Resource Disputes in South Asia: Water Scarcity and the Potential for Interstate Conflict

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Foreword

This report is the result of collaboration between the Robert M. La Follette School of Public Affairs at the University of Wisconsin–Madison and the U.S. Central Intelligence Agency's Office of South Asia Analysis. This study has provided graduate students at La Follette the opportunity to improve their research and policy analysis skills while producing a report that contributes to knowledge about South Asia.

The La Follette School offers a two-year graduate program leading to a master's degree in international public affairs. Students study policy analysis and public management with an international and global perspective, and they pursue a concentration in a policy focus area of their choice. They spend the first year and a half of the program taking courses in which they develop the expertise needed to analyze public policies.

The authors of this report are all in their last semester of their degree program and are enrolled in Public Affairs 860, *Workshop in International Public Affairs*. Although acquiring a set of analytic skills is important, there is no substitute for doing policy analysis as a means of learning policy analysis. Public Affairs 860 gives graduate students that opportunity.

The students in the workshop were divided into four teams. The authors of this report were assigned to work on a research project for the Office of South Asia Analysis. I chose the specific topic of this report—an analysis of the potential for conflict in South Asia over the issue of water scarcity—from a list of potential topics the client provided.

India, Pakistan, and Bangladesh, the most populous countries in South Asia, all face the prospect of serious water shortages. Population growth, coupled with increased urbanization, is contributing to a growing demand for water. Meanwhile, climate experts predict that global warming will eventually reduce the supply of water in the major river systems serving South Asia. The authors of this report explore potential conflicts that could arise between India and neighboring Pakistan, Bangladesh and Nepal over the growing shortage of water. Their detailed analysis highlights international disputes over water that could arise, and they suggest policies that may help minimize these disagreements.

The report benefited greatly from the support of the staff of the La Follette School. Mary Mead and Gregory Lynch contributed logistical and practical support, and Karen Faster, the La Follette Publications Director, edited the report and managed production of the final bound document.

By involving La Follette students in the tough issues facing governments around the world, I hope they not only have learned a great deal about doing policy analysis but have gained an appreciation of the complexities involved in addressing these challenging issues. I also hope that this report will contribute to the work of the Office of South Asia Analysis.

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Glossary

Aquifer: A geological formation beneath the saturate zone that bears, stores and/or transmits groundwater, such as to wells and springs. Use of the term is usually restricted to waterbearing formations capable of yielding water in sufficient quantity to constitute a usable supply for people's uses (USGS, n.d.).

Barrage: An artificial obstruction positioned to increase water levels or divert flows, usually to control peak flow for later release (Eckhardt, n.d.).

Co-riparian: Two countries that share a common, transboundary river (USGS, n.d.).

Crop intensity (CI): The average number of plots grown on a unit of land.

Dam: A structure designed to form a basin and hold and retain water, thus forming a pond, lake or reservoir (USGS, n.d.).

Drainage basin: Land area where precipitation runs off into streams, rivers, lakes and reservoirs. These basins can be identified by tracing a line along the highest elevation between two areas on a map, often a ridge. Large drainage basins, like the Ganges-Brahmaputra Basin, contain thousands of smaller drainage basins (USGS, n.d.).

Environmental water requirements: Level of water flow required to sustain environmental quality of a river system (IWMI, 2009).

Evaporation (E): Amount of water that leaves the basin or country as vapor (IWMI, 2009).

Evaporative factor (EF): Factor expressing the percentage of total water diversions (TWD) actually evaporated. Thus, EF = E/TWD (IWMI, 2009).

Flows to sinks: Portion of the water supply lost to deep percolation and surface runoff. For example, deep or saline aquifers from which the water cannot be economically recovered (IWMI, 2009).

Flush: To force large amounts of water through a system to cleanse a body of water (Eckhardt, n.d.).

Fresh water: Water that contains less than 1,000 milligrams per liter of dissolved solids; generally, more than 500 milligrams per liter of dissolved solids is undesirable for drinking and many industrial uses (USGS, n.d.).

Freshwater withdrawal: Diversion of fresh water for domestic, industrial and agricultural uses (IWMI, 2009).

Gross irrigated area (GIA): Amount of crop area served by irrigation facilities (IWMI, 2009).

Groundwater: Water that flows or seeps downward and saturates soil or rock to supply springs and wells, creating the saturate zone. The upper surface of the saturate zone is the water table where water is stored underground in rock crevices and in the pores of geologic materials that make up the Earth's land surface. Below the surface of the saturate zone lies the aquifer (USGS, n.d.).

Groundwater diversions: Water withdrawals from groundwater reservoirs and aquifers (IWMI, 2009).

Groundwater recharge: Inflow of water to a groundwater reservoir from a land surface. Infiltration of precipitation and its movement to the water table is one form of natural recharge, as is the volume of water that groundwater recharge adds (USGS, n.d.).

Groundwater reservoir: An underground aquifer system that stores water (USGS, n.d.).

Hydrologic cycle: The cyclical transfer of water vapor from the Earth's surface via evapotranspiration (the sum of evaporation and transpiration into the atmosphere), from the atmosphere via precipitation back to Earth, and through runoff into streams, rivers, and lakes, and ultimately into the oceans (USGS, n.d.).

Internally renewable water resources: Amount of runoff generated within a country, plus any flows into the country, less any flows to a neighboring country (IWMI, 2009).

Irrigation: Controlled application of water for agriculture through artificial systems to supply water requirements not satisfied by rainfall (IWMI, 2009).

Irrigation sector efficiency (ISE): At basin or country level, the ratio of net evapotranspiration requirements to primary water diverted to irrigation. Irrigation sector efficiency relates to the project efficiency (PE) and multiplier (M) in this way: ISE = PE x M. Therefore, increases in irrigation sector efficiency are a result of increases in project efficiency or the multiplier (IWMI, 2009).

Meltwater: Liquid water running from snow or ice, often in reference to melting of glaciers (USGS, n.d.).

Multiplier (M): ratio of total water diversions (TWD) to primary water diversions (PWD): M=TWD/PWD. The multiplier indicates how many times water is recycled within an irrigation system. Another relation to derive the multiplier in irrigation is to divide the irrigation sector efficiency (ISE) by the project efficiency (PE): M=ISE/PE (IWMI, 2009).

Natural renewable water resources: Amount of runoff produced internally, plus flows from other countries (IWMI, 2009)

Net irrigated area (NIA): The amount of area under crops in an annual cycle. Derived by multiplying crop intensity by gross irrigated area: NIA = CI x GIA (IWMI, 2009).

Peak flow: The maximum instantaneous discharge of a stream or river at a given location, usually occurring at or near the time of maximum stage (USGS, n.d.).

PODIUM model: A statistical model developed by the International Water Management Institute to determine increasing water demand in 2025 as a result of population growth and changing food demand (IWMI, 2009).

Precipitation: Natural sources of water from rain, snow, hail, sleet, dew and frost (USGS, n.d.).

Primary water diversions (PWD): The amount of first-time diversions of water from the total water supply, not including recycled water. A primary water diversion is the amount of water released upstream plus any downstream runoff to rivers diverted for the first time. Primary water is an important concept in that it provides an upper limit to the amount of water that can be depleted by various uses, but it is difficult to quantify. Primary water equals total water diversions divided by the multiplier: PWD= TWD/M (IWMI, 2009).

Project efficiency (PE): The ratio of net evapotranspiration requirements to total water diversions for a given irrigation project: PE = NET/TWD. The water not withdrawn by net evapotranspiration requirements recharges groundwater or runs off as return flows. Groundwater recharge and runoff are available for reuse in many cases (IWMI, 2009).

Recharge: Water resources added to an aquifer. For instance, rainfall that seeps into the ground (USGS, n.d.).

Recharge rate: Quantity of water per unit of time that replenishes or refills an aquifer (Eckhardt, n.d.).

Recycled water (R): Water that has already been diverted at least once upstream. The difference between total water diversions and primary water diversions is the amount of water recycled: R = TWD-PWD. Takes place, for example, by reusing drainage water or pumping groundwater (IWMI, 2009).

Riparian: An area near or on the banks of a river or other major body of water. Also referred to in the context of “upper” and “lower” riparians, which designate the country in which a certain transboundary river originates (USGS, n.d.).

Reservoir: A pond, lake, tank or basin (natural or artificial) where water is collected and stored. Large bodies of groundwater are called groundwater reservoirs; water behind a dam is called a reservoir of water (USGS, n.d.).

Return flow: See project efficiency.

River basin: The area drained by a river and its tributaries (Eckhardt, n.d.).

River discharge: The volume of water that passes a given location within a given period of time, often expressed in cubic feet per second or “cusec” (USGS, n.d.).

River flow: The rate of water discharged from a source expressed in volume with respect to time (Eckhardt, n.d.)

Runoff: Precipitation entering rivers, freshwater lakes or reservoirs (Eckhardt, n.d.).

Salinization: A process by which water-soluble salts accumulate in soil and water. Salinized soil and water is of particular concern in agriculture, as excess salts hinder the growth of crops and reducing overall water quality (USGS, n.d.).

Saturate zone: The area below the water table where water fills all open spaces (USGS, n.d.).

Sedimentation: Accumulation of materials suspended in water or recently deposited (USGS, n.d.).

Sub-basin: In general, a portion of a river basin (Eckhardt, n.d.).

Subsidence: Dropping of the land surface as a result of groundwater being pumped. Cracks and fissures can appear in the land; subsidence is virtually irreversible (USGS, n.d.).

Surface water: Water on the Earth’s surface, such as in a stream, river, lake or reservoir (USGS, n.d.).

Total recycling factor (RF): The percentage of primary water diversions that is recycled, as related to the multiplier, which is the ratio of total water diversions to primary water diversions: M=TWD/PWD. The recycling factor is defined as (M-1) x 100 percent. For example, if the multiplier is 1.5, the recycling factor is 50 percent (IWMI, 2009).

Total water diversions (TWD): The amount of water diverted from its natural courses for various uses. Typically, in water resource systems, water is recycled. Thus, total water diversions are the sum of primary water diversions and recycled water: TWD = PWD + R. As a result, total diversions are often larger than primary water supply and could be larger than potential utilizable water resources (IWMI, 2009).

Tributary: A stream that flows into another stream or body of water (Eckhardt, n.d.).

Tubewell: A tube or pipe bored into a well to remove groundwater from an aquifer (USGS, n.d.).

Water table: Level below the Earth's surface at which the ground becomes saturated with water. The surface of an unconfined aquifer that fluctuates due to seasonal precipitation (Eckhardt, n.d.)

Water productivity, evaporation: A function of how efficiently water sourced from evaporation (E) is used, on a scale from 0 to 100 percent (IWMI, 2009).

Water productivity, primary: A function of how efficiently primary water diversions are used, on a scale from 0 to 100 percent (IWMI, 2009).

Water productivity, total: A function of how efficiently total water diversions are used, on a scale from 0 to 100 percent (IWMI, 2009).

Executive Summary

Due to regional scarcity of water, India has had long-standing disputes with its South Asian neighbors over the regulation and distribution of shared water resources, particularly rivers. These disputes are intensifying, as rising demand outpaces a shrinking supply of fresh water. Population growth, urbanization, industrialization and increased reliance on irrigated agriculture have steadily increased regional demand for water. These trends are only expected to accelerate in coming decades. In addition, as climate change alters weather patterns and shrinks glaciers, the quantity of water in these river systems is expected to become increasingly erratic, leading to a higher frequency of severe floods and droughts. In the long-term, experts predict, the quantity of water in these river systems will decrease, especially in the Indus River system. The combination of these two trends—increasing demand plus decreasing supply and access—is likely to exacerbate disputes over regional water resources.

Thus far, conflicts between India and other nations have been mediated through a combination of treaties and international arbitration. As a number of rivers flow across national boundaries, these agreements govern water allocation between India and its neighbors and develop a protocol for hydrological construction projects. Foremost among these accords is the Indus Waters Treaty, which has been a successful tool for addressing water-sharing issues between India and Pakistan since 1960. However, if present demographic, economic and environmental trends continue, increased tensions between India and its neighbors may lead to conflicts that could threaten regional stability.

Despite a history of cooperation, the likelihood of conflict between India and Pakistan over shared river resources is expected to increase. Due to Pakistan's heavy reliance on the Indus system, as well as India's control and damming of many of its major tributaries, increased shortages are liable to translate into increased tensions. Disputes over water will likely undermine prospects for a more stable and sustainable peace between the two countries.

To the northeast, India is also likely to face ongoing disputes with Nepal and Bangladesh over flood control and river diversion. However, the risk of armed interstate conflict is minor. Nepal and Bangladesh remain weak politically and militarily in relation to India, and they generally possess little leverage in negotiating water issues. Of greater concern are the substantial public health consequences of these disputes. Flooding, soil salinization and destruction of arable land in the northern Indian states of Bihar and Uttar Pradesh and in Bangladesh have displaced people and disrupted economic, social and political life. Such issues raise the potential for increased local-level, interprovincial and border-area conflict. In addition, these disruptions threaten the quality of economic, social and political relationships between India and Nepal, and between India and Bangladesh.

In sum, increasing water demand and the effects of climate change are likely to lead to more serious disputes between India and its neighbors—especially Pakistan. This report begins by summarizing current conflicts between India and its neighbors Pakistan, Bangladesh and Nepal. Next, it employs available data and statistical projections to examine anticipated trends in supply and demand for water. By integrating political, economic and climactic trends, the report highlights areas of concern and outlines probable developments. Finally, the report assesses several policy measures that South Asian countries might employ to mitigate water shortages and the conflicts likely to accompany them. External assistance may play an important role in these efforts.

Introduction

Water scarcity is a serious and growing problem throughout the world, and the twin pressures of population growth and climate change will likely only intensify this problem. The United Nations estimates that “the number of people living in water-stressed countries will increase from about 700 million today to more than 3 billion by 2035” (UNESCO, 2009a). The developing world alone will be home to 90 percent of the 3 billion people expected to be added to the global population by 2025. However, the increase in the absolute number of people is not the only concern. The changes in lifestyle of those living in developing countries, where rising rates of economic development will increase demand for water as diets shift from primarily grain-based to include a greater diversity of meats and vegetables, is also an important factor. As the latest World Water Assessment Report notes, the relevant question for contemporary water issues is often not “How much water do people drink?” but rather “How much water do people eat?” (UNESCO, 2009a).

Climate change is the second major driver of pressure on water supply and access. As temperatures rise, glaciers that feed the world’s most important rivers are retreating at an accelerating rate. Rainfall patterns are becoming more extreme, with greater rainfall during the monsoon months—leading to more frequent and severe floods in vulnerable lowlands—and less rainfall in the dry season, when it is needed most. Increasing salinization[1] due to rising sea levels and intensive irrigation reduces accessibility to safe and usable water supplies. Human activities, including those relating to agriculture and industry, also exacerbate the effects of climate change. All of these factors contribute to increased volatility of water supplies and a general downward trend in the availability of freshwater resources.

Nowhere is the challenge of water scarcity more visible than in South Asia. Seventy-five percent of water used annually in India comes from international rivers, primarily the Indus and Ganges-Brahmaputra basins that India shares with Pakistan, Bangladesh and Nepal (ADB, 2007). With the largest rural population in the world—estimated at more than 1 billion in 2009—the agriculture-dependent Indian subcontinent relies heavily upon water resources for irrigation (CIA, 2009a, b, c, d). In India in 2000, for example, 86.4 percent of annual freshwater withdrawals were for agricultural use, while 8.1 percent were used domestically (UN, 2009). In South Asia, as elsewhere, water is not only important for drinking, but is essential to food and industrial production. Thus, great potential exists for increased conflict over water resources.

This report is divided into four main components. Section 1 summarizes the history and status of major water disputes between India and three of its neighbors, Pakistan, Bangladesh and Nepal (see Map 1). Section 2 forecasts trends in water

[1] Accumulation of salts in soil and fresh water.

demand by analyzing expected growth patterns in domestic, agricultural and industrial use. It also examines the probable effects of climate change on the projected water supply in each major South Asian river system. Section 3 extrapolates from current trends to forecast the likelihood, location and magnitude of conflicts about water in South Asia. Finally, Section 4 presents an opportunity analysis, in which strategies to mitigate potential conflict are discussed.

Map 1. South Asia

Source: United Nations Cartographic Section (2009b)

Section 1:
History and Status of Water Disputes in South Asia

Any projection of the development of water disputes in South Asia is necessarily based upon an understanding of the history and status of these disputes. Geographical and political background provides the context for conflicts, while a history of dispute resolution provides a strong indication of how future disagreements may be resolved. In addition, specific rivers and dam projects are likely to remain contentious issues well into the future. When incorporated with supply and demand projections and expected political developments, this information provides the context for estimates of the likelihood of regional conflicts over water. For a summary of major disputes in South Asia, please see Appendix A.

I. India and Pakistan

India and Pakistan have been at odds since the partition of British India in 1947. Disputes over water only serve to compound existing tensions between these regional rivals, who continue to contest control of the Jammu and Kashmir region. The map of Pakistan illustrates the geographical ambiguity inherent in the Indo-Pakistani borders. Indeed, limited freshwater resources, which are critical to irrigated agriculture and industrial development, remain an ongoing area of conflict between India and Pakistan. While a longstanding treaty has governed their shared river resources, India and Pakistan continue to feud over interpretation of the agreement, with dam projects often serving as a flashpoint for tensions.

