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"The next war in the Middle East will be over water, not politics." -- Boutros Boutros-Ghali, 1991

Geographical variables and their importance to international relations and political military affairs are easily ignored, even though two events of the 1970s drew the attention of policymakers to the issue of resource availability with an urgency unknown in peacetime. The first was the Arab oil embargo of 1973-74; the second was the 1978 invasion of Zaire's Shaba province by Angola-based guerrillas. The former quadrupled petroleum prices and reminded producers and consumers alike that the world economy depended on the highly concentrated deposits of this increasingly scarce fossil fuel. In the latter case, even the brief curtailment of cobalt shipments from Zaire caused prices to escalate from $6 to over $50 per pound on the spot market. Disruption of the cobalt market forced a wide-scale reevaluation of the concept of strategic resources. In the United States, the review included non-fuel minerals essential to US industry, such as chrome, manganese, and platinum group metals, virtually 100 percent of which are imported. Analysts were reminded that, as with petroleum, world reserves of these minerals were not evenly distributed but were largely concentrated in politically unstable regions. Policymakers, in turn, acknowledged that the destabilizing imbalance of natural resource supply and demand can have profound consequences for US security interests.

The vice president of the World Bank, Ismail Serageldin, captured the current wisdom on natural resource issues when he said, "Many of the wars of this century were about oil, but wars of the next century will be about water."[1] When President Jimmy Carter drew his line in the sand with the Carter Doctrine, he was simply formalizing what everyone knew: Middle Eastern oil was vital to the national security of the United States and its Western allies. Few would argue that petroleum was not a major underlying cause of the Gulf War, and currently Iran is putting pressure on Saudi Arabia to reduce its oil production in order to drive up world oil prices and help Iran pay for its $10 billion arms buildup. The growing nuclear program of Iran, Israel's nuclear weapons program, and the interests of other Middle East states in nuclear weapons continue to show the potential for oil to lead the world to further conflict. However, in terms of its relative scarcity and the ability of economics and technology to mitigate the imbalance of its supply and demand, water poses different and potentially more difficult problems for strategists. Efforts to manipulate the global supply of petroleum have been a leading phenomenon of the final decades of the 20th century. Control of the sources of fresh water could be equally significant in the opening decades of the next.

The insufficiency of fresh water has in the past led to violent conflict, and is currently the source of international tensions, but one should not simply assume that population growth will inevitably lead to war over water. Technology, pricing, conservation, trade, and industrial and agricultural policy changes *may* mitigate water scarcity and alter the prescription for conflict. Research on environmental security issues generally accepts the multiple causes of conflict, but fresh water is undeniably an important variable. Given assumed population growth, changes in climatic conditions, and the imbalance of water resource supply and demand, it will continue as a source of tensions; it could become the determinant variable in future international conflict. This article examines the strategically important environmental security issue of water resource scarcity, imbalances in fresh water supply and demand, methods of mitigating water scarcity, conditions that are likely to signal when water resources may lead to conflict, and policy options that might help us to change that equation.

Water Supply

Petroleum is but the currently most popular energy alternative in a relatively crude stage of mankind's energy technology development. It remains cheap, widely available, and easily transported. Even if conventional oil reserves were to be contaminated by a nuclear exchange, or denied through war or political ideology, non-conventional oil reserves locked in deposits such as the Alberta tar sands or global deposits of oil shale could be called upon, albeit at higher cost, to offset some of the disruption of conventional petroleum supplies. Moreover, the increase in oil prices resulting from loss of access to conventional oil would drive the industrial world to implement meaningful energy strategies, including research and development programs designed to develop the technology for the many alternative energy sources. The major per capita consumers of petroleum are the industrialized countries, which have the greatest potential to initiate the required technological and economic policies. Thus, pricing mechanisms, substitution, and technology make the implications of potential oil shortages less dramatic.

Water presents a considerably less-manageable problem. Most of the water on the earth, some 97 percent, is contained in the world's oceans and is therefore of little use for essential agriculture, drinking, or most industrial uses. Only three percent of the water on the earth is fresh and, of this, more than two percent is locked away in the polar ice caps, glaciers, or deep groundwater aquifers, and is therefore unavailable to satisfy the needs of man. Furthermore, only 0.36 percent of the world's water in rivers, lakes, and swamps is sufficiently accessible to be considered a renewable fresh water resource.[2] The supplies of useful fresh water are finite, and most of the forms in which it is used have no substitute. Our fresh water is made available through the hydrologic cycle in which solar radiation evaporates ocean water, which subsequently falls to land as rain and returns to the sea as runoff through rivers or aquifers. Precipitation, then, is the original source of all fresh water; it is highly variable in its geographical occurrence.

Precipitation in large sections of the world is inadequate to support substantial agriculture, populations, or industry. Migration, along with exponential population growth, have increased the number of people living in marginal, arid lands, where survival depends upon the availability of scarce water resources. At the same time, scientists have warned of coming changes to the earth's climate and increasing periods of unstable weather patterns and rainfall. It is not yet clear whether such variations result from industrialized society and the activities of man that may give rise to global warming, or are simply part of a long-term global climate cycle which man has yet to define. The El Nino phenomenon points out the vulnerability of civilization to such variations in the hydrologic cycle.[3]

The uneven global distribution of fresh water is striking. Most global rainfall occurs in the equatorial zone that stretches from South and Southeast Asia across Africa into Central America and the Amazon Basin. In general, rainfall decreases north and south of this zone. By itself, the Amazon River accounts for 20 percent of average global runoff, compared to all of Europe with only seven percent. The Zaire river basin accounts for 30 percent of Africa's total runoff.[4] Areas chronically short of fresh water include parts of the western United States and northern Mexico; much of Africa, the Middle East, and central Asia; and small portions of South and Central America. Water-scarce countries should receive close examination, because of the rainfall variability within the borders of a given country.

