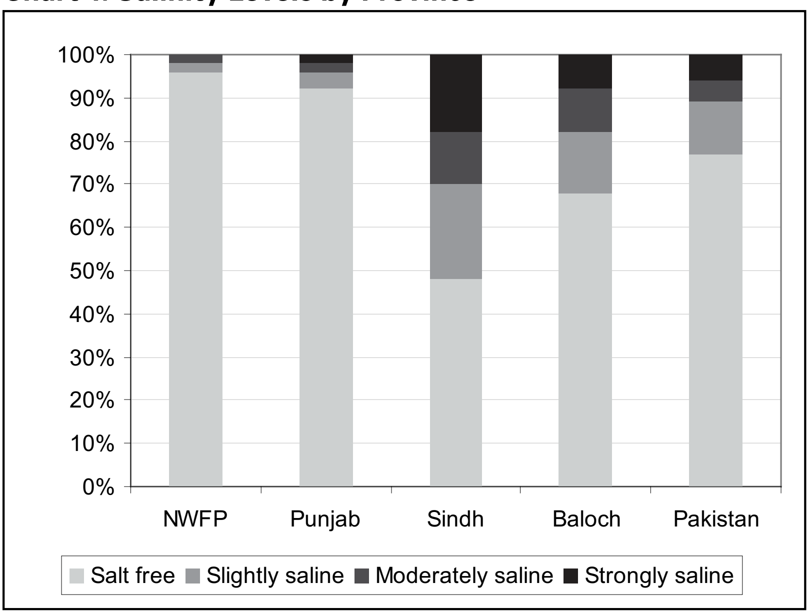
Source: FAO Corporate Document Registry, http://www.fao.org/DOCREP/005/AC623E/ac623e0i.htm.

a water table within 1.5 meters. This rising water table indicates a worsening situation in terms of soil salinity. The problem has been attributed to additional recharge from enhanced water supplies in newly constructed canal commands; to the failure of SCARP (Salinity Control and Reclamation Project) efforts to control waterlogging; and to inadequate sub-surface drainage. In fact, the rise in the water table has been faster than expected and has required an additional loan to introduce drainage.

Salinity

Waterlogging brings subsoil salts to surface levels and leads to problems of soil salinity. Nearly a quarter of land in the canal command area is saline and rendered unfit for cultivation. The situation is worst in Sindh, where over 50 percent of land in the canal command area is afflicted by salinity (see Chart 1).

Chart 1: Salinity Levels by Province



Source: Bhutta and Smedema (2005).

The need to resolve this man-made disaster led to another massive civil works initiative: the U.S. $785 million Left Bank Outfall Drain (LBOD) project, consisting of 1,950 kilometers of surface drains, 2,000 kilometers of underground drains, 2,000 tubewells, and 5,000 other structures. About 60 percent of the cost was financed by foreign exchange provided by international creditors. The project was ill-designed, choked the natural flow of drainage, and did not take into account tidal flow levels. Consequently, large pools of saline water have accumulated and part of the protective weir has been washed away by tidal action. The project is now in need of another remedial project. Meanwhile, the fiscal and balance of payments impacts have been profound.

Fiscal Constraint

The technocentric investment portfolio has almost always leaned exclusively toward civil works packages. These investments have required substantial budgetary allocations, in rupees as well as in foreign exchange. The vast physical network inherent in such projects has also required an extensive bureaucracy to manage the same and imposed enormous operations and maintenance (O&M) costs. An historical review of capital and recurrent expenditure on the water sector highlights the point.

The allocation of funds for water-related projects has always commanded high priority in terms of funding. Pakistan has prepared eight five-year development plans over the period of 1950–1998. On average, 14 percent of resources have been apportioned for water- related projects. The allocations were as high as 20–28 percent during the third and fourth plan periods (1965–1975), on account of the Indus Basin replacement works (see Table 5).

With the exception of the second five-year plan, none of the plans were implemented as stipulated. Nevertheless, the allocations do provide an indication of the relative priority accorded to water projects. A more relevant process for purposes of development planning and allocation of development funds has been the Annual Plans. A review of these plans over the period of 1948–2008 shows that, on average, 17 percent of development resources have been devoted to water-related projects; this expenditure was as high as 25 percent during 1948-50. Moreover, on average, 27 percent of the project costs have been funded through external loans, with the external element being as high as nearly 53 percent during 1991-2000 (see Table 6).

On average, water-related projects have apportioned 0.8 percent of GDP, and—on account of the Indus Basin replacement works—as high as 1.4 percent of GDP during the 1960s (see Table 7).

Projects, once completed, create a stream of O&M expenditures. In the case of water projects, such costs must be borne by provincial governments. These expenditures, on average, have grown by 2.4 percent per annum and accounted for 0.34 percent of GDP. During the earlier years, 1973-1990, O&M expenditures on average grew at 4.9

Table 5: Profile of Water Sector Allocations under Five-Year Plans (in current rupees)

Plan	Years	Total Allocation (Rs. Million)	Water Allocation (Rs. Million)	Share of Water Allocation (%)
1st	1955-60	NA	NA	NA
2nd	1960-65	9,500	866	9.1
3rd	1965-70	14,000	2,922	20.9
4th	1970-75	19,600	5,500	28.1
5th	1977-83	163,000	19,000	11.7
6th	1983-88	295,000	32,000	10.8
7th	1988-93	350,000	28,400	8.1
8th	1993-98	483,320	55,570	11.5
Average	1960-98			14.3

NA = Not Available

Source: Government of Pakistan, Ministries of Finance and Planning, Five-Year Plans.

percent and accounted for 0.45 percent of GDP. Since the 1990s, however, O&M expenditure has remained stagnant in real terms and now accounts for 0.16 percent of GDP (see Table 8). The lack of growth in O&M expenditures can be attributed largely to the growing constraints on provincial finances. Such constraints have been imposed by the shifting of the burden of federal fiscal deficit containment to the provinces. The result of the non-availability of O&M funds has been the deterioration of the irrigation infrastructure, and its attendant effects on the performance of the agricultural sector.

Clearly, the technocentric approach has imposed a high cost on the economy. Even in the current fiscal year, water projects constitute the single-largest allocation in the federal public investment budget and account for 17 percent of this budget's total. These projects account for 1 percent of GDP.

Table 6: Profile of Water Sector Allocations under Annual Plans-I (in current rupees)

Plan Years	Total Allocation (Rs. Million)	Water Allocation (Rs. Million)	Share of Water Allocation (%)	Share of Foreign Exchange in Water Projects (%)
1948-1950	876	220	25.1	NA
1950-1961	6,116	996	16.3	20.8
1962-1970	19,700	3,359	19.3	20.7
1971-1980	79,701	13,714	16.0	16.3
1981-1990	327,560	37,804	12.7	37.1
1991-2000	673,350	113,574	20.4	52.8
2001-2008	1,604,009	210,164	11.9	14.0
Average			17.4	26.9

NA = Not Available

Sources: Government of Pakistan, Pakistan Development Projects (1948-1950; 1950); Planning Commission report on "Development Projects: Progress of Important Approved Schemes" (1961); and Annual Plans (1970-2008).

Table 7: Profile of Water Sector Allocations under Annual Plans-II (in current rupees)

Plan Years	Gross Domestic Product (Rs. Million)	Plan Allocation (Rs. Million)	Plan Allocation as Share of GDP (%)	Water Allocation (Rs. Million)	Water Allocation as Share of GDP (%)
1948-1950	NA	876	NA	220	NA
1950-1961	171,000	6,116	3.6	996	0.6
1962-1970	248,000	19,700	7.3	3,359	1.4
1971-1980	1,258,000	79,701	7.2	13,714	1.1
1981-1990	5,243,000	327,560	6.3	37,804	0.8
1991-2000	20,972,000	673,350	3.5	113,574	0.5
2001-2008	52,504,000	1,604,009	2.9	210,164	0.4
Average			5.1		0.8

NA = Not Available

Sources: Government of Pakistan, Pakistan Development Projects (1948-1950; 1950); Planning Commission report on "Development Projects: Progress of Important Approved Schemes" (1961); Annual Plans (1970-2008); and Economic Surveys (1950-2008).

The current fiscal deficit is stated to be in excess of 7 percent of GDP, which is about twice the IMF-accepted norm. Capital and recurrent expenditures on water projects—the former largely and the latter to some extent—have been foreign debt-financed. The external debt-GDP ratio stands close to 30 percent and is a principal cause of Pakistan's severe balance of payments problems. The country's fiscal and current account imbalances have been responsible for persistent bouts of macroeconomic instability. The share of water projects in contributing to the crisis is not insignificant.

Table 8: Profile of Provincial Irrigation Sector O&M Expenditure

Plan Years	Total Allocation (Rs. Million)	Water Allocation (Rs. Million)
1973-1980	6.1	0.44
1981-1990	3.7	0.46
1991-2000	1.0	0.31
2001-2008	-1.3	0.16
Average	2.4	0.34

Sources: Social Policy & Development Centre Database and government of Pakistan Economic Surveys.

WATER MANAGEMENT PARADIGMS: SOCIOCENTRIC APPROACH

The technocentric approach is driven by the logic that engineering expertise alone will provide the capacity to manage water. It overlooks the fact that water constitutes a system: a hydrological cycle in which every intervention may be a possible disruption to the system. The glacier in the high mountains and the delta below are as interconnected as the rains and the underground water aquifers. The creation of a vast network of canals was a great human feat; however, it has raised water tables and turned fertile lands into saline marshes.

The constraints of water availability and fiscal balances, aggravated by the environmental and economic costs imposed by technocentric engineering projects, call for recognizing the potential of socioengineering responses. As opposed to the technocentric reliance on large, capital-intensive foreign debt-funded approaches, the sociocentric approach places a relatively greater reliance on indigenous physical and human resource management and is more resource-efficient and ecologically conducive.

Dams do not produce water; they merely store the water that is available. And there is now sufficient evidence that water is in short and declining supply. Two imperatives emerge from the above:

1. The need to move from a fetish with expanding water supply through water storage to a stress on conserving available water resources, and
2. The need to move away from large-scale capital-and technology-intensive, foreign debt-funded, and environment-degrading approaches to indigenous technology-and management-intensive, ecologically balanced approaches.

To begin with, there is a need to put in place a comprehensive water-management planning framework, mandated to address surface and groundwater issues, with a view to ensuring sustainable water use. Conservation needs to be the guiding principle, with the stress on efficiency of water conveyance—particularly in zones where groundwater is brackish and not amenable to retrieval in terms of quality. There is also an urgent need to identify various water-saving technologies that can be applied to different agro-ecological zones. Attention also needs to be focused on changes in cropping patterns, with a view to shifting acreage away from water-intensive crops. Furthermore, given the high rate of urbanization and the rapidly expanding consumption of water in Pakistan's cities, there is an imperative to introduce the extensive recycling of urban wastewater.

Primarily, the water management paradigm has to be informed by the constraints the economy is facing. The water constraint is likely to intensify further in the long run, given the climate changes underway. The fiscal and external account constraints are also likely to remain in the foreseeable future. There is, thus, a need to adopt a water management paradigm that conserves water and economizes on investment and O&M funding needs, particularly those in foreign exchange.

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Appendix: Annual Western River* Inflows by Seasons: 1923 - 2008 (Million Acre Feet)

Years	Kharif	Rabi	Total	Years	Kharif	Rabi	Total
1922-23	121.47	25.23	146.70	1965-66	117.81	21.09	138.90
1923-24	130.47	23.55	153.02	1966-67	116.64	23.83	140.47
1924-25	109.56	20.13	129.69	1967-68	120.42	25.76	146.18
1925-26	100.50	18.15	118.65	1968-69	115.63	23.21	138.84
1926-27	099.16	18.15	117.31	1969-70	114.49	19.76	134.25
1927-28	090.44	20.41	110.85	1970-71	90.20	15.90	106.10
1928-29	108.21	22.09	130.30	1971-72	88.27	15.74	104.01
1929-30	097.20	26.96	124.16	1972-73	101.62	24.45	126.07
1930-31	117.14	19.72	36.86	1973-74	145.20	19.77	164.97
1931-32	101.28	22.31	123.59	1974-75	80.64	19.67	100.31
1932-33	107.63	17.63	125.26	1975-76	116.30	23.22	139.52
1933-34	125.68	18.76	144.44	1976-77	116.85	18.43	135.28
1934-35	108.19	18.66	126.85	1977-78	104.36	23.10	127.46
1935-36	116.81	22.29	139.10	1978-79	NA	NA	NA
1936-37	124.92	20.92	145.84	1979-80	108.84	23.12	131.96
1937-38	110.10	21.35	131.45	1980-81	109.81	26.59	136.40
1938-39	125.37	22.59	147.96	1981-82	117.68	22.93	140.61
1939-40	127.25	17.55	144.80	1982-83	97.11	25.27	122.38
1940-41	107.48	15.82	123.30	1983-84	128.29	21.67	149.96
1941-42	106.61	25.61	132.30	1984-85	115.99	18.93	134.92
1942-43	145.96	23.40	169.36	1985-86	91.66	26.02	117.68
1943-44	130.54	19.61	150.15	1986-87	116.38	30.27	146.65
1944-45	119.42	20.37	139.79	1987-88	117.77	29.28	141.05
1945-46	131.64	19.10	150.74	1988-89	136.56	24.84	101.42
1946-47	112.01	18.42	130.43	1989-90	102.01	29.31	131.32
1947-48	101.36	23.31	124.67	1990-91	130.97	35.14	166.11
1948-49	132.15	23.75	155.72	1991-92	141.53	30.57	172.10
1949-50	132.29	23.71	156.00	1992-93	138.62	31.06	169.68
1950-51	151.27	20.38	171.65	1993-94	104.68	22.80	127.48
1951-52	093.60	20.21	113.81	1994-95	138.02	27.79	165.81
1952-53	112.33	17.97	130.30	1995-96	129.70	28.93	158.63
1953-54	116.31	26.77	143.08	1996-97	137.49	23.76	161.25
1954-55	119.98	20.27	140.25	1997-98	110.10	32.22	142.32
1955-56	107.51	25.02	132.53	1998-99	124.93	24.68	149.61
1956-57	131.92	25.46	157.38	1999-00	107.45	22.12	129.57
1957-58	123.00	28.10	151.10	2000-01	86.33	16.56	102.89
1958-59	124.47	34.09	158.56	2001-02	79.85	17.28	97.13
1959-60	154.74	32.05	186.79	2002-03	94.94	23.06	117.99
1960-61	NA	NA	NA	2003-04	115.61	22.14	137.76
1961-62	119.58	20.93	140.51	2004-05	82.14	30.56	112.70
1962-63	089.96	19.85	109.81	2005-06	121.22	23.95	145.17
1963-64	113.40	21.66	135.06	2006-07	121.85	30.84	152.69
1964-65	116.11	22.39	138.43	2007-08	105.87	19.99	125.86

* Includes three western rivers: Indus, Jhelum, and Chenab.
Rabi = Winter crop season; Kharif = Summer crop season
NA = Not available

Source: Government of Pakistan, Ministry of Water and Power.

Pakistan's Water Economy, the Indus River System and its Development Infrastructure, and the Relentless Struggle for Sustainability

Shams Ul Mulk

The adventure of taming the mighty Indus River and its tributaries to serve the Indus Basin and now Pakistan has been a fascinating story of human need, hope, sweat, and toil. Occasionally, greed and blood have played their role too. The men and women, the main actors, have been not only local inhabitants but also those from far-off countries, in pursuit of careers and national colonial goals. Such foreign personnel—mostly British—were carrying modern technology to a land that had remained insulated from advances in scientific knowledge bearing on engineering technology.

In times past, frequent famines in the Indus Basin magnified the urgency of using abundant national resources (land, water, and population) to meet the increasing needs of food grains. An extensive irrigation infrastructure was the pressing need, and it came into being, slowly and steadily over a century. This infrastructure has been the most valuable asset of the Indus Basin for the past century. Its value to Pakistan comes from the fact that it generates production that accounts for 25 percent of gross domestic product (GDP), 47 percent of total employment, and more than 60 percent of annual national foreign exchange earnings.

In essence, irrigation is the application of additional water to the natural balance, thereby increasing seepage to groundwater. This disturbs the dynamic balance of groundwater levels. When such conditions persist for a long time, groundwater levels rise to reach the nat-

Shams ul Mulk is former chairman of the Water and Power Development Authority (WAPDA) of Pakistan.

ural ground, thereby creating waterlogged conditions. Agricultural production potential is adversely affected and eventually is totally ended; a productive piece of land becomes a pond. Such a process was witnessed in the Indus Basin soon after the introduction of irrigation facilities. The problem increased with the expansion of irrigated areas. It appeared that the absence of mechanisms to facilitate the exit of excess water—the drainage infrastructure—was the prime reason for the problem. Remedial measures were theorized, researched, concluded, and implemented. However, satisfactory solutions remained somewhat elusive. And by the middle of the 20th century, Pakistan was losing, every year, thousands of productive acres to the waterlogging menace. Not until the 1960s was the most important initiative launched to control the hazard of waterlogging and its accompanying menace, salinity (the presence of salt in freshwater): the Salinity Control And Reclamation Projects (SCARPs). The half century that followed has been the era of SCARPs, with the result that the trend of increasing waterlogging and salinity in afflicted areas has been reversed. An extensive drainage infrastructure has become an emblem of human intervention in the Indus Basin to sustain productivity.

Rising in the Tibetan Plateau to an elevation of about 5,494 meters (almost 18,000 feet) above mean sea level (MSL), the Indus River discharges at Kalabagh into the Indus Plains at an elevation of 214 meters above MSL. This point is midway in the Indus River's momentous total journey of about 2,880 kilometers (km), before it throws its burden of water, sediment, and salt into the Arabian Sea. The total drop of the Indus River in Pakistan surpasses 2,000 meters. With such a drop and the enormous quantities of water flowing through it, a great potential of hydropower is created. This holds true for its tributaries also, but to a lesser degree. Because of these features, the Indus River system has attracted the interest of hydropower developers. Rough estimates indicate an economically viable and technically feasible Indus River hydrogenation capacity of 35,700 megawatts (MW) out of a potential 55,000 MW for the entire river system. The Tarbela Hydropower Station (with an installed capacity of 3,478 MW), Ghazi Barotha Hydropower Station (1,450 MW), and Chashma Hydro Station (184 MW) have all been commissioned on the Indus River. Warsak Dam, on the Kabul River (the western tributary of the Indus), and the Mangla Dam, on the Jhelum River (the eastern tributary of the Indus), are medium/major hydrogeneration stations. The Malakand III Hydro Station is another medium-sized source of power. There are also a few other hydro stations in operation, which bring a total actual installed capacity of 6,444 MW in the entire Indus River system. This hydel power is very important for Pakistan, because the production cost of hydel energy is less than a single U.S. cent per unit of kilowatt-hour, compared to about 10 cents per unit for thermal. And hydel energy is about 30 percent of the total national generation.

The development strategy of the Indus River system has emphasized multipurpose development. The two major purposes have been supplying water for irrigation in the Indus Basin and hydropower generation to feed the national power grid. Drainage facilities came in the wake of irrigation. The necessary infrastructure for the three main activities—irrigation, drainage, and hydropower generation—are the main instruments for the production of benefits in these areas. The operation of these instruments has not been trouble-free. Some problems were so complex that they even exceeded the frontiers of knowledge. The first impounding of the Tarbela reservoir was one such event. Major damage occurred, and there were serious fears of a breach of the world's biggest earth-rock dam. Additionally, the twin menace of waterlogging and salinity endangered the productivity of the Indus Plains to such an extent that a tragic disaster was feared.

However, such doomsday scenarios did not come to pass. Luck and the input of the best engineering minds saved the day for the basin and for Pakistan. This story has been extensively covered in technical literature, reports, and memoranda. However, a version that is user-friendly has not been attempted, and this paper shall provide such a perspective. Because of the enormity of technical details—which cannot be presented due to space limitation—this paper serves as an outline of the digest of the summary of the problems, the attendant issues, and the momentous events that took place. Yet even with such limitations, the story is worth telling.

PHYSICAL SETTING

The western Himalayas, the Hindu Kush, Karakorum, and their associated mountain ranges are located in the north and northwest of Pakistan. It is in this area where some of the world's highest peaks, as well as a concentration of glaciers and snow lakes surpassed only in the polar regions, are located. This area marks the origin and birth of the Indus River system.

This system is composed of the Indus River; the Jhelum and Chenab rivers (eastern tributaries); the Kabul and Gomal rivers (western tributaries); and the Ravi, Beas, and Sutlej rivers (allocated to India under the Indus Waters Treaty of 1960).

THE IRRIGATION INFRASTRUCTURE

The Indus Basin has witnessed the practice of irrigation, in its simplest form, for thousands of years. The world-famous archeological site of Moenjo Daro City, located on the banks of the Indus River in lower Sindh Province, relied on the extensive use of riverwater for domestic and economic purposes. However, it was only in the second half of the 19th century that the government of British India (which included present-day Pakistan) took a landmark initiative to develop irrigation works on the Subcontinent. There were three compelling reasons for doing so:

- Famine had become a major problem;
- There was a need to resettle the dissolved armies of the indigenous rulers who had been replaced by colonial administrations; and
- The irrigation system offered great potential for generating revenue.

There has been no looking back. This leap not only led to an expansion of the irrigated area in the basin, but also to an extension of the frontiers of knowledge in irrigation engineering. With such improvements in engineering sciences and technology, the 20th century became a landmark period in the history of irrigation development in the Indus Basin. For instance, Sukkur Barrage was completed in 1932. A single barrage feeding seven canals and commanding a cultivable area of 3.16 million hectares (ha) to provide assured supplies, this project was an achievement unparalleled in the world.

The colonial rule of Great Britain came to a close in August 1947, resulting in the partitioning of the Indus Basin between Pakistan and India. By that year, the area irrigated in Pakistan's Indus Basin had grown to 10.75 million ha. This tempo of irrigation development was maintained after independence. In the half century ending in the year 2000, the irrigated area had grown to 18 million ha.

It is important to note that the hydrology of the Indus River system is highly variable, season-wise and year-wise. The flows of the western rivers (Indus, Jhelum, and Chenab) allocated to Pakistan under the 1960 treaty with India are shown in Table 1.

Table 1 shows that the flow variation between summer and winter, on average, is about five to one. However, the demand of agriculture—which consumes 95–97 percent of river flows—is two to one between summer and winter, which explains why there are seasonal surpluses (in summer) and shortages (in winter).

Table 1: Western River Flows in Million Cubic Meters (Post-Storage Period, 1968 -1996)

	Kharif (summer)	Rabi (winter)	Annual Total
Minimum	94.0	19.9	113.9
10% Probability	111.6	20.4	135.5
50% Probability	136.0	27.1	162.1
90% Probability	159.7	32.8	189.8
Maximum	182.0	37.8	206.0

Source: Water Resource Management Directorate, WAPDA.

The Indus Aquifer is a large body of groundwater underlying the vast Indus Plains. Rain, rivers, and other surface water bodies are the normal sources of recharge for this aquifer. The quality of water in the aquifer is, however, very variable. Where it is useable, it has been used for irrigation through traditional wells. Tubewells have taken the place of traditional wells in modern times. Almost 700,000 tubewells have been installed over about four decades by landowners in the basin. It is estimated that these tubewells extract about 60 billion cubic meters (bcm) of water from the aquifer every year. The estimated annual inflow into the aquifer is about 70 bcm from all sources.

Under the terms of the Indus Waters Treaty of 1960, Pakistan is obliged to construct storage to compensate for the water lost from allocating the three eastern rivers (Ravi, Beas, and Sutlej) to India. The Mangla Dam, followed by the Tarbela Dam, were thus added to the inventory of national physical assets. The implementation of the Indus Waters Treaty interlinked the western rivers so effectively with the then-existing irrigation infrastructure that the whole of Pakistan's Indus Basin—with its dams, barrages, canals, and cultivated/irrigated land—has become the world's largest integrated, contiguous irrigated system. The list of the infrastructure of irrigation is given in Table 2.

Table 2: Land and Water Resources and Related Infrastructure in Indus Basin

Land	
Total cropped area	21.35 million hectares (ha)
Canals commanded area	13.96 million ha
Annual irrigated area	16.19 million ha
Water	
Annual average flow in the Indus River system	162.1 billion cubic meters (bcm)
Extraction from Indus Aquifer	60.0 bcm
Storage capacity in reservoirs	19.2 bcm
Infrastructure	
Major storage sites	3
Barrages (diversion dams)	18
Inter-river link canals	16
Irrigation canals	64,000 km long
Irrigation water courses	100,000
Irrigation tubewells (private)	700,000 (estimated)

This integrated system has become a major national asset and earned itself the honorific title of "The Indus Food Machine." However, it is not problem-free. Two problems surpass all others in their overarching and overwhelming potential to disable the system. These are the Indus water dispute and the twin menace of waterlogging and salinity. This paper will focus on the latter problem.