A. History of Disputes between India and Pakistan

Following independence from Britain in 1947, India was subdivided into the separate nation states of India and Pakistan. During this partition, borders were drawn with little consideration to water resources. In particular, the borders near the Indus and its major tributaries—the Beas, Chenab, Jhelum, Ravi and Sutlej, all of which flow from India into Pakistan—were drawn without considering the conflict that such political boundaries might provoke. This division led to a number of disputes in which India, which is entirely upstream from Pakistan, attempted to restrict or alter flows, to the detriment of Pakistani quality of life. For example, subsequent to a bilateral dispute in 1948, India suspended the flow of the Sutlej River into Pakistan, severely harming Pakistani agriculture (Sahni, 2006). Hostilities between India and Pakistan continued to grow over the next decade as each vied for control of common water resources.

Map 2. Pakistan

Source: United Nations Cartographic Section (2009d)

In 1960, India and Pakistan negotiated a settlement to the dispute under the auspices of the World Bank. The Indus Water Treaty divided the six major rivers of the Indus River system between the two nations. India was allocated complete ownership—or exclusive usage rights—to the three eastern rivers: the Sutlej, the Beas and the Ravi, while Pakistan was allocated nearly unfettered ownership to the three western rivers: the Indus, the Jhelum and the Chenab (Wirsing &

Jasparro, 2007). Although each nation was awarded ownership of three rivers, both are allowed, under certain, narrowly defined circumstances, to use one another's river resources. For example, India, the upper riparian state, is allowed under the Indus Water Treaty restrictive use of the Indus, Jhelum and Chenab for agriculture, hydrogeneration and other purposes that do not store or divert water destined for Pakistan. In practice, Pakistan has little to gain from this provision, as no major rivers originate within its political borders (Sahai, 2007).

As co-signer of the treaty, the World Bank continues to serve a procedural role in settling differences and disputes. The World Bank also serves as a legal recourse to both nations with respect to the Indus Water Treaty. Should either nation violate the terms of the treaty, through fault of interpretation or application, the matter is first brought to the Permanent Indus Commission, after which it is brought to a World Bank-appointed neutral arbitrator. Upon receiving the neutral arbitrator's ruling, the nations could seek reference to a court of arbitration or appeal to the International Court of Justice at the Hague, under Article IX (paragraphs 3 through 5) of the treaty (Salman, 2008).

While the Indus Water Treaty created a legal framework for governing water resources, it failed to mitigate several important areas of tension. Specifically, three key points of the treaty have contributed to subsequent disputes. First, Pakistan is wholly dependent upon the Indus River system for its freshwater supply. While dwindling groundwater provides for some of Pakistan's needs, the Indus and its tributaries represent the only source of surface waters for the entire country, including its prominent agricultural sector. Second, the headwaters of all six rivers are within Indian territory, and, accordingly, the Indian government can significantly limit the flow of water into Pakistan. Third, while India is not permitted to build projects on the Indus, Jhelum or Chenab rivers to divert or store water flowing to Pakistan, many of India's current or proposed dam projects do both. To compound matters, the Indus, Jhelum, and Chenab all flow through the volatile region of Jammu and Kashmir, where India and Pakistan have engaged in sporadic fighting during a decades-long territorial dispute. Together, these elements provide a basis for several major disputes as India and Pakistan seek to meet growing domestic water demand.

B. Current Disputes between India and Pakistan

The discrepancy between political borders and the natural course of rivers, coupled with the structure of the Indus Water Treaty, creates multiple areas of potential conflict between India and Pakistan. The greatest issue under dispute is India's construction of dams and other projects that divert water that would otherwise reach Pakistan. The most important current disputes involve the Baglihar Dam, the Tulbul Navigation/Wular Barrage, the Kishenganga Dam and Indian retention of water from the Beas, Ravi and Sutlej rivers. In most cases, Pakistan believes it has been the victim of Indian strong-arm tactics.

1. The Baglihar Dam

Under dispute since 1992, the Baglihar Dam on the Chenab River is nearing completion in 2009. The river runs from India directly through the disputed territory of Jammu and Kashmir and then into Pakistan. The project entails a 144.5-meter concrete gravity dam with a 450-megawatt hydroelectric plant, with potential to expand to 900 megawatts. The project also includes substantial storage capacity and gated spillways that would allow for flood-control and reduction of sedimentation for the greater region. However, Pakistan has opposed the hydroelectric plant's construction, arguing that its design violates the Indus Water Treaty because of its potential to store or divert waters destined for Pakistan (Sahai, 2007).

Formal talks between the two nations began in 2000 to address India's resolve to move forward with the Baglihar hydroelectric plant. Though senior government officials and even both heads of state met regarding the topic, no agreement was reached. On January 15, 2005, Pakistan appealed to the World Bank to name a neutral arbitrator who would formally rule on the compliance of India's design with the Indus Water Treaty.

Dr. Raymond Lafitte of the Federal Institute of Technology at Lausanne, Switzerland, was appointed by the World Bank and confirmed by India and Pakistan in May 2005 as the neutral arbitrator. Lafitte was charged with hosting several rounds of talks with the two nations, as well as visiting the project in the presence of representatives from both countries. On February 12, 2007, Lafitte recommended the reduction of the planned storage from 37.5 million cubic meters to 32.45 million cubic meters, the reduction of the free board[2] from 3 meters to 1.5 meters, and the increase of the water intake by 3 meters. Lafitte also found the gated spillways to be in compliance with the Indus Water Treaty, international practice and state-of-the-art technology (Sahai, 2007).

As Salman M.A. Salman (2008), lead counsel to the World Bank, notes, Pakistan "seemed to have viewed the difference as largely a legal one, involving the interpretation of the Treaty, while India seemed to have viewed it mainly as an engineering one, regarding hydropower plants." Though Lafitte ruled favorably toward India on three of the four main criteria, both nations claimed victory. Each emphasized points of the ruling that favored their respective initial positions. Both countries have accepted the ruling, and India continued construction. However, Robert Wirsing (2007) of the U.S. Department of Defense Asia-Pacific Center for Security Studies notes that "Lafitte's call for conspicuously modest alterations to the dam's design, and his insistence on assigning more importance to the dam's efficient and cost-effective operation (the heart of the Indian argument) than to its strict adherence to the [Indus Water Treaty's] detailed, albeit ambiguous provisions aimed at restricting New Delhi's ability to control the river's flow (of utmost concern to Pakistanis) seemed more likely to fuel existing tensions over the future of the Indus's waters."

[2] The height of the watertight portion of the dam.

Pakistan's options with respect to Baglihar may include (1) seeking continued access from India to the project site to monitor progress and assess compliance and (2) taking the issue of the gated spillways to the World Bank's court of arbitration (Sahai, 2007). Pursuing the latter course may imply a belief by Pakistani officials that Lafitte was not qualified to issue a ruling. Neither of these actions had been attempted as of May 2009.

2. Tulbul Navigation/Wular Barrage

Dating to the 1980s, the dispute regarding the Tulbul Navigation/Wular Barrage remains unresolved. India's construction of a barrier along the Jhelum River aims to improve water flow and, thus, navigation of a 20-kilometer stretch between Sopore and Baramulla. Though construction began in 1984, it was halted in 1987 due to Pakistani opposition. Pakistan argues (1) that the project violates the Indus Water Treaty's provision restraining India from constructing storage (except in limited amounts for the purpose of flood control), (2) that the barrier would change the volume of daily water flow, and (3) that the barrier would harm Pakistan's three-canal system downstream. In turn, India points out that (1) the project is not meant for storage, (2) that the project will regulate the flow of the river, and (3) that the project will benefit both nations (Sahai, 2007). By halting the project, the Indian government implicitly acknowledged the shortcomings of its arguments. Construction has not yet resumed, though in late 2008, India renewed efforts to renegotiate (Bhaskar, 2008).

3. Kishenganga Dam

The dispute over the proposed Kishenganga Dam also remains unresolved. Under the plan, India seeks to build a 330-megawatt hydroelectric plant on the Jhelum River in the Jammu and Kashmir region. As with the Baglihar and Tulbul project, Pakistan claims the project violates the Indus Water Treaty because of its downstream effects. Pakistani officials and environmentalists also argue that this project may "submerge vast tracts of land in the Gurez area and displace local residents" (Sahai, 2007). Though India has agreed to review the portions of the project to which Pakistan objects and both sides have gone through several rounds of negotiations, no resolution has been found. As of March 2009, the Pakistan Commission of Indus Water notified India that it would request a World Bank neutral arbitrator to resolve the conflict (Mustafa, 2009).

Pakistan, meanwhile, is planning construction of the Neelhum-Jhelum Dam along the same river. Like India's project, this endeavor would involve building a hydroelectric plant on Pakistan's side of the Jammu and Kashmir border (Mirani, 2009).

4. Indian Retention of Water from the Beas, Ravi and Sutlej Rivers

Under the Indus Water Treaty, India holds exclusive rights to the Beas, Ravi and Sutlej rivers, which provide approximately 20 percent of the flow to the Indus River (Alam, 2002). However, India diverts most of this water into canal and navigation systems on its side of the border (Pakistan Bureau of Statistics, 2002).

As a result, little water from these three rivers reaches Pakistan. For the Ravi River, the water that does reach Pakistan is so polluted that the World Wildlife Fund–Pakistan (2009) calls the Ravi River a "large open sewer." In fact, the raw sewage output of the city of Lahore into the Ravi approximately equals the flow of the river at that location (Roberts, 2005). While in compliance with the Indus Water Treaty, this severely limited and highly polluted flow of water from the eastern tributaries aggravates Indo-Pakistani disputes over the western tributaries.

II. India and Bangladesh

India shares 54 transboundary rivers with Bangladesh, including the major rivers of the Ganges,[3] Brahmaputra and Meghna, making water management a major issue between the two nations. The map of Bangladesh provides a picture of the country's river networks. The Ganges flows from the Himalayas, joins with the Brahmaputra at the Jamma channel and unites with the Meghna near the Bay of Bengal. Numerous other tributaries crisscross Bangladesh. Ninety-three percent of the Ganges River system flows through Bangladesh, discharging approximately 1,360 billion cubic meters of water into the Indian Ocean each year (Shamim, 2008). Bangladesh's low elevation makes it vulnerable to flooding during the monsoon season, though Bangladesh is also prone to drought during the "lean period" of January through May. Management of common river resources is especially critical for Bangladesh (Ahmed & Roy, 2007).

A. History of Water Disputes between India and Bangladesh

Negotiations over the Ganges began in 1951 between India and Pakistan, which then controlled Bangladesh, as a result of India's proposal to build the Farraka Barrage in West Bengal. Ten meetings regarding the barrage were held between 1960 and 1970. During this time the two nations collected and exchanged a substantial amount of data. In 1970, Indian and Pakistani representatives agreed to establish a committee on water delivery and decided that Farraka would remain the point of entry for water distribution into east Pakistan (Wirsing & Jasparro, 2007).

[3] The Ganges River is known as the Padma River in Bangladesh.

Map 3. Bangladesh

Source: United Nations Cartographic Section (2009a)

Following Bangladeshi independence from Pakistan in 1971, the Indo-Bangladesh Joint Rivers Commission was formed. The commission's purpose is to address the sharing of interstate river systems between the two countries and monitor all consequent agreements on the Ganges River. Meeting on a biannual basis, the Joint Rivers Commission serves as a forum for discussion and negotiation of water issues (Wirsing & Jasparro, 2007). India and Bangladesh signed the Treaty of Friendship, Cooperation and Peace in 1972 to promote goodwill and support for common ideals. In addition to other goals, the treaty supported joint action in managing shared water resources and remained in force until its expiration in 1997 (Salman & Uprety, 2002). The Joint Rivers Commission has been involved in three short-term agreements: the Ganges Waters Agreement in 1977; a joint communiqué issued in 1982 that initiated new negotiations; and the Indo-Bangladesh Memorandum of Understanding of 1985, which created the Joint Committee of Experts in 1997 to address development issues (Wolf & Newton, 2007). The memorandum lapsed in 1988, with no further agreements until the 1996 Ganges River Treaty, which is discussed in more depth in the next section.

B. Current Disputes between India and Bangladesh

The many rivers crossing the India-Bangladesh border provide the basis for a series of ongoing disputes between the two countries, particularly India's efforts to divert water destined for Bangladesh. Disputes include disagreements over the Farraka Barrage, the Teesta River project and the River Linking Project to connect the Ganges and Brahmaputra rivers in the east to the Kaberi and Mahanada rivers in the south. These disputes have historically been resolved through careful diplomacy, though Bangladesh often believes its more powerful neighbor treats it unfairly (Hossain, 1998).

1. The Farraka Barrage

The distribution of Ganges water during Bangladesh's lean months has historically been a contentious issue between India and Bangladesh. The Farraka Barrage is the most important concern to Bangladesh. It diverts water through the Bhagirati-Hoogli river system in an effort to flush sediment from India's port city of Kolkata. Bangladesh argues that the Farraka Barrage harms the agro-ecological and economic well-being of southern Bangladesh (Ahmed & Roy, 2007).
At present, the downstream effects of the Farraka Barrage include harm to fisheries, lower quantities of fresh water for domestic and agricultural uses during the dry season, reduced navigability of the Ganges and damage to the Sundarban's mangrove ecosystem (Wirsing & Jasparro, 2007).

Bilateral treaties provide a structure for resolving these points of discord. On December 12, 1996, Bangladesh and India signed the Ganges River Treaty, which regulates the seasonal allocation of waters reaching Farraka (Wirsing & Jasparro, 2007). Specifically, the treaty outlines the distribution of Ganges River waters during the lean period. It schedules division of water according to 10-day average availability of water at Farraka. The allocation formula is based on a 40-year average, taken between 1949 and 1988, and provides each country with an equal share of water when Ganges flow is less than 70,000 cusecs, or cubic feet per second.[4] When flow is between 70,000 and 75,000 cusecs, Bangladesh receives 35,000 cusecs and India receives the remaining balance. When Ganges River flow at Farraka exceeds 75,000 cusecs, India receives 40,000 cusecs and Bangladesh receives the remaining balance of the flows (Government of Bangladesh, 1996).

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[4] A cusec is a measure of water flow. One cusec is equivalent to 450 gallons per minute.

The Joint Committee of Experts is staffed by the secretaries of water resources for each country and is charged by Article IX of the 1996 Ganges Treaty with negotiating agreements on common rivers between India and Bangladesh. Since its inception, the committee has met seven times and made little progress in resolving these disputes. However, the committee could provide a framework for resolving other conflicts about water in the region.

2. The Teesta River

The Teesta River is another source of conflict between India and Bangladesh. In the late 1980s, India constructed the Gazoldoba Barrage 60 kilometers north of the Bangladesh border to divert water toward irrigation projects in northern West Bengal. In 1998, Bangladesh constructed the Teesta Barrage 20 kilometers south of the Indian border. Bangladesh has raised concerns about the distribution of the Teesta's waters. In particular, Bangladesh contends that India is increasingly diverting more water to Gazoldoba at the expense of Bangladeshis downstream (Wirsing & Jasparro, 2007).

3. The River Linking Project

India and Bangladesh are in the early stages of a dispute over the proposed India River Linking Project. Announced in 2002, the project would link water from the northern section of the Ganges and Brahmaputra rivers in the east to the Kaberi and Mahanada rivers in the south, ultimately joining their flow to the Beas River in western India (Hossain, 1998). Eventually, the Brahmaputra and Teesta would be connected and would carry water as far as the Farraka Barrage on the Ganges. The project would necessitate linking 30 canals totaling about 10,000 kilometers and constructing 33 dams. By any measure, the River Linking Project is a massive undertaking in water transfer.

Bangladesh opposes the proposal. Bangladeshi officials state that it would lead to flooding in Bangladesh and intensify the country's dry season. The country further argues that the project violates the International Law Association's 1966 Helsinki Rules on the Uses of Waters of International Rivers (superseded by the 2004 Berlin Rules on Water Resources), which provided a framework for the United Nations Convention on the Law of International Watercourses of 1997 (Dellapenna & Gupta, 2008).[5]

[5] The Helsinki/Berlin rules and the UN convention all address the "equitable and reasonable" distribution of international waters and include provisions mandating that countries sharing rivers have an "obligation not to cause significant harm" and a "general obligation to cooperate" (UN General Assembly, 1997).

III. India and Nepal

In contrast to Bangladesh and Pakistan, Nepal is the upper riparian for four major rivers flowing into India, as Map 4 illustrates. While constituting only 4 percent of the Ganges basin area, Nepal's four major rivers (Mahakali, Karnali, Gandak and Kosi) and five minor tributaries (Babai, West Rapti, Bagmati, Kamala and Kankai) constitute 47 percent of the overall flow in the Ganges basin and 71 percent of its glacial-fed flow (Dixit et al., 2004). These tributaries provide much-needed water to the two northern Indian states of Bihar and Uttar Pradesh during the dry season and cause extensive flooding during the monsoon season. Regulation of these shared waters has therefore been an important issue for India and Nepal for more than 60 years.

Map 4. Nepal

Source: United Nations Cartographic Section (2009c).

A. History of Water Disputes between India and Nepal

India and Nepal have signed several treaties governing their shared rivers. The 1954 Kosi Agreement and 1959 Gandak Agreement primarily established schemes of diverting water for irrigation. Because the majority of the benefits of these treaties accrue to India, later revisions granted Nepal the exclusive right to withdraw water for irrigation or any other purpose as needed. In 1996, the two governments signed a treaty regarding the waters of the Mahakali River, which provided for the building of the Sarrada and Tanakpur barrages and the creation of the Pancheshwar project, a 315-meter multipurpose dam. Much of the work on these projects is not complete, so the full implications of their construction remain unknown. However, like the Kosi and Gandak agreements, the Mahakali treaty primarily benefits India. In this context, many Nepalis complain of being "cheated" by their more powerful southern neighbor (Dixit et al., 2004).

B. Current Disputes between India and Nepal

Unlike India's situation with Pakistan and Bangladesh, Nepal controls the headwaters of the rivers flowing into India. Nepal's *lack* of diversion or storage capacity is at the root of conflict with India. Disputes about Indian and Nepali water resources relate primarily to flood control and potential dam projects.