- Take the case of the United States; in its eastern portion, water *quality* is the major concern, while the western portion focuses chiefly on water *quantity*. Overall, the United States appears to have sufficient water, but large portions of the plains and western mountain and inter-basin regions are arid and have overexploited aquifers. Rising populations in the water-scarce west are exceeding sustainable water yields and creating tensions with Mexico over the quality and quantity of water from the Colorado and Rio Grande rivers.
- Southeastern China benefits from seasonal monsoons and has sufficient water supplies, while the North China plain, a fertile area that accounts for 25 percent of the country's grain harvest, has water scarcity problems. Over-pumping aquifers to support wheat and millet cultivation has caused approximately one third of Beijing's wells to go dry, with the water table dropping between one and two meters annually. This condition is indicative of the water scarcity problems of this agriculturally and industrially important region of the country. China's situation is particularly important since that country, with approximately one-quarter of the world's population, can claim only eight percent of its fresh water resources.[5]
- Unlike the case of other natural resources, it is sometimes difficult to declare that certain countries do or don't meet standards for water sufficiency. Nevertheless, World Bank statistics identify approximately 20 countries that have been declared chronically water scarce. The list includes Saudi Arabia, Israel, Jordan, Kuwait, Egypt, Kenya, Somalia, and Singapore.[6] Other strategically significant countries with pronounced rainfall variability include Pakistan, Mexico, and India.

It is important to note that water scarcity from a lack of precipitation can be mitigated through desalinization and external annual river flows. Desalinization plants require substantial investments of energy, technology, and capital; as a result, most of the world's desalinization plants are located in the energy-rich Middle East. Desalinization is not a practical solution for most water-scarce regions. More important, from both historical and practical perspectives, are the countries that share access to major rivers. Syria, Egypt (the heart of the Roman Empire's granary), and Iraq, where the Tigris-Euphrates Valley gave birth to modern civilization, had dominating cultures throughout much of their history because of waters originating in upstream countries. Decisions by upstream countries to develop the heretofore common water resources, however, can have major implications for the economic viability and continued cultural existence of those downstream. Tensions currently exist within all these countries, and between them and their neighbors, as a result of upstream user decisions.

Water Demand

Demand for fresh water is examined from the perspectives of population growth, urban growth, and global water use. The latter falls into three categories: irrigation, which accounts for some 73 percent of fresh water consumed; industrial uses, with 21 percent of consumption, and public uses at six percent.[7] Water use patterns differ between industrialized and developing countries. In the former, industrial uses account for approximately 40 percent, while in the latter industries use no more than ten percent of annual fresh water consumption.[8] Conversely, in the developing world, agriculture accounts for 90 percent of water use.

Populations. So long as the supply of fresh water is provided by the hydrologic cycle, the demand for water is primarily dictated by the world's rising population. The earth's population approximates a J-curve and is growing faster than at any time in its history, with nearly 90 million people born each year. The current world population figure of 5.8 billion is too abstract for many people to grasp, but it can be put in context by these facts: at the beginning of the century there were only 1.6 billion people, and in 1950, the world population was only 2.5 billion.[9] It required from the beginning of time until approximately 100 years ago for the world's population to reach 1.6 billion; today, less than a century later, the earth is home to an additional four billion. This exponential rate of increase is not predicted to taper off for some time. Developing world countries account for 95 percent of this population increase. It is difficult to see how the hydrologic cycle will keep pace with the demands of this exploding population.

Increased development, industrialization, and growing affluence expand the per capita demand for water, in part because increased wealth generates demand for animal protein, such as beef and chicken, which require greater quantities of grain to produce similar amounts of calories for human consumption. An increasing population requires increased irrigation and dams, and generates ever-increasing quantities of untreated pollutants, both of which can affect adversely the quality of water in a state or region. Thus, water passed to downstream users, even in water-rich regions, is often contaminated by toxic and hazardous wastes, pesticides, and fertilizer; its use may also be limited by increased salinity due to multiple iterations of irrigation. Some recent statistics indicate that global demand for water for irrigation, household, and industrial use will increase faster than the rate of population growth.[10]

Population growth greatly increases the demands placed on governments struggling to maintain legitimacy in the eyes of their people. This is particularly important to those countries that are newly democratic or seeking to move toward democracy. The figure that best communicates population pressure is *doubling time*, the time in which the population of a country is expected to increase 100 percent. The United States is expected to double its population in 114 years, an estimate that allows for annual immigration of nearly one million people. The doubling time for the following strategically important countries is particularly noteworthy: Egypt, 31 years; India, 37 years; China, 66 years; Iraq, 19 years; Iran, 24 years; North Korea, 38 years; and Mexico, 32 years.[11]

Urban growth. By the year 2000, fully 50 percent of the world's population is expected to be living in urban areas, where demand for fresh water even now cannot be met consistently. The new century will be characterized by increased urbanization, caused primarily by rural dwellers flocking to the cities to take advantage of presumed job opportunities. Because economic growth is the pulse taken almost daily to determine the health of a country and the ability of an administration to govern, governments tend to favor industrialization over water quality, despite the fact that water-borne health threats can often create long-term health problems. And the very countries in which most population growth will occur will be unable to fund both economic growth and adequate social infrastructure for the uncontrolled influx of people to the cities.