The Twin Menace—Waterlogging and Salinity

Generally speaking, waterlogging is a condition in which soil profiles are saturated with water near or in the zone of plant roots, and consequently the roots do not obtain nutrients for their growth. Plant growth is arrested, and eventually land becomes barren. When this saturation zone nears the surface, the water starts evaporating. However, the salts carried and contained in the water in soluble form cannot evaporate, and so the salts remain on the surface. This is the beginning of the process of salinity. The normal remedy for waterlogging is to lower the water table (the water level of groundwater deposits) through drainage infrastructure. However, reclamation of saline lands is somewhat more difficult. Hence, salinity is somewhat of a greater menace.

Doomsday Scenario

A system of well-fed rivers flowing for millions of years has a natural corollary: the development of an underground water deposit. Thus the Indus Aquifer came into being. The dynamic balance between inflows into the aquifer, and its disposal into return flows in the natural drainage outlets, had initially been established at a depth exceeding 70 feet from the surface in most of the basin—before the construction of irrigation projects. In the active flood plains in the vicinity of streams, this balance stabilized around 20 feet below the ground. There were, nevertheless, annual variations depending on whether the year was drier or wetter than the long-term average.

In the middle of the 19th century, as construction began on a large number of irrigation weirs/barrages and canals, new elements were introduced into the water balance: a massive canal system, water courses, and extended irrigation into traditionally non-irrigable areas. Massive quantities of seepage into underground areas without drainage infrastructure led to a rise in the water table in most areas of the basin. And this was a rapid rise—about one to two feet per year in general. As the water table rose to only 10 feet below the surface, crop health and productivity became adversely affected. At five feet, the area became a wasteland. Areas with depressed surface levels became ponds. By the middle of the 20th century the problem had become so massive that Pakistan was losing about 100,000 acres of productive irrigated land every year to the twin menace. A doomsday scenario was now in the making for the Indus Basin. Pakistan had to take serious measures to safeguard the survival of the important national asset that the irrigation infrastructure had become.

Remedial Measures

The problem of waterlogging was noticed for the first time in 1857, in the non-irrigable area of the Sirhind Canal (fed by the Sutlej River). The problem was then observed in other areas irrigated by canals, when the construction of weir-fed canals continued in the basin. The first response was to monitor water table levels in the areas comin g under irrigation. It was noticed that in the river valleys where the natural water table levels were not too deep, the problem of waterlogging was very serious because it was accompanied by soil salinity.

The problem was not well understood. Technical studies were undertaken to fill in gaps in the needed knowledge. This included the construction of pilot projects to test the remedial measures proposed at various stages—such as the creation of drains; the reduction of the drainable surplus by restricting flows in the irrigation canals; the lining of canals (this practice involves covering canal bottoms and sides with concrete, brick, or similar materials, which reduces water seepage from the canals); and the pumping out of groundwater. Steps for strengthening institutional capacity were also taken, including the establishment of the Drainage Board in 1918; the Irrigation Research Laboratory in 1925; the Waterlogging Board in 1928; the Land Reclamation Board in 1940; and the Land Reclamation Directorate

Table 3: Status of Waterlogging and Salinity in Indus Basin in Mid-20th Century (Pre-WAPDA Period)

Gross area	16 million hectares
Area with water table less than 10 feet	37.5%
Surface salinity (moderately saline)	34.8%
Surface salinity (severely saline)	16.4%

in 1945. These steps and initiatives had little impact, however, and the situation by the middle of the 20th century was as depicted in Table 3. After almost a century of using an extended irrigation system, and following numerous studies and field experiments, it was concluded at this stage that while all the aspects of the menace had not been understood, an effective drainage system appeared to be a necessary remedial measure. Seepage reduction measures, like the lining of canals, also appeared to be helpful. The installation of tubewells helped in checking the rise of water tables and in providing additional water supplies for irrigation.

By the time Pakistan attained its independence, its elusive success in protecting a valuable national asset from the debilitating effects of waterlogging and salinity, coupled with the continued Indus water dispute with neighboring India, had created a major crisis for Pakistan's most important economic sector. The strategy Pakistan chose to tackle the crisis was to redesign its water- and power-related institutional architecture. Pakistan's Water and Power Development Authority (WAPDA) was established, through an act of parliament, to ensure the country's national survival through the crisis. Fortuitously, the Groundwater Development Organization was merged with WAPDA, therefore bringing experienced manpower and both indigenous and foreign expertise to the new agency. A real battle with the twin menace had now begun.

Water and Power Development Authority of Pakistan

The WAPDA Act's preamble states that

> "Whereas it is expedient to provide for the unified and coordinated development of water and power resources of . . . Pakistan, it is hereby enacted as under . . . ."

and then follows the provisions of the Act. In Chapter III of the WAPDA Act, specifying the powers and duties of WAPDA, Section 8(2)(iv) includes "the prevention of waterlogging and reclamation of waterlogged and salted lands" as one of its duties.

WAPDA took immediate steps toward controlling waterlogging and reclaiming salted lands, starting with the conducting of studies. In May 1961, WAPDA presented a report titled "Programme for Waterlogging and Salinity Control in Irrigated Areas of . . . Pakistan." This report contained a 10-year remedial program, and marked the beginning of the Salinity Control And Reclamation Projects, or SCARP.

The concept of SCARPs was an innovation. The use of tubewells for the extraction of groundwater for drainage or irrigation had been well-known. However, the concept of SCARPs involved controlled extraction from groundwater in conjunction with surface water—thereby providing supplemental supplies that considerably mitigated the shortage of canal supplies. The optimal productivity in canal irrigated areas had been greatly impeded by capacity constraints in the canals, which handicapped the system from meeting consumptive needs at the critical time of plant growth. The new concept of SCARPs provided an answer to this dilemma, which in turn enabled the optimum production of agricultural commodities.

In view of the criticality of the problem, progress toward controlling waterlogging and eradicating salinity was under close watch by the government of Pakistan. In a meeting chaired by the president in 1961, WAPDA was directed to prepare a national plan for eradication of the twin menace. WAPDA proceeded to hire international consultants, one for the upper basin, the Northern Indus Plains (NIP), and another for the lower basin, the Southern Indus Plains (SIP). WAPDA's manpower was deputed to work with the consultants, and it was this group of WAPDA's staff that provided the agency with the capacity to undertake the gigantic task lying ahead. This was an effective first step for the transfer of technology, and it proved very useful.

For the lower Indus basin, the firms M/S Hunting Technical Services and Mott MacDonald of Pakistan were engaged. Working with WAPDA-deputed manpower, the combined group produced the Lower Indus Report in 1966. This study comprised the main two-volume report; supporting reports numbering 12 volumes along with six map boxes; supplements comprising 37 volumes and 11 map boxes; and a development atlas. Not only the reports, but also the field investigations and studies, supported by desk studies, were of a professional standard that few in the world could have matched. This was one of the highest points of excellence in the entire endeavor of engineering.

The SIP divided the lower basin plains into 16 projects, covering 0.3 to 0.8 million ha each. The major drainage infrastructure was to be open drains of 54,500 km-length—the main and supplemental drains. Tubewells were only to serve drainage purposes because of the dominance of the saline aquifer.

The NIP was allocated to M/S Tipton Kalmbach, which with assistance from WAPDA staff produced a six-volume project report in 1967. The project plan divided the upper basin into 10 SCARPs, ranging from 0.4 to 1.6 million ha each. The SCARP concept—the conjunctive use of tubewell water extracted from groundwater with surface water, which improved irrigation intensities in the project area—was retained.

Implementation of SCARPs

From the 1960s to the first decade of the 21st century, spanning half a century, SCARPs have remained under implementation, one after the other, depending on the availability of resources. An impressive inventory of the drainage infrastructure has been created. The original strategy of SCARPs survived for awhile, but eventually came under modification and revision.

By June 2004, 63 SCARPs had been completed, covering an area of 7.86 million ha. Since then, five SCARPs that were under implementation have been completed—bringing the total number of SCARPs to 68 and the covered area to 7.864 million ha.

Comments and Challenges Ahead

Battles have been won, but the war on waterlogging and salinity is not yet over. And there are reasons for this lack of finality. Firstly, three large storage reservoirs with a capacity of 19.2 billion cubic meters have been added to the system. Accordingly, the use of riverwater for irrigation increased from about 83 billion cubic meters per year in 1968 to about 130 billion cubic meters in the 1990s. This additionality has overburdened the aquifer with even more seepage inflow. Secondly, the science of interaction between water and land (and the waterlogging and salinity that can result) has not been well understood in all its processes; in some cases it continues to be so even today. Accordingly, project designs have occasionally lacked effective responses. Thirdly, efforts have not been supported by an effective and responsive program of research. Monitoring and evaluation have not been conducted with regularity. Mistakes have thus been repeated, rather than becoming useful sources of correction.

However, considering the odds, there has been a clear improvement in the situation, as shown in Table 4. Given the enormous amount of work already done, the partial successes, and the partial failures, the lesson appears to be that while the strategy is sound, the action plans have to be fine-tuned. And that would be possible if the knowledge gaps that continue to exist are given a high priority in the national research agenda. There is an urgent need to fill in these gaps.

Table 4: Comparative Status of Waterlogging and Salinity in Indus Basin

Year	Water used in irrigation (billion cubic meters)			Gross area (million hectares)	Area waterlogged (percent)	Area saline (percent)
	From rivers	From ground-water	Total			
1960	83	2	85	16	37.5	51.1
2008	130	60	190	21	12	25

HYDROPOWER INFRASTRUCTURE

The Indus irrigation system is the world's largest contiguous irrigation network. However, its sustainability is conditional on effective drainage infrastructure that in turn needs electric power. Before independence in 1947, only two hydro facilities existed in present-day Pakistan. One was the Malakand Hydel Station, located on the Upper Swat Canal in NWFP. It had an installed generation capacity of 9.6 megawatts and had been completed in 1938. The other was the Remala Hydro Station, sited on the Lower Bari Doab Canal in Punjab Province. Commissioned in 1925, it had an installed capacity of only 1.1 MW. The first major hydro facility established in Pakistan was the Warsak Hydro Power Station, commissioned in 1960, along with the Warsak Dam, built on the Kabul River. In its first phase, generation capacity was 160 MW, and another 83 MW were added in 1980. The real push, however, came from the super-large dams built under the provisions of the Indus Waters Treaty of 1960. Mangla Dam was the first one. The initial two units of 100 MW capacity were commissioned in July 1967. By July 1994, capacity had increased to 1,000 MW. Next was the famous Tarbela Dam. The first two units of Tarbela Power House, each with 175 MW capacity, were commissioned in April 1977. With periodic additions up to November 1992, Tarbela Power House has now acquired an installed capacity of 3,478 MW, which is 19.8 percent of the total national installed capacity as of the year 2007. Table 5 shows the installed capacity of the major hydro stations in Pakistan.

Table 5: Hydro Power Stations in the Public Sector

Name of station	Type of structure	River on which sited	Installed capacity (MW)
Tarbela	Dam/reservoir	Indus River	3,478
Mangla	Dam/reservoir	Jhelum River	1,000
Warsak	Dam/reservoir	Kabul River	243
Chashma	Low diversion dam	Indus River	184
Ghazi Barotha	Diversion/low head	Indus River	1,450
Nine small hydro stations	Power Channels	Indus River	89
			Total: 6,444 MW

Tarbela, as a single source, provides about 54 percent of Pakistan's total hydro capacity. When the installation of its current capacity was completed in 1993-94, this one source comprised 36 percent of the total national capacity (which also included thermal power). Tarbela is thus the most important hydro facility in Pakistan. In fact, however, the Tarbela Dam project has faced major adversity, threatening the very life of the project. It was here that WAPDA—the national agency for development, transmission, and distribution of electric power—had to engage all the adverse odds head-on, with the strength of the best engineering minds of the world. With this and with luck, WAPDA succeeded in securing the safety of the project and ensuring the continuation of its enormous benefits. In addition to its contribution to the national electric power sector, this project has provided almost 12 billion cubic meters of additional water for irrigation every year. This has almost equalled the annual winter flows of the Indus River, measured at Tarbela. In other words, Tarbela Dam has duplicated the Indus River for its winter supplies.

For such reasons, the Tarbela Dam project and its problems provide a useful case study for describing Pakistan's hydro power infrastructure.

Tarbela Dam Project

Tarbela Dam is a rock and earth-fill dam sited on the Indus River. It is 143 meters high (470 feet) and 2.74 kilometers long. About 143 million cubic meters (190 million cubic yards) of earth and rock have been used on its embankments. For many decades after its completion in 1974, it has been rated as the largest earth-rock dam in the world. The outlet works include five tunnels in the right abutment, and two spillways with a combined discharge capacity of 42,470 cubic meters/second (equivalent to 1.50 million cubic feet/second). The outlet tunnels, with internal diameters of 13.7 meters (45 feet), were used as diversion tunnels during the diversion stage of the dam construction. Later they were to become the power tunnels. The dam's power house has 10 units of 175 MW generating capacity and 4 units of 432 MW capacity, making up the total of 3,478 MW.

Unprecedented Features of the Project

At the dam site, the Indus River flows in a broad, flat valley as a stream. The bedrock surface at the dam site is 220 meters deep for about 1.8 km, going along the dam axis from the left bank. For the remaining length of 610 meters, the bedrock has formed a shelf, and it is here where the dam embankment was founded on rock. For the remaining length of about 1.8 km, the dam embankment had to be founded on alluvial deposits as deep as 220 meters. These alluvial deposits are skip-graded (that is, the deposits consist of materials of varying sizes, with some intermediary sizes completely absent—and this lack of mid-sized material creates space for water to percolate), and in places where the gravel component was not choked by fine sand.

These site conditions represented red signals, and were identified as such during the investigation of the dam foundations. One basic decision was made to use the observational method in the design of the embankments. In such an approach, the structure in question is very closely monitored, which gives the operator the type of actual information needed for the safety of the structure and its operation. Seepage control through the dam foundations was understood to be the core issue. There were now two options in terms of how to proceed: construct a deep grout curtain, or build a long upstream impervious blanket. The blanket was chosen for the following reasons:

- Cost economy
- Facility of inspection access during construction
- Safety considerations during seismic activity
- Potential of progressive improvement due to sedimentation, which helps prevent seepage.

This blanket was to be an extension of the impervious sloping core; the core was 5 meters thick at top and 38 meters at the base. The connecting impervious blanket had a thickness of 12.8 meters at the dam toe, and a length of 2,286 meters. A line of relief wells was provided at the downstream toe of the main dam, to safely collect the seeped water for disposal. It was expected that maximum seepage through the foundations of the main dam would be 4.1 cubic meters/second.

First Impounding of Reservoir

The filling of the Tarbela reservoir was started on July 1, 1974, just as scheduled. This new phase necessitated the termination of the diversion stage of the project by closing the diversion tunnels located in the right abutment. The beginning was inauspicious. The central intake gate of Tunnel 2 got stuck during the closure operation. This led to highly unstable hydraulic conditions in Tunnel 2 and its vicinity. A few days later, huge chunks of concrete and rubble were visibly coming out of the tunnels. Damages appeared obvious, but the severity and extent were not to become known until later. Yet this matter notwithstanding, the reservoir kept on rising.

With the rise in the reservoir level, seepage coming through the main dam alluvial foundation was becoming a matter of concern. It was excessive, and becoming more so with every passing day. By August 21—that is, seven weeks after the start—the reservoir was filled to 80 percent of maximum design depth. At that point, the seepage through the foundations was measured at 8.5 cubic meters/second, which was more than double the maximum expected.

The risk of continued seepage, coupled with the damage to Tunnel 2's gates and the huge chunks of concrete flowing out of the tunnel at its visible outlet, was no longer acceptable. It was decided to terminate the filling and resort, instead, to an emergency emptying out of the reservoir. This was a blessing in disguise. The true condition of Tunnel 2 now became visible, and it was a horrible scene. The stuck gate at the Tunnel 2 entrance had generated so much cavitation damage that 76 meters of the upstream part of Tunnel 2 had collapsed. In consequence, serious damage had been inflicted on the outlet gate chambers and concrete chutes of the stilling basins of Tunnels 3 and 4. About 765,000 cubic meters of overlying material (at the top) and bedrock (at the bottom) at the tunnel intake area were eroded and swept through the tunnel. More was to come. With the complete emptying of the reservoir, the supposedly impervious blanket on the riverbed became visible. It had 362 sinkholes from 0.3 to 12 meters in diameter, along with 140 cracks.

These damages were enormous, and, for Pakistan, almost a crippling blow. But there was no time for mourning. Work to repair the damage had to start immediately. And this was done. The most urgent task was to carry out a detailed site investigation, so that the repair work could be designed in a professional manner. The time limitation was critical; everything had to be ready before the next flood season. All these targets were met. The blanket was repaired. Every year during filling, a reduced number of sinkholes would appear, and by 1988 the last one had disappeared. Seepage through the foundations followed the same pattern of reduction with time. By 1988, there was no seepage at all. The damages inflicted on Tunnel 2 and on the stilling basin of Tunnel 3 were repaired with improved materials and technology. When the next flood season came in July 1975, it appeared as if nothing had happened a year earlier.

CONCLUSION

The Tarbela Dam project was an undertaking of unprecedented size and technical complexity. Its completion, in physical terms, was an achievement truly reflective of the jewel of the crown. But a more appropriate description of this gigantic project would be the miracle at Tarbela—and particularly because of its repairs, repairs in which electric power production never diverted from its original schedule. International records of physical and qua ntitative progress were surpassed without compromising quality standards of work. For example, the right abutment, which was substantially eroded away, was rebuilt with Roller Compacted Concrete (Rollcrete). The quantity placed and compacted for this purpose was equivalent to two-thirds (67 percent) of the concrete used for Warsak Dam—a mass concrete gravity dam that is 250 feet high and 460 feet long. Incredibly, the placement of the Rollcrete for rebuilding the intake area of the Tarbela tunnels was done in a period of just 42 days.

Even once the dam was deemed repaired and safe, the challenges did not end at Tarbela. Sinkholes in the auxiliary embankment were followed by one in the main dam—though these have now been stabilized and repaired. The depositing of sediment in the Tarbela reservoir—at the rate of 0.6 million tons on average every day—and the movement of the sediment delta toward the intake area of the power tunnels are sources of concern.

However, the project is serving the nation with water supplies for agriculture and cheap power, and it is being closely monitored.

The lesson is that human intervention in processes of nature exacts a price. And the currency of payment is knowledge, commitment, perseverance, and integrity.

Water, Governance, and Corruption in Pakistan

Feisal Khan

The World Bank, in an exhaustive 2005 analysis of the Pakistani water situation, declared Pakistan to be one of the world's most arid and water-stressed (soon to be water-scarce) countries, on par with those of the Sahara Desert. A per capita annual water availability of 1,000 cubic meters (m^3) is believed to be low enough to "impede development and harm human health" (Faruqui 2004, 178). In the most optimistic scenario, Pakistan will fall to that level in 2035 (see Figure I). According to some reports, Pakistan reached 1,100m^3 per capita annually in 2006 (WWF 2007, 1).

Agriculture accounts for about 93 percent of the country's water use (WWF 2007, 7), employs 43.61 percent of the workforce, and contributes 21.8 percent of Pakistan's Gross Domestic Product (GDP)[1] (FBS 2008b, 2008c). The true magnitude of Pakistan's "water scarcity" is made more striking when one considers that in 2007, agriculture was almost wholly dependent on the world's largest contiguous irrigation system to irrigate 19.07 million hectares of land (FBS 2008a, 65, Table 1.16). Since Pakistan's irrigation is based solely on the Indus River and its tributaries, it is more vulnerable to supply shocks than it would be if its irrigation were drawn from multi-river systems.

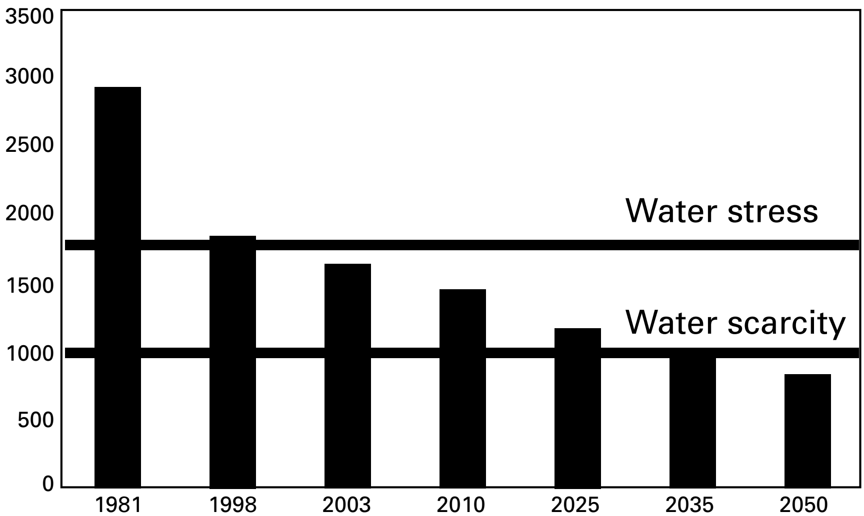
As shown in Figure I, Pakistan went from being relatively water-abundant in 1981 to water-stressed by about 2000, and will be water-scarce by 2035. Indeed, in one important sense, the story of Pakistani agriculture is a story of declining farm-gate water availability throughout its history (Bandaragoda 1996). Compounding the difficulty is

Feisal Khan is assistant professor in the Department of Economics at Hobart and William Smith Colleges.

the fact that Pakistan does not make efficient use of the resources it does have. As shown in Figure II, Pakistan's wheat yield (a vital staple in Pakistan) is extremely low in both absolute and relative terms. It is understandable that wheat yields in the Pakistani Punjab would be lower than those in the United States (due to lower capital intensity in the production process, less access to inputs, and so on). However, the fact that the Pakistani Punjab's wheat yields are approximately half those of Indian Punjab (in both absolute terms and per unit of water used) attests to the inefficiency of the Pakistani Punjab's agriculture—and yet the Punjab represents the breadbasket of Pakistan.

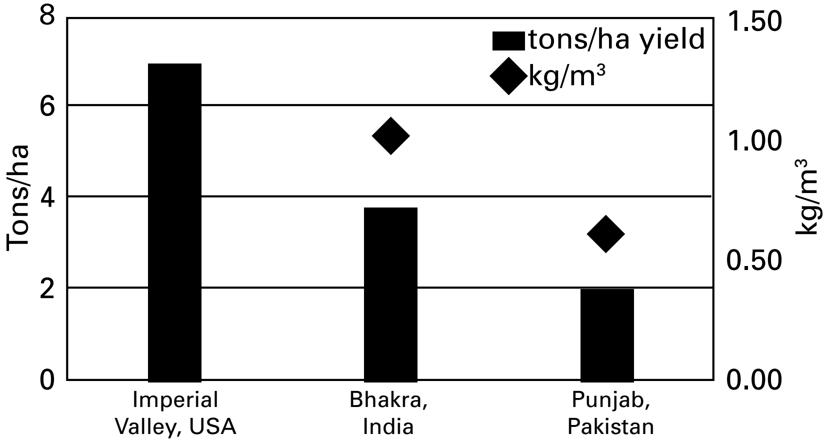
So, considering the importance of water to Pakistan's economy and its relative scarcity, water conservation and use-efficiency should be high on Pakistan's list of national priorities. Unfortunately, they are not. A major factor behind the severity of the Pakistani water crisis is a historical legacy of bad policies, misgovernance, and corruption. Despite recent attempts by the Pervez Musharraf administration at wide-ranging reforms, the situation is still grave.

Figure I: Declining Per Capita Water Availability in Pakistan (meters^3/capita/year)



Source: World Bank (2005).

Figure II: Comparison of Yields and Water Productivity of Wheat in USA, Pakistan, and India



Source: International Water Management Institute (2003).

The following pages seek to identify some of the key policy, governance, and corruption issues relevant to the current water crisis in Pakistan.

HISTORICAL CONTEXT

While there was a centuries-old tradition of irrigation works in the Subcontinent, work on what became the Pakistani irrigation system was started by the British colonial administration. By the time of independence in 1947, Pakistan already boasted an extensive and well-developed irrigation structure with provincial irrigation departments of considerable technical expertise and professional ability. Shortly after independence, this technical competence was demonstrated when, after the lapse of the irrigation "standstill agreement,"[2] India shut down the water flow to Pakistan in April 1948. The Punjab Irrigation Department rapidly dug the 100-mile Bombanwala-Ravi-Bedian-Dipalpur canal to divert water from the Ravi to the Sutlej River, thereby forestalling another Indian attempt to cripple Pakistan by shutting the downstream flow of the Sutlej (Gazdar 2005).