1. Flood Control

Leaders in Bihar and Uttar Pradesh frequently accuse Nepal of "releasing waters" from barrages, actions that allegedly lead to devastating floods in the two states. However, these claims are unfounded as Nepal has no barrages and, therefore, no place from which waters could be released. Instead, increased melting of Nepal's Himalayan glaciers may be to blame for the general rise in seasonal flooding as larger quantities of water enter Nepal's rivers each year. In particular, a glacial lake outburst flood triggered by global warming can contribute to sudden floods. These floods occur when glacial rock debris can no longer retain glacial meltwater. The result is a sudden, catastrophic flood similar to a dam bursting. Glacial lake outburst floods can be expected to increase as glacial retreat accelerates (Yamada & Sharma, 1993).

Ajaya Dixit, Pradeep Adhikari and Rakshya Rajyashwori Thapa (2004) argue that such misperceptions obscure the true causes of water problems in the region and fundamentally undermine constructive solutions. They note that a lack of data and a heavy focus on macro- rather than micro-level problems have led to an unsustainable system of treaties, agreements and projects that speed the degradation of South Asia's water resources.

2. Future Dam Projects

Though unexploited, a tremendous potential for hydropower development exists in Nepal. The capacity of Nepal's hydropower stations is 250 megawatts, a mere 0.3 percent of the country's estimated 83,280 megawatt potential (Pokharel, 2001). Many of Nepal's recent leaders have viewed this enormous potential for hydropower as the key to development in the country. However, the expansion of hydropower faces serious cost and political constraints. With increasing demands on water and electricity, the expansion of hydropower in Nepal could have serious implications for relations with India, especially its provinces of Bihar and Uttar Pradesh. (See Section 4 for more details on Nepal's hydropower potential.)

Section 2:
Projections of Water Supply and Demand in South Asia

Projecting supply and demand of water and its implicit price is arguably one of the best indicators for how disputes about water resources in South Asia will develop. Reasonably accurate supply and demand projections indicate the relative value that the countries of South Asia are likely to place on water in the coming decades, whether from shared rivers or other sources. Calculating such estimates requires a combined analysis of domestic, agricultural and industrial demand parameters; likely river flows under climate change; and an understanding of population growth, agriculture and water pricing and management in the region. Combining these elements allows for rough prediction of which countries likely will face water shortages and the likely severity of these shortages. While these projections are based on models and subject to error, they are drawn from the best available information on the subject.

I. Methodology

Water demand and supply in India and Pakistan can be forecast with a quantitative model known as PODIUM produced by the United Nations, the International Water Management Institute and the International Food Policy Research Institute. Based on world water demand and supply data from as far back as 1990 and projections to 2025, the online PODIUM tool lets users segregate variables so they can concentrate on specific aspects of a sample nation's economy and thus create their own variations on the base model. PODIUM's variables include population growth, rainfall, irrigated grain production and local consumption patterns. We use PODIUM to modify assumptions and to project country-specific water demand and supply in 2025. We craft predictions of socio-economic changes based on data the U.N. Food and Agriculture Organization (FAO) collected from 1985 to 1995. Data for cereal crops and population growth are drawn from the FAO and the World Bank, respectively. Using a base year of 1995, we use PODIUM, U.N. and World Bank data to make our predictions about whether India and Pakistan will have enough water to sustain their people. Not enough data are available to make similar projections for Nepal and Bangladesh.

PODIUM projects water demand and supply in three steps: (1) selection of national cereal crop requirements, (2) estimation of cereal production and (3) conversion of predicted grain production into agricultural demand, compared to available renewable water resources (IWMI, 2009). Since PODIUM assesses cereal crops, it is an ideal tool for projecting water demand and supply in South Asian countries whose peoples primarily depend on a diet of grains. Moreover, the heavy reliance on irrigated agriculture in South Asia makes agricultural estimates indispensable in any water demand and supply projection. For more information on our statistical projection methodology, please see Appendix B.

We also contrast our findings with PODIUM to the projections researcher Bharat R. Sharma and his co-authors (2008) derived with the widely used Falkenmark Water Stress Index. This measure sets a threshold of 1,000 cubic meters of water per year per capita as the Falkenmark Water Scarcity Standard. A nation that cannot meet this standard is said to be "water scarce," per the Falkenmark Index. Sharma et al. provide an alternative view of projected water shortages in South Asia and are summarized along with our final PODIUM-driven estimates at the end of Part II.

Estimating the current and future supply and demand for water resources in South Asia is the best method for projecting where disputes about water may occur. However, our estimates are subject to several limitations.

First, due to poor data collection capabilities in many regions, many of the data needed to produce the most accurate estimates are unavailable or incomplete. As a result of limited resources, data are often fragmented, poorly collected or not collected at all. For example, India has not published a substantial reevaluation of its water supplies in decades. More seriously, Bangladesh and Nepal lack sufficient baseline data to conduct a true PODIUM analysis, meaning that a more qualitatively focused analysis is necessary. This qualitative approach requires the use of information that may be imperfect or incomplete.

Second, the rate and precise effects of climate change remain the subject of considerable debate. Some of this variation is evident in the estimates of river volume. However, the sheer complexity of environmental effects from climate change impedes accurate estimates of change. For example, no one is certain how much increased monsoon rains will offset reduced glacial flows in India. Researchers and governments share this ongoing problem of uncertainty.

Third, as a general matter, all projections are subject to uncertainty. Projections are based upon mathematical models that incorporate numerous assumptions. Some estimates, such as population growth, can be modeled with relative ease. Other estimates, such as agricultural water usage, depend on many factors. Thus even where the base information is reliable, estimates are subject to error.

These unavoidable limitations and uncertainties must be kept in mind when interpreting projections. In particular, these limitations severely hamper any effort to accurately forecast demand for Bangladesh and Nepal. Nonetheless, the available data do indicate specific problem areas and likely time frames for water shortages in the region, which allows for some prediction of where water disputes are likely to occur.

II. Demand for Water: Growing Needs and Poor System Management

Demand for water resources in South Asia has increased significantly during the past 10 years. Population growth has been a primary force driving higher levels of regional water demand. Changes in agriculture throughout the subcontinent have affected water demand in past decades and will continue to be a major component of demand. In addition, ineffective water pricing schemes and inadequate management of irrigation systems continue to complicate South Asian governments' responses to increasing water demand, most of which is overwhelmingly from the agricultural sector (UN, 2003). Regional demand for water resources is likely to grow significantly in tandem with growth in population and development. An understanding of regional growth trends related to water demand is therefore crucial in predicting the relative importance that South Asian nations will place on shared river resources. We examine the agricultural, domestic and industrial demand for water, and then we explore water pricing and the management of water systems in South Asia.

A. Agricultural Water Use

Agriculture constitutes 90 percent of all water use in South Asia, making it by far the most significant sector for water demand. Agriculture is also the most important economic activity and largest employer in the region. Approximately 68 percent of India's workforce rely on farming, though agricultural contributions accounted for 19 percent of total gross domestic product in 2007 (Agoramoorthy & Hsu, 2008). According to the World Bank (2008), agriculture accounts for one-quarter of Pakistan's gross domestic product, two-thirds of its employment and 80 percent of its exports. Similar estimates exist for Bangladesh and Nepal. At the same time, the availability of clean groundwater, an essential input for rural farmers and an important source of potable water, is declining throughout the region. A majority of Indian residents, for example, suffer from water shortages, due in large part to uneven availability (Agoramoorthy & Hsu, 2008). A number of important South Asian agricultural indicators are included in Table 1.

Table 1. South Asian Agricultural Indicators				
	India	Pakistan	Bangladesh	Nepal
Irrigated land area, in square kilometers	558,000	182,300	47,250	11,700
Water use for agriculture in 2000	87%	96%	96%	96%
Estimated cropping intensity of irrigated area in 2000 (per 1,000 hectares)	109-130%	115%	171%	108%
Irrigation water withdrawals for agriculture in 2000, in cubic kilometers	558.39	162.65	76.35	9.82
Approximate percentage of surface water used as share of total irrigation	65% (in 1985)	63% (in 1990)	31% (in 1990)	74% (in 1994)
Main crops, ranked by annual production of each in 2005, in metric tons	1) sugar cane: 232,320,000 2) rice, paddy: 129,000,000 3) wheat: 72,000,000	1) sugar cane: 47,244,100 2) wheat: 21,591,400 3) rice, paddy: 7,351,000	1) rice, paddy: 40,054,000 2) sugar cane: 6,500,000 3) potatoes: 3,908,000	1) rice, paddy: 4,100,000 2) sugar cane: 2,376,103 3) potatoes: 1,738,840

Sources: UN (1996); UN (1997a,b); UN (1999a,b); UN (2004a,b,c,d); UN 2005a,b,c,d); UN (2009); CIA (2009a,b,c,d)

Agricultural trends in South Asia contribute heavily to increased water demand. South Asia's staple food crops are wheat and rice, both of which are relatively water-intensive. These two crops occupy nearly 13.5 million hectares[6] of the Indo-Gangetic plains of India, Pakistan, Bangladesh and Nepal (Gupta & Seth, 2006). Other important South Asian crops include sugar cane and potatoes. Declining cereal prices in 2008-09 have increased pressure on farmers to diversify their crops. However, capital, labor and soil conditions limit farmers' ability to do so. Crop diversification, therefore, implies a high level of risk and depends upon how strongly demand and consumption patterns will respond to alternative crops (Barker & Molle, 2004).

The commercialization of cereal crops known as the "Green Revolution" has significantly boosted South Asian agricultural productivity over the past 40 years, particularly with respect to wheat and rice. An estimated 80 percent of grain production in South Asia between 1988 and 2010 is attributed to increased yields, with approximately 5 percent due to increases in arable land and 15 percent to cropping intensity. Use of fertilizers, pesticides and irrigation has risen during this

[6] Approximately 33.4 million acres.

period, resulting in more toxic runoff and overdrawn water tables. Inefficient management of water resources has led to the saturation of surface soil with water and salinization, which degraded cropland (UN, n.d.). Though the recently formed South Asian Rice-Wheat Consortium has promoted better management of water resources, including encouraging zero-till growing methods that use less water, overall progress has been slow (Gupta & Seth, 2006).

The use of wells and groundwater for agriculture has increased in recent years, leading to overexploitation of groundwater resources. A rise in the use of tube-wells and pumps has allowed farmers unlimited access to water, leading to low irrigation efficiency. As surface and groundwater hydrological systems are inter-dependent, the tapping of shallow and deep aquifers by wells and pumps has compromised the rate at which groundwater replenishes regional river basins. Salinity intrusion, land subsidence, soil saturation and declining water levels have contributed to a reduction in water quality. These issues are less severe in monsoonal areas, as rainfall consistently replenishes aquifers, but the reliability and delivery of surface water resources is still reduced. Tables 2 and 3 highlight the regional dependence on cereal crops and emphasize the high level of surface waters utilized for irrigation purposes.

Table 2. India: Agricultural Water Requirements

	1995	2025	Average Annual Growth (%), 1995-2025	Total Change (%), 1995-2025
Primary water diversions, in cubic kilometers	495.58	601.99	0.65	21.47
Total water diversions, in cubic kilometers	589.74	716.37	0.65	21.47
Groundwater diversions, in cubic kilometers	324.35	394.00	0.65	21.47
Evaporation, in cubic kilometers	272.46	354.39	0.88	30.07
Flows to sinks	45.02	41.13	-0.30	-8.64
Total recycling factor	0.19	0.19	0.00	0.00
Evaporative factor	54.98	58.87	0.23	7.08
Water productivity, total, in kilograms per cubic meter	0.21	0.29	1.08	38.10
Water productivity, primary, in kilograms per cubic meter	0.25	0.35	1.13	40.00
Water productivity, evaporation, in kilograms per cubic meter	0.33	1.46	5.08	342.42

Source: Authors' calculations using PODIUM
The glossary contains definitions of these terms and the calculations used to determine them.

Table 3. Pakistan: Agricultural Water Requirements				
	1995	2025	Average Annual Growth (%), 1995-2025	Total Change (%), 1995-2025
Primary water diversions, in cubic kilometers	188.75	190.27	0.03	0.81
Total water diversions, in cubic kilometers	188.75	190.27	0.03	0.81
Groundwater diversions, in cubic kilometers	47.19	47.57	0.03	0.81
Evaporation, in cubic kilometers	116.25	130.94	0.40	12.64
Flows to sinks	38.41	31.18	-0.69	-18.82
Total recycling factor	0	0	0	0
Evaporative factor	61.59	68.82	0.37	11.74
Water productivity, total, in kilograms per cubic meter	0.12	0.19	1.54	58.33
Water productivity, primary, in kilograms per cubic meter	0.12	0.19	1.54	58.33
Water productivity, evaporation, in kilograms per cubic meter	0.34	1.09	3.96	220.59

Source: Authors' calculations using IWMI's PODIUM
The glossary contains definitions of these terms and the calculations used to determine them.

While relatively little information is available on Bangladesh or Nepal's use of water for agricultural purposes, the general trend toward high levels of irrigation usage appears to hold for these countries as well. For example, development sources indicate that Nepal's 2001 annual water withdrawals totaled 18.5 cubic kilometers and averaged 800 cubic meters per capita. Most of the increase in total withdrawal that occurred between 1995 and 2001 was due to increased agricultural usage, which accounts for roughly 96 percent of water withdrawals in Nepal (ADB & International Center for Mountain Development, 2006). Agricultural demand accounts for 9.82 cubic meters of total freshwater consumption and industrial demand 0.06 billion cubic meters per year (UN, 2004c). Specific agriculture data for Bangladesh are limited, though agricultural uses make up the largest share of water demand in Bangladesh (UN, 1999a). As such, we infer a similar upward adjustment of Bangladesh's water demand due to agriculture.

B. Domestic Water Use

The nations of South Asia make up nearly one-quarter of the world's population, a proportion expected to increase. In 2009, the four countries examined here had a total population of more than 1.5 billion people. The growth rates for Bangladesh and Pakistan are higher while Nepal's is similar. By 2025, these countries' total population is projected to reach more than 1.7 billion, as shown in Table 4.

Table 4. South Asian Population Projections, in thousands						
	2005	2010	2015	2020	2025	Increase, 2005-25
India	1,094,583	1,164,837	1,233,228	1,297,133	1,353,360	23.64%
Pakistan	155,772	172,989	191,876	211,011	228,974	46.99%
Bangladesh	153,281	166,574	179,995	193,129	205,689	34.19%
Nepal	27,094	29,554	32,178	34,898	37,554	38.61%

Source: World Bank (2009b)

Yet while the populations of all South Asian countries continue to rise, human development indicators remain among some of the lowest in the world. Table 5 outlines major South Asian measures of human development.

Table 5. Selected Human Development Indicators for South Asia, 2000-2007				
	India	Pakistan	Bangladesh	Nepal
Infant mortality, deaths per 1,000 births	30.15	65.14	59.02	47.46
Life expectancy at birth, years	64	65	64	63
Male literacy	73.4%	63.0%	53.9%	62.7%
Female literacy	47.8%	36.0%	31.8%	34.9%
Education expenditures as percentage of gross domestic product (GDP)	3.2%	2.6%	2.7%	3.4%
Unemployment rate	6.8%	7.4%	2.5%	46.0%
Percentage of population with access to improved water source	89.0%	90.0%	80.0%	89.0%
Percentage of urban population with access to improved sanitation facilities	52.0%	90.0%	48.0%	45.0%
Paved roads as percentage of total roads	47.0%	56.0%	10.0%	31.0%
Agriculture, value added (as percentage of GDP)	18.0%	20.0%	19.0%	34.0%
Industry, value added (as percentage of GDP)	29.0%	27.0%	29.0%	17.0%
Services, etc., value added (as percentage of GDP)	53.0%	54.0%	53.0%	49.0%
Number of internet users per 100 people	17.8	10.8	0.3	1.2

Sources: CIA (2009a,b,c,d) and World Bank (2009a)

India’s demand for water will increase as its population rises, as Table 6 shows. For example, we predict that in total, per-capita primary water diversions will increase from 12.46 cubic meters per year to 30.78 cubic meters per year. Population trends in Pakistan indicate similar growth (see Table 7).

Table 6. India: Domestic Water Use			
	1995	2025	Average Annual Growth (%), 1995-2025
Population, in millions	933.66	1,273.07	1.04
Per-capita water diversions, in cubic meters	12.46	30.78	3.06
Percentage of total domestic water recycling	1.06	1.48	1.12
Evaporative factor	20%	20%	0
Total water diversions, in cubic kilometers	11.63	39.19	4.13
Primary water diversions, in cubic kilometers	5.65	15.80	3.49
Evaporation, in cubic kilometers	2.33	7.84	4.13

Source: Authors' calculations using IWMI's PODIUM
The glossary contains definitions of these terms and the calculations used to determine them.

Table 7. Pakistan: Domestic Water Use			
	1995	2025	Average Annual Growth (%), 1995-2025
Population, in millions	122.0	215.5	1.91
Per-capita water diversions, in cubic meters	22.8	32.51	1.19
Percentage of total domestic water recycling	0	0	0
Evaporative factor	70	70	0
Total water diversions, in cubic kilometers	2.78	7.01	3.13
Primary water diversions in cubic kilometers	2.78	7.01	3.13
Evaporation, in cubic kilometers	1.95	4.91	3.13

Source: Authors' calculations using IWMI's PODIUM
The glossary contains definitions of these terms and the calculations used to determine them.