Water quality will become the most pressing problem in the world's major urban centers. In the Caribbean and Latin American regions of the Western Hemisphere, 70 percent of the population is urban, and 33 percent of that urban population is concentrated in 15 large cities of two million or more inhabitants. While immediate security threats are well known, such as Brazil's use of its army to control the barrios that encroach on the outskirts of Rio De Janeiro, health threats attributable to inadequate treatment of water may in time overshadow such coercive measures. Less than half the urban population in this region has access to sewer systems; approximately 40 percent of urban residents don't have proper sanitation facilities. Some 90 percent of the waste water generated in the large urban zones is discharged without any treatment at all. The emergence of cholera in Latin America, after a 100-year absence, should be considered less an aberration than an indicator of the potentially lethal combination of population growth and inadequate supplies of fresh water. Even in a relatively sophisticated technological environment like Moscow, health officials warn travelers to beware of hepatitis A, bacterial dysentery, and other gastrointestinal diseases from organic contamination in drinking water. Few experts are sanguine about the possibility of providing safe fresh water supplies to the growing wave of urbanites in many parts of the world.

In spite of concerted efforts by the UN and the World Health Organization, in 1990 some 1.2 billion people lacked a safe supply of water and 1.7 billion had inadequate sanitation. Given anticipated growth rates in urban areas and pressures on poorly performing governments, the situation is not likely to improve.[12] The availability of fresh water in certain parts of the globe is already a problem, one for which there appears to be no immediate solution.

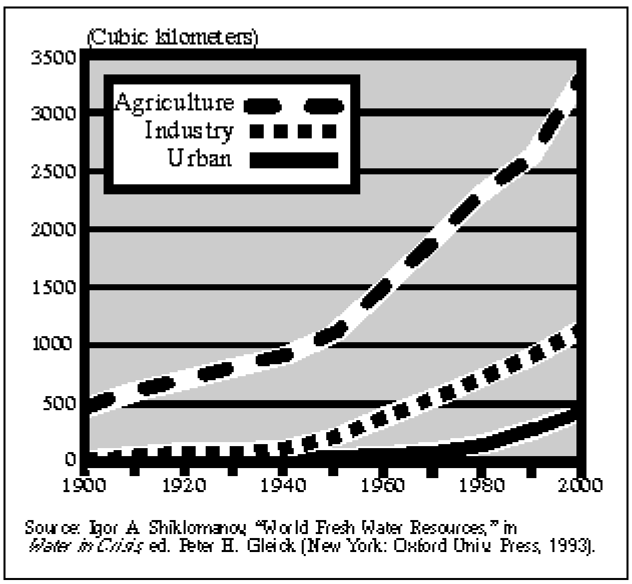

Figure 1. Global Water Use, 1900-2000.

Agriculture. The amount of fresh water consumed in agriculture has gone up in the wake of the Green Revolution, which introduced high-yield strains of grain requiring massive increases of irrigation, fertilizer, and pesticides. Seventy percent of the increased grain production in populous Asia has been made possible by irrigation.[13] Global irrigation acreage has increased in parallel with acceptance of the new grains. In 1950, worldwide irrigated land totaled 94 million hectares, whereas in the second half of the century, land under irrigation has risen to 235 million hectares. Currently, 16 percent of the world's agricultural land is irrigated, and that 16 percent produces 33 percent of the global food supply.[14]

The rate of increase in irrigated land appears to be declining; there are many possible explanations for the downturn:

- Most of the easily developed land was chosen first; remaining irrigation projects seek to improve yields from land that is of marginal quality and expensive to develop.
- Donors and lending institutions are increasingly circumspect about loans for costly irrigation infrastructure, such as dams and canals, where the environmental costs are high and the economic return on investment is in question. In addition, many of the developing countries have substantial debt burdens that they currently cannot meet.
- Irrigation is an inefficient way to use fresh water. It is estimated that only 37 percent of water applied through irrigation is absorbed by the crops; the rest is lost through evaporation, seepage, or runoff. Runoff, in turn, typically is

polluted with agricultural chemicals and salts; it is consequently of less economic value to others and may even pose health threats.

- Water to be used in irrigation schemes frequently is pumped from deep, non-renewable fossil aquifers, and many of the most important irrigation aquifers are drying up. In the United States, the well-known Ogallala fossil aquifer that runs under much of the fertile southern Great Plains is 50-percent depleted, and large areas of once-irrigated land in north Texas have been abandoned. Similar situations exist in northern China and in India. In Israel, the Arabian Gulf, and several US coastal states, excessive pumping of ground water aquifers along the coast has led to the intrusion of sea water which is contaminating drinking water supplies.[15]
- Irrigation schemes are difficult to maintain. Dams fill up with silt, as do canals and channels, and the fertility of the soil is eroded by the buildup of salts. Several strategically important countries are struggling with their irrigation programs. China has been forced to remove 930,000 hectares of irrigated land from agricultural production in the last 15 years and is losing over 100,000 additional hectares each year. From 1971 to 1985, the former Soviet Union abandoned an astounding 2.9 million hectares of irrigated crop land. The high cost of maintaining existing irrigation systems will eventually absorb some of the funds required to start new irrigation schemes.[16] A preliminary conclusion is that the increasing world population and the growing affluence of some nations will greatly influence the requirement for grain, and correspondingly power will shift to those countries with sufficient water to feed themselves and produce a grain surplus.