The guiding ethos of the colonial-era irrigation department was a rigidly hierarchical one that focused on technical administration and water project construction, with virtually all decisions made internally and without any user/beneficiary input into the decision-making process. This view of irrigation as a purely technical issue best left to those with the requisite scientific qualifications continued long after independence, and was in sync with the prevailing irrigation paradigm worldwide. After World War II, water issues were seen as "large-scale, scientific, and top-down" problems that required a high level of engineering expertise to resolve (Wescoat, Halvorson, and Mustafa 2000, 396).

The colonial-era Canal and Drainage Act of 1873 gave the state all rights and authority over water issues. Furthermore, "the legal lack of rights for the water users enshrined in the Act" was further strengthened by government of Pakistan amendments that stripped the Act of the extremely limited redress available to water users—i.e., farmers (Mustafa 2001, 820 and 828). Furthermore, citing considerable historical research, Daanish Mustafa (2001, 824) concludes that a key aim of the Act was to consolidate the power of loyalist large landowners, and that colonial irrigation policy was designed as much to directly control the native population as to improve agriculture. Thus the power of irrigation department officials to unilaterally acquire private land for "public purposes"; to declare farmers to be in violation of a wide range of rules; to levy fines and deny farmers irrigation water; and generally to micromanage down to the individual small-farmer level (e.g., to dictate the size and location of the field's irrigation outlet and the time of water delivery) made it clear that irrigation department officials were "policing agents of the state" with considerable unaccountable discretionary power to extort money from small farmers (Mustafa 2001, 830; see 826–830 for more details). However, large landowners, with greater political influence, were (and still are) free from this kind of harassment and extortion and, on the contrary, often ordered officials about with impunity. The Canal and Drainage Act has remained the legal foundation for irrigation in post-colonial Pakistan as well, enabling the powers of irrigation officials to stay unchecked.

In 1959, the military government of General Ayub Khan established WAPDA, the Water and Power Development Authority, to plan and implement an overall development strategy for Pakistan's water resources. As part of the overall water-use planning policy, the riparian disputes with India were resolved with the signing of the World Bank-brokered Indus Waters Treaty in 1960, which gave Pakistan full rights over the Indus, Jhelum, and Chenab rivers, and India the Ravi, Beas, and Sutlej rivers. Pakistan, as the lower riparian state, received about 75 percent of the Indus River Basin (IRB) water and India the remainder.[3] WAPDA, divided into a Water Wing and a Power Wing (i.e., hydroelectric power generation), planned and implemented the Indus Basin Project (IBP).

Among the first accomplishments of the IBP were two very large dams, the Mangla on the Jhelum (completed in 1967) and the Tarbela on the Indus (completed in 1974). These were both dual-purpose dams (meant to provide irrigation and hydroelectric power) and enabled the rapid expansion of both electricity provision and irrigated agriculture.

These were highly successful projects with substantial economic benefits for the Pakistani economy. For example, overall benefits from Tarbela Dam, for 1975-1998, exceeded initial feasibility estimates by 25 percent (World Bank 2005, 9-10).[4] Pakistan's massive irrigation expansion has almost doubled the irrigated area: from 9.15 million hectares in 1951 to 18.1 million hectares in 1999–2000 (Hussain 2004, 9). However, the expansion of irrigation has resulted in serious waterlogging and salinity problems. Currently, estimates are that soil salinity reduces Pakistani agricultural output by approximately 25 percent overall (Dinar, Balakrishnan, and Wambia 2004, 415). The problem is much worse in lower Sindh, which was previously a seabed and so has much higher natural soil salt content (World Bank 2005, 45). Approximately 6.3 million hectares are currently affected by a salinity problem to some degree, with 1.1 million hectares virtually unreclaimable and over 40,000 hectares lost annually (*Dawn* 2006b). At the height of the problem in the 1970s, the World Bank warned that Pakistan was seemingly "doomed to a watery, salty grave" (World Bank 2005, 14).

The main response to this dual crisis of salinity and waterlogging was the initiation of extensive land reclamation projects. The Salinity Control and Reclamation Project (SCARP) and the Left Bank Outfall Drain (LBOD) were both gigantic, multibillion-dollar, multi-year projects designed to make land usable for agriculture again.[5] Essentially, the solution to the salinity problem was increased use of irrigation (mainly groundwater) to flush the salts below the crop root zone. Waterlogging was reduced by extensive use of tubewells to pump water out of the ground, thereby lowering the water table; the LBOD then took the now-saline water to the ocean. Both of these solutions have led to other problems that will be discussed later in this paper.

These projects were only partially successful in that the SCARP returned about 10 million tons of salt annually to the sea and the LBOD 4 million, leaving an annual salt deposit of approximately 15 million tons on land, or about one ton per hectare annually (World Bank 2005, 46).[6] However, this is obviously not uniformly deposited across the irrigated area. Nonetheless, while far from "solved," the waterlogging and salinity problems would at least appear to be stabilized within acceptable parameters. However, despite good news on some fronts, the overall water situation is likely to deteriorate further unless drastic steps are taken.

BAD POLICIES, BAD GOVERNANCE, AND CORRUPTION

Bad Policies

Three policies are highlighted here. First, the entire Pakistani irrigation system is characterized by grossly inadequate infrastructure investment, especially in maintenance and repair. While some key projects, such as the Mangla and Tarbela dams, SCARP, and LBOD, get lavish Pakistan government and external donor funding, the bulk of the system is starved of even basic maintenance funds, with most of the budgetary allocation going to pay for a bloated water bureaucracy. For example, in Punjab Province alone, the irrigation infrastructure is valued at an estimated U.S. $20 billion, which (using international "best practice" benchmarks) would require an annual replacement and maintenance budget of U.S. $0.6 billion. The actual replacement and maintenance budget was about U.S. $0.02 billion, and 76 percent of the total irrigation budget was spent on personnel (World Bank 2005, 58). Meanwhile, to ensure full water cost recovery, user fees (again according to international "best practice" benchmarks) should be 1 percent of the value of infrastructure stock, which in Punjab works out to Rs.1,800/hectare for water. The actual *abiana* (water rate) collected was Rs.150/hectare (World Bank 2005, 58–59).[7] Even ignoring capital recovery, simple operations and maintenance would require a 0.5 percent *abiana* charge. Thus "[m]uch of what is built is not being maintained, and that which does still function, delivers services of a low quality" (World Bank 2005, 60)—a quality so low that the canal irrigation system operates at approximately 35–40 percent of rated capacity (Dinar, Balakrishnan, and Wambia 2004, 415). The Bank characterizes Pakistani government policy as "Build/Neglect/Rebuild," where all basic maintenance is literally ignored until the infrastructure is teetering on collapse (World Bank 2005, ix).

Urban areas are also characterized by gross underinvestment in basic facilities. A 2002 survey of Pakistan's 10 largest urban areas (producing 60 percent of the country's total urban wastewater) indicated that only 7.7 percent of urban wastewater was treated and that household and industrial waste were mixed together and directly discharged into the nearest waterway (WWF 2007, 4). The resulting pollution levels in groundwater and waterways are unsurprisingly high, and, combined with agricultural runoff (fertilizer and pesticides), are approaching critical levels. In 1991, for example, pesticides and other contaminants at levels exceeding World Health Organization guidelines were found in 70 percent of samples taken in a 1,000 km^2 test area in the Punjab, but had penetrated only to the shallow aquifers. By 2005, there were traces found in deep aquifers as well (WWF 2007, 5). Again unsurprisingly, even in Pakistan's capital, Islamabad, which has the country's highest level of municipal service provision, 75 percent of water samples tested in 2005 were "unsafe for human consumption" (WWF 2007, 8). While there could be many reasons for the systematic underinvestment in basic water treatment facilities (misplaced budgetary priorities, non-realization of the importance of wastewater treatment, poor oversight, and so on), the consequences of this underinvestment are obvious.

Second, as discussed in Box I on the following page, promoting sugarcane cultivation and sugar mills in Pakistan has had a greatly negative impact upon an already precarious water situation. This is because sugarcane is an extremely water-intensive crop that is particularly sensitive to saline growing conditions, and sugar refining contributes substantially to Pakistan's industrial pollution problem.

Finally, the massive diversion of river waters into agriculture has led to a dramatic decline in the lower Sindh wetlands, the Indus Delta mangrove forests, and coastal fishing, as well as taken a horrible toll on the biodiversity and fauna of the entire Indus Basin ecosystem. For example, the mangrove forests in the Indus Delta have declined from 263,000 hectares in 1977 to 160,000 in 1990 to 106,000 in 2003 (World Bank 2005, 50). In addition, Pakistan's U.S. $100 million worth of fish and shrimp exports have been hurt by the destruction of the mangrove forests—which are necessary for the coastal fish and shrimp reproductive cycle. While declining freshwater flow (and the consequent flow upstream of seawater) is not the sole reason for this decline, it is the major cause. The blind freshwater Indus dolphin, found virtually everywhere in the Indus and its tributaries before the 1930s, now exists in only six isolated and shrinking populations.

Thus, poor policy choices—systematic underinvestment in basic infrastructure, excessive cultivation of water-intensive crops, and overwhelming riverwater diversion into agriculture and away from other water-dependent sources—have exacerbated a bad water situation, and decades of neglect have allowed major problems to reach near-catastrophic levels.

Bad Governance

Given the perennial irrigation water shortage in Pakistan, interprovincial water disputes—which usually pit Punjab against some combination of the smaller provinces of Sindh (the lower riparian in the Indus system), Baluchistan, and the Northwest Frontier Province—are chronic. Each party accuses the other of bad faith, duplicity, and out-

Box I: Sugarcane as a Microcosm of Pakistan's Water Ills

Sugarcane is one of Pakistan's main crops, grown on 1.03 million hectares in 2006-07 (FBS 2008a, Table 1.5) and producing about five million tons of sugar, making Pakistan the world's 10th-largest sugar-producing nation (Ilovo 2008, 46). Sugarcane is an extremely water-intensive crop. The following data on water consumption for major crops in Pakistan show how it compares with the rest of Pakistani agriculture (WWF 2002, adapted from Table 3.1):

Rice		Cotton		Wheat		Sugarcane	
hectares	water m^3 (millions)	hectares	water m^3 (millions)	hectares	water m^3 (millions)	hectares	water m^3 (millions)
2,419,000	70,508	2,955,000	51,427	7,554,000	51,418	1,059,000	48,882

Thus, per hectare sown, sugarcane uses 6.8 times more water than wheat, 2.7 times more than cotton, and 1.6 more than rice. Sugarcane yield is extremely sensitive to water salinity, decreasing by up to half under heavy salinity conditions; approximately half the sugarcane grown in Pakistan is in saline areas (WWF 2005a, 7). This results in Pakistan's average yield of 47.5 tons/hectare being "perhaps the lowest among all major sugarcane growing countries in the world." By comparison, the world average is 62.5 tons/hectare, and many countries average well over double Pakistan's yield (WWF 2005b, 23).

Pakistan's sugar yield from cane is also extremely low: sucrose recovery from Pakistani cane is about 8 percent, while many countries average 12-14 percent (Rehman 2008). The World Wildlife Fund (2005b, 29) offers two main contributing factors to this low recovery rate: delays in transporting harvested cane from field to mill (0.1 percent lower sucrose yield for each day in transit with an average transit time of 4-5+ days), and 92 percent juice recovery from cane instead of the world average of 98 percent (due to poor production technology).

Thus Pakistan is among the world's highest-cost sugar producers (Ilovo 2008, 47) with an ex-mill gate (i.e., wholesale) price in 2005 of Rs. 18-19/kilogram versus Rs. 12-14 in the international market (WWF 2005b, 29). In the 1990s, Pakistan could actually have imported sugar from low-cost producers for less than half of the domestic production cost (Faruqui 2004, 183), although this would have exposed Pakistan to the considerable world sugar price fluctuations seen in the market recently (the 2001-2008 price ranged between U.S. $0.06-0.18 per pound—Ilovo 2008, 47).

The World Wildlife Fund (2005b, 30) attributes the growth in sugar mills (from 2 in 1947 to 76 in 2005), resulting in a 45 percent excess refining capacity, to "political considerations." A substantial portion of this increase took place between 1990-2004, with the number increasing from 51 to 76 (WWF 2005b, 18). Reputedly, in the 1990s Prime Minister Nawaz Sharif favored subsidized loans for building sugar mills because his family firm, Ittefaq Foundries, was a major equipment supplier for sugar mills. In addition, many large landowners in Sindh and Punjab own sugar mills and grow sugarcane on their land, and the sugar mills reportedly have the second-highest market capitalization on the Karachi Stock Exchange.

Thus Pakistan, a water-scarce country, is one of the world's largest and highest-cost producers of sugar because it is politically expedient, even if economically foolish, to do so. Many of the most powerful Pakistani politicians benefit tremendously from this extremely misguided policy.

Since sugarcane is grown on approximately 5 percent of Pakistan's irrigated area (i.e., on one million hectares), but uses so much more water than wheat, Pakistan could greatly increase wheat cultivation and save irrigation water. Since Pakistan has recently experienced a major wheat shortage, shifting from sugarcane to wheat would help reduce both Pakistan's water use and dependence upon wheat imports.

right water theft. In 1992, following the signing of the interprovincial Water Accord of 1991, the Indus River System Authority (IRSA) was established to implement the Accord and to coordinate water sharing among Pakistan's four provinces. Its five-member board consists of a representative from each province and one from the federal government, with the chairmanship rotating annually. Unfortunately, IRSA's functioning has been disharmonious and characterized by continued bitter interprovincial wrangling. While the water allocation ratio is agreed upon, there is continuous disagreement over the actual amount of water available in the Indus River system. A substantial portion of this disagreement could be due to the fact that there is simply no reliable real-time data available on actual water flow in the Indus and its various tributaries (World Bank 2005, 37–38). For example, there is considerable argument over the degree of water loss in the canal system and over who should pay for the upgrade and maintenance costs of the water telemetry system (*Dawn* 2006a).[8]

However, a great deal of the dispute is simply fighting over a zero-sum and shrinking water pie. For example, in March 2008, IRSA rejected the Punjab government's contention that water flow into the dam reservoirs was 28 percent below normal, and revised the shortfall to only 22 percent. Significantly, accepting a larger shortfall estimate would have forced IRSA to reduce water flow to Sindh, eventually leading to a lower discharge of water to the Indus Delta. However, the increased water discharge from the Tarbela and Mangla reservoirs resulted in the dams reaching "dead-level"[9] in March instead of late April, consequently risking massive damage to the standing wheat crop in Punjab and Sindh.[10]

Sometimes the provinces simply ignore IRSA rulings. For example, in September 2004, the Punjab government rejected IRSA's water allocation for that month, denied that it was taking more water than authorized, and categorically refused the IRSA chairman's orders to reduce water discharge into a key main canal by 60 percent. Punjab irrigation authorities then countercharged that the aim of these reductions was to ensure that Sindh received more water than it had actually been allocated (Kiani 2004).

Thus, in evaluating a decade and a half of IRSA's operations, Ahmad Faraz Khan (2008b) concluded that IRSA "has reduced itself to a debating club, where provincial officials, loyal to their ethnic identities, try to rig the system in their own favor." The Water Accord, Khan adds, "is now more known for creating discord." As an example of the gross politicization of IRSA, Khan argued that:

> The last Rabi [i.e., 2008 spring harvest] season water calculations and distribution problems reflect the twisted working[s] of the body. According to the original calculations, the authority claimed that the country would have 3 percent more water than its historic ([and] post-Tarbella Dam) uses. Actually, Pakistan suffered [from a] 30 percent shortage during the season. This kind of gross miscalculation is an unpardonable act. The debate whether it was a case of sheer incompetence or deliberate data rigging can only generate more political pressure on the federation.

Granted, these kinds of vicious interprovincial water disputes are found in many other parts of the world as well. For example, in Australia, none of the four states (Victoria, Queensland, New South Wales, and South Australia) using the waters of the Murray-Darling River Basin trust a water-use auditor from a rival state; one has to be imported from Western Australia (three thousand miles away) to periodically evaluate the system (World Bank 2005, 77)! Presumably, for Pakistan, the federal government nominee could be an impartial non-national who would preside over IRSA and make final decisions.

There are serious governance issues at the intraprovincial level as well. Surface irrigation water in Pakistan is usually released from a barrage (dam) as follows:

> Main canal => Branch canal => Distributary => Minor => Sub-minor => Watercourse[11]

There are also several branching-offs at each step of the chain, so there are multiple smaller delivery streams as well. From the watercourse, each individual farmer takes his turn according to the old and well-established *warabandi* system—wherein he has a specific day on which his fields are to be irrigated, "and the actual timing and quantity of the demand is irrelevant" (Mustafa 2002, 43). Agricultural water pricing is done on a flat-fee basis irrespective of actual water usage, and the common method is to flood the field and let the excess run off.

Since each main/branch canal and distributary has several subsidiary takeoffs (which are usually opened on a turn-by-turn basis) and the system is severely water-short,[12] the farmers at the tail-end (i.e., those at the end of the distribution chain) receive much less water than do farmers at the head of the chain, and large farmers (those who can bribe or intimidate provincial irrigation officials) receive much more than their fair share, and usually out of turn. In addition, large farmers often have "direct outlets" that bypass the *warabandi* system and provide them with, virtually on demand, as much water as they need. Up to 30 percent of total flow in some areas is from "direct outlets" which are, needless to say, illegal under the 1873 Canal and Drainage Act (World Bank 2005, 38).

The *warabandi* system, designed to give each user an equal water right, in practice ensures that, within each watercourse, the tail-enders typically get about 20 percent less water than those in the middle, who in turn get about 20 percent less than those at the head-end (World Bank 2005, 30). Tail-enders often get no water at all. Mustafa (2002, 45) quotes a senior irrigation official as admitting that "miles of lower reaches of watercourses and distributaries are dry." Obviously this results in much lower crop yields and income for those lower down the distribution chain. For example, the head-enders usually apply four to five irrigations (waterings) per field while the tail enders may apply as few as one or even none (Latif 2007, 516). Predictably, income per hectare varies massively as well: from a high of Rs. 14,575/ha (about U.S. $243) to a low of Rs. 6,771 (U.S. $113) (Latif 2007, 516).[13]

So serious is the water shortage that many farmers do not rely on surface irrigation for their water supply and have instead installed private tubewells. Over 75 percent of the increase in water supply in Pakistan since 1980 has come from tubewells (World Bank 2005, 39). The number of tubewells has skyrocketed: from 98,000 in 1971 (Hussain 2004, 9) to 904,688[14] in 2004 (ACO 2004, Table 49), with the total essentially doubling every decade since the 1970s. Despite subsidized diesel and electricity that reduce costs by 35 percent in rural areas, tubewells have very high operating costs; Latif (2007, 517) reports that tail-tail-end farmers may pay up to 30 times the cost of canal water. Still, many farmers have no choice but to use tubewells. Groundwater (tubewell) productivity is approximately twice that of canal water as the former allows for water-on-demand at the appropriate time in the growing cycle, while canal water is highly unpredictable (World Bank 2005, 32).[15] Approximately 70 percent of tubewells in the Punjab (and more in Sindh) report some degree of water salinity (*Dawn* 2006b), but the water quality is better the closer the well is to a large watercourse (Latif 2007, 517-518).

In general, in the past few decades, the professional competence of provincial irrigation officials and the overall level of system governance have declined considerably. Mustafa (2002, 48-51) shows how powerful landowners (who are often members of the national or provincial assemblies or their relatives) intervene directly, sometimes on a daily basis, with irrigation officials to ensure that (i) their (and their tenants') fields receive water in contravention of *warabandi* rules; (ii) officials who have denied them favorable treatment are punished or transferred; and (iii) flood abatement procedures do not damage their land, no matter how much resultant damage there may be to the basic system infrastructure. In addition, these same large landowners/politicians issue orders directly to lower-level irrigation officials, thereby undermining the authority of senior water officials. Similarly, such political interference often completely undermines and negates official policy (which has a pronounced technocratic/engineering bias). This effect on policy occurs because the interventions are made directly at the lower level (the level of actual implementation) to ensure that policies detrimental to the large landowners' interests are blocked.

Finally, Mustafa (2002) describes how the majority of water bureaucracy officials view "participatory management" or "water users associations" or any other reform effort as, at best, external-donor-funded fads that detract from officials' "real" task of efficiently managing an engineering problem (irrigation) along scientific lines. This, he argues, reflects the perpetuation of a colonial administrative ethos that isolates the administrative machinery from any input and influence from the administered population. Indeed, the average water bureaucracy official treats the average user (small farmers) with contempt, viewing them, at best, as a distraction from his "real" task and, at worst, as a source of bribes.

The Pakistani canal irrigation system is becoming increasingly less relevant as a source of direct water for agriculture. In Punjab, 60 percent of farm-gate-delivered water is from tubewells (World Bank 2005, 16). The main function of canal irrigation seems to be recharging the water table: over 80 percent of Punjab's groundwater recharge comes from leakage from the canal system (World Bank 2005, 15).

Massive groundwater pumping has led to a considerable drop in the nation's water table in many areas and the intrusion of saline groundwater into what had previously been freshwater (Hussain 2004). For example, Lahore, Pakistan's second-largest city, has seen its water table fall at 0.5 meters annually for the past 30 years, leading to a "cup-shaped depression prone to the migration of saline groundwater" (World Bank 2005, 40). This depletion occurs despite the fact that Lahore sits on the Ravi River, is traversed by major unlined canals, and therefore would appear to benefit from at least a partial replenishment of its water table. The situation is much worse in Baluchistan, which has no major rivers or canals to recharge the water table, and where unrestrained aquifer pumping has caused Quetta's water table to drop by 3.5 meters annually. According to recent trends, Quetta's aquifer will likely run dry by 2018 (Brown 2003). The ever-dropping water table in much of Pakistan has also led many older (and therefore shallower) tubewells to run dry, necessitating deeper drilling and more powerful pumps, all at considerable expense to small farmers (Hussain 2004, 140).

Corruption

Like the rest of the Pakistani government, the water bureaucracy is notoriously corrupt. The World Bank (2005, 17) equation of corruption is defined as monopoly plus discretion minus accountability. Under the 1873 Act, the water bureaucracy had virtually unchallengeable discretionary power, but the presence of a layer of British senior administrators—who were not vulnerable to political pressure or bribes from large landowners—kept the irrigation bureaucracy relatively honest and effective. Following independence in 1947, however, the removal of this layer of British colonial administrators allowed corruption to flourish. This was due to two main reasons. First, there was no effective internal administrative check on decisions made by irrigation bureaucrats. Second, the bureaucrats themselves were much more vulnerable to pressure to "accommodate" large local landowners and politicians.[16]

The level of money involved is staggering. The World Bank (2005, 18) details how senior officials pay "crores of rupees"[17] to obtain desirable posts and turn down "clean jobs at four times the [official] salary." Presumably this is because, in the late 1990s, for the average official, bribe income (not available in these "clean" jobs) was between 5–8 times the official salary (Rijsberman 2008, 74).[18] In 2002, many farmers were charged an annual "fee" of Rs. 30,000 (about U.S. $500, or more than Pakistan's per capita income) for each watercourse outlet.[19] With about 60,000 outlets in the irrigation system, this gives an income guesstimate of roughly Rs. 1.8 billion (U.S. $30 million) to be shared among irrigation officials. And this is just for having a water outlet that gets some water at some point. This fee did not entitle a farmer to more than one's share, or to receive water out-of-turn, at the appropriate time in the growing cycle, or for the extremely desirable and very expensive "direct outlet." At least 25 percent of farmers report bribing irrigation officials for irrigation water, with the typical payment averaging about 2.5 percent of income/hectare (Rijsberman 2008, 73).

However, all is not bad news. In one—hopefully not isolated—instance of good news, a firm had its U.S. $9.6 million contract for a canal system upgrading cancelled after the Pakistan chapter of Transparency International discovered that the firm had been blacklisted for earlier corrupt practices, but had not disclosed this fact in the bidding process. In the rebidding for the contract, the new winner "provided a technically superior offer" for U.S. $3.4 million less.[20]

One development practitioner with considerable firsthand experience working with irrigation officials in Punjab and Sindh describes these authorities as "the real villains in this piece . . . they are horribly corrupt, inefficient, and bloody lazy."[21] Many corruption opportunities arise from the fact that water entitlements are almost completely opaque, with near-total discretion lying with irrigation officials (World Bank 2005, 20). The World Bank (2005, 20) proposes greater transparency and publicly known water entitlements as an effective measure "for actually providing that to which users are entitled." Even if entitlements are publicly known, given the extremely corrupt and slow Pakistani legal system, there is no actual rights-enforcement system feasible in the current Pakistani context, and so such transparency would not likely have any appreciable effect in the short run. However, increasing literacy and public knowledge about entitlements would at least make it harder for officials to get away with their corrupt conduct and may well make for improvements in the long run, as those who know their rights and the law are less likely to allow themselves to be bullied by large landowners and government officials.

