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Aaron T. Wolf:

**A Long Term View of Water and Security:
International Waters, National Issues, and
Regional Tensions**

**Externe Expertise für das WBGU-Hauptgutachten
"Welt im Wandel: Sicherheitsrisiko Klimawandel"**

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*A Long Term View of Water and Security:
International Waters, National Issues, and Regional Tensions*

A Report to the:
German Advisory Council on Global Change (WBGU)

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10 July 2006

Introduction

Water management is, by definition, conflict management. Postel (1999) describes the roots of the problem: Water, unlike other scarce, consumable resources, is used to fuel *all* facets of society, from biologies to economies to aesthetics and spiritual practice. Moreover, it fluctuates wildly in space and time, its management is usually fragmented, and it is often subject to vague, arcane, and/or contradictory legal principles. There is no such thing as managing water for a single purpose—*all* water management is multi-objective and based on navigating competing interests. Within a nation these interests include domestic users, agriculturalists, hydropower generators, recreators, and environmentalists—any two of which are regularly at odds—and the chances of finding mutually acceptable solutions drop exponentially as more stakeholders are involved. Add international boundaries, and the chances decrease exponentially yet again.

Surface and groundwater that cross international boundaries present increased challenges to regional stability because hydrologic needs can often be overwhelmed by political considerations. While the potential for paralyzing disputes is especially high in these basins, history shows that water can catalyze dialogue and cooperation, even between especially contentious riparians. There are 263 rivers around the world that cross the boundaries of two or more nations, and untold number of international

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groundwater aquifers. The catchment areas that contribute to these rivers comprise approximately 47% of the land surface of the earth, include 40% of the world's population, and contribute almost 80% of freshwater flow (Wolf et al. 1999).

Forty of these international river basins are in Asia and the Middle East, and their basins comprise 65% of the regions' land surface. Most of these rivers are shared by two to four countries, although some are shared by many more: Nile (10 countries), Ganges-Brahmaputra, Mekong and Tarim (6).

Within each international basin, demands from environmental, domestic, and economic users increase annually, while the amount of freshwater in the world remains roughly the same as it has been throughout history. Given the scope of the problems and the resources available to address them, avoiding water conflict is vital. Conflict is expensive, disruptive, and interferes with efforts to relieve human suffering, reduce environmental degradation, and achieve economic growth. Developing the capacity to monitor, predict, and preempt transboundary water conflicts, particularly in developing countries, is key to promoting human and environmental security in international river basins, regardless of the scale at which they occur.

In order to understand the long term implications of transboundary water management, and the potential for future conflict and cooperation, it is critical to assess what the indicators and triggers are of such processes currently, then evaluate their prospects for the future.

Hydropolitical Resilience and Vulnerability

In general, concepts of "resilience" and "vulnerability" as related to water resources are often assessed within the framework of "sustainability," and relate to the ability of bio-physical systems to adapt to change (eg., Gunderson and Pritchard, 2002). As the sustainability discourse has broadened to include human systems in recent years, so too has work been increasingly geared towards identifying indicators of resilience and vulnerability within this broader context (eg. Bolte et al. 2004; Lonergan et al. 2000; Turner 2003). In parallel, dialog on "security" has migrated from traditional issues of war and peace to also begin incorporating the human-environment relationship in the relatively new field of "environmental security" (see UNEP 2004; Vogel and O'Brien 2004).

The term “hydropolitics” (coined by Waterbury, 1979), came about as substantial new attention has been paid to the potential for conflict and violence to erupt over international waters, and relates to the ability of geopolitical institutions to manage shared water resources in a politically sustainable manner, ie. without tensions or conflict between political entities. “Hydropolitical resilience” then, is defined as the complex human-environmental system’s ability to adapt to permutations and change within these systems, and “hydropolitical vulnerability” is defined by the risk of political dispute over shared water systems. Wolf et al. (2003), suggested the following relationship between change, institutions, and hydropolitical vulnerability

"The likelihood of conflict rises as the rate of change within the basin exceeds the institutional capacity to absorb that change."