C. Industrial Water Use

Industrial water use is the least significant source of water demand in South Asia, when compared to the sizable quantities consumers and irrigated agriculture demand, as Tables 8 and 9 show. However, increased development in South Asia is expected to raise industrial demand for water significantly. No data are available for the industrial sectors of Bangladesh and Nepal, though this demand is likely negligible in both countries.

Table 8. India: Industrial Water Use

	1995	2025	Average Annual Growth (%), 1995-2025
Per-capita water diversions, cubic meters	16.61	55.13	4.08
Recycling factor	1.06	1.48	1.12
Evaporative factor	10	10	0
Total water diversions, in cubic kilometers	15.51	70.18	5.16
Primary water diversions, in cubic kilometers	7.53	28.30	4.51
Evaporation, in cubic kilometers	1.55	7.02	5.16

Source: Authors' calculations using IWMI's PODIUM
The glossary contains definitions of these terms and the calculations used to determine them.

Table 9. Pakistan: Industrial Water Use

	1995	2025	Average Annual Growth (%), 1995-2025
Per-capita water diversions, cubic meters	22.80	38.25	1.74
Recycling factor	0	0	0
Evaporative factor	70	70	0
Total water diversions, in cubic kilometers	2.78	8.24	3.69
Primary water diversions	2.78	8.24	3.69
Evaporation, in cubic kilometers	1.95	5.77	3.68

Source: Authors' calculations using IWMI's PODIUM
The glossary contains definitions of these terms and the calculations used to determine them.

D. Water Pricing

South Asia poses a unique water pricing challenge. Unlike many other parts of the world where there have been large investments in building public water provision systems, South Asia's water infrastructure is severely underdeveloped. As a result, water provision has increasingly become the purview of private companies. Consequently, water provision is inconsistent and highly dependent on factors such as the price of fuel for pumping. In some areas water may be dramatically underpriced, while in others it may be available only through expensive groundwater pumping by individual farmers. Shah et al. (2008) note that inadequate water provision leads to shrinkage of the water economy, forcing many poor farmers to reduce their yield by using water-saving techniques or to leave farming entirely. These authors argue that in South Asia, "high water cost achieves water use efficiency but threatens livelihoods and food security of millions of agrarian poor." Overall, the lack of well-managed water provision systems leads to inequality and inefficiency.

While water is too expensive to be provided equitably in some areas, it is dramatically underpriced in areas where public utility systems do exist. The underpricing of water provided by public utilities is evident in Table 10, which compares the prices of domestically provided water versus private vendor prices in urban areas. These data demonstrate the stark disparity between prices charged by government utilities and the true market value of water. With such low prices, consumers see no reason to conserve, while water providers lack the incentive to increase efficiency. This finding suggests that the problem is not only one of water access, but of water system management as well.

Table 10.
Municipal vs. Private Water Pricing for Selected Cities

City	Country	Domestic Cost (in U.S. dollars per cubic meter)	Private Price of Water (in U.S. dollars per cubic meter)	Ratio
Delhi	India	$0.01	$4.89	489.00
Mumbai	India	$0.03	$1.12	37.33
Chittagong	India	$0.09	$0.50	5.56
Faisalabad	Pakistan	$0.11	$7.38	67.09
Dhaka	Bangladesh	$0.08	$0.42	5.25

Source: UNESCO (2009c)

India has traditionally been concerned with providing the greatest possible access to water resources. As a result, most municipalities provide water at prices well below the actual costs of production. In practice, underpriced water constitutes a subsidy to poor Indians and farmers, who are significant politically and economically due to their immense numbers (Kumar et al., 2005). While the goals of low cost and high access are important for development and public health, they have resulted in a system that encourages waste and inefficiency in the use of increasingly scarce water resources. India's 2002 National Water Policy, while recognizing the need for improved management and efficiency, remains primarily focused on equitable distribution (Indian Ministry of Water Resources, 2002). Though India's government recognizes this problem, management and pricing policies do not significantly address the issue (Kumar et al., 2005).

Few comprehensive data regarding Pakistani water management or pricing schemes are available. However, a 2007 quantitative analysis by Mustafa Daanish shows that the price paid for water in the poorest neighborhoods of Karachi was more than 60 times the price paid by residents of the area's more affluent neighborhoods, which have access to standard water connections (Daanish, 2007). This finding conflicts with the issue of underpricing frequently seen elsewhere, indicating that unequal distribution may be as serious a problem as pricing in Pakistan.

Very little information is available on water pricing in Nepal or Bangladesh. In Bangladesh, groundwater-sourced irrigation is privatized, whereas surface water-based irrigation is delegated to the public sector (Chakravorty, 2004). Bangladesh's yet-to-be implemented national water policy outlines a framework for water pricing and directs public service agencies with fiscally autonomous powers to charge and collect fees. The policy stipulates that water prices will reflect the relative scarcity value of water, with reduced rates for domestic consumption and increased rates for commercial and industrial uses (Bangladesh Ministry of Water Resources, 1999). Based on trends in India and Pakistan, a reasonable assumption may be that Nepal and Bangladesh lack an effective water pricing system.

E. Management of Water Systems

Through their dam projects, the governments of India, Pakistan and Bangladesh[7] have concentrated efforts on the technical requirements and physical infrastructure associated with increasing the supply of water. Cultivation of cash crops to meet global demand has been a second major goal of regional water managers. South Asian water management has therefore been supply-side oriented and has not adequately focused on efficient management or holding down consumer demand (Sharma et al., 2008). As a result, wasteful and short-sighted practices compromise the long-term stability of water provision.

The practice of making increased supply the priority has had an important impact on local systems of water resource management. Often, regional water managers have viewed their roles as technical engineers rather than as service providers (Daanish, 2007). Goals such as equalizing differences in water access are set aside in favor of simply increasing supplies. Furthermore, local water users often have

[7] Despite its immense hydroelectric potential, Nepal has yet to construct any major dam projects, as discussed in Sections 1 and 3.

little voice in discussions about how water is allocated, and they may therefore have no incentive to conserve personal resources. Community-wide efforts to manage water are scarce, as are programs to teach sustainable, environmentally conscious crop production.

India's local governments typically oversee water utilities and have little incentive to improve management as long as access is adequate. For example, irrigated agriculture is India's largest consumer of water resources—more than 80 percent by some estimates – and therefore the area with the greatest potential for efficiency gains. Yet India's irrigation system has an estimated efficiency of just 35 percent (Sampath et al., n.d.). This low efficiency implies that India may waste up to half of the water it withdraws, due solely to irrigation inefficiency. Thus there is clearly room for improvement in India's water management as a strategy to offset shortages.

The supply-side management paradigm is slowly undergoing a shift in the region (Sharma et al., 2008) as demand-side solutions to water challenges become more prevalent throughout the sub-continent. Yet local and international political barriers often hinder South Asian nations from collaborating more on water management policy. To date, many international dam and water-sharing agreements have been reached. However, collective management schemes related to the integration of environmental and social concerns with the production and allocation have not yet been attempted on the sub-continent (Agoramoorthy & Hsu, 2008). As a result, comprehensive solutions to South Asia's water management problems remain elusive.

III. Supply of Water: Major Rivers and Climate Change

Estimating total water supply for South Asia involves the analysis not only of rivers, rainfall and groundwater resources but also of the complex interactions between supply and demand, human and environmental factors, and immediate and long-term effects. This study encompasses a wider range of variables in its analysis of river supply. In addition to supply and demand, climate change presents a potentially serious challenge when coupled with diminishing water resources.

However, any projection is subject to a series of assumptions and a range of possible outcomes. Moreover, inconsistent data for countries and river basins makes universal predictions difficult. In general, estimates project a temporary increase in river waters as glaciers continue to melt more quickly and a general decrease in flow over time as the earth reaches a higher equilibrium temperature. Paradoxically, the most severe warming scenarios foresee increased river flows due to glacial melting followed by lower equilibrium flows decades later.

The glacial waters of the Himalayas feed South Asia's major river systems. The accelerating retreat of these glaciers as a direct result of global warming has already had troubling consequences for the region. These consequences are projected to worsen: Some climate change scenarios suggest these glaciers could shrink by as much as 80 percent by 2030 (Sharma & Sharma, 2008). The glaciers' retreat will increase supply in the short term, in many cases leading to flooding. Over the long run, however, diminished glaciers will be incapable of sustaining consistent supplies to the major rivers of the region (Muhammed et al., 2004).

Temperature increases are likely to lead to more variability in rainfall patterns, which could increase regional flooding. In particular, monsoonal rainfall is likely to increase substantially, with the most rain falling during high-intensity storms (World Bank, 2005). The result would be a higher frequency of extreme weather events, especially droughts and floods. Floods are mostly a concern in low-lying areas, especially in Bangladesh, where rising sea levels are also a worry. Flooding and drought have reduced access to water, destroyed crops and interrupted farming cycles. In turn, outmigration has increased.

A. Indus River Basin

The Himalayas are home to the headwaters of the Indus River system, and thus, glaciers and snowpack feed the system, with glaciers covering more than 13,000 square kilometers providing the majority of water in the Indus and its tributaries (Sharma et al., 2008). As the Indus flows from the Himalayas, it joins other glacier-fed rivers from both sides of the India-Pakistan border. The Indus and its large network of tributaries cover roughly two-thirds of Pakistan and one-third of India (Singh & Arora, 2007). The supply of water from the Indus and its tributaries is thus critical to India and Pakistan and to their bilateral relationship. Table 11 outlines the Indus River basin's characteristics.

Table 11. Indus River Basin Descriptive Statistics

Geographic location	Pakistan: 67% India: 23%
Length of Indus River	2,900 kilometers
Basin drainage	1,000,000 square kilometers
Indus River mean annual flow	187 square kilometers

Sources: Sharma et al. (2008); Singh & Arora (2007)

1. Current Flows and Trends

Pakistan and India exploit the waters of the Indus River system. India stores or diverts nearly all of the water from the Beas, Ravi and Sutlej rivers in its territory. Highly dependent upon the Indus for its agriculture, Pakistan consumes the majority of the Indus River system's remaining water. In fact, so much water is stored or diverted that little water actually reaches the Indian Ocean. As a result, in-flowing seawater has replaced out-flowing fresh water in the Indus delta, ruining farmland and delicate ecosystems. This excessive strain on the Indus indicates that future reductions in supply are likely to have severe consequences for India and Pakistan. These strains are precisely the long-term trends the climate models predict.

2. Likely Flows and Trends

Climate change is likely to limit the flow of the Indus River, as shown by Table 12. Unlike the Ganges and Brahmaputra River systems, which rely more heavily on rainfall, the Indus River system is fed primarily by glacial meltwater. Melt-water provides approximately 70 to 80 percent of all the water in the Indus River (Sharma & Sharma, 2008). Global warming thus has a disproportionate impact on the amount of water entering the Indus and its tributaries. The precise effects of climate change on the Indus River system are highly dependent on how climate change is modeled. However, widely referenced estimates indicate a troubling long-term trend for the flow of the Indus River.

Table 12.
Indus River: Flow Estimates Under Climate Change Scenarios

		2000	2010	2020	2030	2040	2050	2060
Best case	Change	–	20%	10%	0%	-10%	-20%	-30%
0.03 degrees/year	Volume	207	248.4	227.7	207	186.3	165.6	144.9
Median case	Change	–	20%	25%	20%	10%	-10%	-20%
0.08 degrees/year	Volume	207	248.4	258.75	248.4	227.7	186.3	165.6
Worst case	Change	–	40%	50%	55%	40%	5%	-20%
0.15 degrees/year	Volume	207	289.8	310.5	320.9	289.8	217.4	165.6

Sources: Upreti (1993); Brisco & Malik (2006), who cite World Bank (2005)
Note: Degrees are in Celsius; volume is cubic kilometers; change is from 2000.

Under assumptions of minimal climate change, the Indus will initially fall below the 2000 baseline by 2030; it will reach 20 percent below baseline by 2050, and level off at 40 percent below baseline by the end of the century (World Bank, 2005). In the most severe scenario, melting glaciers will actually lead to a large but temporary increase in the flow of the Indus to as much as 50 percent above the 2000 baseline by 2030, a steep drop below baseline by 2060, and a 50 percent fall below the baseline by the end of the century. In sum, persistent shortages of water for the Indus River are predicted to begin between 2030 and 2060, even as demand is held constant (World Bank, 2005).

B. Ganges and Brahmaputra River basins

The Ganges River Basin contains 31 sub-basins and drains 1.08 million square kilometers, which is about the area of Egypt (Ahmed & Roy, 2007). The average annual discharge of the Ganges River Basin is 16,650 cubic meters per second, which is nearly 80 percent of the average annual volume discharged by the Brahmaputra Basin (Jain et al., 2007). The Ganges and Brahmaputra rivers form an immense combined basin in South Asia. The Ganges begins in the western Himalayas before spilling into northern India and flowing eastward to Bangladesh. Descriptive statistics for the Ganges River Basin are included in Table 13.

Table 13. Ganges River Basin Descriptive Statistics	
Geographic location	India: 62.9% China: 19.1% Nepal: 8.0% Bangladesh: 7.4% Bhutan: 2.6%
Length of Ganges River	2,525 kilometers
Basin drainage	1,080,000 square kilometers
Basin mean annual flow	525.02 cubic kilometers

Source: Singh & Arora (2007)

The Brahmaputra River Basin spans four South Asian countries. Approximately half of the basin lies in China, one-third lies in India, and equal portions cover Bangladesh and Bhutan. The Brahmaputra River flows east along the northern side of the Himalayas before turning south into eastern India and Bangladesh. The two rivers meet in Bangladesh where they are considered a single, combined river basin. Table 14 outlines the Brahmaputra basin's major descriptive statistics.

Table 14. Brahmaputra River Basin Descriptive Statistics	
Geographic Location	China: 50.5% India: 33.6% Bangladesh: 8.1% Bhutan: 7.8%
Length of Brahmaputra River	2,900 kilometers
Basin drainage	580,000 square kilometers
Basin mean annual flow	629.05 cubic kilometers

Sources: Bricheri-Colombi & Bradnock (2003); Singh & Arora (2007)

1. Current Flows and Trends

The Ganges River has a peak flow of 141,000 cubic meters and discharges 1,150 cubic kilometers into the Bay of Bengal each year (Babel & Wahid, 2008). Himalayan glaciers provide an estimated 30 to 40 percent of the water in the Ganges, primarily sourced from the Gangotri and Satopanth glaciers (Sharma & Sharma, 2008), with the remainder supplied by snow and monsoon rains. However, due to poor water quality, only half of the basin flow shown in Table 14 is usable, with just more than three-fourths directed toward irrigation (Singh & Arora, 2007; Babel & Wahid, 2008). As such, the Bangladeshi economy depends heavily on the Ganges River system.

The Brahmaputra River is fed by glaciers in the Kailash Range of the northern Himalayas and contributes about 67 percent of the total annual surface water flow of Bangladesh (Singh & Arora, 2007; Pun, 2004). After joining the Ganges River in Bangladesh, the Brahmaputra is fed by heavy rainfall, ranging from 2,500 millimeters to 6,400 millimeters per year (Singh & Arora, 2007). Of the total basin drainage area, 47,000 square kilometers lie in Bangladesh, 195,000 in India, 293,000 in China and 45,000 in Bhutan (Bricheri-Colombi & Bradnock, 2003).

The level of total natural renewable water resources in Bangladesh between 1977 and 2001 was 1,211 cubic kilometers. Of these, about 91 percent are annual river flows from other countries, while 9 percent of renewable water resources originate within the country. Total water resources constitute an estimated 8,444 cubic meters per person per year, though annual per-capita water withdrawals make up only 1.5 percent of these available resources (World Resources Institute, 2007).

Water levels in the Brahmaputra vary widely by season, with dramatically higher flows during monsoon season (June-October) and much lower flows in the drier months (Smakhtin & Anputhas, 2006). Like many other lower riparian countries and states, Bangladesh finds flooding to be a major problem. In 1998, severe flooding inundated 66 percent of the country, leaving 25 million people homeless and destroying 575,000 hectares of crops (Action Aid, 1999). Such flooding is hard to contain and often results in reduced access to usable water.

2. Likely Flows and Trends

The key issues affecting the projected flow of the Ganges and Brahmaputra basins are diversion, water quality and climate change (Babel & Wahid, 2008). Nearly 60 percent of the Ganges River discharge is reduced after passing the Farraka Barrage. Diversion of river waters has a significant impact on the surrounding environment. The Brahmaputra and the Ganges rivers have enough flow to sustain their environmental quality. For the Brahmaputra, these range from 20.7 percent of natural mean annual runoff, with a severe amount of environmental damage expected, to 78.2 percent, a level that would best preserve the ecosystem and natural habitat of the river (Smakhtin & Anputhas, 2006). At this highest level of conservation, only 264 cubic kilometers are left available for agricultural, industrial and domestic use.

Groundwater contamination and pollution harm the Ganges River. Within the basin, naturally occurring arsenic has contaminated a groundwater area of 74,452 square kilometers in Bangladesh, affecting 16 percent of the country's population (Ahmed & Roy, 2007). Pollution from industrial sources is also an issue, as manufacturing plants and others dump nearly three-fourths of all untreated wastes into the Ganges. As a result, wastewater comprises an estimated 5 percent of available water resources in the Ganges River system (Babel & Wahid, 2008). Consequently, the actual supply of clean, usable fresh water is less than overall estimates of flow or volume indicate.

As with the Indus River, glacial melting driven by climate change is expected to alter the flow of the Ganges and Brahmaputra rivers. In the near term, accelerated glacial melting will lead to a temporary increase in water supply. In the long term, the rivers' flow likely will fall due to increased global temperatures. For the Ganges and the Brahmaputra rivers, these reductions are expected to be considerable, though not as severe as in the Indus Basin.