REFORM AND DEVOLUTION: PLUS ÇA CHANGE, PLUS C'EST LA MÊME CHOSE

In the 1990s, the Nawaz Sharif government, with much World Bank and other donor input, implemented the Provincial Irrigation Authority Act of 1997—an effort to reform through decentralization. This law broke up the old provincial irrigation departments into Provincial Irrigation and Drainage Authorities (PIDAs), Area Water Boards (AWBs, covering roughly 600,000 hectares), and Farmers' Organizations (FOs). In theory, this system was to allow for a more efficient allocation of water since the various users would now be allowed to buy and sell water to better balance demand and supply, and to contract for needed repairs and other maintenance:

> The AWB would manage and distribute irrigation water, through formal volume-based contracts with FOs, and trade water with other utilities. The PIDA would be responsible for such functions as province-wide water delivery, system maintenance and development, and sales of water beyond amounts contracted with AWBs (World Bank 2005, 71).

In practice, nothing has changed, since the "[w]ater rights and entitlements that were advocated in the [World] Bank's strategy paper were not on the [government of Pakistan's] immediate agenda" (World Bank 2005, 100). Furthermore, as described in Mustafa (2002), neither irrigation officials nor users (large or small) see any appreciable difference between the new system or the old one. In evaluating the impact of the Pakistani government's various water policy reforms, *Dawn* (2007) summed up the position of the representatives of various farmers' trade organizations and lobbying groups as concluding that "the government habit of creating more institutions to cover the inefficiency of parent institutions has damaged the farming sector."

CONCLUSION

It is clear that Pakistan has suffered from bad policies, bad governance, and corruption in its water administration. Given the importance of agriculture to the economy, agriculture's extreme reliance on irrigation water, Pakistan's large and growing population, and the country's existing water shortage, Pakistani agriculture needs a radical restructuring of its water use patterns if it is to stave off disaster.

Pakistani decision making suffers from what can only be described as acute *ad hocism*: very little long-term planning is done and what is done is rarely adhered to. Short-term considerations often override long-term ones and the system has a tendency to lurch from crisis to crisis. Each crisis entails a burst of feverish activity and then all is quiet again. Furthermore, very few, if any, senior decision-makers are ever held accountable for their poor policy choices (as opposed to being scapegoated or blamed, whether justified or not, for past mistakes). Successive governments have favored unproductive defense spending over allocating funds for irrigation maintenance (or education or healthcare for that matter), and the vast and once tightly run irrigation system has suffered to the point where it is teetering on collapse.

While any detailed discussion of reform proposals is far outside the scope of this analysis, it is clear that some major reform efforts will have to be undertaken to shore up the system. The professional competence and integrity of the provincial irrigation bureaucracies need to be improved, and this will require greater centralization and reassertion of administrative control and not devolution and decentralization. This is because, as things stand now, large local landowners can bribe, threaten, or intimidate irrigation officials with impunity and so can easily disrupt the implementation of any policy that affects their interests. Only a much more professional organization would be capable of enforcing stricter water-usage practices—reduced groundwater pumping and more efficient irrigation usage (e.g., drip irrigation instead of flooding fields). At the same time, the government of Pakistan should also discourage sugarcane cultivation and increase the freshwater flow to the Indus Delta.

As is apparent, these policies are relatively straightforward but, to paraphrase von Clausewitz, while winning a war is a simple matter, it is the simplest things that are the most difficult. It is here that Pakistan's current economic crisis could have been of importance in effecting some wide-ranging reforms. In exchange for U.S. $7.6 billion in emergency aid, the International Monetary Fund (IMF) reportedly pressed hard in late 2008 for the imposition of an agricultural income tax for the first time in Pakistani history (Iqbal 2008). Presumably, if the Pakistani government was desperate enough, it might have been willing to overcome the resistance of the extremely powerful large landowners[22] (who dominate parliament) to any effort to tax them.

The Pakistani Federal Board of Revenue estimated that an agricultural income tax, even one with generous exemptions for small and subsistence farmers, would have generated about Rs. 60-70 billion (approximately U.S. $750-875 million) in additional revenue, versus the Rs. 1 billion—U.S. $12.5 million—generated from the current tax collection system (Jamal 2008). This added revenue would have allowed the Pakistani government to fund—among other things—much-needed irrigation system repairs and upgrades. However, the power of large landowners in parliament was so strong that the IMF's proposals came to naught. The IMF now denies that it is encouraging the Pakistani government to implement an agricultural income tax as part of its current assistance program (IMF 2008).

As this amply demonstrates, the prospects for any meaningful reforms in Pakistani agricultural and irrigation administration are extremely unlikely in the immediate future. Pakistan's water crisis and attendant misgovernance will surely worsen.

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NOTES

1. This is the direct contribution. Given that cotton products (raw cotton, yarn, cloth, and textiles) are by far Pakistan's largest export items, the true impact of agriculture on GDP is much greater than this.

2. This December 1947 agreement froze the water allocation between East and West Punjab (now parts of India and Pakistan, respectively) at the pre-independence level until the end of March 1948. Upon the lapse of this agreement, India shut off the water supply to the Pakistani Punjab for four weeks, until Pakistan agreed to pay India for the water it received (see Nayyar 2002 for details).

3. See World Bank 2005 (especially 7-9) for more details on the Indus

Waters Treaty. Gazdar (2005) gives a very critical assessment of the Ayub government's decision to sign the treaty; he argues that as the lower riparian, Pakistan's rights to the waters superseded those of India's (as the upper riparian) and that the treaty essentially legalized India's water theft.

4. Contrary to common arguments that irrigation benefits are overwhelmingly concentrated among larger landowners, the World Bank estimated that the income of landless agricultural laborers also doubled in this same period, presumably through increased labor demand brought about by increased land under cultivation.

5. The SCARP and LBOD were Pakistani federal government projects executed with considerable technical and financial assistance from external donors, with the respective provincial irrigation departments responsible for maintenance once the projects were completed. Both SCARP (initiated in the 1960s) and LBOD (initiated in the 1980s) received massive funding from the Pakistani government, the World Bank (and its related agencies), and other international aid bodies (e.g., the United Kingdom's Department for International Development). World Bank funding for these projects numbered in the billions of current (i.e., 2004/2005) dollars, while over half of the Punjab Irrigation Department's operations and maintenance budget was spent on SCARP in the 1990s. See World Bank 2005 (especially pages 94, 97, and 121) for details.

6. *Dawn* (2006b) quotes the federal minister of science and technology as saying that the average salt deposit per hectare is two tons annually.

7. Irrigation water is, of course, heavily subsidized in many countries, especially the United States. Rijsberman (2008, 70) describes how, worldwide, even 10 percent of total cost recovery is generally not possible. Until the early 1970s, *abiana* rates were sufficient to cover operations and maintenance plus a small portion of the capital cost (i.e., roughly marginal cost pricing); the Zulfiqar Ali Bhutto government, in an era of high inflation, chose not to increase *abiana* rates, presumably as a populist measure (World Bank 2005, 121).

8. The degree of water loss in the canal system is of great importance. If water loss rates are higher than currently estimated (16 percent), then this would affect the allocation of water to all users, with the downstream discharge (i.e., Sindh's share and that being discharged into the sea) getting reduced.

9. The water level at which water discharge from dams has to stop, because the water level has dropped so low that the intake pipes are exposed.

10. See Khan 2008a for more details.

11. A "watercourse" in the Pakistani irrigation context is the irrigation channel that delivers water to the final distribution point from where the farmer actually waters his fields.

12. Mustafa (2001, 826–827) states that water supplied through surface irrigation is only adequate for a 64 percent cropping intensity, while present cropping intensities in the most fertile areas of Pakistan are at 150 percent.

13. Latif (2007) gives extremely detailed income and crop yield data, broken

down by whether a farmer is at the head, middle, or tail of a water distribution network and by what point on the main canal the branching off occurs (i.e., at its head, middle, or tail). Obviously, total water availability at the head of a main canal is much more than at its tail, and productivity is much lower at the tail than the head.

14. There were 7,968 public tubewells in Pakistan in 2004 (ACO 2004, Table 49), mainly for urban water and the SCARP program.

15. Even greater productivity increases are possible with better water and agricultural management. Zhou (2006, 18) reports that Israel's average per hectare water usage has declined from 8,700 meters^3 in 1975 to 5,500 meters^3 now (total water consumption remaining roughly constant), but agricultural output has increased 12-fold by making massive use of micro-sprinkling and drip irrigation. While Israel may be a water-productivity outlier, it does show the extent of potential gains for Pakistan.

16. See Khan (2007) for details on the rapid expansion of corruption in Pakistan immediately following independence in 1947.

17. One crore equals 10 million rupees, about U.S. $164,000 in 2005.

18. Such salary supplements are routine for public sector jobs in Pakistan, and the usual term for this income is "monthlies." It was up to 10 times the amount of an official salary in India in the 1990s, which has a similar irrigation history in many parts of the country.

19. Personal communication with the author.

20. See Gilani (2008, 215) for more details. However, it is not clear from Gilani what action, if any, was taken against the officials who had approved the earlier offer, and who were presumably paid off to approve it.

21. Personal communication with the author. Contrast this with Mustafa (2002), who describes irrigation officials' self-view as one of efficient technocrats hampered by corrupt politicians and ignorant farmers. Also contrast this with Tandon's (1969) description of the service, élan, competence, and professionalism (albeit in a rigidly hierarchical and almost completely insular organizational structure) of the pre-independence Punjab Irrigation Department.

22. "Feudals" in the Pakistani parlance.

Intersections of Water and Gender in Rural Pakistan

Sarah J. Halvorson

Water-society interactions in Pakistan are complex, in part because critical issues of social and environmental equity are embedded in these interactions. Gender serves to shape society's interactions with water and to differentiate the outcomes of water problems and potential solutions. As the case of Pakistan suggests, hydro-social health and well-being depend fundamentally on the consideration of gender in water policy and management. This essay seeks to elaborate the linkages between water and gender while drawing attention to issues of environmental quality, sustainability, and water governance. The focus here is primarily on rural settings, where approximately 67 percent of Pakistan's 160 million people reside, according to 2005 figures (WHO 2008). The aim is to contribute to discussions about the lack of potable water and water vulnerability in rural settings, as well as to debates about stakeholder involvement—particularly women's involvement—in addressing aspects of the water crisis in Pakistan.

Seemingly obvious questions—Who carries water? Who does water work? Who benefits from water?—tend to go unasked and unchallenged. While these questions are well-grounded in real-life experience, the responses have not consistently informed international, regional, or local action toward improving water supplies or expanding the range of alternative actions. The issues and concerns raised in answering these questions underscore the need for a deeper probing of women's authoritative position vis-à-vis governance over common property resources such as water.

Sarah J. Halvorson is an associate professor in the Department of Geography at the University of Montana.

WATER AND ENVIRONMENTAL PROBLEMS IN RURAL AREAS

For many Pakistani women living in rural areas, meeting the water needs of a shifting and growing population is currently one of the greatest challenges they face. Within the rural water sector, decades of policies promoting Green Revolution technologies, intensive agriculture, and industrial development have resulted in a staggering array of environmental problems. These problems include, but are not limited to, decimated wetlands, salinization, waterlogging, carcinogenic chemical and heavy-metal contamination, loss of aquatic resources, groundwater mining, and polluted waterways (Briscoe and Qamar 2005; Mustafa 1998). Many of these problems stem from long-standing bad practices involving the excessive use of agro-industrial chemicals, discharges of animal waste, untreated sewage, and open defecation due to the inadequate provision of sanitation (Bridges 2007). The lack of safe and potable water poses a major public health problem in many rural areas, especially in light of high levels of dysfunctional infrastructure and deteriorating public water supply systems. Water-related disease hazards are a major threat to child survival. Health surveys report that 25–50 percent of mortality in Pakistani children between the ages of one and five is related to waterborne diseases (WHO 2008). The health consequences of water scarcity and the consumption of contaminated water are also gendered, placing an additional burden on women who are charged with caring for sick family members.

WATER WORK, WOMEN'S WORK

When it comes to water work on a local scale, significant divisions of labor prevail between women and men. These divisions of labor reflect a gender ideology that dominates the sociocultural landscape of Pakistan (Halvorson 2002; Mumtaz 2007; World Bank 2005). Women are often responsible for the irrigation of family gardens, orchards, and fields that are essential for sustenance and livelihood security. Furthermore, hauling water, cooking, washing clothes, bathing children, home repair, and cleaning are all gender-defined forms of women's work that involve water to a greater or lesser degree. Women and children bear the primary responsibility for water collection—an arduous and fatiguing task in most cases that can consume significant amounts of time. In mountainous parts of the country, water collection can be hazardous since it involves navigating steep paths over treacherous slopes. Depending upon the location of the water source and the season, the workload associated with procuring water can preclude women from engaging in other productive and reproductive activities. In general, the recognition of women as water managers views women's lives as integrally connected to water resources.

The everyday lives of women in Pakistan are directly influenced by the conditions and decisions surrounding water policy and management. Planning and decision making about water has historically been dominated by men. A major issue affecting the process of decision making in regards to water in rural areas is the fact that poverty has led millions of Pakistani men to migrate out of rural villages and towns to urban centers in Pakistan or outside the country in search of employment opportunities. Male out-migration brings financial benefits to families but also social costs and impacts on resource management. Male off-farm employment has resulted in greater workloads for women and girls as they take up the bulk of the farm and family responsibilities that were once shared more equally between men and women. The result is a feminization of agriculture, whereby women's contributions to food security and agricultural economies have increased over time. This pattern has also been observed in other developing countries. Survey research has revealed that Pakistani women work an average of 12 to 15 hours each day on various livelihood activities and domestic chores (UNESCAP 1997). The extent of men's increasing participation in wage labor, either domestically or internationally, has perforce reshaped the quality of life of, and the water-dependent workloads of, women.

As a result of the absence of many men from their communities, women's involvement in water governance is even more essential. In Pakistan today, the continued trend toward large numbers of women working in the agricultural sector highlights the pressing need for recognizing and addressing the on-farm water needs of women farmers. Women's roles in irrigation are frequently overlooked by agricultural extension agents and water engineers, and women are often excluded from access to irrigation water owing to their lack of ownership of land titles. Despite women's responsibilities in regards to household water needs and irrigation, they have played a relatively small role in public decision making about water management, water quality protection, and flood and drought hazard mitigation.

Within the Pakistani context, several questions help to frame a gender-focused approach to analyzing water access and control: How has women's water work changed over time in relation to men's water work? Is the technology appropriate for women's use? Are there provisions at the water source for other communal water-related activities? What are the ways in which women's work in gardens, fields, and livelihoods is water-dependent? What are the opportunities and constraints to increasing women's participation in water sector decisions? Research conducted with these types of questions in mind has revealed to the water community in Pakistan how scarcity and degraded water quality are of particular concern for rural women. In times of water scarcity it is usually women and children who suffer most. Importantly, as Simi Kamal (2005) points out, it is critical to move beyond thinking of women as unfortunate victims of water deficiencies and deprivations, and instead to consider women's potential leadership in the water sector. Merely delineating women's practices and attitudes toward water supplies at the household level stops short of exploring the social relations and gendered processes that affect women's contributions to water sector planning.

CONSTITUTING WATER-GENDER CONNECTIONS ON NATIONAL AND INTERNATIONAL SCALES

Over the past 20 years, policy discussions and analyses in Pakistan have underscored the connections between water, gender, and rural development in ways that reflect international dialogue and action. One of the earliest international policy statements on the importance of involving rural women in the management of water was put forth at the 1977 Mar del Plata United Nations Water Conference. This conference was followed by the International Drinking Water Supply and Sanitation Decade, 1980-1990 (the "Water Decade"), which also launched international policy directives to promote community participation—especially women's participation—in meeting basic water needs. During the Water Decade in Pakistan, a greater emphasis was placed on women's water needs and preferences, the involvement and participation of women in project design, and the implementation of new and appropriate technology (Pasha and McGarry 1989). Following the Water Decade, the International Conference on Water and the Environment in Dublin (held in January 1992) further elaborated the central role of women in water management in the third guiding principle, as set forth by the Dublin Statement that emerged from the conference:

> This pivotal role of women as providers and users of water and guardians of the living environment has seldom been reflected in institutional arrangements for the development and management of water resources. Acceptance and implementation of this principle requires positive policies to address women's specific needs and to equip and empower women to participate in all levels in water resources programs, including decision making and implementation, in ways defined by them (WMO 1992, 4).

More recently, women's priorities and participation in water resource management have been explicitly acknowledged in the resolution launching the "Water for Life" Decade (2005–2015). The "Water for Life" Decade complements the goals, targets, and timeline for achieving the Millennium Development Goals (MDGs). The MDGs establish objectives and measurable targets for reducing poverty, hunger, disease, illiteracy, and environmental degradation; at a fundamental level, all of these priorities involve or are shaped by water (Gleick 2004, UN/WWAP 2003). Relevant to this discussion is the fact that the MDGs draw close connections between sound water management, the provision of water and sanitation, and gender equality and the empowerment of women.

The government of Pakistan has integrated these MDGs into its national policy framework (GOP 2006). Achieving the MDG on drinking water supply coverage (Goal 7, Target 10: "to halve by 2015 the proportion of people without access to safe drinking water and basic sanitation") in Pakistan will require major expenditure and leadership. As part of its effort to attain MDGs, Pakistan has set national targets for providing safe drinking water to rural areas. In 2004—before the outset of the "Water for Life" Decade—rural water supply coverage in Pakistan was reported to be 89 percent and rural sanitation coverage was reported at 41 percent. Such reported statistics suggest that some of the greatest achievements in meeting MDGs have been made on this front. As such, according to Islamabad, rural water supply coverage is "likely to be achieved" and rural sanitation is "on track" to being achieved (ibid.).

Nevertheless, up to this point policies and water sector reforms have prioritized irrigation technology, hydropower dam construction, and the expansion of intensively irrigated agriculture. There is still a tremendous need for policy and action that involves women (and their families) who are dependent upon common resources such as watersheds, freshwater fisheries, and wetlands for food and subsistence, or who are displaced as a result of large-scale river basin projects. As Kamal (2005, 80) puts it:

> While water is crucial to Pakistan, the nexus of women and water is largely seen in terms of romantic depiction. Although some attempts at addressing women's needs in domestic water management and [wider] scale water projects have been made, these needs remain largely invisible in the agenda of water institutions and are not much in the picture in terms of water policies, strategies, programs and conservation initiatives.

Significantly, gender differences in how these problems are experienced persist. Likewise, gender differences in how these problems are perceived and how responses to these problems are articulated also remain. One area in which the water planning and policy agenda is responding to the important relationship between women's work and water is seen in the context of Pakistan's National Drinking Water Policy. One of the key principles guiding the implementation of this policy recognizes that women "are the main providers of domestic water supply and maintainers of hygienic home environment, [and therefore] their participation in planning, implementation, monitoring and operation and maintenance of water supply systems will be ensured" (GOP 2007, 4). The National Drinking Water Policy also presents a community participation and empowerment strategy that explicitly includes a statement about the inclusion of women. Furthermore, gender training for all tiers of local government staff and government representatives is encouraged "so that they are able to respond in a sensitive manner to the gender differentiated needs in the drinking water sector." (ibid., 7).

In mobilizing action around the goals of the "Water for Life" Decade and the MDGs, Pakistan's government and members of the development community realize that concerted efforts to mainstream gender in water management must grapple with the cultural and material realities of gender ideology, high population growth, rural-to-urban migration, the feminization of agriculture, and gendered geographies of rural poverty.

IMPACTS OF NATURAL HAZARDS AND DISASTERS

The issues and concerns highlighted above have been exacerbated by natural hazards and disasters that impact women's roles in water provision. Severe drought affecting arid and semi-arid areas in Baluchistan and Sindh Provinces have impacted agricultural systems and drinking water availability in profound ways. Drought exacerbates the consequences of apparent and ongoing processes of land degradation, soil erosion, and long-term denudation. Women in these drought-prone areas have faced particular hardships. These hardships associated with recent drought in Sindh are underscored by Qureshi and Akhtar (2004, 15), who write that "the impact of the drought situation on women is worse due to their sociocultural and economic positioning within the family and the community."

Other destructive events such as landslides, mudslides, natural damming of rivers and streams by landslides, and glacial lake outburst flooding (GLOF) interfere with water supplies and/or cause damages to property and livelihood activities.

A GLOF event occurs when a glacial ice dam across a river fails, thereby causing a subsequent and often catastrophic release of the lake water that had accumulated over time behind the ice dam. The process of ice dam formation that is underway is associated with surging glaciers and suggests a trend toward regional effects of climate change. As such, glacial hazards are an increasing concern in the Karakoram-Himalaya region. The four GLOF events that occurred in upper Hunza Valley in the Northern Areas in 2008 underscore the potential negative impacts of glacial recession on women and their families living within close proximity or downstream of glaciers and glacial lakes. The monitoring of climate variability and climatic risks to Pakistan's glaciers is critical to the mitigation of these environmental hazards.

Earthquakes have also brought tremendous destruction to rural water supplies and irrigation infrastructure. The catastrophic 2005 Kashmir earthquake was extremely detrimental to water access and availability in Muzaffarabad, Balakot, and numerous mountain villages. Irrigation systems, springs, and community water supply schemes were completely buried by landslides triggered by the 7.6-magnitude earthquake. The earthquake's immediate aftermath, the relief and recovery period, and community reconstruction underscored how this event impacted mountain women, particularly as they attempted to collect water and provide for their families during this chaotic time (Hamilton and Halvorson 2007; Shirkat Gah 2006). Women had no choice but to utilize rudimentary ad hoc systems, emergency supplies, or distant streams that were only accessed by crossing rocky and unstable terrain. In the aftermath of the Kashmir earthquake, women have been on the frontlines of reconstructing the water infrastructure in devastated mountainous areas.

EXPANDING WOMEN'S RANGE OF CHOICE: CONSTRAINTS AND OPPORTUNITIES

Drawing from the seminal work of the geographer Dr. Gilbert L. White (White, Bradley, and White 1972), I raise the question: How can women's "range of choice" regarding water supplies in Pakistan be effectively expanded in rural areas? The promotion of meaningful and equitable participation by women is critical to expanding the range of choice in water and the range of alternatives to addressing these issues. Clearly, women have the authority to reject a source if it does not meet their minimum criteria in terms of quality. Nevertheless, women perceive a range of choice that is often very influenced by actions and adjustments beyond their sphere of influence and observation. The paucity of current and disaggregated data on women's priorities in the management of rural water supplies is a serious deterrent to policy initiatives.

One example of a policy that prioritizes women's choice can be seen in the regional programs of the Aga Khan Rural Support Programme in the Northern Areas of Pakistan. The gender approach adopted includes a commitment to an institutional framework with women's organizations as central to the process of assessing household water needs and strategies for addressing water challenges. In the Northern Areas, groups of women have been able to invest in community water supply systems and have benefitted from programs to promote the safe handling of water. The result of this work has demonstrated that women's water priorities are affected by household obligations, access to information, gender relations, cultural and religious preferences, informal codes of behavior, and the viability of technologies (Aziz and Halvorson 1999; Halvorson, Aziz, and Alibhoy 1999).

One of the most influential micro-scale variables—and one that presents an enormous opportunity—is women's own social capital, which is embodied in strong social networks and friendship-kinship relations, and can be mobilized for greater water governance. As stakeholders in the water sector, women are slowly finding the requisite space and support to influence water resources planning and management, in spite of the cultural patriarchy that impedes women's participation in formal institutes of water resource science and planning. They are participating in water user associations and benefiting from programs to improve water supplies and environmental health. For example, the Punjab Rural Water Supply and Sanitation Project has encouraged the participation of women along with men in water sector planning for low-income communities. Improved access to water has brought dramatic changes to women's and girls' lives, since they no longer spend upwards of six hours per day collecting water. Furthermore, women in rural Punjab, the Northern Areas, and elsewhere report gaining confidence to play a role in the management and operation of their water supply systems. The theme of women and water is even slowly trickling into public discourse via the media. In this regard, the innovative radio program *Pani ki kahani, aurat ki zubani* ("Water Stories, Women's Issues") uses radio to bring gender and water issues into the public purview.