This suggests that there are two sides to the dispute setting: the rate of change in the system and the institutional capacity. In general, most of the parameters regularly identified as indicators of water conflict are actually only weakly linked to dispute. Institutional capacity within a basin, however, whether defined as water management bodies or treaties, or generally positive international relations, is as important, if not more so, than the physical aspects of a system. It turns out, then, that very rapid changes, either on the institutional side or in the physical system, that outpace the institutional capacity to absorb those changes, are at the root of most water conflict. For example, the rapid institutional change in “internationalized” basins, i.e., basins that include the management structures of newly independent States, has resulted in disputes in areas formerly under British administration (e.g., the Nile, Jordan, Tigris-Euphrates, Indus, and Ganges-Brahmaputra), as well as in the former Soviet Union (e.g., the Aral tributaries and the Kura-Araks). On the physical side, rapid change most outpaces institutional capacity in basins that include unilateral development projects *and* the absence of cooperative regimes, such as treaties, river basin organizations (RBOs), or technical working groups, or when relations are especially tenuous over other issues (Wolf et al. 2003).

The general assumption of this relationship then, is that rapid change tends to indicate vulnerability while institutional capacity tends to indicate resilience, *and* that the two sides need to be assessed in conjunction with each other for a more accurate

gage of hydropolitical sustainability. Building on these relationships, the characteristics of a basin that would tend to enhance resilience to change include

- international agreements and institutions, such as RBOs
- a history of collaborative projects
- generally positive political relations
- higher levels of economic development

In contrast, facets that would tend towards vulnerability would include

- rapid environmental change
- rapid population growth or asymmetric economic growth
- major unilateral development projects
- the absence of institutional capacity
- the potential for “internationalization” of a basin
- generally hostile relations

Water and Security

Water disputes revolve around one or more of three issues, where the rate of change may exceed the institutional capacity to absorb the change: quantity, quality, and timing. The dynamics of those three issues play out very differently within various scales related to water and security, whether internationally, intranationally, or regionally and indirectly. Each setting might be characterized as follows:

1) *International waters*

- very little violence, but long processes from tension to cooperation, resulting in exacerbated political relations, inefficient water management, and ecosystem neglect
- long, rich record of conflict resolution and development of resilient institutions
- institutional capacity is at the heart of whether environmental stresses lead to conflict or cooperation
- long-term prospect likewise has low conflict potential

2) *Intranational waters* (between sub-national political units, including states/provinces, ethnic/religious groups, and/or economic sectors)

- violence potential higher than in international setting
- rationale for international involvement more difficult, given greater issues of national sovereignty
- long-term prospect has moderate conflict potential

3) *Regional instability (indirect): political dynamics of loss of irrigation water*

- potential for politically destabilizing processes of mass migrations to cities and/or neighboring countries when water supplies for broadly

- irrigated regions are threatened due to drop in quantity (including lowering of groundwater levels) or quality
- issues of poverty alleviation and distribution of wealth are tied directly to amelioration of security concerns
 - has highest potential for long-term violence

International Waters

Water is a unique and vital resource for which there is no substitute. It ignores political boundaries, fluctuates in both space and time, and has multiple and conflicting demands on its use—problems compounded in the international realm by the fact that the international law that governs it is poorly developed, contradictory, and unenforceable. It is no wonder, then, that water is perpetually suspect—not only as a cause of historic armed conflict, but as the resource that will bring combatants to the battlefield in the 21st century. What is the likelihood that “the wars of the next century will be about water,” as some have predicted?²

In order to cut through the prevailing anecdotal approach to the history of water conflicts, researchers at Oregon State University undertook a three-year research project, which attempted to compile a dataset of *every* reported interaction between two or more nations, whether conflictive or cooperative, that involved water as a scarce and/or consumable resource or as a quantity to be managed—i.e., where water was the *driver* of the events,³ over the past 50 years (Wolf et. al 2003). The study documented a total of 1,831 interactions, both conflictive and cooperative, between two or more nations over water during the past 50 years, and found the following:

First, despite the potential for dispute in international basins, the record of acute conflict over international water resources is historically overwhelmed by the record of cooperation. The last 50 years have seen only 37 acute disputes (those involving violence); of those, 30 were between Israel and one or another of its neighbors, and the violence ended in 1970. Non-Mideast cases accounted for only five acute events, while, during the same period, 157 treaties were negotiated and signed. In fact, the only “water

² World Bank vice-president Ismail Serageldin, quoted in the *New York Times*, 10 August 1995. His statement is probably most often quoted.