Industry. Industrial activity cannot be developed, nor can it long survive where already established, without access to substantial quantities of fresh water. Industrial uses for water include boiling, cleaning, air conditioning, cooling, processing, transportation, and energy production. The industries requiring the most water for their processes are petroleum refining, food processing, metals, chemical processing, and pulp and paper. In the more sophisticated industrialized countries, such as the United States, Japan, and Germany, industrial leaders motivated by new environmental and anti-pollution laws have developed technologies that recycle water before discharge. In the United States, industrial water may be used more than twice before it is returned. Purifying water after its industrial use requires costly, sophisticated technology that is not widely available in the less-developed countries to which, paradoxically, industrial production is increasingly being shifted.[17]

Water is particularly important in the energy industry. Fossil fuel and nuclear power plants and hydroelectric systems all require substantial quantities of water. Particularly heavy uses of water in the production of energy are the oil shale and tar sands (synthetic fuels) industries, which must reclaim land, generate power, process the mineral, and dispose of waste. At the Athabasca concession in Canada, where tar sands are mined and boiled to recover petroleum, it requires eight tons of water to produce one ton of final product.[18] Because the tar sands and oil shale tend to be found in arid regions, petroleum production in those regions could be constrained by the availability of water for industrial uses. A major problem of the industrial use of water is the fact that it creates toxic and hazardous pollutants that renders waste water unfit for subsequent human consumption or use in the agricultural sector; these conditions can also permanently pollute aquifers.

The expansion of industry to the developing world, in addition to local human contamination of fresh water supplies, is making it more difficult to maintain water quality in many parts of the world. Other factors, such as heightened economic interdependence and the rationalization of industrial production, have caused substantial migration of heavy industry to the developing world. Ready availability of raw materials, lower labor costs, and higher production costs in the developing countries--often caused by environmental regulations more stringent than found in many developing countries--have driven industries to more hospitable and less constrained locales. Health officials who previously had focused on relatively benign water pollutants such as coliform bacteria must now contend with nitrates, heavy metals, chemicals, and synthetic pollutants such as polychlorinated biphenyls (PCBs).

Many governments facing these new problems lack the technical skills, experience, manpower, and economic resources to correct them. Moreover, the subtle pressure to ignore water-related health threats from industries that promise even a partial solution to the government's economic problems is often not subtle at all. Governments caught in the bind between the promises of industrialization and the warnings of their own public health officials will have incentives to seek access to safe water even at the expense of their neighbors. Downstream countries increasingly will be concerned about pollutants discharged into waterways from upstream states. Trends in water quality and consumption are creating conditions in which conflict over access to fresh water is increasingly possible.

Water and Conflict

Water is an essential resource for which there are no substitutes. The fact that water does not lend itself to international trade complicates the water resource scarcity problem. Unlike metals, grain, timber, coal, or petroleum, water cannot be transported economically in large quantities, certainly not in the quantities necessary to satisfy the demands of even a small country. While there are schemes to divert major rivers, create long canals, tow icebergs, or desalinize water, such schemes have substantial economic and political costs. They appear to be sustainable solutions to water scarcity problems only in rare situations.[19] The supply of fresh water is limited by the hydrologic cycle and general climatic conditions, and demand for water as an agricultural, industrial, or urban resource is increasing exponentially with the rising global population.

If conflict over this scarce resource is to be averted, steps must be taken to allow for fair and equitable resolutions of conflicts over it. Water law in the United States is well developed and backed by numerous precedents. In the eastern part of the United States, the legal allocation of water was historically based on riparian rights, wherein all people living along the river had a claim to river water, but were not allowed to divert the flow of water in any meaningful or permanent fashion. This solution worked reasonably well in an area where there was substantial water, before large-scale industrialization or irrigation schemes were developed. As the United States expanded westward, appropriations doctrine replaced riparian rights as the dominant principle of water law. Under appropriations doctrine, priority was given to the first user of the water. This doctrine is better suited to areas where water supply is limited, and it played a major role in the allocation of Colorado River waters.

Other doctrines are applicable to international (cross-border) water flows. The Harmon Doctrine, implemented in 1909 as a result of a water dispute between the United States and Canada, said the upstream state (the United States) had an indisputable right to water. This finding caused bad feeling between the United States and Canada and did nothing to promote cooperation or more creative solutions to the problem. Subsequently, the principle of equitable apportionment was instituted and became the main principle of a US-Canadian treaty. Equitable apportionment called for a sharing of power and water benefits equally, regardless of the upstream state (or country); this principle overruled the Harmon Doctrine.[20] Though not without margin for interpretation, US water doctrine has substantial case precedents and offers a legally binding and enforceable remedy to conflict over scarce water resources.