As is the case elsewhere in South Asia, Pakistani women's participation in water decision making remains complicated, in part because of gender norms that influence women's behavior and roles within Pakistani society. These norms translate into restrictions on women's mobility outside of the home, even during times of severe water, agricultural, or health crises. Ideologies of seclusion further restrict women's involvement in community-based organizations and decision making, which contrasts with the important productive and reproductive work that they perform. Gender inequalities restrict women's participation in water decision making in various ways. Women face social constraints in developing their knowledge of hydrology, water science, and water policy. In order to play effective and meaningful roles in water management, women need to be well-informed about hydrological systems and the ways in which water decisions have a bearing on their own use of, access to, and control over water.

Women's lack of mobility in Pakistan is compounded by impediments to accessing information needed to enable women to participate effectively in water management. Literacy rates are extremely low; in some areas of Northwest Frontier Province, Baluchistan, Azad Kashmir, and the Northern Areas, female literacy rates are as low as 3 percent. Low levels of literacy coupled with limited mobility reduce the occasions to learn from interactions with other water stakeholders. Women's limited mobility constrains their access to formal education and also to forums aimed at addressing water problems. Another constraint women face is that they are typically not empowered to make independent decisions about participating in local governance or playing a role in community organizing. Although women are often the first to perceive a water problem, they must overcome successive obstacles embedded in traditional decision-making structures within the household and the community. Other forms of social differences—class, ethnicity, religion, socioeconomic standing—also affect participation in ways that can result in profound differences among and between women.

CONCLUSION

Is a turnaround in Pakistan's water crisis possible without a consideration of women? In other words, if the changes—such as long-run investments in location-specific technologies, changes in land use, shifts in water control structures, human capital development, and improvements in infrastructure and water delivery—required for a shifting away from the status quo in water planning bypass women, then can a real turnaround toward solving Pakistan's array of water problems actually take place? This essay has attempted to argue that without giving Pakistani women access to the process of water governance and greater recognition to their water-related roles in society, Pakistan will remain a long way from reducing water vulnerabilities.

In rural areas, water provision is rarely centralized and complex water access regimes prevail. As such, the household stands out as the site where perceptions, access, water use, public policy, and community health intersect. The outcomes of strategies implemented to improve water supplies in rural parts of Pakistan indicate that improved access to water and water quality protection are inherently dependent upon linking householders with the public sphere of water management. The evidence implies quite different approaches to frameworks for stakeholder involvement in water sector decisions and policymaking. Certainly, a strong case can be made for expanding the range of choice of options and solutions for the majority of Pakistan's water workers, namely women. Yet the country's entrenched irrigation practices and differential water resource geographies are slow to embark on change that would bring a reworking of the current consolidation of power and resource control.

Water management strategies and policies that are responsive to gendered understandings of water would also benefit from a focus on power and rights distributions across gender lines. As evidence from Pakistan suggests, efforts to reduce water deprivation at the local level will have a far greater success rate when women's participation becomes a reality.

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Tackling the Water Crisis in Pakistan: What Entrepreneurial Approaches Can Add

Adrien Couton

Water availability in Pakistan is quickly declining, a dire prospect for a country largely dependent on agriculture. Aiming for rapid results, public schemes are being implemented to address the crisis—yet they run the risk of bypassing smallholders. This essay uses the example of Acumen Fund's work on drip irrigation to illustrate how market-based solutions can be used to integrate an effective "voice mechanism" for poor farmers in these support schemes. By providing small investments coupled with management support, Acumen Fund is supporting the development of two companies focused on smallholders. The success of these companies hinges on making sure that their products and distribution channels meet these smallholders' needs. The strategy has already been very successful in India, and could be used to increase the efficiency of a subsidized drip irrigation scheme rolled out by Pakistan's government in 2007.

BLUE GOLD

Pakistan is one of the world's most arid countries, with an average rainfall of under 240 millimeters per year. The population and economy are heavily dependent on an annual influx of water into the Indus River system coming from neighboring countries and mostly derived from snowmelt in the Himalayas.

Yet, agriculture continues to be the single-largest sector of the Pakistani economy. According to Pakistan government data from June

Adrien Couton is water portfolio manager for the Acumen Fund.

2008, the sector provides livelihoods for 66 percent of the country's population; employs 43.4 percent of the total workforce in the country; and accounts for 20.9 percent of gross domestic product.

This is made possible by one of the largest integrated irrigation networks in the world: 96 percent of the country's water use goes to the agricultural sector.[1] Pakistan gets the bulk of its water from the mighty Indus River Basin system, which originates in the northern and northwestern parts of the country. Since the 1960 Indus Waters Treaty with India (which determined how the waters of the Indus system were to be shared by the two countries), many water development projects—including the massive Mangla and Tarbela dams, link canals, and a number of barrages—have been executed in the country. This has given Pakistan one of the world's largest gravity-flow irrigation systems, with three big reservoirs storing some 20 million-acre feet of water, 19 barrages, 12 river-interlinking canals, and 59,200 kilometers of distribution canals. More than 160,000 watercourses comprise the distribution network that takes water directly to the farms—more than half of them in Punjab, the largest of the country's four provinces and the biggest agricultural producer. In total, the irrigation system of Pakistan serves close to 36 million acres of contiguous cultivated land.[2]

THE LOOMING WATER CRISIS

However, this fragile balance is coming under increasing stress given the combined pressures of a rising population and an aging infrastructure. Population growth of about four million people a year puts significant stress on the country's resources. Meanwhile, after decades of deficient investments, the country's water infrastructure has been on the decline. From the commissioning of the Tarbela Dam in 1976 to the official approval of the Diamer-Bhasha Dam project in 2008, no major water project was undertaken. Dams are losing storage capacity due to siltation, and huge volumes of water seep through canals in poor condition. According to an estimate by the Ministry of Water and Power, 35 million-acre feet, "the equivalent of six Tarbela reservoirs," is lost in ground seepage annually.[3]

Overall, per capita water availability declined from 2002.6 cubic meters in 1950–51 to 1136.5 cubic meters in 2003–04, positioning the country's per capita water availability only marginally above the threshold level of water scarcity (1,000 cubic meters),[4] a decline accompanied by growing water quality problems. More recent data suggest that per capita water availability continues to plummet. The sustainability of agriculture in Pakistan will largely depend on the judicious use and management of available water resources. Failure to be cautious about handling scarce water supplies will have major social implications.

Approaches to the Issue

Solutions to the challenge of water availability can be explored at three levels. It can be tackled by increasing the upstream storage capacity; by improving the efficiency of the transportation and distribution infrastructure; and by better allocating water to end uses.

Infrastructure improvements have received significant focus. Under the gigantic National Water Resources and Hydropower Development Program—Vision 2025, the Pakistan Water and Power Development Authority (WAPDA) launched the construction of several medium-size reservoirs as well as major irrigation extension projects (the Greater Thal and Kachi canals), while planning for and advocating major new reservoirs.

Unsustainable water-use practices are likely to be more difficult to address. As an illustration, numerous studies have documented that the sugarcane industry in Pakistan consumes a disproportionate amount of water in return for a low sugar output. This was the conclusion of a recent study by the Islamabad-based Sustainable Development Policy Institute.[5] This view in fact echoed the assessment of a former head of WAPDA, who noted in 2001 that "the return [on the] cash crop is not commensurate with the input of water that is required to produce sugar. We could import sugar from Cuba at less than half our production costs."[6] In Pakistan, however, the sugar industry is a powerful lobby.

Estimates of the investments needed to address the crisis vary, but all concur that considerable investment will be required. As an illustration, the National Water Resources Development Program (NWRDP) 2000-2025, designed by the government to address the crisis, estimated the investment needs for water resource development over 10 years at $14.8 billion. Out of this total investment, the share of dams represented around 40 percent, new canal construction 20 percent, lining and maintenance of existing canal systems 26 percent, and drainage 14 percent.[7]

THE ATTRACTIVENESS OF DRIP IRRIGATION

Very simply, drip irrigation consists of running water through pipes to supply small amounts of water continuously at the base of plants (surface drip) or directly at the roots (sub-surface drip) through emitters attached to lateral lines. It is one of the most efficient forms of irrigation technologies currently available. With this technology, water can be conserved and yields increased for farmers, especially for those cultivating crops in semi-arid regions. Drip irrigation in fact offers many advantages over conventional flood irrigation, including water savings, reduced labor required for irrigation, less soil erosion, and increased crop productivity.

Among all solutions considered by policymakers to address the water availability issue, drip irrigation has particularly attractive characteristics. It generates massive increases in the efficiency of water use (the increase in yield as compared to conventional irrigation methods is from 20 to 100 percent, while savings in water range from 40 to 70 percent).[8] It offers much more granularity than typical infrastructure intervention, since no heavy capital investments are involved, and investments can easily be spread geographically and over time. Drip irrigation also delivers immediate benefits. Finally, the system is a mechanism to educate end users about the immediacy of the water issue and the urgent need for more water efficiency.

In August 2007, the government of Pakistan launched a $1.3 billion subsidized drip irrigation program. It sought help from the Japanese government to double the efficiency in irrigation water use from the present 45 percent to 90 percent, with the help of drip irrigation. Pakistan's federal minister for food and agriculture set a target of 300,000 acres of land to be brought under drip and sprinkler irrigation in the first year, with federal and provincial governments to provide an 80 percent subsidy on drip irrigation equipment.

This type of program aims for quick results—yet it may be of no benefit for smallholders (as the Indian experience, detailed below, has shown). Indeed, existing product offerings and distribution channels in place are typically suited to the needs of larger farmers. Since its commercial acceptance in the mid-1970s, the hardware used in drip irrigation systems has evolved to fit large fields and to minimize management and labor requirements. As a result, the standard equipment that is now available is expensive and rather sophisticated. Most commercially available micro-irrigation systems are optimized for fields of four hectares or larger, requiring expensive emitters (to do the dripping) and highly qualified staff to operate and maintain the system. The cost of installing a drip irrigation system is high—typically at least $1,200 per acre. Systems are usually too expensive and impractical to operate in small plots, and hence, irrelevant to the majority of poor farmers.

Yet, small farmers represent a growing population in Pakistan. As illustrated below, average farm size declined from 5.3 hectares in 1971-73 to 3.1 hectares in 2000, during which time the number of small farms more than tripled.

Data on Farm Size in Pakistan for 1971-73, 1989, and 2000

Census year	Average farm size in hectares	Total area of holding in hectares	Number of farms under two hectares
1971-1973	5.3	19,913,000	1,059,038
1989	3.8	19,149,637	2,404,057
2000	3.1	20,437,554	3,814,798

Source: Oksana Nagayets, "Small Farms: Current Status and Key Trends," 2005.[9]

LESSONS FROM INDIA

Neighboring India has had significant experience with drip irrigation. The technology gained popularity there in the late 1980s, supported by public programs. Various research institutes conducted experiments on drip irrigation and made people aware of its benefits. Some manufacturers also conducted their own studies by importing the materials before venturing into commercial production of drip systems. Today, India has about 0.6 million hectares under micro-irrigation (drip irrigation), out of an estimated 6.1 million hectares worldwide. Additionally, Jain Irrigation—an Indian company—is one of the world's leading commercial drip irrigation companies.[10]

India has also seen the development of a leader in drip irrigation technology for smallholders: International Development Enterprises India (IDEI). IDEI is an Indian nonprofit with 17 years of experience in the development of irrigation technologies and market linkages for smallholder farmers. Realizing that no appropriate technologies were available for the smallholder farmers it was working with, IDEI focused on developing a product to meet these farmers' needs, building on work conducted in Nepal by its parent organization, International Development Enterprises (IDE).

IDEI's design principles were clear and followed three golden rules: miniaturization, affordability, and expandability. As a starting point, IDEI acknowledged that the basic unit had to be small; smallholders typically have less than two hectares of land, divided into five or six separate plots. As a result, the company took the quarter-acre plot as the building block within which new technology for small farmers should be developed. Second, IDEI saw affordability as a priority to let smallholder farmers gain access to income-generating technologies. As CEO Amitabha Sadangi has explained, "Shrinking a drip irrigation system from ten acres to a quarter acre not only makes it fit a small farmer's field, but it also makes it considerably cheaper." Systems are cheap, and the money invested in the drip system leads to quick improvements in yields and profits, sparking a rapid payback. Finally, IDEI designed its systems to be expandable. "If a farmer can only afford a drip system that irrigates a sixteenth of an acre to start with, design it so he can use the income it generates to seamlessly double or triple its size the next year," Sadangi has said.

With these principles in mind, IDEI designed a system that worked on a small scale and enabled farmers to gain access to an affordable and efficient technology, which has increased water efficiency by 50 percent and increased yields by over 30 percent. This technology generates dramatic economic benefits for small farmers. For them, access to drip systems has three consequences: they can suddenly harvest three crops each year instead of one; grow higher-value crops (e.g., chillies); and achieve higher yields. By offering a price around 60 percent lower than currently available solutions, IDEI makes these benefits accessible to small farmers—even without public subsidies. Indeed, the poorer farmers are typically at a disadvantage, being too poorly equipped to follow the procedures that allow them to receive a subsidy. Additionally, having little cash at hand, they are also more heavily penalized by long waiting times to get refunded than are more wealthy farmers.

SPREADING THE TECHNOLOGY: ACUMEN FUND'S EXPERIENCE

Acumen is a global nonprofit venture fund, founded in 2001 to address the issue of world poverty in a unique way—filling a niche between traditional capital markets and grant-based philanthropy by investing in enterprises that bring critical goods and services to low-income markets. Its objective is to create markets for the poor in essential goods and services where such markets do not currently exist. Acumen Fund combines targeted investments, financial leverage, and management support to build thriving enterprises addressing the needs of the poor. Its country offices in India, Pakistan, and Kenya work closely with a team based in New York to identify and support local social enterprises. Acumen Fund has successfully impacted over 10 million lives so far, through over $40 million invested in South Asia and Africa.

While the early focus of IDEI was on smallholder farmers in India, the company's ambitions were international in scope. With Acumen

Fund's support, IDEI created a socially minded, for-profit wholesale distribution company called Global Easy Water Products (GEWP). The nonprofit, IDEI, continued to focus on research as well as advocacy, while the for-profit company concentrated on building a sales and distribution model that serves the very poor. In the past seven years, IDEI and GEWP have sold over 250,000 systems in six Indian states, impacting the lives of over 1.2 million people by improving their nutrition and income levels.

In Pakistan, Acumen's contacts were with the Thardeep Rural Development Program (TRDP), a major nonprofit and the third largest of the Rural Support Programs, a group of integrated rural development organizations operating across Pakistan. TRDP operates in 3,000 villages in the arid regions of Sindh Province and serves over 130,000 households. Its core model involves mobilizing and organizing villagers into "self-managed" village organizations, which serve as a channel for rural microfinance services and other integrated alleviation programs that TRDP offers to rural communities. The regions where TRDP operates are among the poorest in Pakistan. Water is scarce, which restricts farming and sometimes forces the poorest and most vulnerable families to sell the few assets they possess and migrate to other regions.

In 2005, Acumen Fund introduced IDEI to TRDP. The latter's founder immediately saw the potential value of IDEI's irrigation technologies for TRDP customers. That same year, demonstration plots were set up in Pakistan with a $50,000 grant from Unilever, which had been supporting TRDP's work. The demonstration plots were largely successful; the agronomic conditions were close to those experienced by IDEI across the border in nearby Rajasthan, India, and IDEI's technology proved to work very well in Sindh.

Over 2006–07, Acumen facilitated further cooperation between TRDP and IDEI by placing a consultant at TRDP to lead the rollout of the project in Pakistan, and by seconding a staff member at GEWP. In July 2007, Acumen Fund approved a $1,000,000 investment in GEWP, and a $500,000 investment in MicroDrip, a joint venture between TRDP and Acumen Fund. Meanwhile, significant progress was achieved in the collaboration between IDEI and TRDP. In October 2006, IDEI's marketing manager visited the demonstration plots in Pakistan. This was followed by a visit by one of IDEI's area managers in February 2007, during which time an installation demonstration took place. A first large-scale shipment of goods was finally sent to TRDP in April 2007, and a second shipment was made in July 2007.

The roll-out of IDEI's low-cost drip irrigation technologies in Pakistan is only starting, but it has the potential to transform the lives of the rural families that MicroDrip will service. MicroDrip plans to reach between 20,000 and 30,000 farmers over the coming five years, improving their income and health and also generating environmental benefits for these communities.

MicroDrip's work provides direct feedback on the needs of smallholder farmers, their comfort with the technology, and the specifications of the products that they need. By treating smallholders as customers rather than recipients of charity, this approach gives smallholders a voice and ensures that the products and distribution channels used do not only benefit wealthier farmers. The subsidy scheme rolled out by the government of Pakistan can catalyze MicroDrip's work if the organization is able to leverage subsidies efficiently while maintaining its ability to serve smallholder farmers in a proactive manner.

CONCLUSION

In 2005, the World Bank's Country Water Resources Assistance Strategy highlighted that Pakistan had overcome three challenges related to the water sector throughout its history. The first challenge came when "the lines of partition of the India-Pakistan Subcontinent severed the irrigated heartland of Punjab from the life-giving waters of the Ravi, Beas, and Sutlej rivers." This challenge was solved by the Indus Waters Treaty of 1960.[11] The second challenge arose because there was now "a mismatch between the location of Pakistan's waters (in the western rivers) and the major irrigated area in the east." It was solved by building the world's largest earth-fill dam, the Tarbela, on the Indus River, and by constructing link canals running for hundreds of kilometers and carrying flows 10 times that of the Thames River.

The third major challenge, which remains today, is to manage "the twin curse of waterlogging and salinity." By responding to the first two challenges, Pakistan took measures that addressed issues of upstream water capacity and improved the transportation and distribution infrastructure. Such measures, however, addressed neither inefficient water usage by a rapidly growing population nor the strong disparities in access to water between rich and poor farmers.

Today, there is a need for a more decentralized solution. As illustrated by the example of drip irrigation, private sector-led approaches can be an efficient vehicle to give a voice to smallholder farmers. By treating farmers as customers, such private sector approaches offer a valuable listening device, a way to understand the needs of the smallholder farmers, and a mechanism for tailoring answers to the water crisis. The private sector alone will not solve Pakistan's water challenges, but it can inform and strengthen public programs, for a more equitable solution.

NOTES

1. Government of Pakistan (Ministry of Water and Power/Office of the Chief Engineering Advisor/Chairman Federal Flood Commission), "Pakistan Water Sector Strategy—Detailed Strategy Formulation," Islamabad, 2002.

2. Ibid.

3. Ibid.

4. Data obtained from 2020 Vision project of the International Food Policy Research Institute (IFPRI), http://www.ifpri.org/2020/welcome.htm.

5. Nadia M. Akbar and Mahmood A. Khwaja, "Study on Effluents from Selected Sugar Mills in Pakistan: Potential Environmental, Health, and Economic Consequences of an Excessive Pollution Load," Sustainable Development and Policy Institute, Islamabad, June 2006. Available from http://www.sdpi.org/whats_new/recent_publications/SIP_Final.pdf.

6. Quoted in "Pakistan: IRIN Special Report on the water crisis," Integrated Regional Information Networks (IRIN), United Nations Office for the Coordination of Humanitarian Affairs, May 14, 2001. Available from http://www.reliefweb.int/rw/rwb.nsf/db900sid/ACOS-64C9BS?OpenDocument.

7. "State Bank of Pakistan Annual Report FY04." Available from http://www.sbp.gov.pk/reports/annual/arfy04/Chapter_2.pdf.

8. To illustrate yield increases and water savings when using drip irrigation for two of Pakistan's major crops: sugarcane, 33 percent yield increase and 56 percent water savings; cotton, 27 percent yield increase and 53 percent water savings.

9. Oksana Nagayets, "Small Farms: Current Status and Key Trends." Prepared for the Future of Small Farms Research Workshop, Wye College, Kent, United Kingdom, June 26–29, 2005. Available from http://www.ifpri.org/events/seminars/2005/smallfarms/sfproc/Appendix_InformationBrief.pdf.

10. Data on Indian land under micro-irrigation was cited by India's agriculture minister in response to questioning in India's parliament in 2006. See "Lok Sabha Unstarred Question No. 1602, Answered 06/03/2006," available from http://164.100.47.133/lsq14/quest.asp?qref=26264.

11. This treaty gave Pakistan rights in perpetuity to the waters of the Indus, Jhelum, and Chenab rivers, which comprise 75 percent of the flow of the whole Indus system. See World Bank, *Pakistan Country Water Resources Assistance Strategy—Water Economy: Running Dry,* Report No. 34081-PK, November 22, 2005, Agriculture and Rural Development Sector, South Asia Region, World Bank, vii–viii.

Water Shortages and Water-Conserving Urban Design in Pakistan

James L. Wescoat Jr.

Pakistan faces unprecedented rates of urbanization and urban population growth in the decades ahead. The country's municipal water supply and sanitation systems are presently inadequate, let alone prepared to meet the twofold increase in demand anticipated by 2025. Severe urban water problems—shortages, disease, floods, deteriorating infrastructure, and degrading aquatic ecosystems—are already chronic. These problems affect the poor most severely, though entire urban populations struggle with them and will suffer increasingly until they are addressed.

This essay focuses on innovations in environmental design that can help address Pakistan's urban water problems, drawing upon examples from Pakistan, South Asia, and the United States. But it is appropriate as a first step to distinguish among the different urban water resource situations in cities as diverse as Karachi, Lahore, Rawalpindi, and Peshawar, in order to put these urban water systems in context. After differentiating among cities, this article will concentrate on the other side of the coin by focusing on the larger-scale shared contexts in Pakistan that help explain some of the problems, and more importantly, some of the promising paths for addressing them.

DIVERSE URBAN WATER PROBLEMS

The urban water problems of Pakistan vary enormously from arid, coastal Karachi to the semi-arid plains of Lahore and the hills of

James L. Wescoat Jr. is Aga Khan Professor in the Aga Khan Program for Islamic Architecture at the Massachusetts Institute of Technology.

Islamabad and Peshawar. They vary in hydroclimatic, infrastructural, institutional, and cultural ways. Selected examples from the larger cities of Pakistan establish this important point (Table 1).

Table 1: Urban Centers in Pakistan

Rank	City	City Population (2002)	Rank	City	City Population (2002)
1	Karachi	10,272,500	6	Multan	1,310,400
2	Lahore	5,611,500	7	Hyderabad	1,275,900
3	Faisalabad	2,191,200	8	Peshawar	1,094,900
4	Rawalpindi	1,558,400	9	Quetta	620,900
5	Gujranwala	1,349,300	10	Islamabad	586,500

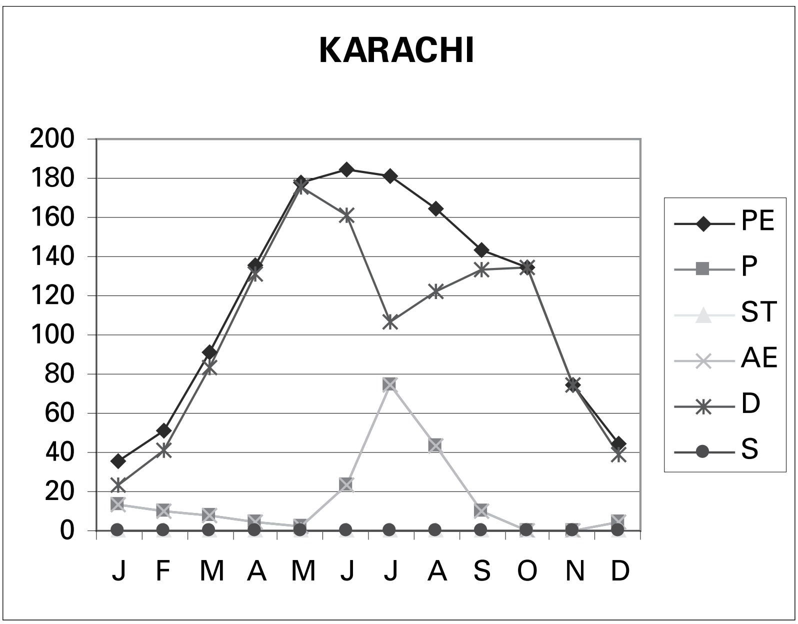
Source: http://www.mongabay.com/igapo/Pakistan.htm.