³ Excluded are events where water is incidental to the dispute, such as those concerning fishing rights, access to ports, transportation, or river boundaries. Also excluded are events where water is not the driver, such as those where water is a tool, target, or victim of armed conflict.

war” between nations on record occurred over 4,500 years ago between the city-states of Lagash and Umma in the Tigris-Euphrates basin (Wolf, 1998). The total number of water-related events between nations of any magnitude are likewise weighted towards cooperation: 507 conflict-related events, versus 1,228 cooperative events, implying that violence over water is neither strategically rational, hydrographically effective, nor economically viable.

Second, despite the occasional fiery rhetoric of politicians—perhaps aimed more often at their own constituencies than at the enemy—most actions taken over water are mild. Of all the events, some 43% fell between mild verbal support and mild verbal hostility. If the next level on either side—official verbal support and official verbal hostility—is added in, the share of verbal events reaches 62% of the total. Thus almost two-thirds of all events were only verbal and more than two-thirds of those had no official sanction (Wolf et al. 2003).

Third, there were more issues of cooperation than of conflict. The distribution of cooperative events covered a broad spectrum, including water quantity, quality, economic development, hydropower, and joint management. In contrast, almost 90% of the conflict-laden events related to quantity and infrastructure. Furthermore, almost all extensive military acts (the most extreme cases of conflict) fell within these two categories.

Fourth, despite the lack of violence, water acted as both an irritant and a unifier. As an irritant, water can make good relations bad and bad relations worse. Despite the complexity, however, international waters can act as a unifier in basins with relatively strong institutions.

This historical record suggests that international water disputes do get resolved, even among enemies, and even as conflicts erupt over other issues. Some of the world’s most vociferous enemies have negotiated water agreements or are in the process of doing so, and the institutions they have created often prove to be resilient, even when relations are strained.

The Mekong Committee, for example, established by the governments of Cambodia, Laos, Thailand, and Viet Nam as an intergovernmental agency in 1957, exchanged data and information on water resources development throughout the Viet

Nam War. Israel and Jordan have held secret “picnic table” talks on managing the Jordan River since the unsuccessful Johnston negotiations of 1953–1955, even though they were technically at war from Israel’s independence in 1948 until the 1994 treaty. The Indus River Commission survived two major wars between India and Pakistan. And all 10 Nile Basin riparian countries are currently involved in senior government-level negotiations to develop the basin cooperatively, despite “water wars” rhetoric between upstream and downstream states.

Tensions and Time Lags: Causes for Concern

So, as we look to the future, if there is little violence between nations over their shared waters, what’s the problem? Is water actually a security concern at all? In fact, there are a number of issues where water causes or exacerbates tensions, and it is worth understanding these processes to know both how complications arise and how they are eventually resolved.

The first complicating factor is the time lag between when nations first start to impinge on each other’s water planning and when agreements are finally, arduously, reached. A general pattern has emerged for international basins over time. Riparians of an international basin implement water development projects unilaterally—first on water within their own territory, in attempts to avoid the political intricacies of the shared resource. At some point, one of the riparians, generally the regional power, will implement a project that impacts at least one of its neighbors. In the absence of relations or institutions conducive to conflict resolution, the project can become a flashpoint, heightening tensions and regional instability, and requiring years or, more commonly, decades, to resolve—the Indus treaty took 10 years of negotiations, the Ganges 30, and the Jordan 40—and, all the while, water quality and quantity degrades to where the health of dependent populations and ecosystems are damaged or destroyed. This problem gets worse as the dispute gains in intensity; one rarely hears talk about the ecosystems of the lower Nile, the lower Jordan, or the tributaries of the Aral Sea—they have effectively been written off to the vagaries of human intractability. During such periods, threats and disputes rage across boundaries with relations as diverse as those between Indians and Pakistanis and between Americans and Canadians. Water was the last and most contentious issue resolved in negotiations over a 1994 peace treaty

between Israel and Jordan, and was relegated to “final status” negotiations—along with other of the most difficult issues such as Jerusalem and refugees—between Israel and the Palestinians.