Unfortunately, in the international milieu water law is not nearly as robust or useful in settling conflict. The method of determining sovereignty over international or transboundary rivers remains contentious throughout the international community. Most water law developed since 1800 has focused on freedom of navigation rather than water sovereignty. Difficulty in developing consensus on water law often turns on simple definitional issues. In addition, two competing doctrines of international water law have developed. The first is that of absolute state sovereignty, derived from the Harmon Doctrine, in which the upstream state has absolute sovereignty over its territory and the waters therein. The alternative doctrine is absolute integrity, which looks upon a river basin in a way that favors the downstream states by suggesting that the waters be apportioned in an equitable and reasonable fashion. Quite predictably then, when looking at the Tigris-Euphrates waters conflict, Turkey takes the position that it has absolute state sovereignty over the river waters because it is the upstream state, while Iraq and Syria champion the doctrine of absolute integrity, insisting on a reasonable and equitable apportionment of water from those rivers. Conspicuously absent, and a guarantee that international water law will remain ineffectual, is an enforcement mechanism. While an arbitrator or an international court may make a decision on a particular water dispute, that decision does not establish an enforceable precedent; enforcement depends on the good will of the parties involved. Most international water disputes are approached through bilateral or multilateral negotiations rather than legal precedents.[21]

History is replete with examples of violent conflict over water, from competition for desert oases and water holes to the battles between the Mesopotamian cities of Lagash and Umma in 4500 B.C., to the fighting between Syria and Israel over Syria's attempts to appropriate the headwaters of the Jordan River in the 1960s.[22] Water conflict is most likely when rivers are shared by multiple users and downstream users are vulnerable to decisions made by upstream states. Twenty percent of the world's population is supported by the 200 largest river systems; 150 of the systems are shared by two nations, with the remaining 50 shared by three to ten nations. Particularly important river systems and the number of countries that share their river basin are: the Nile, nine; Zaire (Congo), nine; Tigris-Euphrates, four; Mekong, six; Amazon, seven; and the Zambeze, eight.[23] From a strategic perspective, upstream states have an advantage in the control of water; downstream states generally remain vulnerable to the political decisions of those upstream.

Conflict Potential in the Middle East. Water conflict in this region has a long history, and there is great potential for renewed conflict. Since political borders in the Middle East are artificial and divide various ethnic and religious groups, all Middle East rivers and most major aquifers are international and shared by multiple states. Industrial and agricultural growth is already constrained by the lack of water. The population growth rate is among the highest in the world; by the turn of the century the population will reach 423 million, and it is expected to double in the 25 years thereafter.[24] Water disputes in the region are complicated by ongoing conflict, war, large areas of desert, climate, and political instability.

There are four distinct Middle East water sources over which potential conflict looms: the Tigris-Euphrates River basin, the Jordan River basin, the West Bank ground water aquifer, and the Nile River. In each instance water represents an essential resource for the security for all involved states, and in all instances the potential for water conflict has led to communication and an effort to seek agreement, as the following summaries of past and potential conflicts suggest.

- Turkey, which controls less than 20 percent of the Tigris-Euphrates basin land mass, controls the headwaters of the basin and therefore can dictate terms to downstream users Iraq and Syria, which between them control some 66 percent of the basin. Turkey has begun a large water management scheme known as the South-East Anatolia Project (GAP). Citing its rights as upstream riparian, Turkey has begun building 22 dams and 25 irrigation systems to take advantage of its water resources. Iraq and Syria fear that as Turkey begins filling the dams, downstream flow will be substantially reduced, impairing their agricultural sectors. Extensive irrigation schemes in Turkey have already on occasion substantially reduced water quality downstream; the concern is that chemicals and salts carried away from the irrigated land will continue to degrade the quality of water reaching Syria and Iraq. Thus, both states are strategically vulnerable to political decisions made in Ankara but lack the military, political, or economic leverage to modify the behavior of Turkey, the region's strongest military state. Moreover, the dams would not be an easy military target; even if they could be breached, the resulting floods would destroy towns and irrigation schemes downstream. Because of their own bad relations, Syria and Iraq have been unable to mount a successful bilateral effort either to negotiate a settlement or to find a solution to Turkey's control. As one consequence, both have supported minority Kurdish rebels operating against the Turks. In response, Turkey is alleged to have threatened to turn off water flowing to its downstream neighbors.[25]
- The ongoing conflict over the Jordan River basin is complex; it is perhaps the most difficult current water dispute to resolve. The Jordan River's discharge is less than two percent of that of the Nile, but it is exceptionally important to the countries involved: Israel, Jordan, Syria, Lebanon, and the new Palestinian state. The Jordan River is fed by four upstream rivers: the Dan, the Hasbani, the Banias, and the Yarmouk. As a result of capturing territory in the 1967 war and carving out a security zone in southern Lebanon, Israel is now the de facto upstream state for most of the Jordan river basin. This gives Israel substantial control over, and access to the major share of, the Jordan River water. Of particular interest, the headwaters of the Banias are located on the Golan Heights, and the Golan Heights contribute waters to the Hasbani and to Lake Tiberius, a large holding lake on the Jordan River.[26] Jordan has been left extremely vulnerable, as the majority of its water comes from the Jordan River. The dispute over water is being negotiated as part of the Madrid peace process; success so far has been defined as bringing all parties to the negotiating table and promoting communication and cooperation where otherwise there would have been no meaningful diplomatic contact. Recently an Israel-Jordan Peace Agreement was signed that recognized Jordan's right to "the minimal water needs of domestic uses for its survival."[27]
- A second water resource issue that involves Israel concerns the West Bank and access to the Mountain Yarqon-Taninim aquifer. Israel has occupied the West Bank since the 1967 Arab-Israeli War and has heavily exploited the water from this aquifer. The West Bank is a highland area that catches rainfall off the Mediterranean; its subterranean aquifer tilts toward the coast and crosses the Green Line, the former Israeli boarder. Israel is now heavily dependent upon this aquifer, counting on it for between 25 and 40 percent of its sustainable water supply.[28] Until restrictions were put in place in 1990, Israel had consistently overdrawn water quotas from this aquifer and still heavily restricts Palestinian use. Approximately 80 percent of this water is taken by either Israel or its West Bank settlers, with only 20 percent allocated to the Palestinians.[29] Although Israel could continue to withdraw water from the aquifer west of the Green Line, Palestinian control of the West Bank would inevitably mean Israel's loss of control of quantities