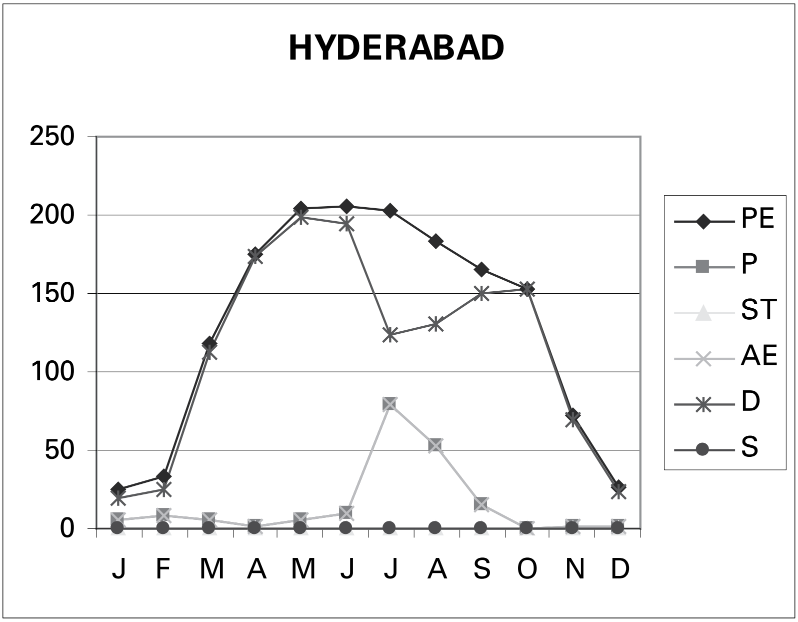
Hydroclimatic Water Budgets and Climate Change

The natural availability of water in Pakistani cities can be described with water budget diagrams that plot average monthly precipitation (P) and potential evapotranspiration (PE) rates during the year. Precipitation is a measure of local water supply while potential evapotranspiration is the maximum amount of water that would be consumed by evaporation and the transpiration of plants. The difference between these two values for precipitation and potential evapotranspiration rates provides a rough estimate of the actual evapotranspiration (AE) that can occur, soil moisture storage (ST), and the key concerns of monthly water deficits (D) and surpluses (S). Figure 1 displays the hydroclimatic water budgets for 8 of the 10 largest cities.[1] These budgets indicate that Multan, Hyderabad, and Karachi have truly arid climates—because the meager monsoon precipitation in these cities (P), which occurs only in June through August, does not come close to evapotranspiration demand (PE) in those months. In other words, the small amount of moisture generated by the monsoons is rapidly consumed—resulting in a very dry climate. The monsoon climates of Faisalabad, Lahore, and Rawalpindi are progressively more mesic (though still semi-arid). Peshawar and Quetta have more continental climates. What these cities share is a net annual water scarcity. That is, in no case does annual precipitation exceed the annual actual evapotranspiration that can occur. Rainfall is adequate for arid and semi-arid vegetation, and for *barani* crops like peanuts in the northern Punjab city of Jhelum, but not for most row crops.[2] Irrigation from surface and groundwater supplies is required to meet the deficit.

Monsoon rainfall does exceed potential evapotranspiration in Rawalpindi, Peshawar, and Quetta, which generates runoff that must be routed downstream. Flooding in other cities results from poor drainage design or extreme events.

Figure 1: Hydroclimatic Water Budgets for Eight Large Cities[3]

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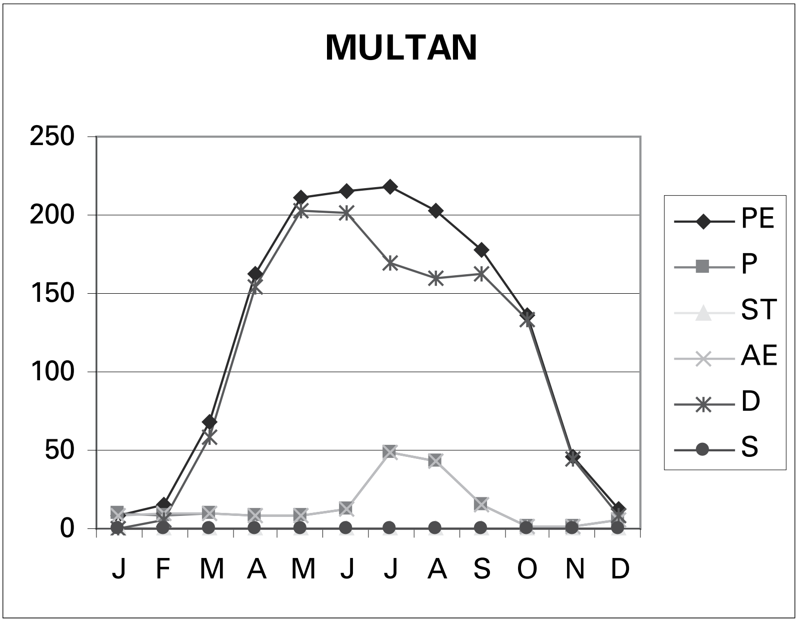
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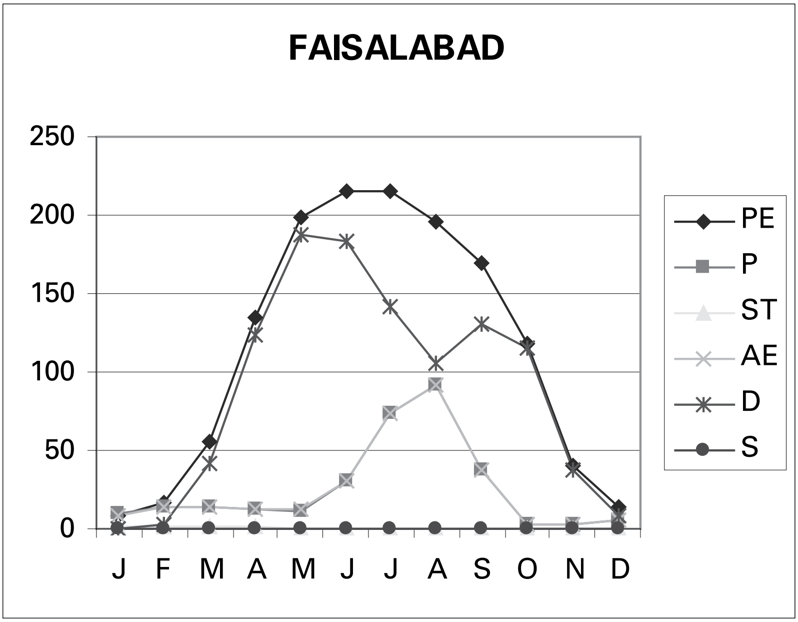
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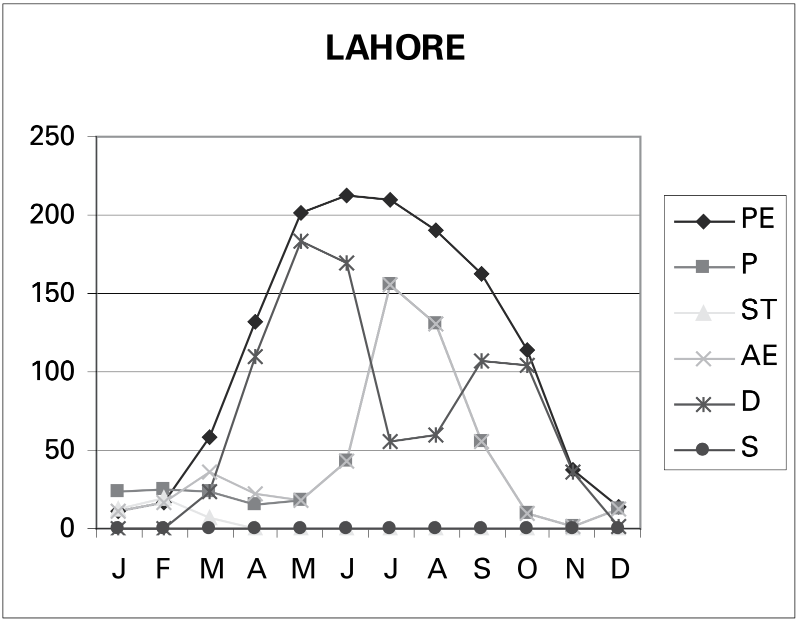
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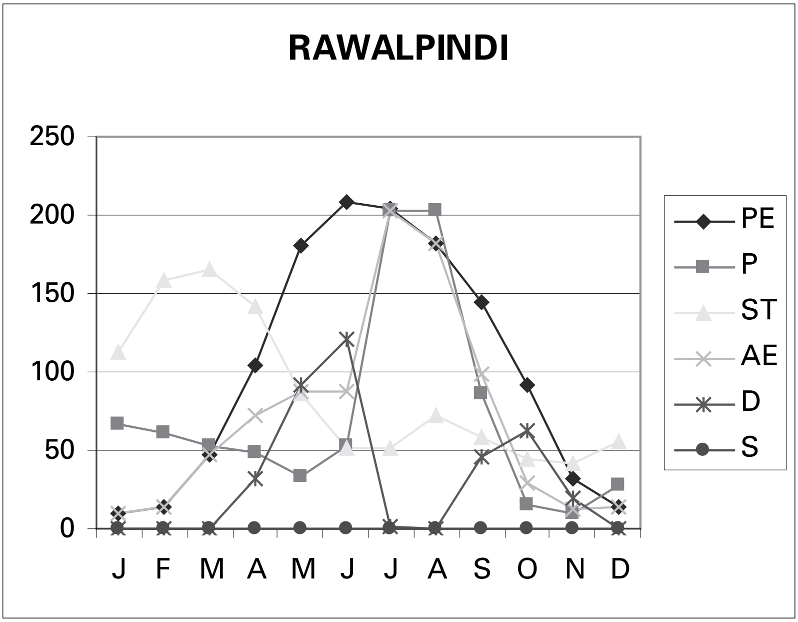
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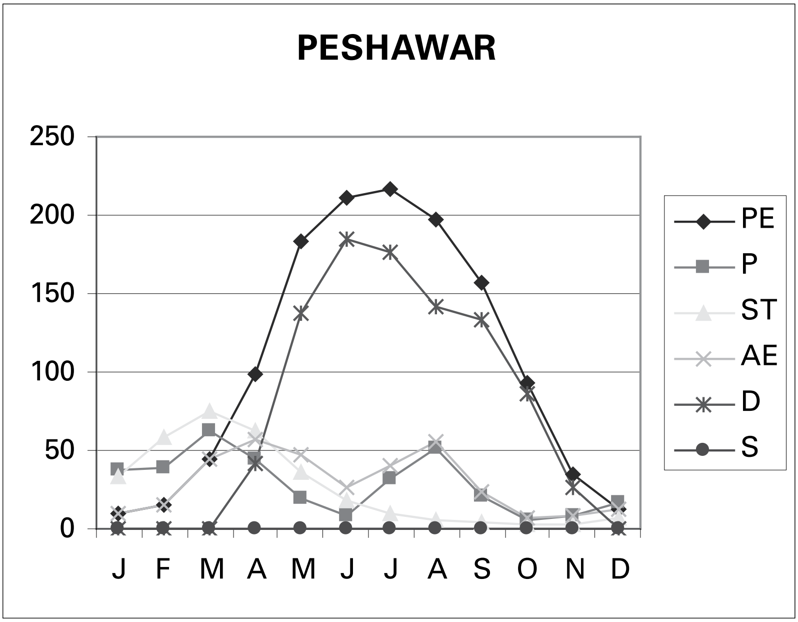
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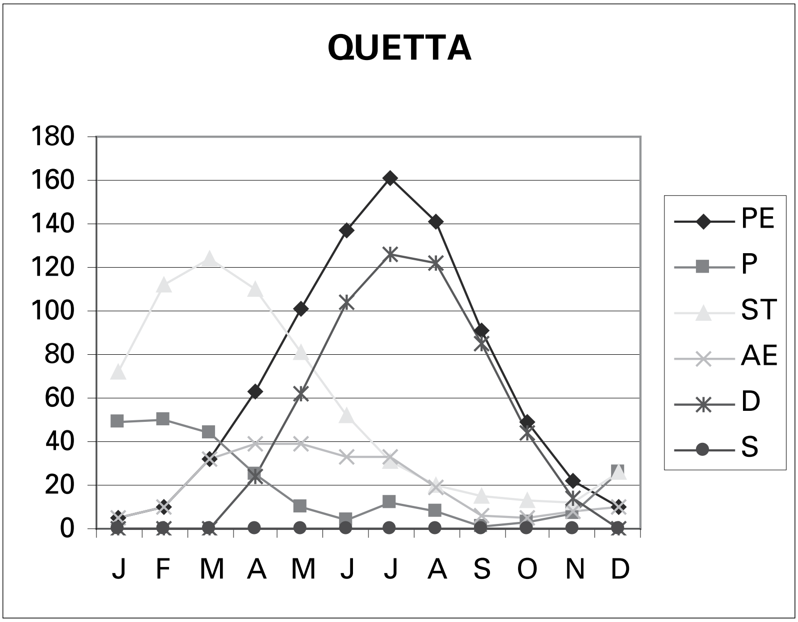
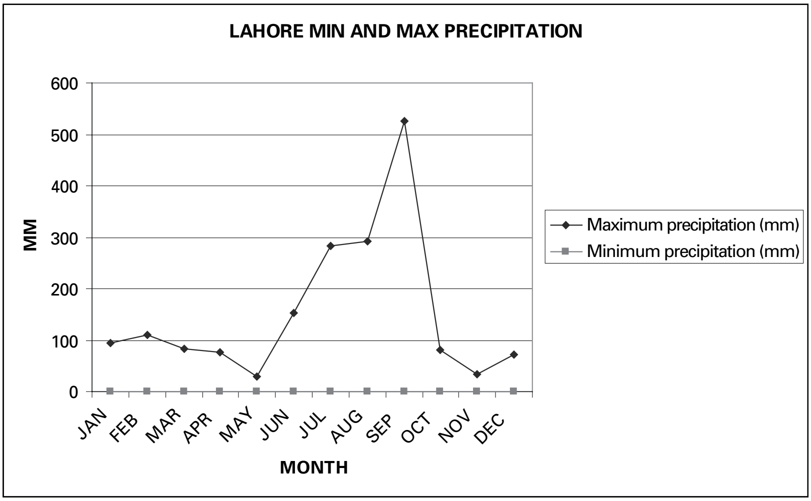


Source: Thornthwaite Associates (1963).

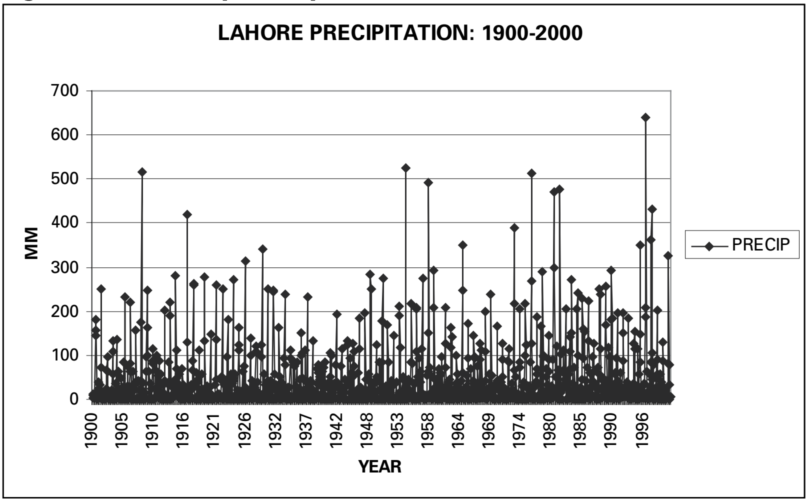
Figure 1 depicts average climate conditions in the mid-20th century. Pakistan's cities face variable climatic conditions each year, as shown in the minimum and maximum monthly precipitation records for Lahore (Figure 2), which range from no precipitation at all to over 500 millimeters (mm) in a single month. Another way to visualize these patterns of surplus and scarcity is a 100-year plot of monthly rainfall data, which indicate the enormous inter-annual as well as decadal variability in precipitation (Figure 3). While it may be tempting to view the higher frequency of peak events in recent years as an indicator of climate change, monsoon variability is so great that the primary effect of climate change on precipitation in Pakistan is increased uncertainty.

Figure 2: Monthly Minimum and Maximum Precipitation in Lahore



Source: Pakistan Meteorological Department (2008).

Figure 3: Monthly Precipitation Data for Lahore



Source: Pakistan Meteorological Department (2008).

Urban water budgets can also be measured in terms of surface water inflows from river and groundwater resources (renewable and non-renewable), for which cities have various allocations. Setting water rights aside for the moment, each city has dramatically different surface and groundwater resources. However, today none of Pakistan's cities has a major riverfront. All rely on different combinations and technologies for groundwater withdrawal from tubewells and long-distance surface water transfers. Groundwater remains largely unregulated. Large-scale surface water transfers rely on a small reservoir and vast canal system—which brings us to the human aspects of water resource systems.

Urban Water Resource Systems and Human Problems

Pakistan's urban water systems vary as much in social as in natural terms. They supply different industrial economies in different municipal and provincial institutional contexts. Additionally, the federal government lacks overarching jurisdiction of urban water systems, as in the United States.

It comes as little surprise, then, that Pakistan's urban water problems vary each year. One city may suffer flood damages while another experiences severe shortages or waterborne disease outbreaks. To examine the current array of urban water problems, three national newspaper archives (*Dawn, The Nation,* and *The News*) were searched in October 2008, using the search term "water," and selecting the first 100 records taken from each source. After deleting irrelevant references (e.g., to other countries), the news accounts were coded and sorted by topic (Figure 4).

The array of water-related problems in Figure 4 will be discussed in later sections of the paper. The initial point is that urban water issues constitute nearly 30 percent of the total. This may at first seem unsurprising, as some 40 percent of the population is urbanized and rates of urbanization and urban population growth are increasing rapidly. However, access to safe water and sanitation and resilience to water hazards are all very salient issues in rural areas as well.

Figure 4: Water Problems Reported in National Newspapers (*Dawn, The Nation,* and *The News,* October 2008)

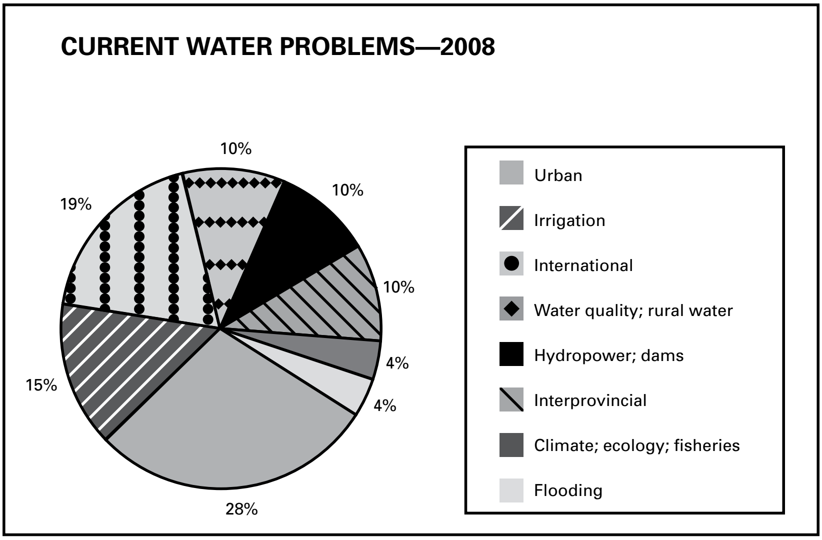
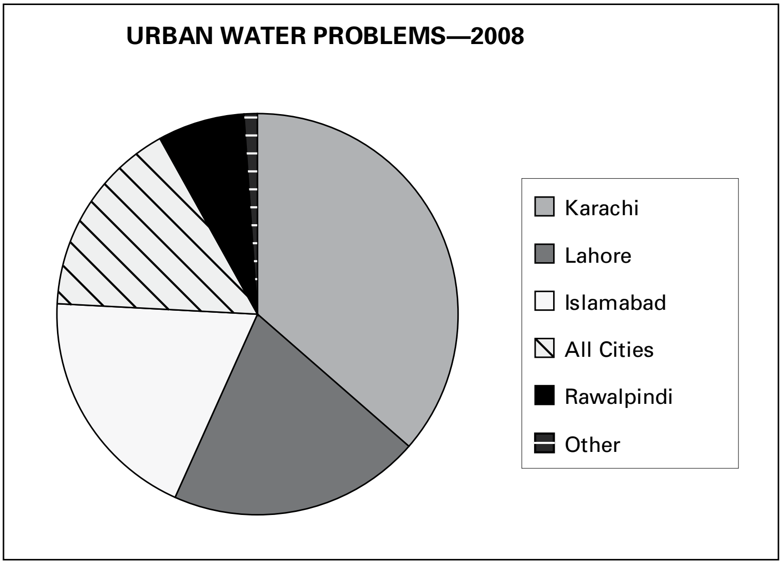


Figure 5 indicates the geographic distribution of articles on urban water problems. Not surprisingly, given its climate, size, and systemic infrastructure problems, Karachi had by far the largest proportion of articles on shortages, pollution, waterborne disease, and loadshedding-related water problems. Lahore suffers from some of these same problems, though the Pakistani media also reported drainage, flooding, and disease vector problems in this city, including a dengue outbreak. The capital region also reported serious water supply and distribution problems, as well as flood hazards in the Lai Nullah.

Only a few water articles dealt with cities outside these large centers, such as Hyderabad. In fact, secondary cities have problems of frequency and severity comparable to those of large cities. This reflects a search engine sampling bias for large city articles.[4] In some articles, secondary city problems were lumped into general discussions. Nonetheless, a more serious deficiency is the limited coverage of innovative responses to these problems at any scale.

Figure 5: Water Problems Reported By City (*Dawn, The Nation* and *The News*, October 2008)



INNOVATIVE WATER-CONSERVING URBAN DESIGN

Pakistani cities also vary in their responses to water problems, and these responses include innovations in water-conserving design. It is useful to distinguish three types or aspects of urban water conservation:

a. Waterworks conservation—i.e., hydrologic features and infrastructure
b. Water resources conservation—i.e., water use, re-use, and quality
c. Water experience conservation—i.e., equity, enjoyment, symbolic meaning, hazards

Water-conserving design occurs at the intersection of these three fields—or to put it another way, water-conserving design encompasses all three aspects of conservation (Wescoat 1995a and 2007).

Pakistan is a leader in urban community-based planning and design. Examples of such efforts include the Orangi Pilot Project (OPP), initiated by Dr. Akhtar Hameed Khan (2005); the Urban Resources Centre of Pakistan (URC), spearheaded by the architect Arif Hasan; NED University of Karachi's work, led by the architect Noman Ahmed; the Karachi Water Partnership (KWP), led by the geographer Simi Kamal; and other organizations (Ahmed 2008; Bengali 2003; and Hasan 2000). Water-conserving landscape design is less well-developed, although it has enormous potential. We can describe this potential by following the hydrologic cycle, beginning with rainwater harvesting.

a. The *rainwater harvesting* movement has expanded dramatically worldwide (Agarwal and Narain 1997). It ranges from rooftop diversion into gardens, tanks, and underground cisterns in densely settled locations—and which does not yet include the types of Awami tanks analyzed by Noman Ahmed (2008) in Orangi—to urban open space impoundments and small watershed collection structures in outlying areas.[5] Karamat Ali (undated) reports rainwater harvesting in the area of the Himalayan resort city of Murree, the desert area of Cholistan, and at Karachi University.[6]

b. *Water use efficiency.* Urban plumbing codes, low-water use fixtures, advanced building water conservation systems, and ornamental irrigation standards can reduce water use at the high-income end, such as in the context of five-star hotels and corporate buildings in Pakistan. It comes as a surprise that these innovations, while mentioned, are not yet mandatory in most South Asian cities.

c. *Energy-conserving water systems.* Many upper-income buildings still have hot-water heaters, air conditioners without condensate collection, and conventional chiller plants—all in areas subject to frequent loadshedding. However, Karachi's warm coastal climate offers good potential for passive solar heating, cooling, and ventilation systems.

d. *Grey water re-use.* This refers to the re-use of washwater, which happens as a matter of necessity in *katchi abadi*s (Pakistan's slum settlements), and also in water-conscious households of every class. It can be as simple as bucket collection of washwater, or as complex as re-plumbing buildings to divert washwater to outdoor irrigation uses.
e. *Stormwater best-management practices.* These are advancing in Pakistani cities, though their application in monsoon climates poses technical challenges, and most cities suffer seasonal monsoon drainage and related problems. The new Aga Khan University Faculty of Arts and Science campus in Education City, Karachi, plans to use stormwater harvesting to support plant growth, as well as wastewater re-use for fountains, irrigation of drought-adapted plantings, fire control, and toilets (Gorini 2008).
f. *Ecological treatment of sanitary wastewater.* Raw sewage discharge occurs extensively and informally in Pakistani cities. It is used in market garden production with serious health hazards. However, managed use of constructed wetlands and advanced pond and lagoon treatment systems, coupled with floodplain restoration, have untapped potential in metropolitan areas such as the Ravi River floodplain in Lahore, the Lai Nullah in Rawalpindi, the Malir and Lyari Rivers in Karachi, and others (Van der Hoek 2002). This type of large-scale ecological engineering requires coordinated metropolitan and provincial water management that is difficult to attain or sustain.
g. *Green infrastructure.* Sanitary wastewater systems raise a larger question about how rivers have become sewers—that is, the trend from dilution to pure pollution. Yet even more important are the exceptions. For example, the Canal Road in Lahore was built for irrigation purposes and acquired recreational and aesthetic functions that have additional potential. The Islamabad torrents and Lai Nallah in Rawalpindi were partially embraced in the original plan for the new capital city prepared by Doxiadis Associates in the 1960s, and they could be en-

hanced through an ecological approach to urban floodplain design (Mahsud 2008 and Mustafa 2005). Current debates over coastal and estuarine land uses in Karachi constitute another opportunity for green infrastructure design.

h. *Conserving water experience.* The water-conserving design measures described above are increasingly well-known and incorporated in professional practice worldwide and in nongovernmental organization (NGO) programs. Less well-understood is the nature of water-conserving experience, especially in metropolitan areas that strive to consciously build upon or break with tradition. Among the newspaper articles sampled in Pakistan, one described a local theatrical performance about the Karachi Water and Sanitation Board.[7] The article reminds one of the theater movements that advocate for social justice in South Asia (Nagar 2002 and Enwezor 2003).