The timing of water flow is also important; thus, the operation of dams is also contested. For example, upstream users might release water from reservoirs in the winter for hydropower production, while downstream users might need it for irrigation in the summer. In addition, water quantity and water flow patterns are crucial to maintaining freshwater ecosystems that depend on seasonal flooding. Freshwater ecosystems perform a variety of ecological and economical functions and often play an important role in sustaining livelihoods, especially in developing countries. As awareness of environmental issues and the economic value of ecosystems increases, claims for the environment’s water requirements are growing. For example, in the Okavango Basin, Botswana’s claims for water to sustain the Okavango Delta and its lucrative ecotourism industry have contributed to a dispute with upstream Namibia, which wants to use the water passing through the Caprivi Strip on its way to the delta for irrigation.

Water quality problems include excessive levels of salt, nutrients, or suspended solids. Salt intrusion can be caused by groundwater overuse or insufficient freshwater flows into estuaries. For example, dams in the South African part of the Incomati River basin reduced freshwater flows into the Incomati estuary in Mozambique and led to increased salt levels. This altered the estuary’s ecosystem and led to the disappearance of salt-intolerant flora and fauna important for people’s livelihoods (the links between loss of livelihoods and the threat of conflict are described below).

Excessive amounts of nutrients or suspended solids can result from unsustainable agricultural practices, eventually leading to erosion. Nutrients and suspended solids pose a threat to freshwater ecosystems and their use by downstream riparians, as they can cause eutrophication and siltation, respectively, which, in turn, can lead to loss of fishing grounds or arable land. Suspended solids can also cause the siltation of reservoirs and harbors: for example, Rotterdam’s harbor had to be dredged frequently to remove contaminated sludge deposited by the Rhine River. The cost was enormous, and consequently led to conflict over compensation and responsibility

among the river's users. Although negotiations led to a peaceful solution in this case, without such a framework for dispute resolution, siltation problems can lead to upstream/downstream disputes such as those in the Lempa River basin in Central America (Lopez, 2004).

Prognosis for the future

As we move into the future, it stands to reason that each of these exacerbating factors – quantity, quality, and timing – will only become more difficult to manage. Nevertheless, there is little reason to anticipate violence at the international level. If one were to launch a war over water, what would be the goal? Presumably, the aggressor would have to be both downstream and the regional hegemon -- an upstream riparian would have no cause to launch an attack and a weaker state would be foolhardy to do so. An upstream riparian, then, would have to launch a project which decreases either quantity or quality, and find international funding for that project in contravention of the rules of all development banks, knowing that it will antagonize a stronger down-stream neighbor.

The down-stream power would then have to decide whether to launch an attack - - if the project were a dam, destroying it would result in a wall of water rushing back on down-stream territory; were it a quality-related project, either industrial or waste treatment, destroying it would probably result in even worse quality than before. Furthermore, the hegemon would have to weigh not only an invasion, but an occupation and depopulation of the entire watershed in order to forestall any retribution -- otherwise, it would be extremely simple to pollute the water source of the invading power. Both countries could not be democracies, since the political scientists tell us that democracies do not go to war against each other, and the international community would have to refuse to become involved (this, of course, is the least far-fetched aspect of the scenario). All of this effort would be expended for a resource which costs at most about a US dollar per cubic meter to create from seawater, costs which are dropping every year. There are "only" 263 international watersheds -- there are only a handful on which the above scenario is even feasible (the Nile, Plata, and Mekong come to mind), and many of those either have existing treaties or ongoing negotiations towards a treaty. Finding a site for a "water war" turns out to be as difficult as accepting the rationale for

launching one.

We have seen worst case scenarios which will likely become more common in, for example the Jordan basin where there is tremendous hostility both across and within borders (to this day, all riparians will not even sit in the same room) complicated by the fact that the basin “ran out” of water (ie. demand reached supply) in 1968, and yet the last shot fired across international boundaries over water was in 1970. This means that in this arid and hostile setting, *all* economic and population growth over the last forty years has come through greater and greater efficiencies, and through dialog and collaboration (or at least through unwritten coordination, when integration has proved impossible), *not* through violence at the official level.

All of this is not to say that people will not continue to suffer and die in increasing numbers, and that ecosystems will not see unprecedented destruction, as will be explored below. But the politics which lead up to warfare often have little to do with suffering and water will likely continue to be a diffuse resource with little relative contribution to most economies, and from which the elite who make decisions related to war and peace rarely benefit.