pumped; it would also increase the possibility that toxic wastes and other pollutants from inadequate waste disposal would alter the aquifer's water quality. The dependence of Israel on this aquifer is an important dimension of ongoing peace negotiations in the Middle East.

- While Israel often receives praise for developing commercial drip irrigation technology, its management of overall water resources is not without blemish. The Crystal Plain aquifer, which is exclusively in Israeli territory and runs along the coast, has been badly overdrawn. Salt water encroachment from the Mediterranean has occurred, and salts or nitrates from agricultural pollution have contaminated at least 20 percent of this valuable aquifer.[30]
- The Nile River is the heart of Egypt; from an airplane, one can see the green strip of agriculture and civilization that the Nile brings to what is otherwise an inhospitable desert. In 1898, Britain threatened military action when the French sent an expedition to gain control of territory that constituted the headwaters of the White Nile. The importance of upstream sources of the Nile has not been lost on subsequent Egyptian governments; Egypt has made quite clear its willingness to go to war to preserve its portion of the Nile River.[31] Egypt depends on the Nile for 97 percent of its water supplies, yet it contributes virtually no water to the Nile. Egypt is the last downstream state on the world's longest river, which has an additional eight upstream countries with the potential to withdraw water supplies before the Nile reaches Egypt.

Precipitation in the Ethiopian highlands is the source of water for the Blue Nile, which carries 85 percent of the Nile into Sudan. At Khartoum, the White Nile provides the additional 15 percent, and the remainder flows downstream into Egypt. Fortunately for Egypt, the upstream users have been unable to mount serious development schemes that would draw upon the Nile. Disagreement between Sudan and Egypt in the late 1950s brought the nations to the edge of violent conflict, but ultimately led to a 1959 agreement allocating 55.5 billion cubic meters (bcm) of the Nile to Egypt and an additional 18.5 bcm to Sudan. By recapturing municipal waste water and agricultural runoff, and by tapping minor aquifers, Egypt was able to increase its water supply to 63.5 bcm by 1990. Egypt's demand, however, is projected to reach nearly 70 bcm by the year 2000, and its population is expected to double by the year 2027.[32]

As Ethiopia recovers from the Mengistu regime and seeks to promote development, it will inevitably look toward the waters of the Blue Nile. Dams could provide irrigation to lands that are fertile but dry, and hydroelectric power to sustain new industries. Egypt's aggressive stance has been able to keep such schemes in the planning stage, and keep donors such as the World Bank from funding Ethiopian development projects. However, the region's heavy population growth, droughts in northern Africa, bad relations between Egypt and Sudan's radical Muslim government, and political pressures on newly democratic Ethiopia to satisfy the demands of its constituents portend increased conflict over this important river.

Other Regional Water Issues. While the Middle East has been the focus of most attention, several locations in Asia also have water resource problems. The Indus River basin, which begins in Tibet and has the downstream riparian states of India and Pakistan, has long been a source of conflict between those two states. The British partition of India and Pakistan in 1947 complicated the management of water from the Indus, disrupting an irrigation system that had endured for nearly 5000 years. Shortly after the partition, conflict arose as East Punjab (India) withheld water flows to canals in West Punjab (Pakistan). These destabilizing tensions continued until 1960 when, under the leadership of the World Bank, the Indus Waters Treaty was signed on the principle of equitable apportionment of Indus water resources.[33]

India has struggled elsewhere with artificial colonial borders and riparian environments. In the east, conflict exists between India and Bangladesh concerning the Ganges River, which flows from the Himalayas through India and Bangladesh, where it joins the Brahmaputra to finally empty through multiple delta exits into the Bay of Bengal.[34] In 1975, India began diverting water from the Ganges upstream from Bangladesh; the latter, deprived of Ganges water, took the dispute to the United Nations. As a result of the United Nations' examining the issue, a settlement was reached in 1977 called *The Agreement on Sharing of the Ganges Waters*. While designed to last only five years, the agreement continues to govern water flows on the Ganges; from the Bangladesh point of view, the agreement provides the important aspect of natural river flows during the dry season. The recent agreement between Nepal and India concerning upstream tributaries to the Ganges, however, includes irrigation schemes, flood control, and hydroelectric dams. Undoubtedly this agreement will affect the quality and quantity of the water reaching Bangladesh; without a revision of the 1977 agreement, there is potential for renewed conflict between India and Bangladesh over the Ganges.[35]