These water-conserving design methods complement those of engineers, which have been paramount in the major water planning studies for Karachi, Lahore, and the Capital Development Authority. When water is largely invisible to the public—conveyed in pipes, stored in underground tanks, and discharged in sewers—it can become disconnected from everyday conservation practice, which is as true in Washington, D.C. as in Islamabad.

Karachi has pioneered the Orangi Pilot Project, Lahore has combined cultural heritage conservation with urban infrastructure upgrading, and Rawalpindi seems poised to undertake a new approach to floodplain design. Each city has undertaken different design interventions in different hydroclimatic and water management contexts.

How relevant are these design innovations for each other? To pose the question differently, are Karachi's design innovations more like those of Mumbai, and Lahore's more comparable with those of Delhi? How do Pakistan's urban water innovations relate to national and provincial water issues?

These questions point toward a larger-scale contextual approach. In the newspaper article search cited earlier, urban water problems constituted almost 30 percent of all the articles dealing with water. Yet what of the other 70 percent? For starters, consider that some 95 percent of consumptive water use in Pakistan is for irrigation agriculture. We need to consider urban water problems within a broader context, and for two reasons. First, they are a vital part of that much larger context. Second, their relationships within that context constitute, for better and worse, a shared framework that can lead urban water planning in creative new directions.

THE SHARED CONTEXT OF URBAN WATER PROBLEMS AND PLANNING

To provide a wider perspective on urban water problems, one should concentrate on the shared contexts of urban water management in Pakistan. These shared contexts range from the historical and cultural geography of Indus civilization to integrated river basin management of the 21st century. Let us begin with the shared historical-geographic context of urbanization.

Shared Historical-Geographic Context of Urban Water Systems

Pakistan's major cities continue the legacy of Indus Valley civilization and urbanization that is nearly five millennia in duration. I have previously written reviews of the past 50 and 500 years of water management in Pakistan, and it would be interesting to extend this to the full depth of 5,000 years of urban water management (Wescoat 1999 and Wescoat, Halvorson, and Mustafa 2000). This record includes urban water innovations such as baths, drains, and a sewerage system at Moenjo Daro, the ancient city-settlement in what is today Sindh Province (Jansen 1989). A full history of Pakistan's urban water management would also have to take into account the well-documented Ghaggar-Hakra river channel change, which left many formerly riparian cities stranded in the Cholistan Desert (Mughal 1997).

The early history of urban water design also includes Gandharan cities in northern Pakistan; Ghaznavid, Hindu Shahi, and Sultanate city-building in central Pakistan; and Persianate canal irrigation systems in Mughal Lahore. British water management consciously built upon this heritage, grafting international standards of urban water management with innovative hydraulic engineering in the Punjab Irrigation Department. The independence period witnessed the development of the Indus Basin Management Program, which had strong agroeconomic and hydropower foci but a limited connection with urban water infrastructure—and even fewer connections with modern architecture in Lahore and Karachi. Islamabad is a fascinating exception (Mahsud 2008 and Mumtaz 1985).

Most recently, the entire Subcontinent has witnessed two divergent urban trends—one toward the innovative engagement of architects in low-income water and sanitation programs (Hasan 2000; Ahmed 2008; and Pervaiz, Rahman, and Hasan 2008), and the second a regressive shift toward gated communities with independent water and power supplies, which bespeaks failures of urban governance. Future Indus Valley urbanization might reweave these disparate urban trends, in part through new secondary city-building and low-cost infrastructure upgrading to address the coming urban boom, e.g., as undertaken in the Khuda ka Basti Incremental Development Scheme implemented by the Hyderabad Development Authority in Pakistan, which won an Aga Khan Award for Architecture in 1995 (Davidson and Serageldin 1995).

Shared Agroeconomic and River Basin Planning Context

The development of the Indus Basin after 1947 consolidated the largest contiguously irrigated region of the world. To give a sense of scale, some of Pakistan's link canals connect rivers of the Punjab that carry a larger annual volume of water than the Colorado River. Irrigation accounts for an estimated 95 percent of consumptive water use—but has only 35 to 40 percent water use efficiency. Consider that Karachi receives an allocation of 1,200 cusecs (cubic feet per second) from Kotri Barrage on the lower Indus River—but this accounts for only 3.4 percent of total allocations from the barrage.[8]

Comparable tensions in the western United States are slowly but steadily driving transfers of water from the irrigation to the urban sector. The process is slow in both countries, but more so in Pakistan, where agricultural production, food security, and rural livelihoods are major national and provincial policy goals. River basin development in Pakistan is one of the great experiments of modern water management. The experiment is vital to Pakistan's future, but is in jeopardy due to waterlogging, salinity, infrastructure deterioration, reservoir sedimentation, loadshedding, institutional capacity-building needs, and water management needs from the farm to the nation as a whole (Briscoe et al. 2005). The survey of recent news articles reflects these problems. For example, agricultural water shortages for the *rabi* (winter) crop affect food prices and urban as well as rural livelihoods. It is notable that the World Bank's 2005 Pakistan Country Water Resources Assistance Strategy, which diagnosed national water sector problems, gave little attention to urban water issues, innovations, and their linkages with large-scale river basin management (ibid.).

It should be underscored that Pakistan has some of the most sophisticated irrigation and river basin management research in the world (Wescoat, Halvorson, and Mustafa 2000). The Indus Basin optimization model is more detailed than any such model for any basin in the United States, and it has enabled scientists to run joint scenarios of climate change and water sector investment alternatives that have not been replicated elsewhere on that scale to date (Wescoat and Leichenko 1992). However, it needs substantial updating and refinement. The World Bank (2008) water sector capacity-building project will build upon past successes by updating the Indus Basin model and training the next generation of water engineers and managers, most of whom are and will be urban professionals. Upgrading river basin modeling tools has direct analogues with the needs of megacity water management, which includes SCADA (Supervisory Control And Data Acquisition) operating systems, asset management, new sensor systems, and capacity building. The interdependency of Pakistan's urban and agricultural economies cries out for provincial and national policies that link urban planning with river basin management. Interestingly, the World Bank has published a very similar assessment of water problems in India, which brings us to the subject of a shared institutional context.

Shared Institutional Context

The Indus Basin Development Program grew out of the Indus Waters Treaty of 1960 between India and Pakistan, brokered by the World Bank and financed by a consortium of "friendly countries." It is rightly celebrated that this treaty has weathered wars, floods, and droughts for almost 50 years.

Interprovincial water conflicts between Punjab and Sindh date back more than a century. Both interprovincial and international levels of political tension are generating news. International disputes have arisen over Chenab River releases and upper Jhelum and Chenab hydropower projects in India. Within Pakistan, Sindh, Punjab, and the Northwest Frontier Province contend with the Indus River System Authority (IRSA) regarding water allocations, reservoir operations, and proposed hydropower projects. These issues contribute to high-level political tensions on provincial, national, and international levels, and might prudently be avoided by urban water planners.

Still, the glass is half-full. Arbitration, a provision invoked recently for the first time in the Indus Waters Treaty's history, has worked. Institutional mechanisms for interprovincial negotiation have developed and hold promise. Provincial water institutions are attempting reform, with the Sindh Water Management Ordinance of 2002 one notable example (World Bank 2007). City water agencies are also pursuing reform (Hasan 2000).

What bearing do these macropolitical issues have on urban water management? First, negotiation is centered in the cities; and second, negotiated agreements have consequences that cascade from river flows to canal diversions and waterfront environments. The cities of Pakistan, upstream and down, share these roles and concerns.

Institutionally, there is no professional association of Pakistani utilities and water managers comparable to the American Water Works Association or the International Water Association. However, encouraging developments have occurred among South Asian urban water organizations. These include:

a. SaciWaters—South Asia Consortium for Interdisciplinary Water Resource Studies, http://www.saciwaters.org/.

b. SACOSAN—South Asian Conference on Sanitation, http://www.ddws.nic.in/infosacosan/Home.aspx.
c. SAWUN—South Asian Water Utilities Network, http://www.adb.org/Water/sawun/default.asp.

These organizations are sharing experience and innovations, and they are benchmarking performance across international as well as interprovincial boundaries. In their own way, these entities constitute a type of multitrack diplomacy as well as professional and institutional development.

FROM METROPOLITAN TO COSMOPOLITAN WATER MANAGEMENT

This paper has sought to discern the shared contexts of urban water problems and innovations in Pakistan. It has sought connections with long-term, large-scale water management from Harappan civilization to the present, from information technology to irrigated cotton, and from municipal to international water governance. The prominent role of the state in this analysis, from local to international scales, invites skepticism about the promise of a shared context. Thus, the final shared context considered here is that of nongovernmental civil society organizations like the OPP, URC, KWP, Pani Pakistan, and many more—all of which have close counterparts across South Asia, connected with one another by NGO networks facilitated by decades-long civil society networks convened by the International Institute for Environment and Development, the Water Engineering Development Centre, the International Water and Sanitation Centre, the Water Supply and Sanitation Collaborative Council, and others. The commitment and power of these urban organizations cannot be underestimated. They have "scaled-up" from their own cities to inspire and draw support nationally and internationally, which bespeaks the increasingly cosmopolitan character of urban water management. It is a cosmopolitanism of many hues that includes pro-poor water programs that strive to improve the health and livelihoods of millions. The main question that arises from this contextual analysis of

Pakistan's urban water problems is whether this wider perspective can help answer the question of how the tens of millions of new urban residents will secure safe water and sanitation in the coming decade.

CONCLUDING THOUGHTS

The media search carried out for this essay did not find any newspaper articles on this fundamental question about Pakistan's urban water future. There are answers, however, that are latent in Pakistan's cities and their larger contexts. Within the cities, Professor Noman Ahmed's (2008) survey research in Karachi has documented a nearly universal belief that basic domestic water needs are an inherent public good. My research in Lahore found extensions of a natural right to water to animals (Wescoat 1995b). These findings are in accord with a growing body of inquiry and international opinion that access to safe drinking water and basic sanitation is a natural right. Human drinking water requirements are variously estimated as 50 liters per capita per day (lpcd), or 62 lpcd for domestic use, which must be increased from a water supply standpoint to encompass related water withdrawal, treatment, and conveyance uses. However, some of the poorest urban residents in Pakistan have only 10 lpcd of drinking water—and it is all polluted (Ahmed 2008). I sense that Pakistan is reaching a point where providing basic domestic water needs will be deemed a strict obligation of society and the state to all citizens, and will find that there is sufficient freshwater to fulfill this duty on a national scale.

How that duty is met, along with the next level of water supply for human wants and ecosystem needs, is a major design problem in the broadest sense of the term that can build upon the community-based design of the Orangi Pilot Project, Aga Khan Development Network projects, and a host of other design exemplars. This paper has briefly noted recent trends in water-conserving design that have enormous promise in professional as well as community-based design. A leading university in each of Pakistan's major cities could take on this challenge, ideally in a consortium of universities—comprising both public and private institutions.[9]

Water-conserving design is an ethical, social, functional, ecological, and cultural necessity for meeting and managing future urban water demand in Pakistan. It is necessary, but of course not sufficient, for all of the reasons discussed in the larger geographical sections of this paper. Cities draw upon surface and groundwater resources outside their municipal boundaries. They discharge wastewater that must be more wisely re-used and treated in the ecohydrologic system to reduce downstream health hazards and environmental degradation. Cities consume a relatively small proportion of their water withdrawals through evaporation, but far too high a proportion through pollution. Finally, cities can provide leadership in economic, political, and cultural policymaking for the larger Indus Basin that encompasses them all and many of their sister-cities in the region.

This final role of cities is perhaps the least clearly envisioned at present in Pakistan and globally. Cities are professional design centers, but they lack an expansive design vision that is integrative beyond their boundaries, with canal commands, regional aquifers, and river basins. A half-century ago, that vision was partially attained in the concurrent design of Islamabad and the Indus Basin Development Program. It is true that both projects had limitations and failings. Still, these limitations define the next generation of design problems to be pursued in fresh integrative ways that meet the natural rights of all of Pakistan's citizens; that restore its ecosystem services, including its agricultural ecosystem and economy; and that resolve its seemingly intractable institutional water conflicts at all levels. This, it seems to me, is the scale of design vision, and humility, needed to address Pakistan's water crisis today.

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NOTES

1. Gujranwala is omitted due to similarity with Lahore, and Islamabad due to similarity with Rawalpindi.

2. *Barani* crops are grown in dryland areas that do not receive canal irrigation.

3. These Thornthwaite water budget diagrams employ a common methodology and provide rough portraits of local urban conditions. While evapotranspiration modeling has advanced significantly since these estimates were produced, these graphs facilitate the types of comparisons made in this essay.

4. The sampling of articles by "relevance" is biased toward those with the most frequent hits, which is biased against smaller cities; there may also be reporting bias.

5. See the technical literature on rainwater and stormwater harvesting on the need to avoid contamination and disease vector breeding in these facilities.

6. The Centre for Science and Environment in Delhi has compiled an extensive set of urban and rural examples that link environmental, technological, and social aspects of their sustainability (Agarwal and Narain 1997). Severely water-scarce cities like Chennai have adopted mandatory rainwater harvesting for new construction.

7. "Underlining water and sanitation problems through theatre," *The News*, June 10, 2008. Available from http://www.thenews.com.pk/print1.asp?id=117706.

8. This figure probably needs to be adjusted upwards to reflect continuous urban diversions vis-à-vis seasonal and rotating agricultural diversions. There is also a proposal to double Karachi's share, but it is still a relatively small fraction of total water allocations in southern Sindh.

9. Public universities with water resources engineering programs include University of Engineering and Technology, Lahore (UET), Karachi University, Quaid-i-Azam University, Peshawar University, Jamshoro, and others. Private universities that could make outstanding scientific and policy contributions include Lahore University of Management Sciences (LUMS), Aga Khan University (AKU), and others.

Securing Sustainable Access to Safe Drinking Water in Lahore

Anita Chaudhry and Rabia M. Chaudhry

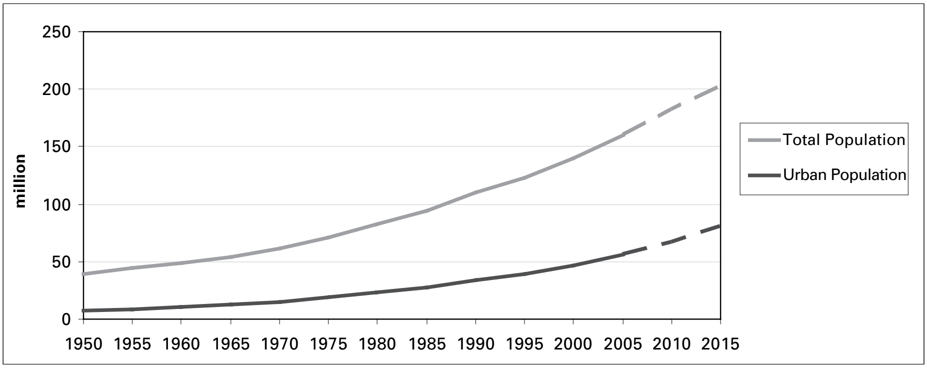
Lahore is the second largest city in Pakistan, and the largest Asian city that relies completely on groundwater for its drinking water needs (Mcintosh and Yniguez 1997). More than one-third of its residents may not have access to safe drinking water. This essay presents the trends in availability and quality of drinking water in Lahore, and explores some of the economic, institutional, and environmental factors driving these trends. The major focus is on the pressing issue of groundwater overdraft and the deteriorating quality of water in and around Lahore.

URBAN GROWTH AND STATUS OF WATER PROVISION IN LAHORE

Pakistan is a predominantly rural country, though its urban population is steadily increasing. Its total population increased from 82 million in 1980 to 160 million in 2005. Over the same period, the percentage of the population living in urban areas increased from 28 to 35 percent. Figure 1 shows the increase in urban and total populations in Pakistan, a trend emerging in many Asian countries as urban-focused industrial and service sectors gain relative importance over the agricultural sector.

Anita Chaudhry is assistant professor of economics at California State University, Chico. **Rabia M. Chaudhry** is an environmental engineer with MWH Americas, Inc. in Walnut Creek, California. The analysis and opinions expressed here are the authors' and do not reflect the views of MWH Americas, Inc.

Figure 1: Urban Population in Pakistan



Source: United Nations data.

The two largest cities in Pakistan—Karachi and Lahore—together account for roughly a third of the urban population in Pakistan, and have followed similar trends in population increase. According to United Nations data, Lahore's population doubled from 3.4 million to 7 million residents in the 25-year period spanning 1980 to 2005.

Available data from international agencies regarding access to safe drinking water and sanitation in urban and rural areas of Pakistan are presented in Table 1.

Table 1: Access to Safe Drinking Water and Sanitation in Pakistan

	Access to Safe Drinking Water (percent)		Access to Sanitation (percent)	
Year	Urban	Rural	Urban	Rural
1970	77	4	12	N/A
1975	75	5	21	N/A
1980	72	20	42	2
1985	83	27	51	6
1990	82	42	53	12
1994	77	52	53	19
2000	96	84	94	42
2002	95	87	92	35

Source: Gleick et al. (2006).

The data in Table 1 show very high levels of access to safe water and sanitation—so high, in fact, that they seem inconsistent with anecdotal evidence. Also, closer inspection reveals increases in water supply and sanitation from 1994 to 2002 that seem implausible given the fact that public expenditure on these services did not change significantly. If these data are taken at face value, they indicate that Pakistan has met the seventh Millennium Development Goal, which is to halve, by 2015, "the proportion of people without sustainable access to safe drinking water and basic sanitation" (Pernia and Alabastro 1997).

Gleick et al. (2006) offer several reasons to question whether these data present an accurate picture of water and sanitation access in Pakistan. One of the key issues is that this information was collected by surveys of water providers or public water supply agencies, rather than by surveying consumers. Therefore, the figures may not accurately capture the experiences of water users regarding water access. Secondly, "access" was very loosely defined, in that it could mean a walking distance of anywhere from 5 to 30 minutes to the water source. A third reason to question the data is that the surveys did not adequately measure the level of water quality for residents. Poor water quality that endangers the health of users is often a sign of poverty and water insecurity, and must be part of the basic definition of water access. Another reason to be concerned about access to water in Pakistan's urban areas, especially in northern and central Punjab Province, is that improvements in water access are being achieved by the unsustainable mining of groundwater aquifers. One of the major assertions of this essay is that such improvements in water access are temporary, and occur at the expense of future residents.

Given these reasons, we are left to piece together other evidence regarding access to safe drinking water. Independent estimates judge that such access is around 30 percent in urban areas, and around 24 percent in rural areas of Pakistan (Rosemann 2005).

COMPLETE RELIANCE ON GROUNDWATER

Water supply in Lahore relies exclusively on groundwater resources, giving Lahore the unusual distinction of being the largest city in Asia that relies exclusively on groundwater (Mcintosh and Yniguez 1997).[1] The upper Punjab plains are underlain by a very productive, unconfined aquifer system that has fueled the growth of not only urban water demand but also irrigated agriculture in Punjab (Qureshi, Shah, and Akhtar 2003).

Public water supply agencies in Lahore use electric groundwater wells, locally referred to as tubewells, to pump groundwater from 300–600 feet below ground surface; this groundwater is then supplied directly to distribution networks.[2] Average daily supply is not uniform within the city, and most households receive public supply for only a few hours each day. As the population of the city has increased, public water supply agencies have responded by installing more electric wells and pumping a greater amount of groundwater. In 1995, water supplied to the city by the primary public water supply agency amounted to 156 million gallons per day (Mcintosh and Yniguez 1997). By 2007, the volume of water had jumped up to 350 million gallons per day (Lahore Development Authority 2008). Despite this increase, the public water supply does not meet the full needs of residents.

Many households have their own groundwater pumps to augment the public water supply. These privately owned electric water pumps pull water from shallower depths, compared to the larger public water pumps, and they allow residents to augment the intermittent public water supply. The private extraction of groundwater has allowed residents to cope with the deficiency of public water supply. While the number of existing privately owned wells and the annual volume of water extracted from them are not known, the Pakistan Social and Living Standards Measurement Survey estimates that in 2006–07, 34 percent of the urban households in Punjab had a motor pump to secure their water (Government of Pakistan 2008a). Household-owned water pumps may therefore constitute a significant component of total groundwater extraction in Lahore.

The Inequity of Groundwater Usage in Lahore

Inadequate public supply and the presence of productive groundwater aquifers have allowed for the emergence of a duality in water access in Lahore. On one extreme are the wealthier households, which can afford the capital and energy costs of installing and operating their private electric well pumps, and which can adopt measures to protect themselves from water quality concerns. On the other extreme are poorer households that rely only on intermittent public supply for a few hours a day. Moreover, public infrastructure, where it exists, may work to the benefit of wealthier households, which may have much higher water use per capita. Water use in Pakistan is not metered, and water bills are usually based on land area and the nature of property usage (domestic, commercial, etc.), thus giving no incentive to conserve water.

The Inefficiency of Groundwater Usage in Lahore

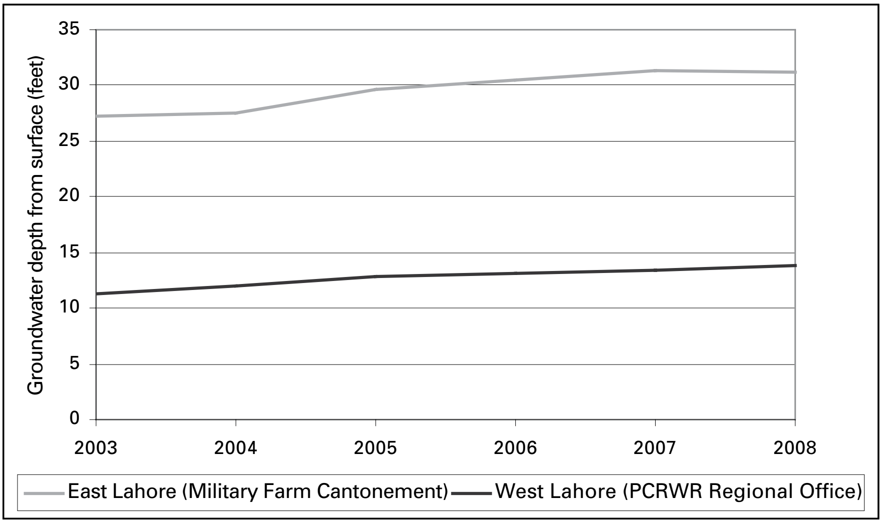
The existing situation is not only inequitable but also inefficient. Public water supply systems have very high economies of scale, i.e., the average cost of providing water to a user declines as the number of users increases. These economies may also exist for water quality monitoring, i.e., it is cheaper to monitor and control the quality of drinking water at one centralized location, rather than at several dispersed sites. This suggests that the aggregate costs of coping mechanisms adopted by all households may be several times more than the cost of delivering clean water from a central, efficiently run water distribution system. Residents pay for the operation and maintenance of household-owned water pumps in addition to the health costs from drinking contaminated water. If these economies exist, it would mean that Lahore could reap tremendous benefits from investing in a central water storage and delivery system.