Intranational Waters

The second set of security issues occur at the sub-national level. Much literature on transboundary waters treats political entities as homogeneous monoliths— “Canada feels ...” or “Jordan wants ...” Analysts are only recently highlighting the pitfalls of this approach, often by showing how different subsets of actors relate very different “meanings” to water. Rather than being simply another environmental input, water is regularly treated as a security issue, a gift of nature, or a focal point for local society. Disputes, therefore, need to be understood as more than “simply” over a quantity of a resource, but also over conflicting attitudes, meanings, and contexts. Throughout the world, local water issues revolve around core values that often date back generations. Irrigators, indigenous populations, and environmentalists, for example, can see water as tied to their very ways of life, and increasingly threatened by newer uses for cities and hydropower. Moreover, the local setting strongly influences international dynamics and vice versa.

If there is a history of water-related violence, and there is, it is a history of incidents at the sub-national level, generally between tribes, water-use sectors, or states/provinces. In fact, the recent research at OSU suggests that, as the scale drops, the likelihood and intensity of violence rises (Giordano et al. 2002). There are many examples of internal water conflicts ranging from interstate violence and death along the Cauvery River in India, to California farmers blowing up a pipeline meant for Los Angeles, to inter-tribal bloodshed between Maasai herders and Kikuyu farmers in Kenya. The inland, desert state of Arizona even commissioned a navy (made up of one ferryboat) and sent its state militia to stop a dam and diversion on the Colorado River in 1934.

Another contentious issue is water quality, which is also closely linked to water quantity. Decreasing water quality can render it inappropriate for some uses, thereby aggravating its scarcity. In turn, decreasing water quantity concentrates pollution, while excessive water quantity, such as flooding, can lead to contamination by sewage. Low water quality can pose serious threats to human and environmental health. Water quality degradation is often a source of dispute between those who cause degradation and the groups affected by it. As pollution increasingly impacts upon livelihoods and the environment, water quality issues can lead to public protests.

One of the main causes of declining water quality is pollution, e.g., through industrial and domestic wastewater or agricultural pesticides. In Tajikistan, for example, where environmental stress has been linked to civil war (1992-1997), high levels of water pollution have been identified as one of the key environmental issues threatening human development and security. Water pollution from the tanning industry in the Palar Basin of the Indian state of Tamil Nadu makes the water within the basin unfit for irrigation and consumption. The pollution contributed to an acute drinking water crisis, which led to protests by the local community and activist organizations, as well as to disputes and court cases between tanners and farmers. (Carius et al., 2004).

Prognosis for the future

One might anticipate a moderate likelihood of tensions over intranational waters in coming years. Clearly, this aspect has been seeing more violence in recent years, from South Asia to eastern Africa. Disenfranchised peoples within nations without the

infrastructure or economy to mitigate water scarcity or degradation may well find their needs driving conflict with competing populations.

Regional Instability: Political Dynamics Of Loss Of Irrigation Water

As water quality degrades—or quantity diminishes—over time, the effect on the stability of a region can be unsettling. For example, for 30 years the Gaza Strip was under Israeli occupation. Water quality deteriorated steadily, saltwater intrusion degraded local wells, and water-related diseases took a rising toll on the people living there. In 1987, the intifada, or Palestinian uprising, broke out in the Gaza Strip, and quickly spread throughout the West Bank. Was water quality the cause? It would be simplistic to claim direct causality. Was it an irritant exacerbating an already tenuous situation? Undoubtedly.

An examination of relations between India and Bangladesh demonstrates that these internal instabilities can be both caused and exacerbated by international water disputes. In the 1960s, India built a barrage at Farakka, diverting a portion of the Ganges flow away from its course into Bangladesh, in an effort to flush silt away from Calcutta's seaport, some 100 miles to the south. In Bangladesh, the reduced upstream flow resulted in a number of adverse effects: degraded surface and groundwater, impeded navigation, increased salinity, degraded fisheries, and endangered water supplies and public health. Migration from affected areas further compounded the problem. Ironically, many of those displaced in Bangladesh have found refuge in India.

Two-thirds of the world's water use is for agriculture so, when access to irrigation water is threatened, one result can be movement of huge populations of out-of-work, disgruntled men from the country-side to the cities—an invariable recipe for political instability. In pioneering work, Sandra Postel identified those countries that rely heavily on irrigation, and whose agricultural water supplies are threatened either by a decline in quality or quantity. The list coincides precisely with regions of the world community's current security concerns, where instability can have profound effects: India, China, Pakistan, Iran, Uzbekistan, Bangladesh, Iraq, and Egypt (Postel & Wolf 2001).