Under the best-case scenario, the average annual flow of the Ganges River would drop below the 2000 baseline by 2030 and reach 15 percent below by 2060. As illustrated in Table 15, the impact of climate change under a median temperature rise on the flow of the Ganges River is high until 2020 and then decreases beyond 2040. The worst-case scenario would initially lead to increased flow. However, these temporary increases would be matched by sharp reductions in overall flow by the end of the century.

Table 15.
Ganges River: Flow Estimates Under Climate Change Scenarios

		2000	2010	2020	2030	2040	2050	2060
Best case	Change	–	20%	5%	-5%	-10%	-10%	-15%
0.03 degrees/year	Volume	493	591.6	517.6	468.4	443.7	443.7	419.0
Median case	Change	–	15%	15%	10%	10%	5%	5%
0.08 degrees/year	Volume	493	567.0	567.0	542.3	542.3	517.7	517.7
Worst case	Change	–	25%	35%	40%	40%	30%	20%
0.15 degrees/year	Volume	493	616.3	665.6	690.2	690.2	640.9	591.6

Sources: Upreti (1993); Brisco & Malik (2006), who cite World Bank (2005)
Note: Degrees are in Celsius; volume is cubic kilometers; change is from 2000.

Under a best-case scenario of climate change, the Brahmaputra River flow will decrease to 5 percent below current volume by 2060, and may decrease up to 15 percent under a worst-case scenario. Table 16 estimates how flow levels would respond to an annual rise in temperature of 0.03 to 0.15 degrees over the next 60 years. In comparison to the projected effects of climate change on the Indus River, a rise in temperature will have a relatively less severe impact on the Brahmaputra. While these supply reductions are not as sharp as those predicted for the Indus River system, they remain a serious issue, considering the large and growing population of the area through which they flow.

Table 16. Brahmaputra River: Flow Estimates Under Climate Change Scenarios								
		2000	2010	2020	2030	2040	2050	2060
Best case	Change	–	5%	0%	0%	-5%	-5%	-5%
0.03 degrees/year	Volume	370.0	388.5	370.0	370	351.5	351.5	351.5
Median case	Change	–	5%	0%	0%	-5%	-5%	-10%
0.08 degrees/year	Volume	370.0	388.5	370.0	370.0	351.5	351.5	333
Worst case	Change	–	5%	5%	0%	-5%	-10%	-15%
0.15 degrees/year	Volume	370.0	388.5	388.5	370.0	351.5	333	314.5

Sources: Upreti (1993); Brisco & Malik (2006), who cite World Bank (2005)
Note: Degrees are in Celsius; volume is cubic kilometers; change is from 2000.

IV. Overall Supply and Demand Estimates by Country

Combining available information on supply and demand allows for the generation of overall projections for the supply and demand of water in South Asia. These estimates indicate that water shortages exist and will intensify in India and Pakistan, with especially severe shortages in Pakistan. The somewhat more limited data for Bangladesh and Nepal indicate potentially serious shortages in Bangladesh and moderate surpluses in Nepal. Due to the difficulty in generating accurate projections out to 2050, two separate sets of estimates are employed to provide the most robust range of estimates.

First, we compare water demand statistics calculated with PODIUM to river basin supply statistics calculated using flow projections for the major river basins. This comparison provides an estimate of the overall surplus or shortage of water for given time periods, incorporating median climate change projections. Data are unavailable for Nepal and Bangladesh.

Second, we compare our PODIUM projections with projections Sharma et al. made for the region using the Falkenmark Water Stress Index. Sharma's estimates combine water source data, including groundwater and river basin information, with population projections under different sets of growth assumptions, providing an alternative method of estimating shortages. Incorporating these additional shortage estimates into our discussion provides greater depth to our understanding of the disparities the region faces.

The Falkenmark Index is widely used to calculate countries' water stress based on their per-capita supply of water. This index defines these water stress indicators: countries with less than 1,700 cubic meters per capita are classified as "water stressed"; countries with less than 1,000 cubic meters are considered "water scarce"; and countries with less than 500 cubic meters are said to experience "absolute water scarcity" (Falkenmark et al., 1989). While the Falkenmark Index cannot measure access or regional variations, nor adequately account for how water is used, it does provide a useful metric for comparing countries on a common basis. Tables 18, 20, 21 and 22 use the water scarce standard to show past and expected per-capita water shortages and surpluses in India, Pakistan, Bangladesh and Nepal.

Together, our PODIUM projections and Sharma et al.'s estimates provide the best available estimates of water shortages in South Asia. Each method has its strengths and its weaknesses. Their differences also help stress the degree to which estimates may vary depending on the methodology used to generate projections. In combination, the two methods sketch out a future of increasing water scarcity in South Asia.

A. India

India is likely to face moderate water shortages into 2050, as Table 17 illustrates. India's booming population, coupled with its reliance on irrigation-intensive agriculture, will drive an increased need for water supplies. Estimates derived using the PODIUM model indicate that India already faces a moderate shortage of water overall. In absolute terms, the shortfall in supplies is already severe due to India's high population, agricultural use and growing economic development. The model predicts that this shortage will intensify even if supply is held constant, accelerating from a 40 percent shortfall in 1995 to a nearly 70 percent shortfall by 2050.

Table 17. India: Projected Shortages

	1995	2025	2050
Shortage, cubic kilometers	-508.76	-646.09	-820.47
Deficit as percentage of total environmental water requirement	39.9%	53.3%	68.0%*

Sources: Upreti (1993); Brisco & Malik (2006)
**Rough projection given expected change from 1995 – 2025*

India's shortages may be considered on a per-capita basis, as originally calculated by Sharma et al. (2008). These independently prepared estimates provide another method for considering the relative severity of water shortages in the region. By these estimates, India will experience overall water stress by 2025, while water scarcity will emerge in the populous Ganges region by 2025. While shortages will intensify somewhat by 2050, decreased use of irrigated agriculture is expected to circumvent more severe water scarcity. Table 18 outlines this second set of estimates.

Table 18. India: Projected Water Supplies Per Capita and Surplus or Shortage Relative to Falkenmark Water Scarcity Standard of 1,000 Cubic Meters				
	1990	2000	2025	2050
Per-capita water for all of India, in cubic meters	2,352	1,971	1,429	1,254
Per-capita surplus or shortage on Falkenmark Index	1,352	971	429	254
Per-capita water in cubic meters for Indus Region	2,487	2,109	1,590	1,732
Per-capita surplus on Falkenmark Index	1,487	1,109	590	732
Per-capita water in cubic meters for Ganges Region	1,831	1,490	969	773
Per-capita surplus or shortage on Falkenmark Index	831	490	-31	-227

Sources: Sharma et al. (2008); authors

Overall, both estimates indicate India will experience moderate shortages of water. Supply estimates indicate that the Ganges will gradually experience a moderate reduction in flow due to climate change. These estimates suggest that the shortages Sharma et al. cite and the PODIUM model will be more severe than indicated in Tables 17 and 18. However, India's shortages will not be as severe as Pakistan's.

B. Pakistan

Pakistan is likely to face serious water shortages based on two main factors. First, Pakistan already has very limited water resources relative to its population size, while the population is expected to grow by 97 percent by 2050. Second, Pakistan is heavily reliant upon the Indus River system, which climate change is likely to tax severely. Together, these factors lead to stark shortage estimates for Pakistan, as Table 19 highlights.

Table 19. Pakistan: Projected Shortages			
	1995	2025	2050
Shortage, in cubic kilometers	-194.31	-205.52	-217.38
Deficit as percentage of total environmental water requirement	135.60%	143.40%	149.8%*

Sources: Upreti (1993); Brisco & Malik (2006)
**Rough projection given expected change from 1995–2025*

According to the estimates generated using the PODIUM model, Pakistan is already facing a water shortage. India's overall shortage is larger in absolute terms due to India's larger size and level of development. Nonetheless, Pakistan's water deficit remains proportionally more severe. These estimates indicate that Pakistan's current water usage is clearly unsustainable. Even if supplies remain constant, shortages will intensify by 2025 according to the PODIUM projections. By 2050, Pakistan will experience a 150 percent deficit. By any measure, Pakistan's shortage will be acute.

These shortages appear especially severe when viewed on a per-capita basis, applying the Falkenmark Index. According to this index, Pakistan will face water scarcity by 2025, with notable scarcity in the Indus region, as shown in Table 20. By 2050, Pakistan's water scarcity will intensify, with the Indus region approaching absolute water scarcity. This scarcity is troubling given the Indus region's large role in irrigated agriculture, which is crucial to Pakistan's economy. This pattern is similar to the one seen in the independent PODIUM flow projections for the Indus River, indicating an especially troubling long-term trend.

Table 20. Pakistan: Projected Water Supplies Per Capita and Surplus or Shortage Relative to Falkenmark Water Scarcity Standard of 1,000 Cubic Meters

	1990	2000	2025	2050
Per-capita water for all of Pakistan, in cubic meters	2,008	1,561	892	639
Surplus or shortage on Falkenmark Index	1,008	561	-108	-371
Per-capita water for Indus Region, in cubic meters	1,713	1,332	761	545
Surplus or shortage on Falkenmark Index	713	332	-239	-455

Sources: Sharma et al. (2008); authors

On the whole, Pakistan's shortages are very serious under both the PODIUM-derived shortages and Sharma's per-capita estimates. However, when coupled with the supply estimates indicating the likely long-term decline of the Indus River, actual overall shortages probably will become far more severe than is readily apparent in the estimates. Collectively, these estimates indicate that Pakistan will face some of the most severe shortages in the region.

C. Bangladesh

Limited data on agricultural trends and other critical areas make the use of PODIUM impossible for Bangladesh. As such, estimates of overall surplus or shortage are limited to what can be imputed from supply information and population growth.

Table 21 shows that on a per-capita basis, shortages likely will be dramatic: the estimates indicate that Bangladesh already meets the Falkenmark Index's definition of water scarcity. By 2025, Bangladesh likely will approach the threshold of absolute water scarcity and fall well below that threshold by 2050, meaning it will not have enough water to meet its people's needs. Agricultural water use estimates are unavailable for Bangladesh and thus not incorporated into Table 21. However, regional agricultural trends indicating a heavy reliance on irrigation suggest that the shortages in Table 22 are likely to be severe.

Table 21. Bangladesh: Projected Water Supplies Per Capita and Shortage Relative to Falkenmark Water Scarcity Standard of 1,000 Cubic Meters				
	1990	2000	2025	2050
Per-capita water for all of Bangladesh, in cubic meters	960	761	504	412
Shortage on Falkenmark Index	-40	-239	-496	-588

Sources: Sharma et al. (2008); authors

D. Nepal

As with Bangladesh, data limitations make generation of a PODIUM model for Nepal impossible. However, given Nepal's small population relative to its water resources, Nepal will retain an overall surplus of water for the foreseeable future. Despite this surplus, Nepal's lack of infrastructure and storage capacity means that it will continue to face severe problems in terms of access.

Even when viewed on a per-capita basis, Nepal does not appear to suffer any shortage of water, as Table 22 demonstrates. Though the surplus is projected to shrink rapidly, Nepal likely will maintain a comfortable level of supply per capita. None of Falkenmark's stress indicators are met, indicating a continued water surplus.

Table 22. Nepal: Projected Water Supplies Per Capita and Surplus Relative to Falkenmark Water Scarcity Standard of 1,000 Cubic Meters				
	1990	2000	2025	2050
Per-capita water for all of Nepal, in cubic meters	11,121	8,934	5,556	4,137
Surplus on Falkenmark Index	10,121	7,934	4,556	3,137

Sources: Sharma et al. (2008); authors

Nepal does not appear likely to suffer the same shortages that will afflict India, Pakistan and Bangladesh. Even when climate change is taken into account, Nepal's water surplus is sizable compared to its neighbors. With its relatively low population compared to other South Asian nations and its position at the headwaters of several rivers flowing into India, Nepal is comparatively well off. However, Nepal's poor water management results in shortages caused by lack of access. Therefore, policy improvements in Nepal need to focus on better management of water supply.

These estimates of shortages based on current trends provide an important indicator for the likelihood of intensifying disputes between South Asian nations. However, a more complete understanding of the trajectory of water disputes in South Asia requires us to incorporate these estimates with our qualitative analysis of disputes. By combining qualitative analysis, quantitative projections and an understanding of the region's political situation, an improved exploration of key problem areas in South Asia stemming from changes in the region's water resources is possible.

Section 3:
Future Developments
of Water Disputes in South Asia

Combining the history and present status of South Asia water disputes, supply and demand projections, and political trends allows us to construct reasonable inferences about India's probable water disputes with its neighbors. Clearly, the likelihood of increasing water scarcity due to a combination of rising demand and dwindling supply could exacerbate conflicts about river resources. These trends are particularly troubling in their implications for the India-Pakistan relationship and less so for the India-Bangladesh and India-Nepal relationships. Overall, intensifying conflicts between India and its neighbors are expected as a reaction to sharply increased water demand and steadily falling supplies. The nature and likely directions of these intensified disputes are analyzed below.

I. Likely Trends in India-Pakistan Water Disputes

Declines in the flow of the Indus River are likely to create discord between India and Pakistan as each country seeks to control the water it needs to meet increasing demand. India is likely to maintain its policy of providing plentiful, affordable water. Meanwhile, Pakistan's ongoing political troubles will impede development of an effective water policy or comprehensive new bilateral agreement with India.

A. The Problem: Sharp Future Declines in the Indus River's Flow

India's water disputes with Pakistan are likely to be the region's most contentious, as well as potentially the most dangerous. As water scarcity intensifies, each country will have increased incentive to seek a greater portion of the shared water resources in the Indus River system. Pakistan's serious projected shortages, India's trend of damming and diverting waters destined for Pakistan and global warming's expected depletion of water in the Indus River system are a collective source of increasing tensions between the nuclear-armed rivals.

Pakistan will likely be the most water-scarce country in the region well into the 21st century. Pakistan largely depends on the Indus River system for its water needs, supplemented by limited groundwater and meager rainfall. River water provides 80 percent of all irrigation water for Pakistan's critical agriculture sector (Singh & Arora, 2007; Sharma & Sharma, 2008). These water sources are already near their limits, with most water diverted to northern Pakistan's agricultural regions at the expense of the south. In fact, so much water is diverted from the Indus before it reaches the ocean that seawater has invaded the river channel miles inland. Overall, Pakistan's water management remains passive and its prices low or nonexistent, in spite of expectations of rising demand and falling supply.

Climate change is likely to harm the Indus River system. Due to the system's heavy reliance on glacial meltwater, shrinking glaciers will sustain a smaller annual flow after an initial melt-off. Based on current projections, the Indus River system is expected to fall below 2000 flow levels between 2030 and 2050. The drop-off is estimated to be most serious between 2030 and 2040, with a new equilibrium flow of 20 percent below that of 2000 reached after 2060.

Water shortages would be severely disruptive to Pakistan's economy and society. By some estimates, any reduction in the flow of the Indus River system in excess of 15 percent will severely harm irrigated agriculture (Sharma & Sharma, 2008). Per the climate change models, a shift equal or greater than this magnitude is all but assured by 2050 and possibly as soon as 2030. Some models project more severe shortages that would pose still greater difficulties for bilateral relations. As a result, Pakistan will face increasing domestic pressure to increase the supply or delivery efficiency of its water system. New Indian efforts to store or divert water headed for Pakistan will exacerbate these problems.

India controls virtually all of the Indus River system's headwaters, a circumstance that could complicate relations between the two rivals. Based on supply and demand projections, India faces its own water scarcity, which would give India added incentive to store or divert river water that would otherwise reach Pakistan. Already, India has all but ceased flow of the Beas, Ravi and Sutlej rivers into Pakistan. While this policy choice is technically permissible under the Indus Waters Treaty, it nonetheless drastically reduces the flow of water into Pakistan.

B. Likely Indian Actions

Access to plentiful, low-priced water is likely to remain an important government priority in India. For decades, the provision of water at little to no cost has essentially subsidized India's farmers and poor people, who represent an immense portion of the electorate. National policy debates in India subsume water issues into larger programs of development and rural support. The official policy platform of the Congress Party does not mention water but does propose rural development and subsidy programs implicitly inconsistent with higher water prices (AICC, 2009a). The opposing Bharatiya Janata Party is not substantially different in this regard, though its platform briefly mentions subsidizing "traditional rain-fed crops" (as opposed to irrigated agriculture) and vaguely refers to "importance given to" the melting of Himalayan glaciers (AICC, 2009b). The regional parties, whose influence is growing of late, do not have any unified position on the issue. Most observers expect the monthlong Indian elections to end in a coalition government in India's parliament.

National elections in April and May 2009 may ultimately have little effect on India's water situation. Regardless of who holds political power, the structural incentives to maintain plentiful, inexpensive water supplies will not change. As such, India's political leaders are unlikely to restrict demand. Instead, we expect a national policy that emphasizes efforts to increase supply or the efficiency of water systems. Expanding supply through diversion and storage is arguably the likeliest alternative, given the relative ease of that practice compared to improving management and efficiency. In short, regardless of political changes, India will have every incentive to increase its water supplies.

India's desire and ability to capture a greater share of the Indus River system's diminishing flows suggests that new dam projects will be the most likely source of water conflicts with Pakistan. Construction of the Baglihar Dam on the Chenab River is likely an ill omen for Indo-Pakistani relations because of the dam's immense capacity to retain water destined for Pakistan. The dam's construction is arguably at odds with the original intent of the Indus Water Treaty, which did not permit India to build retention or diversion projects on the Chenab, Indus or Jhelum rivers. With the construction recently permitted under World Bank arbitration, India may have found a crack in the Indus Water Treaty that it can continue to exploit. India is likely to attempt other large-scale dam projects with storage capacity on the Chenab, Indus and Jhelum rivers, whose entire flow the Indus Water Treaty reserves for Pakistan. Such projects, if pursued, will further strain the institutions of the treaty by bending the rules of the agreement and violating its spirit of fairness and equality.