Although Asia and Africa, because of their high population growth rates and strategic importance, have been the focus of world attention on water conflict, other river basins have been the subject of dispute. The damming of the Parana River brought Argentina and Brazil to the conference table to resolve a difficult dispute in the 1970s. Damming and salinization were also the cause of disagreement between Chile and Bolivia over the Lauca. The United States and Mexico have been at odds over salinization and water flow quantity in the Rio Grande, while industrial pollution has caused substantial disagreement among European riparian states on the Elbe, Szamos, and Werra/Weser.[36]

From a strategic perspective, competition over scarce water resources is taking on increased importance due to the proliferation of weapons of mass destruction. The leakage of fissile materials from Russia is thought to continue, and the availability of technology to produce chemical and biological weapons is more problematic today than at any other time. Population pressures will continue to complicate the search for solutions to regional, ethnic, religious, and resource problems; any competition over regional water resources can escalate quickly from noteworthy to significant. Because the availability of water determines the production of food, and the latest grain technologies emphasize irrigation as well as pesticides and fertilizers--all of which create water pollution problems--one can expect conflict over scarce water resources in the future. Such conflicts will have international security implications beyond their regional origins.

Policy Options

The linkage between water scarcity and conflict is clear; given this fact, what can be done that might modify the conditions that could lead to conflict? The answer to this question traditionally was increasing sources of supply, primarily through irrigation. However, the best thinking on the subject now argues that water demand management is the key to improving the balance of supply and demand and mitigating conflict in the future. It is in the best interest of the United States, other donor nations, multinational groups, and non-governmental organizations (NGOs) to promote technologies and policies with the potential to reduce, at least at the margin, aspects of demand in situations of water resource scarcity. The best approach to reducing demand may be an integrated demand management system instituted by a government or regional commission. Such a policy looks at demand across all uses (agricultural, industrial, and urban) and uses incentives such as pricing, investment credits, and penalties to promote efficient water use. For example, after instituting an intense, countrywide demand management policy in the 1970s, Israel saw the per-unit product value of land and water increase significantly, with industrial production per unit of water increasing 80 percent.[37]

Many things can be done to increase the efficiency of water use. Most fresh water is used in agriculture, and irrigation increasingly has been the method by which agricultural production has been expanded. Yet as a result of over-irrigation and evaporation during transport, irrigation efficiencies worldwide are only 37 percent. Experts suggest that more efficient canal system management could save ten to 15 percent of irrigation water losses.[38] Advanced irrigation technologies substantially improve efficiencies. For example, in Israel row crops such as cotton, when irrigated with a drip irrigation system, had a 50-percent increase in product value over traditional sprinkler irrigation.[39] Drip irrigation in combination with other policies has reduced Israel's water use per irrigated acre by one-third, even as crop yields have increased. Although deep-seated political enmities in the Middle East have been a barrier to disseminating this technology in the region, Israel has worked closely with the Muslim central Asian republics in sharing it. As a result, joint irrigation projects involving Israel, Kazakhstan, and Uzbekistan have experienced "several-fold" increases in crop yield "while cutting water consumption by up to two-thirds."[40]

Water use policy decisions are also central to the availability of water. In Morocco, for example, diverting five percent of the water from irrigation would double municipal water supplies. Diverting five percent of Jordan's irrigation water would increase municipal and industrial water supplies by 15 percent.[41] However, reducing irrigation water could reduce the size of the agricultural sector and promote renewed migration of the rural population to urban centers, where jobs may not be available. One way to foster this change is to apply market forces and allow water to be priced at its true market value.

Subsidized water costs promote inefficiency and contribute to the 37-percent worldwide irrigation efficiency figure. In the United States, western water supplies are heavily subsidized. When the Government Accounting Office performed its 1981 study of a half-billion-dollar irrigation scheme in Colorado, it found that the water used to grow cattle feed had a delivered cost of $54 per acre foot, while the government-subsidized price to farmers was seven *cents* per acre foot.[42] According to US Bureau of Reclamation figures, at one to three dollars per acre foot of water, the efficiency of irrigation is less than 40 percent; however, increase that price to $10 per acre foot and farmers increase irrigation efficiency to levels in excess of 60 percent.[43] Rising prices encourage efficiency, which allows water to be diverted to the industrial or municipal sectors, thereby diversifying and strengthening the economy and making it possible for a country to purchase "virtual water" in the form of food products on the world market.[44]

In addition to demand management, several other steps could be taken to reduce the potential for conflict. One is to encourage the development of an international body of laws concerning water resources that would be capable of gaining universal acceptance and practice. Another is subsidizing research for the purposes of developing new strains of crops and increasing climatic knowledge. Donor countries can also increase funding for agricultural education to improve agricultural efficiencies in the 84 percent of the world's non-irrigated cropland.[45]

Strategic Implications

With current population trends, the worldwide per capita supply of water will be reduced by approximately 33 percent by the year 2025.[46] If this situation comes to pass, one can expect additional competition for scarce resources, territorial encroachment, regional instability, and conflict. In such an environment, certain concepts should be of importance to strategists.