Water management in many countries is also characterized by overlapping and

competing responsibilities among government bodies. Disaggregated decision-making often produces divergent management approaches that serve contradictory objectives and lead to competing claims from different sectors. And such claims are even more likely to contribute to disputes in countries where there is no formal system of water-use permits, or where enforcement and monitoring are inadequate. Controversy also often arises when management decisions are formulated without sufficient participation by local communities and water users, thus failing to take into account local rights and practices. Protests are especially likely when the public suspects that water allocations are diverting public resources for private gain or when water use rights are assigned in a secretive and possibly corrupt manner, as demonstrated by the violent confrontations in 2000 following the privatization of Cochabamba, Bolivia's water utility (Postel and Wolf 2001).

Finally, there is the human security issue of water-related disease. It is estimated that between 2.2 and 5 million people die each year from water-related diseases or inadequate sanitation. More than half the people in the world lack adequate sanitation. Eighty percent of disease in the developing world is related to water (Gleick 1998). This is a crisis of epidemic proportions, and the threats to human security are self-evident.

Prognosis for the future

These more subtle connections between water and security are the most likely to drive human suffering and violence, and ecosystem degradation into the future. The world community has simply not shown the political will to alleviate the death and destruction caused by the lack of a safe, stable supply of water resources, nor is there any indication that these trends are likely to do anything but continue to degrade.

Monitoring for Conflict Indicators

Besides the general degradation in water quantity, quality, and timing, understanding the link between change and institutional capacity allows for monitoring specific indicators for the likelihood of future political tensions between nations. As mentioned, the two most likely sources of rapid change within a basin are unilateral development in the absence of institutional arrangements, and the potential for basins within international boundaries to "internationalize." These indicators allow us to

monitor for “red flags,” or markers which may suggest new basins at risk as they arise:

Tenders for future projects. The best sources for cutting through the rhetoric and wishful thinking inherent in public pronouncements of development projects are the public calls for project tenders. Tenders are not put out until project funding has been ascertained, so countries must be fairly certain that a project will actually be developed, but they still can give three to five years lead time (more for large projects) before impact will be felt in neighboring countries – enough time to exercise preventive diplomacy. There are two good print sources for water development tenders: the Financial Times’ Global Water Report (biweekly) and the Global Water Intelligence (monthly). Also, the website of Water International Publishing Ltd. (www.e-waternews.com/) provides daily updates of water project tenders and contracts in developing countries.

The next question is whether the basin has the institutional capacity to mitigate the impacts of major construction. The Transboundary Freshwater Dispute Database (www.transboundarywaters.orst.edu) includes listings of all freshwater treaties and river basin organizations (RBO’s). As mentioned earlier, major projects *in the absence* of treaties, RBO’s, or genial working relations would tend to indicate settings conducive to dispute.

Countries with active nationalist movements. If internationalizing a basin provides a setting of potential dispute, one might monitor the world’s nationalist movements and ethnic conflicts and, if one wanted to act proactively, one could assess the potential impacts of a successful drive for independence. One can then map those countries around the world with active nationalist movements drawing from two sources: 1) Armed Self-Determination Conflicts, as identified by Prof. Ted Gurr’s Minorities at Risk Project, at the University of Maryland’s Center for International Development and Conflict Management (as of June 2006) <<http://www.cidcm.umd.edu/inscr/mar/>>; and 2) Unrepresented Nations and Peoples Organisations (UNPO). Participation in UNPO is open to all nations and peoples who “are inadequately represented as such at the United Nations and who declare adherence the Organisation’s Charter.” Since these principles espouse non-violence, the conflict level associated with many of these movements is lower. Data on unrepresented nations

and peoples are drawn from the UNPO website: <<http://www.unpo.org/>>

Why Might the Future Look Nothing Like the Past?

Some aspects of the future will probably look very similar to the present, especially the potential for the global wealthy to be able to adapt to change, while the poor will not. Consider for example, the problem of flooding in the Netherlands versus in Bangladesh. Both are low lying countries with little topography, and both are subject to the hazards of flooding potentially exacerbated by rising sea levels. Multi-million dollar sea-walls are built to protect the Netherlands, with the result that flood-related deaths and damage are negligible, while every year thousands die amid wide-spread devastation in Bangladesh. Similarly, few suffer from the effects of water shortage in the developed world, while 2.2 to 5 million people die every year in the developing world from water-related causes. There is no evidence to think that any of this will change except for the worse in the future. In the developing world, people will continue to suffer and die at unprecedented rates, and ecosystem degradation will continue at alarming rates.