C. Likely Pakistani Actions

Pakistan's political situation remains volatile, hampering its ability to formulate and execute a sufficiently strong strategy to address water issues. Following the reinstatement of Supreme Court Justice Chief Iftikhar Chaudray in March 2009, political tensions throughout Pakistan have eased, yet disputes between the Pakistan People's Party and the Pakistan Muslim League remain a significant problem for the nation. The People's Party, which leads the government, ceded control of Punjab, Pakistan's largest politically most important province in early April 2009. This move has been viewed as a major concession by the party. However, Nawaz Sharif, opposition leader of the Pakistan Muslim League, as yet refuses to rejoin Prime Minister Yousaf Raza Gilani's coalition government. Polls have shown Sharif to be the most popular politician within the country. President Asif Ali Zardari, widower of assassinated former Prime Minister Benazir Bhutto, meanwhile, remains much less popular than Sharif (Anthony, 2009). Rising Islamism and a stagnant economy are major concerns to the Pakistani government and Pakistan's international partners.

Important water management, environmental and other policies have therefore taken a back seat to more immediate concerns. Although the Pakistani Ministry of Environment officially declared 2009 the "National Year of Environment," few substantive initiatives have been undertaken (Pakistan Ministry of Environment, 2009). Pakistan has stated that it wants to resolve water issues with India bilaterally and in accordance with the Indus Water Treaty (*Pakistan Daily Times,* 2009). In this environment, Pakistan is unlikely to pursue the type of concerted long-term water policy that would address its growing water scarcity. Current policies imply that little will be done to stave off water shortages Pakistan is likely to face.

These shortages would in turn pressure the Pakistani government to increase its share of water drawn from the Indus system under the treaty. Pakistan is heavily reliant on the Indus and has few alternative water supply sources. Moreover, management and efficiency are tough problems to address in light of the arguably necessary policy emphasis on low-cost access. Given the difficulty of increasing water supplies and the longstanding contentious relationship between Pakistan and India, Pakistan may be tempted to blame India for its water woes. Such an approach would enable Pakistan's political leadership to deflect public discontent over its own poor water management policies. In this environment, renegotiation of the Indus Water Treaty may become an important diplomatic issue between India and Pakistan.

Alternatively, if shortages are acute, Pakistan may feel compelled to threaten India or even to utilize military force. While general discord is not uncommon in the India-Pakistan relationship, Pakistan would actually have a potential pathway for successful military action to secure additional water resources. With water resources already scarce and key dams and reservoirs just inside Indian-controlled Kashmir, limited military action could be a rewarding proposition for Pakistan. Given both nations' nuclear arsenals, a direct offensive seems unlikely due to the potential for a catastrophic conflict. However, the Kashmir campaign could shift to encompass the objective of threatening, capturing or even destroying key dams and reservoirs. Doing so could allow Pakistan to improve its access to the limited water supplies of the Indus River system. Only the most serious shortages likely would prompt such a risky series of actions. Overall, though, the accelerating water shortages will almost certainly fuel increased tensions between India and Pakistan.

II. Likely Trends in India-Bangladesh Water Disputes

For Bangladesh, India's construction of dams and barrages is likely to lead to disputes between the two countries. India may continue to seek negotiations, which Bangladesh may welcome, given its government's recent statements about the need for resource conservation.

A. The Problem: Possible Indian Diversions of Dwindling Water Resources

Existing and anticipated hydrologic projects are likely to be the main source of ongoing disputes between India and Bangladesh. Longstanding disputes over the diversions by the Farraka and the Teesta barrages, plus soil salinization caused by the Tipaimukh Dam, remain ongoing sources of contention between India and Bangladesh.

The Indian River Linking Project, which is in the planning stage, is a potential area for greater discord between India and Bangladesh. The River Linking Project would connect multiple Indian rivers and divert water that would otherwise reach

Bangladesh. Although India assured Bangladesh during a Joint Rivers Commission meeting in 2006 that it would not divert the Ganges and Brahmaputra rivers, there is still a possibility that India will break its agreements. If so, the River Linking Project will be a major source of contention between the two countries.

Chinese proposals may complicate Indian-Bangladeshi relations by reducing the flow of the Brahmaputra, which flows from China through India and into Bangladesh. China's plans to divert the Brahmaputra in its territory as part of a hydro-engineering project will transfer an estimated 40 million cubic kilometers of water each year from the Tibetan plateau to northern China. Already, a reduction in the Ganges' water flowing into Bangladesh has prompted Bangladeshis to migrate to northeast India, exacerbating ethnic tensions. Migration likely will increase if China's new project reduces the Brahamputra's flow. India and Bangladesh have no bilateral water-sharing treaties with China. As such, the new hydroelectric project may increase tensions among India, Bangladesh and China (Ramachandran, 2008).

Reducing the amount of water in the Ganges and Brahmaputra river systems will compound these disputes. While glacial melting will reduce flow volume, current models predict increased rainfall will largely offset this reduction. Thus while water availability will fall, the decline will be neither as steep nor as deep as that projected for the Indus River system. These prospects increase the likelihood that India and Bangladesh will be able to resolve disputes about water shortages through longstanding negotiating mechanisms.

B. Likely Indian Actions

India is likely to continue its pattern of resolving water disputes with Bangladesh through bilateral negotiations. The anticipated stability of India's water policy means we can expect the nation to continue its emphasis on maintaining a large supply of water to ensure low-cost access to its residents. As the relatively more powerful and upper-riparian state, India has clear advantages in negotiations with Bangladesh. However, given India's long record of successful cooperation with Bangladesh over water issues, as well as the two nations' overall cordial relations, India may be disinclined to leverage its power against Bangladesh too severely.

C. Likely Bangladeshi Actions

Bangladesh's political scene is becoming more secular, with a trend toward greater religious freedoms in the wake of 30 years of periodic military rule. The election of Sheikh Hasina Wajed as prime minister in the ninth parliamentary elections in December 2008 is a landslide victory for the Bangladesh Awami League (2008), which advocates a return to the country's founding secular values. Sheikh Hasina's platform, a vision for 2021, emphasizes a return to a liberal democracy with a focus on economic stability, anti-corruption measures; alternative and fossil fuel-based energy production; eradication of poverty and inequality; and the establishment of good governance. The Awami League also pledges to achieve Bangladeshi agricultural self-sufficiency by 2013, identifying subsidies, loans and other incentives to promote the modernization, commercialization and rural development of agriculture. Relating to water, Sheikh Hasina supports the conservation of resources, flood control, reduced pollution and Ganges barrage projects that would expand irrigation, prevent salinity and reduce scarcity of water in the Sundarban region. Additionally, the Bangladeshi Awami League has stated interests in developing a comprehensive regional water policy with India, Nepal and Bhutan. In short, constructive water policy and associated development goals appear to be a high priority for Bangladesh's political leadership.

In this context, ongoing talks between India and Bangladesh are a promising method for resolving differences over these many hydrologic projects. While Bangladesh has not been fully satisfied with prior outcomes, the results have generally been equitable. Those disagreements that have persisted have not developed into major disputes. In addition, unlike the India-Pakistan relationship, there is little additional bilateral conflict that affects the issue of water. This lack of conflict reduces the likelihood that India would use water as a "stick" or "carrot" to influence Bangladesh on other issues.

III. Likely Trends in India-Nepal Water Disputes

Disputes will focus on Nepal's control of shared rivers, its potential expansion of hydropower resources, and the need for greater storage capacity. India's cooperation in using its expertise and resources to help Nepal in these endeavors could play an important role in resolving these disputes.

A. The Problem: An Unmet Need for Dam Construction in Nepal

India and Nepal will continue to disagree about flood control, which is the largest source of water-related conflict between the two countries. As warming trends continue, glacial melting and the rupture of glacial lakes will lead to temporarily increased flows with occasional severe flooding (Yamada & Sharma, 1993). Eventually, overall flow will decrease due to diminished glaciers feeding Nepal's rivers. Nepal's lack of dam infrastructure means that it is unable to store the excess water or prevent severe flooding downstream in India. In the near term, some tensions are likely to arise over flood control.

These problems create incentives for greater cooperation between India and Nepal to control and store floodwaters. While Nepal has the geographic position to best control flooding, India has greater resources and expertise in dam construction. Therefore, India and Nepal might cooperate to form a coordinated scheme for monitoring, flood control and/or storage. India could compensate Nepal for providing a controlled flow of water, directly or indirectly, through cooperation in constructing a comprehensive system. The incentives for such cooperation will only increase as population growth and warming trends exert pressure on existing water supplies.

Nepal also possesses enormous hydropower potential, which it could use to gain greater leverage in its relationship with India. Currently, Nepal uses only 0.3 percent of its hydropower potential (Pokharel, 2001). Because Nepal's demand for electricity in 2009 is only 350 megawatts, the opportunity for exporting electricity to India and Bangladesh is immense. However, significant cost barriers impede construction and completion of hydropower projects. In January 2009, concerned with a severe energy crisis, leaders of Nepal's government announced a plan to install a series of generators with the capability to produce up to 200 megawatts of electricity (Khadka, 2009). This decision signals a move away from hydropower, and while the government calls the generator investment an "emergency plan," the government is unlikely in the near future to have the resources or political will to incur substantial investment in hydropower development.

B. Likely Indian Actions

India's likely continued emphasis on maintaining high levels of supply is relevant to India-Nepal relations in a unique way. As the more powerful and lower-riparian state, India holds a strong position but lacks control over the rivers that originate in the Nepali Himalayas. Unlike its relationships with Pakistan and Bangladesh, India is unable to force its desired policies upon Nepal and then offer concessions. Instead, India is in the unusual position of being at the mercy of its far smaller northern neighbor.

Provincial Indian leaders may continue protests about flooding, which appears to be the most likely consequence of climate change in the region. Occasional uproar in northern India may result, as this part of the country is most affected by the adverse consequences of accelerated glacial melting. Since Nepal has virtually no capacity to prevent the flooding, the situation is likely to worsen. The absence of efforts to stop the flooding is result of Nepali passivity, and no amount of protest on India's part will prod Nepal to create expensive dam infrastructure.

The potential for gains from India and Nepal cooperating on water management, however, is great. Given Nepal's political turmoil, any such initiative will likely have to come from India. India has not yet given any indication of willingness or desire to cooperate extensively with Nepal on water management. With its resources and expertise, India could cooperate with Nepal under the auspices of an international organization such as the World Bank. In this context, external financing and assistance could help a constructive partnership emerge to control flooding and develop hydropower potential, which would mutually benefit India and Nepal.

C. Likely Nepali Actions

While water issues are an important component of development in Nepal, political conditions make serious changes in water management policy unlikely in the near future. Nepal is writing a new constitution, one year after ending its monarchy and two-and-a-half years after ending a 10-year civil war (BBC, 2009). The political situation remains tenuous. The challenges of democracy-building are immense, and, during such a political transition, few resources are available to commit to long-term investments in sustainable development. The government has therefore taken an ad hoc approach to impending crises, including water shortages due to severely limited access to clean water, and it lacks a long-term strategy for addressing such issues.

Nepal is unlikely to take the initiative in the construction of new hydrologic projects to control flooding and aid Nepal's development. With so many challenges, such developments must be a regional endeavor, despite the fact that much of the potential storage capacity and hydropower lies within Nepal's borders. While many Nepalis are wary of Indian involvement in Nepali politics, India's financial and political support are necessary for hydropower development in Nepal. Such development is likely to be popular with large segments of the Nepali public because it would ease electricity shortages. Cooperative development and water management policies could improve relations between India and Nepal. Outside funding by international organizations and foreign governments could be critical for the success of capital-intensive projects such as dam construction. Improved India-Nepal relations and cooperation may contribute a great deal to enhanced water resource management in the region.

Section 4:
Opportunities to Mitigate Water Shortages and Disputes

Projected water shortages in South Asia could exacerbate existing disputes about regional water resources. These disputes are troubling, particularly in light of the already difficult relationship between India and Pakistan. However, several basic policies could help mitigate water shortages and the disputes likely to emerge from them. Alternatives include improvements in water management, increased storage capacity, improved crop planning, rationalized water prices and outright privatization of water utilities. We evaluate each policy on the basis of efficacy, political feasibility, technical feasibility and the usefulness of foreign aid.

First, efficacy considers how well the policy would address regional water scarcity. To evaluate this criterion, we assess the policy's impact on water supply and demand levels. Second, political feasibility evaluates the political will of India and its neighbors to adopt the policy. Third, technical feasibility weighs the technical capacity of the four nations to actually implement recommendations. Technical feasibility is an important consideration, because administrative capacities, particularly the ability to collect and share information, are often very poor within the region. Finally, usefulness of foreign aid considers how outside actors might offer to assist in policy implementation. All four criteria are essential to understanding which policies would be most effective in mitigating water shortages and disputes in South Asia. We summarize key points of the policy alternatives in Appendix C.

I. Investments in Management and Efficiency

Water management has been a long-standing problem for South Asia. Were present demand and supply to remain constant throughout the sub-continent, better management would be an important policy goal to pursue for long-term stability. However, as PODIUM supply and demand projections in Sections 2 and 3 make clear, rising demand and dwindling supply—and the resultant potential for regional conflict—necessitate an immediate focus on better management in the short- and long-term to make the distribution and use of water more efficient.

Interprovincial management suffers from a lack of cooperation and coordination. Demand-side management has been slow to catch on throughout the region. Policies focused on low-cost access further compound these problems. Several management policies should be considered to improve cooperation, increase demand-side management and expand low-cost access. Potential policies include (1) the promotion of community water management and (2) improving interprovincial water management. Each policy alternative is described below.

A. Promotion of Community Water Management

Since 2000, rural India has seen a rise in the number of village irrigation cooperatives primarily formed to promote "collective management, sustainable livelihood, human resources development, and financial self-reliance" (Agoramoorthy & Hsu, 2007). Government agencies, the Sadguru Foundation (an Indian non-governmental, non-profit organization) and private sponsors piloted several cooperatives throughout western India. The irrigation cooperatives focused on building locally run lift irrigation systems and check dams, which are relatively small, temporary structures constructed across a swale or channel (EPA, 2006).

Organizers began by visiting villages and meeting with community leaders and local farmers to discuss water management. Organizers invited farmers to join irrigation cooperatives, which were run by committees of 12 elected local members. In addition to holding meetings, the committees "oversaw auditing, financial management, water distribution, collection of water charges, payment of electricity bills, payment of staff salaries, maintenance of lift irrigation machineries, and solving water distribution disputes" (Agoramoorthy & Hsu, 2007). Overall, the cooperatives have been well-received by rural Indians, who have benefited from the collective decision-making process and increased self-sufficiency. Furthermore, as noted by Agoramoorthy and Hsu (2007), all cooperatives saved money and increased water efficiency.

With regard to the building of check dams, groundwater levels have risen in many villages, indicating that groundwater may be recharged (Agoramoorthy & Hsu, 2007). Recharging is an important development because poor management had led to falling water tables, which threatened the sustainability of agriculture in many areas. Additional benefits of the dams include their environmental neutrality—they do not destroy natural resources—and their storage capacity that makes water available during dry seasons.

In terms of evaluative criteria, this policy alternative creates strong incentives for communities to collaborate in using water efficiently. Importantly, local buy-in helps to guarantee success. Furthermore, cooperatives may be formed quickly, encouraging short-run solutions with long-term sustainability. Politically, local leaders have supported creation of irrigation cooperatives in rural India. However, the extent to which politicians in Pakistan, Bangladesh and Nepal will be receptive to the proposal is untested. Considering technical feasibility, the institutional framework does exist to promote community water management, as domestic experts could assist with the initial training required to support cooperatives. International aid would be useful were this policy to be pursued, as international experts could help with training and continued monitoring of the cooperatives.

B. Improvement of Interprovincial Water Management

Within India, Pakistan, Nepal and Bangladesh, major responsibility for water resource management lies with provincial governments (Wirsing, 2007). This policy has led to significant interprovincial conflict throughout the region, as provinces battle over their shares of water resources. Interprovincial conflict, in turn, heightens water disputes between India and its neighbors as they search for more water resources. Wirsing (2007) points out that "the huge interprovincial trust deficit between India and Pakistan regarding water resources, for instance, inevitably reinforces the oversized interstate trust deficit that exists among virtually all the co-riparian states in the region." In other words, the inability of neighboring territories of different countries to cooperate on water management has harmed relations between their central governments.

Encouragement for provinces of different countries to collaborate in managing water resources is likely to improve relations between their respective countries. Recent efforts to improve interprovincial cooperation, however, have thus far failed. For example, though the Pakistani Federal Water Council was established in 2004, it has been ineffective in strengthening provincial relations with neighboring Indian provinces with respect to water issues (Wirsing, 2007). Renewed efforts by India, Pakistan, Bangladesh and Nepal to support the council and other such initiatives may be a critical element of a larger strategy to address regional water shortages.

Interprovincial water management would create strong incentives to efficiently use scarce resources, though timely and sustainable results would be difficult to achieve in the short term. While measures such as updating provincial water statutes may be accomplished in the near term, large-scale cooperation among provinces, such as promoting environmentally friendly crop planting and coordinating water pricing schemes, would need a longer time frame. Political feasibility is weak under this policy, as recent regional efforts at coordination have failed. In terms of technical feasibility, most provinces lack the administrative capacity to collect and share information to improve management. Greater local and provincial-level administrative capacity is thus a prerequisite for better water management. International aid would be useful in promoting interprovincial water management, as experts could help with training, the establishment of administrative systems and continued monitoring of regional efforts.