- Geopolitical thinking will increase in importance in the post-Cold War environment, where regional issues have become--and seem destined to remain--the chief concern of US security interests.
- Saul Cohen described geopolitics as "the relation of international political power to the geographical setting,"[47] while Peter Jay refined the term to "the art and process of managing global rivalry."[48] Geopolitics is the marriage of geography and grand strategy. In today's regional security milieu, geographical variables can be ignored only at the strategist's peril. Although "the geographical setting does not determine the course of history, it is fundamental to all that happens within its borders."[49]
- Homer Lea, the American who became a general in the Chinese army, wrote in 1909 that "only as long as man or nation continues to grow and expand, do they nourish the vitality that wards off disease and decay."[50] The Darwinesque pattern of expanding nation-state borders and territorial conquest characterized by early geopoliticians is, in general, no longer considered acceptable.[51] This lack of physical expansion does not, however, mean that the vitality or competitive drive of the major states has withered. Indeed, it may be argued that Lea remains essentially correct, and that competition between the major powers is more intense now than ever. It may be that the form of competition has changed: from a quest for territorial expansion and defensible borders to a struggle for economic power, increasing gross national products, and access to the resources on which they depend. In that form, it may be the need for access to natural resources that should help underpin geopolitical strategy. Antagonists may seek to contain one another economically, leading one to expand its economy while precluding a rival from doing the same. If it is possible to deny access to essential resources to an adversary, then doing so has the same effect as physical containment: meaningful growth of power can be denied.
- Many adjustment mechanisms exist to mitigate resource scarcity, even for water. Technology, market pricing, legal doctrine development, conservation, and overall demand management policies (if aggressively applied), can contribute at the margin to reducing the imbalance between the supply and demand of fresh water. Unfortunately, barring a catastrophic reduction in world population, the exponential growth of population will overwhelm these marginal improvements and exacerbate water scarcity tensions in the next century. Because "no country can be economically or socially stable without an assured water supply,"[52] strategists assessing regional threats to US security interests would be wise to determine whether the countries of the region have access to adequate fresh water resources, as well as the policies to ensure that access, and know how their efforts to secure access might affect regional stability.
- Beware of generalizations and linear thinking; it is difficult to prove that water causes conflict. The 1967 Arab-Israel War is a case in point. Conflict generally has multiple causes, and it may be that water will serve as the catalyst to ignite an existing flammable mixture of ethnic, religious, or historical enmities. From the diplomatic perspective, environmental security issues, such as tensions over scarce water resources, may serve as a useful vehicle to promote communication and goodwill among potential regional combatants.[53] Thus, while it may lead to conflict, water resource scarcity may also advance the foreign policy objectives of the United States or any other nation.
- Should food prices rise in the near future, a premium will be placed on access to sufficient water to support

agriculture. Several trends account for this. India will soon have the world's largest population. India and China are struggling to feed their growing populations, and, in spite of such water resource schemes as China's Three Gorges Dam, many experts expect China and other Asian countries to enter the world cereal market as importers. In addition, negotiations in the General Agreement on Tariffs and Trade resulted in reduced agricultural subsidies in the United States and Europe, and the Uruguay round of trade talks resulted in reduced import tariffs for agricultural products. Increased demand in Asia and a liberalization of agricultural trade portend an era of increased food prices. This will result in a shift of power to food-producing countries, and it will complicate the efforts of water-scarce developing countries to decrease their dependence on irrigation.[54]

Conclusions

Water resource scarcity is an environmental security issue that currently exercises considerable influence on regional stability, particularly in arid regions. Trends in population growth, water demand, and climatic weather irregularities could make water resource scarcity more influential in geopolitical matters than heretofore has been the case.

Fresh water--who has it, who needs it--could approach access to oil in its effects on national and international security policies. The implications of this heightened importance will be noteworthy for US domestic agricultural policy, the behavior of powerful Asian states, and US efforts to encourage peace in the Middle East.

Water scarcity issues such as salinization and health are often long-term and therefore less visible to the emergency management approach to foreign policy favored by so many states. Nevertheless, water issues will continue to be a strategically important variable in foreign policy development, and they should be used as an indicator of potential regional instability and a constant reminder of the importance of geographical variables to international relations and political military affairs.

NOTES

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23. Walter H. Corson, ed., *The Global Ecology Handbook* (Boston: Beacon Press, 1990), p. 160; and Gordon J. Young, James C. I. Dooge, and John C. Rodda, *Global Water Resource Issues* (Cambridge, Eng.: Cambridge Univ. Press, 1994), p. 21.

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25. Peter Rogers and Peter Lydon, eds., *Water in the Arab World: Perspectives and Prognosis* (Cambridge, Mass.: Harvard Univ., 1994), pp. 57-58; and Beschorner, p.27.

26. Beschorner, pp. 8-10; Miriam R. Lowi, *Water and Power: The Politics of a Scarce Resource in the Jordan River Basin* (Cambridge, Eng.: Cambridge Univ. Press, 1995), pp. 147-50; and Ya' ar, pp. 56-57. Miriam Lowi offers a compelling and well-written argument for why the Jordan water dispute of the mid-1960s facilitated the deterioration of relations that led to the third Arab-Israeli war. See Lowi, pp. 115-46.

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