Yet, the entire basis of this study rests on the not unassailable assumption that we can tell something about the future by looking at the past. It is worth stopping at this point, then, and challenging the very foundation of that assumption: Why might the future look nothing at all like the past? What new approaches or technologies are on the horizon to change or ameliorate the risk to the basins we have identified, or even to the whole approach to basins at risk?

By definition, a discussion of the future can not have the same empirical backing as a historical study – the data just aren't there yet. Yet there are cutting edge developments and recent trends which, if one examined them within the context of this study, might suggest some possible changes in store for transboundary waters in the near future. What follows, then, are several possibly fundamental changes in the way we approach transboundary waters.

New technologies for negotiation and management. The OSU dataset of political conflict and cooperation mentioned earlier goes back to 1948. In some ways, water management is very similar now as it was then (or, for that matter, as it was 5,000 years

ago). But some fundamental aspects are profoundly different. Institutions are getting better and more resilient, management and understanding are improving, and these issues are increasingly on the radar screen of global and local decision-makers. But most importantly, the 21st century has access to new technology which could not be dreamed of in 1948, and which adds substantially to the ability both to negotiate and to manage transboundary waters more effectively:

- Major advances are being made regularly in water technologies designed either to increase supply – eg. desalination, wastewater reclamation – or decrease demand – eg. drip irrigation, plant genetics, low-flow utilities. As a country's economy grows, its per capita water use initially grows as well, but eventually can drop in water stressed regions, as has been the case in Israel and California;
- Modular modeling systems (MMS's) such as STELLA, Waterware, and Riverware can now be used for comprehensive modeling of hydrologic and human systems. Because of their modular design, they can also act as a facilitation tool by allowing managers/negotiators to cooperatively build the model, increasing the joint knowledge base and communications;
- GIS and remote sensing allow several spatial data layers, encompassing biophysical, socioeconomic and geopolitical parameters, to be viewed and analyzed graphically;
- Real time monitoring tools, such as radio-controlled gauging stations, add new options for real time management, and allocations based on existing hydrologic settings rather than fixed quantities;
- Graphical User Interfaces (GUI's) allow for each component to be brought together into an intuitive, user-friendly setting.

While new technologies and data cannot replace the political goodwill necessary for creative solutions, nor are they widely available outside the developed world, they can if appropriately deployed allow for more robust negotiations and greater flexibility in joint management.

Global Climate Change. It is clear that the likelihood of political tension is related in part to the rate of change within a basin. It is also clear from most climate studies that it is *precisely* the rate of change of the global and regional hydrologic cycles which are most likely to be exacerbated by global climate change. While some areas will become wetter and some drier, the *variability* of extreme events will likely increase throughout much of the world. Since violence becomes likely when change exceeds the rate of institutional capacity to absorb the change, increased variability will put greater stresses

on the hydropolitical system. For example, the entire water rights and distribution network of many parts of the world rely on the natural storage of much water resources in the snowpacks of mountain ranges, snowpacks projected to decrease dramatically in coming years in much of the world. With more water flowing earlier in the year, water allocations in the dry months will become increasingly threatened, at the same time as devastation during wet months will increase, combining to put dangerous stresses on agriculture, industry, and generally on regional natural and human resources.

Globalization: private capital, WTO, and circumvented ethics. Very little of the recent attention on globalization and the World Trade Organization (WTO) has centered on water resources, but there is a definite water component to these trends. One of the most profound is the shift of development funds from global and regional development banks such as the World Bank and the Asia Development Bank to private multinationals, such as Bechtel, Vivendi and Ondeo (formerly Lyonnaise des Eaux). Development banks have, over the years, been susceptible to public pressures and ethics and, as such, have developed procedures for evaluating social and environmental impacts of projects, and incorporating them in decisionmaking. On international waters, each development bank has guidelines which generally prohibit development unless all riparians agree to the project, which in and of itself has promoted successful negotiations in the past. Private enterprises have no such restrictions, and nations eager to develop controversial projects have been increasingly turning to private capital to circumvent public ethics. The most controversial projects of the day – Turkey’s GAP project, India’s Narmada River project, and China’s Three Gorges Dam – are all proceeding through the studied avoidance of development banks and their mores.