II. Increased Water Prices

Raising water prices is one of the most obvious economic solutions to address increasing demand and falling supply. A higher price gives consumers greater incentive to reduce consumption and avoid waste. Government-operated water utilities face similar incentives to reduce waste and improve efficiency in order to profit from higher prices. Given the low (or zero) price many consumers pay in India, Pakistan, Bangladesh and Nepal, especially in the agricultural sector, pricing water at or near its true market value should reduce demand for water and mitigate water shortages.

Pricing would not necessarily be a universal solution to South Asia's shortages. Access to government utility-provided water is uneven, and many consumers pump their own groundwater. Some types of water infrastructure, such as tube-wells or other community sources, do not lend themselves to effective metering and pricing.

On the surface, raising water prices charged by government utilities appears to be an effective solution to at least part of the problem of growing water scarcity. However, implementation of such a policy would be difficult. Higher water prices would end government subsidization of water through artificially low prices, raising a serious equity issue for South Asia's poor populations. While administrative capacity exists to increase prices, most local political leaders appear to be reluctant to impose such costs on local constituents (UNESCO, 2009c). In short, increasing water prices is not politically feasible in the short term. However, non-governmental organizations and foreign donors could provide external aid, in the form of direct subsidies, to facilitate higher water prices in the long term. Beyond subsidization, technical assistance would help support a better pricing scheme by supporting construction of infrastructure.

III. Storage Capacity Expansion

Greater storage capacity is necessary in South Asia for two reasons. First, it would help smooth water consumption over highly fluctuating periods of rainfall. For example, in Bangladesh, 90 percent of the annual rainfall occurs during the monsoon season between July and October. This variation means that while surface water availability exceeds demand in the wet season, there is a serious shortage of water during the dry season (UNESCO, 2009b). The lower riparian areas in Pakistan and the Indian states of Bihar and Uttar Pradesh face similar problems. Second, improved storage capacity would help to minimize the frequency and severity of floods and droughts in the vulnerable lower riparian countries, floods that climate change has only worsened. Expanded storage capacity, therefore, is fundamentally a regional issue. For Bangladesh, a lower riparian whose flat topography makes in-country storage capacity expansion impossible, cooperation with its up-river neighbors is paramount.

With significant regional cooperation—especially cooperation from India—expansion of storage capacity is likely to improve water supply throughout the region. However, Nepal's political climate and limited technical capabilities of this upper riparian country limits the potential for expansion. Foreign aid would thus be useful in helping to fund large-scale infrastructure projects.

IV. Improved Crop Planning

To reduce water used in agriculture, which accounts for more than 80 percent of water use in South Asia, the focus must be on improved crop planning. Strategies include increased crop diversification and utilization of different planting methods. Alternative crops, such as vegetables instead of grains, reduce water use and can increase local income due to the higher profit margin for farmers. As South Asian countries continue to develop, incomes will likely rise and local demand will likely shift from basic cereals to vegetables, dairy products and meat (Aggarwal et. al, 2004). Planting methods include multicropping, crop rotation, intercropping, zero-till and direct seeding techniques, all of which reduce financial and environmental costs of cultivation by lowering labor costs and decreasing soil disturbance (Jat et al., 2006). These techniques may increase water use efficiency (Tilman et al., 2002) and reduce the demand for irrigation in South Asia, as seeds germinate by using moisture left by harvested crops (World Bank, 2008).

Trade-offs exist in selecting any of these agricultural policies. Improved crop planning is likely to result in significantly more efficient water use. To fully implement this policy, South Asian governments might upgrade irrigation systems, creating less reliance on surface water and thereby reducing overall consumption. Furthermore, international aid could reduce the costs of crop planning and improve training programs. However, there is not strong political support for improved crop planning, and infrastructure and supply costs would be high.

V. Privatization of Local Water Utilities

Finally, giving private entities control of local water utilities addresses the management and pricing issues that may otherwise be difficult for local governments to address. In theory, a privately owned utility would be driven by the desire to maximize profits like any other private company. This business model would lead the private utility's managers to set prices at a level at least sufficient to cover costs. The utility would have incentives to optimize efficiency of the delivery system. While organizations such as the Asian Development Bank have lauded this approach, its implementation would be subject to several pitfalls, perhaps more than any other approach.

In practice, privatization entails many of the same political roadblocks as the government increasing the local water price. Private utilities could be expected to raise water prices substantially from their unrealistically low levels. These increases would turn water from a subsidized resource into a resource that would be in effect sold for profit, with consumers forced to reallocate their spending accordingly. Although some consumers do privately pay for water, water privatization is not a widespread practice in South Asia. More generally, removing the management of water resources from the public sphere means ending government influence over pricing. As such, a more limited form of privatization or public-private partnership would be more likely than outright privatization.

Considering the evaluative criteria, private managers would ostensibly have the technical capacity to provide water efficiently. They may also be better equipped to manage and put a price on scarce resources. However, no South Asian government is likely to support such a policy as constituents would undoubtedly oppose adoption of such a measure. Furthermore, foreign aid would not affect privatization of water utilities.

Conclusion

As this report shows, water issues likely will continue to be a major source of conflict between India and neighboring Pakistan, Bangladesh and Nepal in coming decades. As populations rise, levels of economic development increase and the effects of climate change become more extreme, India and its neighbors will struggle to meet growing demand while managing dwindling water supplies. Transboundary rivers, especially those in the Indus and Ganges-Brahmaputra basins, will play a major role in disputes about water. While supply and demand pressures will likely result in shortages throughout the region, the situation in Pakistan is expected to be particularly acute.

Mechanisms such as the Indus Water Treaty can provide a basis for resolving these disputes, but new circumstances, including growing demand and the retreat of glaciers, will lead to new challenges. How South Asian countries respond to these challenges will be key in determining the long-term sustainability of regional water supplies. Moreover, mitigating shortages is an important element in limiting conflicts between India and Pakistan, Bangladesh and Nepal.

The most politically feasible options for mitigating water shortages are those that increase efficiency or supply (as through improved storage). Options that attempt to control demand through higher prices are likely to be less feasible due to public opposition. In practice, the diversity of local problems means that no single policy option will serve as a panacea to water shortages. However, a combined approach that incorporates improved management capacity, increased storage, better crop management and improved pricing where feasible may provide a sufficient framework to diminish the negative effects of water shortages resulting from increased demand and climate change.

In each of these areas, outside aid could provide a crucial role in implementing effective strategies and thereby limiting water shortages and the international disputes likely to emerge from them.

References

Action Aid. (1999). After the Flood: Official Damage Statistics of Bangladesh Flood 1998. Retrieved February 28, 2009, from http://www.reliefweb.int/rw/rwb.nsf/db900sid/ACOS-64BPTF?OpenDocument.

Aggarwal, P.K, Joshi, P.K, Ingram, J.S.I & Gupta, R.K. (2004). Adapting Food Systems of the Indo-Gangetic Plains to Global Environmental Change: Key Information to Improve Policy Formulation. *Environmental Science & Policy*. Vol.7. 487-498.

Agoramoorthy, Govindasamy & Hsu, Minna J. (2008). Small Size, Big Potential: Check Dams for Sustainable Development. *Environment*. Vol. 50, No. 4. 24-35.

Ahmed, Abu Musa Mohamed Motaher & Roy, Kingshuk. (2007). Utilization and Conservation of Water Resources in Bangladesh. *Journal of Development in Sustainable Agriculture*. Vol. 2. 35-44.

Alam, Undala Z. (2002). Questioning the Water Wars Rationale: A Case Study of the Indus Water Treaty. *The Geographical Journal*. Vol. 168, No. 4. 341-355.

All India Congress Committee (AICC). (2009a). Lok Sabha Elections 2009: Manifesto of the Indian National Congress. Retrieved April 11, 2009, from http://www.aicc.org.in/new/manifesto09-eng.pdf.

All India Congress Committee (AICC). (2009b). Lok Sabha Elections 2009: Bharatiya Janata Party Manifesto. Retrieved April 11, 2009, from http://www.bjp.org/images/pdf/election_manifesto_english.pdf.

Asian Development Bank (ADB) & International Center for Mountain Development. (2006). *Environmental Assessment of Nepal – Emerging Issues and Challenges.* Kathmandu. Retrieved April 15, 2009, from http://www.adb.org/Documents/Books/emerging-issues-challenge.

Asian Development Bank (ADB). (2007). Country Profile - India. Water Knowledge Center Statistics. Retrieved on April 18, 2009, from http://www.adb.org/Water/Indicators/cwsi-country-profile.asp?ctry=IND#a1.

Anthony, Augustine. (2009, April 16). Pakistan’s Sharif Says Will Not Rejoin Government. *Reuters India*. Retrieved April 19, 2009, from http://in.reuters.com/article/southAsiaNews/idINIndia-39080320090416?pageNumber=1&virtualBrandChannel=0.

Babel, Mukand S. & Wahid, Shahriar. (2008). Freshwater Under Threat: South Asia. Asian Institute of Technology: United Nations Environmental Programme. Retrieved March 20, 2009, from http://www.unep.org/pdf/southasia_report.pdf.

Bangladesh Awami League. (2008). A Charter for Change: Election Manifesto of the Bangladesh Awami League. Retrieved April 18, 2009, from http:// www. albd.org/autoalbd/index2.php?option=com_content&do_pdf=1&id=367.

Bangladesh Ministry of Water Resources. (1999). National Water Policy. Government of the People's Republic of Bangladesh. Retrieved March 20, 2009, from http://www.mowr.gov.bd/Documents/National %20Water%20Policy%20(English).pdf.

Barker, Randolph & Molle, François. (2004). Evolution of Irrigation in South and Southeast Asia. *Comprehensive Assessment Research Report 5*. Comprehensive Assessment Secretariat, International Water Management Institute. Retrieved March 2, 2009 http://www.iwmi.cgiar.org/ Assessment/FILES/pdf/publications/ResearchReports/CARR5.pdf.

Bhaskar, Utpal. (2008, December 15). India, Pakistan May Hold Talks on Tulbul Navigation Project. *The Wall Street Journal*. Retrieved April 14, 2009, from http://www.livemint.com/2008/12/15223356/India-Pakistan-may-hold-talks.html.

Bricheri-Colombi, Stephen & Bradnock, Robert. (2003). Geopolitics, Water and Development in South Asia: Cooperative Development in the Ganges-Brahmaputra Delta. *The Geographical Journal*. Vol. 169, No. 1. 43-46.

Brisco, John & Malik, R.P.S. (2006). *India's Water Economy: Bracing for a Turbulent Future.* New York: The World Bank.

British Broadcasting Corporation (BBC). (2009). Country profile: Nepal. Retrieved April 27, 2009, from http://news.bbc.co.uk/2/hi/south_asia/country_profiles/1166502.stm.

Chakravorty, Nityananda. (2004). Water Pricing in Bangladesh: A Pro-Poor Framework Based on Two Surface Water Irrigation Projects in Bangladesh. Dhaka, Bangladesh: Centre for Environmental and Geographic Information Services. Posted on Website of China Water Science and Technology. Retrieved March 2, 2009, from http://www.watertech.cn/english/chakravorty.pdf.

Daanish, Mustafa. (2007). Social Construction of Hydropolitics: The Geographical Scales or Water and Security in the Indus Basin. *Geographical Review*. Vol. 97, No. 4. 484-501.

Daily Independent Bangladesh. (n.d.) Government is Not Satisfied with Water Sharing with India. Retrieved April 3, 2009, from http://www.theindependent-bd.com/details.php?nid=118921.

Dellapenna, Joseph, & Gupta, Joyeeta. (2008). Toward Global Law on Water. *Global Governance*. Vol. 14. 437-453.

Dixit, Ajaya, Adhikari, Pradeep & Thapa, Rakshya Rajyashwori. (2004). Nepal: Ground Realities for Himalayan Water Management. *Disputes Over the Ganga: A Look at Potential Water Related Conflicts in South Asia*. Kathmandu: Panos Institute South Asia. 159-192.

Eckhardt, Gregg. (n.d.). Glossary of Water Resource Terms. Edwards Aquifer. Retrieved April 20, 2009, from http://www.edwardsaquifer.net/glossary.html.

Falkenmark, M., Lundquist, J. & Widstrand, C. (1989). Macro-Scale Water Scarcity Requires Micro-Scale Approaches: Aspects of Vulnerability in Semi-Arid Development. *Natural Resources Forum.* Vol. 13. 258-267.

Government of Bangladesh. (1996). Treaty Between the Government of the People's Republic of Bangladesh and the Government of the Republic of India on Sharing of the Ganga/Ganges Waters at Farakka. Retrieved April 10, 2009, from http://www.jrcb.gov.bd/attachment/Gganges_Water_Sharing_treaty,1996.pdf.

Gupta, Raj & Seth, Ashok. (2006). A Review of Resource Conserving Technologies for Sustainable Management of the Rice-Wheat Cropping Systems of the Indo-Gangetic Plains. *Crop Protection.* Vol. 26, No. 3. 436-447.

Hossain, Ishtiaq. (1998). Bangladesh-India Relations: The Ganges Water-Sharing Treaty and Beyond. *Asian Affairs: An American Review*. Vol. 25, No. 3. 331-350.

Indian Ministry of Water Resources. (2002). National Water Policy. Retrieved April 2, 2009, from http://wrmin.nic.in/writereaddata/linkimages/nwp20025617515534.pdf.

International Water Management Institute (IWMI). (2009). PODIUM: Integrated Database Information System. CGIAR Challenge Program on Water & Food. Retrieved February 28, 2009, from http://dw.iwmi.org/idis_DP/home.aspx.

Jain, Sharad K., Agarwal, Pushpendra K. & Singh, Vijay P. (2007). Ganga Basin, in Hydrology and Water Resources of India. Netherlands: Springer. Part 3. Vol. 57. 333-418.

Jat, M.K., Gupta, Raj K., Erenstein, Olaf & Ortiz, Rodomiro. (2006). Diversifying the Intensive Cereal Cropping Systems of the Indo-Ganges through Horticulture. *Chronica Horticulturae*. Vol. 46, No. 3. Retrieved April 10, 2009, from http://www.solutionexchange-un.net.in/food/cr/res01090602.pdf.

Khadka, Navin Singh. (2009, January 16). Nepal Turns Back on Hydropower. British Broadcasting Corporation Nepali Service. Retrieved April 27, 2009, from http://news.bbc.co.uk/2/hi/science/nature/7831911.stm.

Kumar, Kireet, Singh, P. & Sharma, Bharat R. (2005). Water Resources of India. *Current Science*. Vol. 89, No. 5. 794-811.

Mirani, Haroon. (2009, January 13). Race to the Death Over Kashmir Waters. *The Asia Times*. Retrieved April 14, 2009, from http://www.atimes.com/atimes/South_Asia/KA13Df01.html.

Muhammed, Amir et al. (2004). Water Resources in South Asia: An Assessment of Climate Change: Associated Vulnerabilities and Coping Mechanisms. Asia-Pacific Network for Global Change Research. Retrieved May 18, 2009, from reference is http://www.apn-gcr.org/en/products/project _reports/2004/Final%20Report/2004_02_CMY-Muhammed_.pdf

Mustafa, Khalid. (2009, March 24). Kishenganga Project: Pakistan Serves Notice on India. *The International News.* Retrieved April 14, 2009, from http://www.thenews.com.pk/top_story_detail.asp?Id=21115.

Pakistan Bureau of Statistics. (2002). Pakistan Statistical Yearbook. Retrieved April 2, 2009, from http://www.statpak.gov.pk/depts/fbs/publications/ yearbook2008/yearbook2008.html.

Pakistan Daily Times. (2009, March 21). Pakistan Wants to Resolve Water Issues with India Bilaterally. Retrieved April 19, 2009, from http://www.dailytimes.com.pk/ default.asp?page=2009\03\21\story_21-3-2009_pg7_21.

Pakistan Ministry of Environment. (2009). The National Year of Environment 2009. Government of Pakistan. Retrieved April 19, 2009, from http://202.83.164.26/wps/portal/Moe.

Pokharel, Shaligram. (2001). Hydropower for Energy in Nepal. *Mountain Research and Development.* Vol. 21, No. 1. 4-9.

Pun, Santa Bahardu. (2004). Overview: Conflicts Over the Ganga? *Disputes Over the Ganga*. Bhim Subba and Kishor Pradhan (Ed). Panos Institute of South Asia. 2-20.

Ramachandran, Sudha. (2008, December 9). India Quakes Over China's Water Plan. *Asia Times Online*. Retrieved April 12, 2009, from http://www.atimes.com/atimes/China/JL09Ad01.html.

Roberts, Tom. (2005). The Indus – Life Blood of Pakistan. *Asian Affairs*. Vol. 36, No. 1. 1-11.

Sahai, I.M. (2007). Baglihar Decision - An End to the Dispute? *International Water Power and Dam Construction*. Vol. 59, No. 4. 14-16.

Sahni, Hamir K. (2006). The Politics of Water in South Asia: The Case of the Indus Waters Treaty. *SAIS Review*. Vol. 25, No. 2. 153-165.

Salman, Salman M.A. (2008). The Baglihar Difference and Its Resolution – A Triumph for the Indus Waters Treaty? *Water Policy*. Vol. 10. 105-117.

Salman, Salman M.A. & Uprety, Kishor. (2002). Conflict and Cooperation on South Asia's International Rivers - A Legal Perspective. Netherlands: Kluwer Law International.

Sampath, Anitha et al. (n.d.). Water Privatization and Implications in India. College Station, Texas: Association for India's Development. Retrieved April 1, 2009, from http://studentorgs.utexas.edu/aidaustin/water/water_privatization.pdf.

Seckler, David, Amarasinghe, Upali, Molden, David, de Silva, Radhika & Barker, Randolph (1998). 1990 to 2025: Scenarios and Issues. World Water Demand and Supply. Research Report 19: International Water Management Institute. Retrieved April 15, 2009, from http://dlc.dlib.indiana.edu/archive/00004198/01/REPORT19.pdf.