The importance of this issue cannot be overstated. Is a central storage, cleaning, and distribution system more cost-effective than a disaggregated hybrid system where public utilities only provide water to some residents some of the time, and small-scale private provision satisfies the unmet need? It may be useful to examine the evidence from other large and small urban centers of the world. A survey of major cities across 26 African countries reveals that small-scale, private provision of water has become a very important source of water for urban residents. Public water supply and sanitation infrastructure has simply not kept pace with the growing demand. As a result, a duality is observed in many cities—a large-scale public sector provider supplies and satisfies some of the demand, while myriad private mechanisms fulfill the remaining demand. These private provisions are often informal arrangements, and can take the form of water vendors selling water from a truck, or of local privately owned water pumps or boreholes. This private provision is small-scale, privately owned and not regulated by the public authorities. Private provision of water (i.e., water that does not come from the centrally owned system) is responsible for water provision to 56 percent of the residents of Dar es Salaam, Tanzania; 60 percent of the residents in Nairobi, Kenya; and as high as 80 percent of the residents of Khartoum, Sudan (UN Habitat 2006). In Lahore, this private provision takes the form of household- or neighborhood-owned groundwater pumps, and as mentioned earlier could be responsible for water access to at least one-third of Punjab's urban population. (Government of Pakistan 2008a). There is a growing recognition among water policy experts that these private water sources need to be better understood and incorporated into the urban water policy framework. In Pakistan, there is an urgent need to collect data on the prevalence and use of water pumps in order to better understand the status of water access.

When water is not provided by a central authority, evidence suggests that it is the poorest section of society that pays a higher cost. Priscoli and Wolf (2009) document that the poor pay a far higher percentage of their income and available wealth for water, an average of about \$1-\$2.50 per cubic meter. The poor who are connected to a water utility pay \$1 per cubic meter and the unconnected poor pay \$5.50-\$16.50 per cubic meter on average. Although detailed studies have not been conducted in Lahore, and reliable economic information is lacking, existing reports and anecdotal evidence suggest that Pakistan's poor also spend a greater fraction of their income than the rich to secure water—and the water they receive is of worse quality than what the rich get for a lower cost (Pattanayak et al. 2005 and Rosemann 2005). Within households, this is also associated with greater gender inequalities—women are responsible for collecting water and a greater fraction of their labor is expended on this task. It is the poor—especially poor women and children—who suffer the most from such public utility shortcomings.

Another very important dimension of inadequacy in the existing situation is that at current extraction rates, groundwater resources are being depleted for future generations. All existing evidence indicates that groundwater aquifers are being mined at a rate much higher than they are being recharged. Figure 2 shows that water tables have fallen by about five feet over the last five years at two different locations in Lahore. The depletion may be even worse in other areas of Lahore, such as Kamalia and Pakpattan, where water tables have been lowered by about 65 feet.[3] This is a serious concern for the residents and the water managers of the city. The city government currently has no existing plans to prepare for the impending groundwater depletion. At current rates of extraction and wastewater disposal, groundwater availability at shallow depths is either entirely absent or too polluted.

Figure 2: Average Groundwater Depth Measured at Two Locations in Lahore



Source: Personal communication with Pakistan Council of Research in Water Resources.

THE ROLE OF AGRICULTURAL WATER USE

A discussion of groundwater depletion would be incomplete without acknowledging the active groundwater economy in Punjab's agricultural sector. Only 2 percent of Pakistan's freshwater resources are used for domestic purposes, which include drinking, cooking, cleaning, etc. Therefore, a discussion of groundwater use has to pay due attention to the role of agricultural water use (Gleick et al. 2006). The agricultural economy of Pakistan, especially that of Punjab, has become increasingly groundwater-dependent. More than 60 percent of farmers in Punjab rely on groundwater to meet crop water requirements. Pakistan has an extensive surface water irrigation system—it is in fact the largest contiguous irrigation system in the world—but increases in agricultural production have rendered the extensive canal network insufficient to meet agricultural needs. Groundwater resources are exploited to supplement surface water supplies in order to meet the growing water demand of agricultural and urban/industrial sectors. Without groundwater availability, not only Punjab but the entire country could face serious food shortages, because groundwater-dependent Punjab delivers more than 90 percent of agricultural production in the country. Estimates suggest that there are more than half a million tubewells for irrigation purposes in Punjab, which extract up to 43.4 billion cubic meters of groundwater (Qureshi, Shah, and Akhtar 2003).

Pakistan's groundwater economy is largely user-financed; some 77 percent of private well owners use their own funds to install tubewells and electric pumps. The number of tubewells in Punjab increased by more than 300 percent from 1980–2002, and their spatial distribution already shows concentration in northern Punjab. However, due to uncontrolled and unregulated use of groundwater, aquifer overdraft has made pumping more expensive and wells are going out of production (Qureshi, Shah, and Akhtar 2003).

WATER QUALITY CONCERNS

Water quality concerns have been increasing in Pakistan due to the discharge of untreated industrial and agricultural effluents into unprotected water bodies. The relatively continuous alluvial unconfined aquifers in Punjab have few low-permeability barriers capable of confining the flow of groundwater at any level. For the purposes of water quality, this means that contaminants seeping in from the ground directly impact the reserve of groundwater that could potentially be extracted for human consumption. Due to the slow movement of groundwater (on the order of a few feet a day), contamination might remain localized in certain areas. However, once groundwater becomes contaminated, it is extremely difficult to clean up and requires costly, long-term engineering solutions. In Lahore, where residents rely exclusively on groundwater for drinking, sewage treatment and waste disposal are particularly significant. Contaminants from these and other sources easily seep into the subsurface, making shallow groundwater too polluted to be useful.[4]

According to the Pakistan Environmental Protection Agency (EPA), the most imminent threat to drinking water is bacterial contamination through contact with sewage (Government of Pakistan 2008b). This is an issue affecting Pakistan in rural and urban areas alike, since wastewater is not treated. The data presented in Table 2 were collected and analyzed by the Pakistan Council of Research in Water Resources (PCRWR). Sixteen different tubewell locations in Lahore were selected for water quality monitoring from 2002 through 2006 and analyzed for comprehensive water quality. The results were compared against drinking water standards established by the World Health Organization (WHO). Arsenic was found above the WHO established guideline of 10 parts per billion in almost all of the monitored sources. Concentrations of iron were also found to be beyond permissible limits, which may indicate the rusting of water supply pipelines.

Table 2: Major Contaminants in Drinking Water Sources of Lahore

Major Contaminants	Year of Monitoring				
	2002	2003	2004	2005	2006
	Number of Samples Collected				
	16	16	16	16	16
	Percentage of Samples Beyond Permissible Limits				
Iron	6	0	50	56	56
Arsenic	31	100	100	100	100
Bacteriological contamination	43	37	43	63	50
Total percent of unsafe samples	56	100	100	100	100

Source: Kahlown, Tahir, and Raoof (2008).

Pakistan's EPA has established adequate standards for drinking water for physical parameters, bacterial contamination (which include total and fecal coliforms, such as *E. coli*), essential inorganics (heavy metals, nitrate, fluoride, etc.), and radioactive contamination. However, organic contaminants (pesticides, herbicides, aromatic hydrocarbons, and their derivatives, etc.) are not regulated on a compound by compound basis (Government of Pakistan 2008b). Seepage of these contaminants into groundwater can arise from a number of ubiquitous sources such as industrial effluents, agricultural runoff, and even gasoline stations. These organic pollutants belong to an ever-increasing family of compounds that often cause damage to the human body through chronic exposure. Data about the concentrations of these pollutants are scarce in Pakistan, and so the scale of the issue is ill-defined. However, PCRWR is planning to begin monitoring select organic compounds within the next few years.

ENERGY AND WATER USE

When a city the size of Lahore relies solely on groundwater, energy use is very closely tied to water use. Aquifer depletion increases the costs of groundwater extraction because it takes more energy to pump water from greater depths. In addition, one must take into account the capital costs of boring deeper wells and installing larger capacity pumps. Water charges have to be paid to the city water utility, but there are no permits or fees required to pump water from household premises. Instead, households are indirectly charged for pumping via electricity charges.

BOTTLED WATER CONSUMPTION

The most recent factor in water supply in urban areas in Pakistan has been the spectacular growth of bottled water consumption, which underlines the trends of poor public supplies, the deteriorating quality of private provision, and the inequality of access to water. Per capita bottled water consumption in Pakistan increased by 164 percent from 1999 to 2003 (Gleick et al. 2006). At a time when cities in the rest of the world are moving away from bottled water consumption due to a broader recognition of the environmental concerns associated with shipping water and disposing of plastic bottles, such an increase in a poorer country like Pakistan only highlights the urgent need for the reliable provision of clean drinking water.

CONCLUDING THOUGHTS AND THE ROLE OF INFORMATION

The story of water provision and availability that is unfolding in urban and rural areas of Pakistan has a common theme: The inadequate delivery of publicly provided water and growing demand have induced consumers to implement private coping mechanisms to secure water for their basic needs. The primary feature of these coping mechanisms is the unchecked pumping of groundwater aquifers. As this essay has sought to highlight, such extraction is problematic for three reasons:

(i) The current allocation of water is inequitable because richer households—which have better access to private groundwater pumps than do poorer households—may be able to cope better with the lack of publicly provided water. Poorer residents pay a higher fraction of their income on obtaining clean water or go without it.

(ii) The existing water distribution is inefficient. As discussed above, public water supply systems have high economies of scale, i.e., per capita costs are lower if all users are connected to a central well-functioning system, as compared to the costs per user if each individual implements private coping mechanisms. A well-functioning public water supply system, however, can be cost-effective and pro-poor.

(iii) The current patterns of groundwater pumping and waste disposal are leading to the depletion of groundwater aquifers and the contamination of shallow aquifers, thereby threatening the ability of future residents to access water.

This essay has also presented the most current data available on water quality in Lahore. There has been an unmitigated release of agricultural, industrial, and municipal wastewater effluents, all of which have contaminated shallow aquifers. Arsenic, for example, has proven to be a water quality concern in Lahore. Unfortunately, information about organic contamination, which includes thousands of chemicals such as pesticides, plastics, solvents, and preservatives, is scarce. Even low-concentration exposure to these chemicals often manifests after many years, and tends to be overlooked in the face of more prominent water-borne diseases caused by inadequate sanitation. Proper hauling, treatment, and disposal of sewage are essential and should be top priorities in order to protect public health. Also of essence is the management and monitoring of industrial and agricultural effluents in order to mitigate chronic exposure to poisonous chemicals. Efforts by the Pakistan EPA to establish water quality standards are an excellent first step, but the adequacy of their implementation remains to be seen.

Water supply and sanitation experts assert that a well-functioning public water supply system should feature marginal cost pricing, water-use metering and billing based on water use, accountability of water service providers, and proper sewage processing and disposal. Currently, the public water supply system in Lahore is plagued by several problems in all of these areas. Revenue generation is weak, distribution is inefficient, there is a lack of metering of water use, and water charges are based on the size of a property rather than on use.

How can Lahore move forward from the current situation? An increase in volumetric rates without an improvement in service will be politically difficult, if not impossible. However, an improvement in service delivery without a greater investment in infrastructure is also likely to be very challenging. We recommend that a good first step would be to learn more about some of the issues highlighted above. Reliable, useful, and consistent information regarding water quality must be provided to users. There is very limited information available on groundwater availability, quality, and the relationship between withdrawal and recharge. Comprehensive geological studies need to be undertaken to measure the relationship between irrigation water use in Punjab and declining water tables in Lahore and other urban areas. The case study of Lahore presented in this essay aims to highlight the current patterns of population growth, water use and quality, and groundwater depletion existing in many urban centers of Punjab. There is an urgent need to study these patterns so that water policy can be better informed.

Access to information has a critical impact on water users' behavior and willingness to pay for improved water services. A lack of information on water quality may cause water users to undervalue certain water resources. Some users may not understand the relationship between health and water, or that water quality cannot be observed without cost. If prices were to increase, users may substitute lower-quality water, hence leading to a market failure. The reverse problem may also occur, when water users may perceive bottled water to be of higher quality and may be willing to pay more for it. Information access should be a vital part of water service delivery and regulation.

Information regarding groundwater depletion should also be made available to water users and water managers. The perception of unlimited water quantity is misleading. Most policy solutions to water scarcity that have been under discussion and implementation merely increase the number of storage reservoirs and the capacity of distribution networks. Such approaches are short-sighted and will only lead to a faster depletion of the aquifers. Sustainable management of water resources has to take the limits of pumping seriously, improve system efficiency by reducing wastage, and increase conservation. In order to achieve sustainable management, it is important that groundwater resources be better characterized. Information regarding recharges, yields, and depletion rates needs to be collected in order to better understand the effects of users on each other. So far, water management in Pakistan has focused primarily on harnessing abundant surface water flows for agricultural use.

Discussion about water scarcity in Pakistan has been preoccupied with the role of water in agriculture. This focus has been on water as an input in farm production, rather than for people. Groundwater is largely seen as a reserve water source for irrigation and food production. This production-oriented perspective continues in the debate about groundwater use and extraction. Increases in agricultural production, insufficient surface water supplies, and the supply of electricity to rural areas have all contributed to a boom in groundwater extraction in the countryside. Urban areas have followed the broader trend of groundwater use by extracting groundwater to meet drinking water needs. It is time that we look at surface and groundwater in a holistic way. We must look toward long-term solutions without compromising the needs of future generations.

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NOTES

1. According to a survey of water utilities in Asian cities, Lahore, Bishkek, Hanoi, Ulaanbaatar, and Cebu relied on groundwater for 100 percent of their public water supply. The size of the population served in each of these cities at the time of the survey was 3.9 million (Lahore), 1.65 million (Hanoi), 1.3 million (Cebu), 695,000 (Ulaanbaatar), and 605,000 (Bishkek). Faisalabad, with a population of 1.8 million in 1996, situated some 140 kilometers from Lahore, relies on groundwater for 98 percent of its water supplies (Mcintosh and Yniguez 1997).

2. Public water supply is managed by the Water and Sanitation Authority (WASA), which is responsible for the delivery of water and sanitation services

to most of Lahore's residents. No domestic consumers receive continuous 24-hour water supply. In 1995, the average daily supply to a household connected to the grid was 17 hours per day (Mcintosh and Yniguez 1997).

3. This information was reported by the staff of the Lahore regional office of PCRWR through personal communication with one of this essay's authors in November 2008.

4. In addition to anthropogenic pollution, groundwater in Punjab is naturally saline due to an influx of salts from the Indus River and its tributaries. Groundwater pumping also mobilizes salts on the subsurface (Kahlown, Tahir, and Raoof 2008). There are significant spatial variations in groundwater salinity, and considerable efforts are devoted to delineating the "sweet" (freshwater) zones that can be tapped for mining. Occasional zones of saline groundwater in Punjab contain dissolved salts of 20,000 or more milligrams/liter (mg/l) (Water Aid 2002). For purposes of comparison, the average salinity of seawater is 35,000 mg/l. Tubewells in Lahore routinely harvest water at depths greater than 300 feet below ground surface in order to avoid saline or contaminated water.

Public Health, Clean Water, and Pakistan: Why We Are Not There Yet

Samia Altaf

It is instructive to recall that almost 5,000 years ago, the provision of drinking water in Mohenjodaro (a city in present-day Pakistan), as well as its disposal, was better than what exists in many cities of the country today. There were covered drains, perfectly sloped to maintain a continuous flow, and the wastewater received primary treatment in stabilization ponds before it was discharged into the river.

Nor was ancient Pakistan unique. Two thousand years ago, there were aqueducts in Rome for bringing in and disposing of water. Some of these are still in operation.

The economic case for providing clean water has been obvious for many decades. "Willingness to pay" studies in the Punjab in the 1990s demonstrated that the costs of coping with an intermittent and unreliable public water supply exceeded the costs of providing a modern water system. Moreover, the expenses associated with an inadequate public water supply did not even include the public health costs imposed on society due to diseases attributable to a lack of clean water and inadequate disposal.

The research relating health and disease to water quality and availability is also clear. Meanwhile, the costs related to waterborne diseases have been well-known since the United Nations Water and Sanitation Decade of the 1980s, and the Health for All by 2000 campaign (which grew out of a 1978 conference on primary health care and a recognition of the environmental causes of disease.)

There is little need to keep repeating these statistics year after year.

Samia Altaf is a physician and public health/development specialist.

They are all part of the work that has gone into the fashioning of the Millennium Development Goals (MDGs).

In addition, the money and the technical expertise to develop and monitor water programs have generously been made available to Pakistan over the past two decades— almost half a billion dollars from the World Bank alone.

All of this, then, leads to a deceptively simple question: If the technology exists; if the correlations with health are so clear; if the economic and social costs of an inadequate water supply are known; and if funds have been invested in programs for improving Pakistan's water quality, then why have there been so few positive results? Why had so little been achieved by the end of the Water and Sanitation Decade and the Health for All movement? Given this history of failure, can we expect the outcome of the MDGs to be any different?

HISTORY OF SANITATION REFORM

A brief glance at the history of sanitation reform in 19th-century Europe and North America may prove instructive. In both instances, reform became a political issue, with a strong lobby of the powerful pushing for reform. There were essentially two reasons why. First, the low level of technology meant that the privileged could not isolate themselves from the afflictions of the poor. Diseases such as pneumonia, whooping cough, and polio affected the rich as well as the poor. Second, an erroneous theory of health, the miasma theory, ascribed the spread of disease to the bad odors of wastewater carried by the wind—so the risk of disease was thought to be shared by all. As a consequence, many of society's most powerful citizens—such as doctors and businesspersons—were in the vanguard of sanitation reform.

Today, ironically, technology (cars, bottled water, and home filtration, for instance) allows the rich to live separately from the poor. Every city, especially in the developing world, has been transformed into two cities—one where there is clean water, and one where there is not. Moreover, the discovery of the germ theory of disease has shifted the focus from environmental factors and sanitation reform to immunization against the diseases caused by a poor environment.

The powerful political lobby for sanitation reform has disappeared. And the people who live in those sections of the city without services rarely have a voice in the political systems of a country like Pakistan.

The essential point of this history is simple: Sanitation reform and the provision of clean water are political issues. As long as there is no effective demand from the citizens, and as long as there is no strong political lobby behind the demand for decent water, we cannot expect much in the form of outcomes.

Why there is no demand from below is a different issue that needs understanding in its own right.

The argument that Pakistan lacks the resources to provide clean water to its citizenry does not work any more. This country is a nuclear power. It has shown that it can find smart and competent people to do a particular job when it wishes to. Similarly, the argument that Pakistan lacks the infrastructure to transport water to its cities is not quite believable either. This, after all, is a country that can transport men, tents, shoes, blankets, bread, and bullets to the top of a 20,000-foot glacier. Surely it can transport water to the cities—if it wished to do so.

So there is not much to be gained by presenting yet again the research on waterborne diseases, or on the health costs of inadequate water supplies. What we need to understand is why this very simple problem has not been fixed, and why something as easily doable as providing water to cities has not been done. And, perhaps most importantly, what can be done about this going forward?

PUBLIC HEALTH TRIUMPHS

Suppose we look at this matter as we do other public health issues, such as the linkages between cigarette smoking and cancer, or the use of seat belts. Twenty-five years ago, the research clearly made the links. Once the facts were in, specific actions were taken by civil society, by professional and consumer groups, and by citizens and their representatives, all in order to bring about policy changes. This was done by lobbying, by advocacy, and eventually by legislation and regulation. It was done by aligning the incentives and disincentives of stakeholders in a fashion that had very clear consequences. And since many of the stakeholders were not prepared to pay the cost of consequences, there were concrete changes instituted in the interest of citizens. For example, the print and electronic media were not ready to suffer adverse consequences, and so advertisements for cigarettes eventually disappeared.

In addition, states paid for public service messages regarding the importance of safety belts in saving lives, or of cigarettes in destroying them. Under state mandate, manufacturers of products were forced to comply with safety regulations. A public educated about the issues was able to bring pressure on fellow-citizens practicing unsafe behaviors. And in this fashion, personal behavior also changed.

We see something of the same process being followed today on issues related to climate change.

The point here is straightforward: There is a time to get the facts right to support action for change. Then there is a time to focus on the strategy for change. In the case of water and health, the first phase is long over. It is embarrassing even to repeat the same research at meeting after meeting, in study after study. There is no new evidence that overturns the old consensus—the results are consistent and very robust.

We know how to provide water in terms of technology; the latter has existed for 5,000 years. There have been no revolutionary breakthroughs; it is still all about pipes under the ground, filtration, and stabilization. We know the economic and social case for change. We even know that people are willing to pay for better service. There could be a stage where we might discuss the relevance of project design—though even that time has passed. We know that the donor model, with a standardized cookie-cutter approach to program design, does not work. We know that other models, such as the Orangi Pilot Project (OPP), a design based on the use of indigenous technology, community participation, and decentralized decision making, deliver much more. But the OPP design has not been adopted across the country. The ultimate success of the OPP model is dependent on a steady and continuous municipal water supply and a larger overall sanitation disposal system. These elements are not always available, and at any rate are out of the jurisdiction of the local community.

HOLDING PAKISTAN ACCOUNTABLE

So we need to move to the next stage, learn from history, and devise a strategy based on models that have worked. This would be a strategy that mobilizes civil society, that permits and even encourages the participation of citizens, and that is comprehensive and has real and direct consequences.

Appealing to the Pakistani government or to elites by referencing MDGs as a monitoring tool is not going to have the slightest impact. Step two miles outside Islamabad, or talk to people beyond the immediate inner circle of the donor community in Pakistan, and no one has a clue about what MDG means. MDG-watchers are already saying that it does not look like Pakistan will meet these goals.

As the donor community, especially the U.S. government, thinks of helping Pakistan and identifies what needs to be done, serious thought ought to be given to the "how" as well as to the "what." Who will be held accountable for delivering results? What are the consequences to the Pakistani government should it fail to produce acceptable results? To date, there have been no consequences whatsoever for Pakistan's government. In truth, Islamabad has been rewarded with additional aid for failing to use effectively the assistance of the past seven years.

At this time, the international donor community, including the United States, is in a strong position. Donors are committed to helping Pakistan and its people. To translate this commitment into practice, they should, on behalf of the people of Pakistan, lean heavily on the government in Islamabad to deliver results. They should hold the government and its implementing contractors accountable. We have seen that this model works. At county and state levels in the United States, for instance, where civil society and other consumer groups provide close oversight and monitoring of publicly funded projects, there are many examples of successful programs.

WAY FORWARD: A MOBILIZED CIVIL SOCIETY

How to hold Islamabad accountable? One way is to mobilize civil society through the efforts of citizens. This can be done by helping to create citizen groups comprised of people of credibility, standing, and technical expertise. Such groups can work to educate civil society about issues; establish self-evident performance measures; perform continuous internal objective monitoring; and develop checks and balances, which would provide an opportunity for mid-course corrective action and the redirection of social sector program activities based on objective evidence.

Those who care about Pakistan and its future need to lobby donors to insist that such accountability be built into any assistance package. There are precedents; note that the International Monetary Fund's (IMF) 2008 economic support package insisted on an agriculture tax (though the IMF later toned down its insistence on this tax). Setting conditions or asking Islamabad for specific actions will not always be popular among Pakistan's political elite—but doing so is both possible and necessary.

Instituting performance-based standards and strict accountability in program design are critical for the credibility of donors, especially Washington. Research funded by the American government has demonstrated that there has been little change in Pakistani health indicators in past decades. Recent developments, such as the rise in violence in Pakistan and a loss of faith in the United States (as demonstrated by research by the Pew Center), show that the Pakistani people are losing confidence in the international community. The battle for hearts and minds is being lost, yet this battle is not one for the military to win. Because development assistance from the past seven years, including that provided by the United States, has not delivered anything for the common man, Pakistanis think that the donors have a hidden agenda.

Given that the Obama administration plans to increase development assistance to Pakistan, American friends of Pakistan can play a key role in this debate and can influence the direction of future policy. Institutions such as the Woodrow Wilson Center need to leverage their position and share this kind of knowledge and expertise, so as to alert the new administration to a basic but crucial fact: if American assistance to Pakistan's social sector is to be effective and help improve the lives of ordinary citizens, and if it is to help win the hearts and minds of the Pakistani people, it must go beyond the simplistic analysis and cookie-cutter model of program development of the past.

The old methods, based on outmoded methodology and the failure to insist on adequate accountability, have not worked, and should be discarded. New thinking needs to be applied to this old problem.

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