There is a more subtle effect of globalization, though, which has to do with the World Trade Organization (WTO) and its emphasis on privatization and full cost recovery of investments. Local and national governments, which have traditionally implemented and subsidized water development systems to keep water prices down, are under increasing pressure from the forces of globalization to develop these systems through private companies. These large multinational water companies in turn manage for profit and, if they use development capital, both push and are pushed to recover the full cost of their investment. This can translate not only into immediate and substantial

rises in the cost of water, disproportionately affecting the poor, but also to greater eradication of local and indigenous management systems and cultures. If there is to be water related violence in the future, it is much more liable to be of the type as the “water riots” against a Bechtel development in Bolivia in 1999, in which eight people were killed, than “water wars” across national boundaries.

As WTO rules are elaborated and negotiated, real questions remain as to how much of this process will be *required* of nations in the future, simply to retain membership in the organization. The “commodification” of water as a result of these forces is a case in point. Over the last twenty years, no global water policy meeting has neglected to pass a resolution which, among other issues, defined water as an “economic good,” setting the stage at the 2000 World Water Forum for an unresolved show-down against those who would define water as a human or ecosystem *right*. The debate looms large over the future of water resources: if water is a commodity, and if WTO rules disallow obstacles to the trade of commodities, will nations be forced to sell their water? While far-fetched now (even as a California company is challenging British Columbia over precisely such an issue under NAFTA rules), the globalization debate between market forces and social forces continue to play out in microcosm in the world of water resources.

The Geopolitics of Desalination. Twice in the last fifty years – during the 1960’s nuclear energy fervor, and in the late 1980’s, with “discoveries” in cold fusion – much of the world briefly thought it was on the verge of having access to close to free energy supplies. “Too cheap to meter” was the phrase during the Atoms for Peace Conference. While neither the economics nor the technology finally supported these claims, it is not far fetched to picture changes which could profoundly change the economics of desalination.

The marginal cost of desalinated water (between US\$0.80 and US\$1.00 per cubic meter) makes it currently only cost-effective in the developed world where: 1) the water will be used for drinking water; and 2) the population to whom the water will be delivered lives along a coast and at low elevations; and 3) there are no alternatives. The only places not so restricted are where energy costs are especially low, notably the Arabian Peninsula. A fundamental shift either in energy prices or in membrane

technology could bring costs down substantially. If either happened to the extent that the marginal cost allowed for agricultural irrigation with sea water (around US\$.08/m³ on average), a large proportion of the world's water supplies would shift from rivers and shallow aquifers to the sea (an unlikely, but plausible, scenario).⁴

Besides the fundamental economic changes which would result, geopolitical thinking of water systems would also need to shift. Currently, there is inherent political power in being an upstream riparian, and thus controlling the headwaters. In the scenario for cheap desalination above, that spatial position of power would shift from mountains to the valleys, and from the headwaters to the sea. Many nations, such as Israel, Egypt, and Iraq currently dependent on upstream neighbors for their water supply would, by virtue of their coastlines, suddenly find roles reversed.

The Changing Sources of Water and the Changing Nature of Conflict. Both the worlds of water and of conflict are undergoing slow but steady changes which may obviate much of the thinking in this report. As surface water supplies and easy groundwater sources are increasingly exploited throughout the world, two major changes result: quality is steadily becoming a more serious issue to many than quantity, and water use is shifting to less traditional sources. Many of these sources – such as deep fossil aquifers, wastewater reclamation, and interbasin transfers – are not restricted by the confines of watershed boundaries, our fundamental unit of analysis in this study. Moreover, population-driven food demand will grow exponentially in coming years, putting unprecedented pressures on water demand.

Conflict, too, is becoming less traditional, increasingly being driven by internal or local pressures, or more subtle issues of poverty and stability. The combination of changes, in water resources and in conflict, suggest that tomorrow's water disputes may look very different from today's.

⁴ While the shifts described here are very dramatic, current trends suggest that desalinated water is becoming more attractive in the developing world as well. It should also be noted that desalinated drinking water also becomes available as wastewater, which can be treated for agricultural and industrial uses (Asit Biswas, personal communications).

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