Shah, Tushaar, et al. (2008). Is Irrigation Water Free? A Reality Check in the Indo-Gangetic Basin. *World Development*. Vol. 37, No. 2. 422-434.

Shamim, Choudhury. (2008). Alternative Views of Environmental Security in a Less Developed Country: The Case of Bangladesh. *Journal of Third World Studies*. Vol. 25, No. 1. 253-272.

Sharma, Bharat R. & Sharma, Devesh. (2008). Impact of Climate Change on Water Resources and Glacier Melt and Potential Adaptations for Indian Agriculture. New Dehli: International Water Management Institute.

Sharma, Bharat R., Amarasinghe, Upali A. & Sikka, Alok. (2008). Indo-Gangetic River Basins: Summary Situation Analysis. New Delhi: International Water Management Institute.

Singh, P. & Arora, M. (2007). Water Resources Potential of Himalayas and Possible Impact of Climate. *Hydrolog*y *Review (Jalvigyan Sameesksha* in Urdu*).*Vol. 22. 109-132.

Smakhtin, V.U. & Anputhas, M. (2006). An Assessment of Environmental Flow Requirements of Indian River Basins. *International Water Management Institute Research Report 107*. Colombo, Sri Lanka.

Tilman, David, et al. (2002). Agricultural Sustainability and Intensive Production Practices. *Nature*. Vol. 418. 671-677.

United Nations (UN). (n.d.). Irrigation Water Use Per Country in the Year 2000. *Review of Global Agricultural Use Per Country*. FAO AQUASTAT. Food and Agricultural Organization of the United Nations. Retrieved March 21, 2009, from http://www.fao.org/nr/water/aquastat/water_use/index.stm.

United Nations (UN). (1996). Towards a New Green Revolution. *Food for All – World Food Summit, Rome 13-17*. Food and Agricultural Organization of the United Nations. Retrieved March 29, 2009, from http://www.fao.org/docrep/x0262e/x0262e00.HTM.

United Nations (UN). (1997a). Country Profiles: India. *FAO AQUASTAT*. Food and Agriculture Organization of the United Nations. Retrieved March 21, 2009, from http://www.fao.org/nr/water/aquastat/dbase/index.stm.

United Nations (UN). (1997b). Country Profiles: Pakistan. *FAO AQUASTAT*. Food and Agriculture Organization of the United Nations. Retrieved March 21, 2009, from http://www.fao.org/nr/water/aquastat/dbase/index.stm.

United Nations (UN). (1999a). Country Profiles: Bangladesh. *FAO AQUASTAT*. Food and Agriculture Organization of the United Nations. Retrieved March 21, 2009, from http://www.fao.org/nr/water/aquastat/dbase/index.stm.

United Nations (UN). (1999b). Country Profiles: Nepal. *FAO AQUASTAT*. Food and Agriculture Organization of the United Nations. Retrieved March 21, 2009, from http://www.fao.org/nr/water/aquastat/dbase/index.stm.

United Nations (UN). (2003). Water: A Vital Source of Life. *United Nations System in Pakistan*. Retrieved March 1, 2009, from http://www.un.org.pk/unic/pdf/IYF_english.pdf.

United Nations. (UN). (2004a). Country Profiles: Bangladesh. *FAO Statistical Yearbook*. Food and Agriculture Organization of the United Nations. Retrieved March 21, 2009, from http://www.fao.org/es/ess/yearbook/.

United Nations (UN). (2004b). Country Profiles: India. *FAO Statistical Yearbook*. Food and Agriculture Organization of the United Nations. Retrieved March 21, 2009, from http://www.fao.org/es/ess/yearbook/.

United Nations (UN). (2004c). Country Profiles: Nepal. *FAO Statistical Yearbook*. Food and Agriculture Organization of the United Nations. Retrieved March 21, 2009, from http://www.fao.org/es/ess/yearbook/.

United Nations (UN). (2004d). Country Profiles: Pakistan. *FAO Statistical Yearbook*. Food and Agriculture Organization of the United Nations. Retrieved March 21, 2009, from http://www.fao.org/es/ess/yearbook/.

United Nations (UN). (2005a). Major Food and Agricultural Commodities and Producers: Countries by Commodity, Bangladesh. Food and Agriculture Organization of the United Nations. Economic and Social Department, Statistics Division. Retrieved March 21, 2009, from http://www.fao.org/es/ess/top/country.html;jsessionid=28BB97B2DE13C2A4E2AD5A3ACE6D2FAE.

United Nations (UN). (2005b). Major Food and Agricultural Commodities and Producers: Countries by Commodity: India. Food and Agriculture Organization of the United Nations. Economic and Social Department, Statistics Division. Retrieved March 21, 2009, from http://www.fao.org/es/ess/top/country.html;jsessionid=28BB97B2DE13C2A4E2AD5A3ACE6D2FAE.

United Nations. (UN). (2005c). Major Food and Agricultural Commodities and Producers: Countries by Commodity, Pakistan. Food and Agriculture Organization of the United Nations. Economic and Social Department, Statistics Division. Retrieved March 21 from http://www.fao.org/es/ess/top/country.html;jsessionid=28BB97B2DE13C2A4E2AD5A3ACE6D2FAE.

United Nations (UN). (2005d). Major Food and Agricultural Commodities and Producers: Countries by Commodity, Nepal. Food and Agriculture Organization of the United Nations. Economic and Social Department, Statistics Division. Retrieved March 21, 2009, from http://www.fao.org/es/ess/top/country.html;jsessionid=28BB97B2DE13C2A4E2AD5A3ACE6D2FAE.

United Nations (UN). (2009). Aquastat Database. Food and Agricultural Organization of the United Nations. Retrieved February 28, 2009, from http://www.fao.org/nr/water/aquastat/main/index.stm.

United Nations Cartographic Section. (2009a). Bangladesh. Retrieved April 1, 2009, from http://www.un.org/Depts/Cartographic/map/profile/banglade.pdf.

United Nations Cartographic Section. (2009b). South Asia. Retrieved April 1, 2009, from http://www.un.org/Depts/Cartographic/map/profile/seasia.pdf.

United Nations Cartographic Section. (2009c). Nepal. Retrieved April 1, 2009, from http://www.un.org/Depts/Cartographic/map/profile/nepal.pdf.

United Nations Cartographic Sections (2009d). Pakistan. Retrieved April 1, 2009, from http://www.un.org/Depts/Cartographic/map/profile/pakistan.pdf.

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2009a). Valuing Water. UNESCO World Water Assessment Programme. Retrieved April 3, 2009, from http://www.unesco.org/water/wwap/facts_figures/valuing_water.shtml

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2009b). World Water Assessment Programme. (2009b). The United Nations World Water Report 3: Water in a Changing World. Paris and London: Earthscan. Retrieved April 15, 2009, from http://www.unesco.org/water/wwap/wwdr.

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2009c). World Water Assessment Programme. The United Nations World Water Development Report 3: Case Studies: "Facing the Challenges." Paris and London: Earthscan. Retrieved April 15, 2009, from http://www.unesco.org/water/wwap/wwdr.

United Nations General Assembly (1997).Convention on the Law of the Non-Navigational Uses of International Watercourses Adopted by the General Assembly of the United Nations on 21 May 1997. Retrieved April 18, 2009, from http://untreaty.un.org/ilc/texts/instruments/english/ conventions/8_3_1997.pdf

Upreti, B.C. (1993). Politics of Himalayan River Waters: An Analysis of the River Water Issues of Nepal, India and Bangladesh. Jaipur: Nirala Publications.

U.S. Central Intelligence Agency (CIA). (2009a). The World Factbook: Bangladesh. Retrieved March 7, 2009, from https://www.cia.gov/library/publications/the-world-factbook/geos/bg.html.

U.S. Central Intelligence Agency (CIA). (2009b). The World Factbook: India. Retrieved March 7, 2009, from https://www.cia.gov/library/publications/the-world-factbook/geos/in.html.

U.S. Central Intelligence Agency (CIA). (2009c). The World Factbook: Nepal. Retrieved March 7, 2009, from https://www.cia.gov/library/publications/the-world-factbook/geos/np.html.

U.S. Central Intelligence Agency (CIA). (2009d). The World Factbook: Pakistan. Retrieved March 7, 2009, from https://www.cia.gov/library/publications/the-world-factbook/geos/pk.html.

U.S. Environmental Protection Agency (EPA). (2006). Check Dams. Stormwater Menu of BMPs. Retrieved April 17, 2009, from http://cfpub1.epa.gov/npdes/ stormwater/menuofbmps/index.cfm?action=browse&Rbutton=detail&bmp=36.

U.S. Geological Survey (USGS). (n.d.). Water Science Glossary of Terms. Retrieved April 20, 2009, from http://ga.water.usgs.gov/edu/dictionary.html.

Wirsing, Robert G. (2007). Hydropolitics in South Asia: The Domestic Roots of Interstate River Rivalry. *Asian Affairs: An American Review.* Vol. 34, No. 1. 1-21.

Wirsing, Robert G. & Jasparro, Christopher. (2007). River Rivalry: Water Disputes, Resource Insecurity and Diplomatic Deadlock in South Asia. *Water Policy*. Vol. 9. 231-251.

Wolf, Aaron T. & Newton, Joshua T. (2007). Case Study of Transboundary Water Dispute Resolution: The Ganges River Controversy. Transboundary Water Dispute Database. Corvallis: Oregon. Retrieved March 15, 2009, from http://www.transboundarywaters.orst.edu/.

World Bank. (2005). Water Economy: Running Dry. *Pakistan Country Water Resources Assistance Strategy*. Retrieved March 4, 2009, from http://siteresources.worldbank.org/PAKISTANEXTN/Resources/PWCAS-Title&Intro.pdf.

World Bank. (2008). Agriculture for Development. World Development Report 2008. Retrieved April 18, 2009, from http://siteresources.worldbank.org/INTWDR2008/Resources/WDR_00_book.pdf.

World Bank. (2009a). Key Development Data and Statistics. *Data and Statistics.* Retrieved March 1, 2009, from http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS/0,,contentMDK:20535285~menuPK:1192694~pagePK:64133150~piPK:64133175~theSitePK:239419,00.html.

World Bank. (2009b). South Asia Data Statistics. Data and Statistics. Retrieved February 20, 2009, from http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/0,,menuPK:158851~pagePK:146732~piPK:146813~theSitePK:223547,00.html.

World Resources Institute. (2007). Water Resources and Freshwater Ecosystems, Country Profile-Nepal. *Earth Trends: The Environmental Information Portal*. Retrieved March 1, 2009, from http://earthtrends.wri.org/text/water-resources/country-profile-130.html.

World Wildlife Fund – Pakistan. (2009). Water Pollution Fact Sheet. Retrieved April 2, 2009, from http://www.wwfpak.org/factsheets_wps.php.

Yamada, T. & Sharma, C.K. (1993). Glacier Lakes and Outburst Floods in the Nepal Himalaya. *Snow and Glacial Hydrology*. Proceedings of the Kathmandu Symposium, November 1992. International Association of Hydrological Sciences Publication. No. 218. 319-30.

Appendix A. Summary of Major South Asian Water Disputes

Conflict	Countries Involved in Conflict	India's Position	Neighboring Country's Position	Timeline	Current Status of Conflict
Baglihar Dam	India and Pakistan	Project meant for storage, will increase water management efficiency and encourage cost-effectiveness	Pakistan: Project in violation of Indus Water Treaty and will change water flow	Indian construction begins 1992; formal bilateral negotiations over project design begin 2000; neutral World Bank arbitrator appointed 2007; arbitrator issues ruling 2007	Construction of dam projected to finish 2010
Tulbul Navigation/ Wular Barrage	India and Pakistan	Project meant for storage purposes, will regulate river flow and will benefit India and Pakistan	Pakistan: Project in violation of Indus Water Treaty, will change water flow and will negatively affect country's downstream canal system	India construction begins 1984; construction halted in 1987 due to Pakistani opposition;	Bilateral talks regarding project may resume in 2009
Kishenganga Dam	India and Pakistan	Project intended for hydroelectric and storage purposes	Pakistan: Project violates Indus Water Treaty and will submerge vast tracts of Pakistani land	Project still being planned	Pakistan serves notice to India March 2009 that they will seek neutral expert to resolve issue; Pakistan plans construction of Neelhum-Jhelum dam in 2008 on same river
Water retention from Beas, Ravi and Sutlej rivers	India and Pakistan	Retention in keeping with Indus Water Treaty	Pakistan: The little water that does enter Pakistan from the three rivers is highly polluted	From 1960 to present	No change (although no formal conflict has resulted, Indian water retention has exacerbated other Indian-Pakistani water disputes)
Farraka Barrage	India and Bangladesh	Project efficiently diverts waters to flush Kolkata port	Bangladesh: Project will negatively impact agro-ecological and economic well-being of Bangladesh	Bilateral treaty signed 1996 regulating allocation of water reaching Farraka; Joint Committee of Experts formed 1997 to oversee negotiations over common rivers	No recent disputes

Conflict	Countries Involved in Conflict	India's Position	Neighboring Country's Position	Timeline	Current Status of Conflict
Teesta River	India and Bangladesh	Gazoldoba Barrage on Teesta River effectively diverts water to West Bengal	Bangladesh: More water than necessary is being diverted	India constructs Gazoldoba Barrage on river in late 1980s; Bangladesh constructs Teesta Barrage in 1998	No recent disputes
River Linking Project	India and Bangladesh	Project will link Teesta and Brahmaputra rivers to transfer water to water-scarce regions	Bangladesh: Project may lead to flooding in Bangladesh and intensify country's dry season	Two countries agree in 2008 that they will negotiate project	Project in planning stage as of spring 2009
Flood control	India and Nepal	Argues that Nepal releases water into India, causing regional flooding	Nepal: Points out that no barrages exist from which to release waters	From 1950s to present	Ongoing disputes
Future Nepali projects	India and Nepal	Projects may harm northern India	Nepal: Projects will lead to environmentally friendly sustainable development	From 1950s to present	Ongoing disputes

Source: Authors

Appendix B. Statistical Projection Methodology

The United Nations, the International Water Management Institute and the International Food Policy Research Institute produced the PODIUM tool to enable modeling of water demand around the world. Research by David Seckler et al. (1998) supported by the International Water Management Institute provides foundational data for world water demand and supply between 1990 and 2025.

PODIUM determines increasing water demand in 2025 as a result of population growth and changing cereal requirements. The model does not provide hard and fast predictions but rather analyses “what-if” questions. For example, it helps analyze and answer questions such as: “If India’s population in 2025 will consume 3,000 calories per capita per day, what does this imply for water requirements, what does this require in terms of rain-fed and irrigated grain production and, ultimately, what does this mean for irrigation policy? Will water and land resources be sufficient to produce the required food, or will the country have to further import more grains?”

Water demand is affected by the area irrigated with groundwater and by surface irrigation efficiency (the amount of water that crops actually need, minus the amount supplied by rainfall, compared to the amount of water diverted for irrigation). Impacts of increased water withdrawals are assessed in terms of the country’s groundwater balance.

PODIUM also considers industrial and domestic demands. The user can specify the amount allocated for industry, the percentage of the population with access to piped water and the daily use per person. Very little of this water is actually depleted; most flows back into the system and is recycled.

In our example scenario, 100 percent of the population has access to piped water in 2025 and people are using approximately 26 liters per day. Industrial water use remains the same. According to these assumptions, domestic consumption depletes 5.8 cubic kilometers (up from 2.1 cubic kilometers in 1995), and industry depletes 1.8 cubic kilometers.

However, since Podium utilizes statistics from the Food and Agricultural Organization of the United Nations, our PODIUM model is open to the same weaknesses as that of the Food and Agricultural Organization’s model. Specifically, Bangladesh and Nepal are impossible to forecast. There simply are no usable data. Therefore, to provide basic forecasts, we used World Bank projections to integrate current demand with the population growth forecasts.

Appendix C. Policy Alternatives

Policy Goals	Policy Alternatives					
	Crop Planning	Community Water Management	Interprovincial Water Management	Improved Storage Capacity	Increased Water Prices	Privatization of Water Utilities
Efficacy	Strong: Will significantly improve agricultural water efficiency	Strong: Creates stronger incentives for efficiency	Medium: Interprovin-cial cooperation cre-ates stronger incen-tives for efficiency	Strong: This policy would significantly improve control over regional water supply	Medium: Would decrease demand for water, there-by implicitly promoting conservation	Medium: May address manage-ment and pricing issues
Political Feasibility	Weak: Strong political support does not exist for this policy	Medium: The Indian government has promoted irrigation cooperatives	Weak: Recent regional efforts at coordination have failed	Weak: Regional cooperation is not likely in short-term	Weak: South Asian leaders unlikely to promote increased water prices, which could trigger unrest and be highly unpopular	Weak: Strong political support does not exist for this policy
Technical Feasibility	Medium: Infrastruc-ture and supply costs are high	Medium: Domestic experts could help with initial training and continued monitoring	Weak: Information-sharing capacity is low throughout South Asia, particularly in rural communities	Weak: Increasing storage capacity would entail major infra-structure upgrades	Medium: Administrative capacity exists to raise prices	Medium: Private managers may have better capa-city to provide water efficiently
Usefulness of Aid	Strong: Aid could be helpful and reduce costs of crop planting and improve training	Strong: Interna-tional experts could help with initial training and monitoring	Medium: International experts could help with initial training and continued monitoring	Medium: Foreign aid would help fund infrastructure projects	Medium: Foreign aid could provide technical assistance in establishing water pricing scheme	Medium: Foreign aid could provide technical assis-tance in priva-tizing utilities