Exploring the Population / Water Resources Nexus in the Developing World

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Introduction

Any discussion on the population/water resources nexus in the developing world tends to be clouded by preconceived notions. The very concept of "population growth" is invariably constructed so as to be linked with value-laden notions like the "population time-bomb" and "population explosion," which are, in turn, closely associated with Malthusian catastrophe and social decay. This article explores the population/water resources nexus by using empirical examples from Africa in order to isolate some of the strategically important issues that policymakers should recognize. Two distinct areas of Africa have been selected: first, "Southern Africa," which for purposes of this article will mean countries belonging to the Southern African Development Community (SADC); and second, "East Africa," which for purposes of this article will mean countries geographically located within the Nile River Basin.[1]

The article begins by listing some fundamental points of departure, laying out our approach to the concepts of scarcity, resources, and legitimacy. These concepts provide a logical conceptual foundation for the article's subsequent analysis. This foundation is followed by an analytical separation between what will be identified as "first-order" and "second-order" levels of analysis. It is in this separation that the article offers an alternative perspective on the issues at hand. Special attention will be paid to the use and usefulness of technologies like Geographic Information Systems (GIS) in the context of this first-order/second-order framework. The article concludes by answering four key questions, which are deemed to be important to an understanding of the strategic significance of water resource management in Africa.

Points of Departure: Some Key Concepts

What immediately follows are fundamental ideas that form the article's logical foundation. Three concepts of this foundation are of paramount importance: scarcity, resources, and legitimacy.

1. "Water scarcity" seems at first so tantalizingly straightforward as to seduce the non-specialist reader into a rather superficial understanding of its definition and implications. Isn't water scarcity simply a shortage of water in time and space? While this definition adequately defines the concept in many cases, the spatial/temporal dimension of water scarcity involves subtle but important nuances. Rather, water scarcity should be defined as a condition in which demographically-induced demand for water exceeds the prevailing level of local supply (Turton & Ohlsson, 1999). Pressures resulting from absolute population growth and increasing density from urbanization of course raise the number of people per unit area. But a focus on "demand" forces us to take into account how the notion of scarcity is also economically and culturally constituted. Beyond the three liters per person per day required for basic human survival, "demand" and even "need" are not absolute values; they depend on social and consumptive habits that are culture-

bound, differing between countries and within regions.

The availability of water also quite naturally changes with the season. For large parts of Africa, a drought condition is a totally normal set of circumstances if viewed in terms of oscillations within the global hydrological cycle. This climatic variability acts as a fundamental driver to many of the African ecosystems in the semi-arid regions, and humans and other living organisms have adapted to it. The timing and intensity of a flood can make the same sum total of floodwater a boon or a curse for the cropping season.

Thus, the technical ability with which societies are able to handle their water-resource base is paramount. A perceived condition of water scarcity may in fact exist in the face of apparent abundance. Current work in Zambia (Turton et al*.,* 2000a), one of the most well-endowed countries in Southern Africa in terms of water availability, shows how acute water scarcity can exist even in that country simply because its government lacks the capacity to harness its water in dams and then process and distribute it via an adequate reticulation system. Heavy water pollution also results in a form of scarcity, sometimes called "hydrocide" (Lundqvist, 1998). Water quality has a major impact on the functionality of water: the better its quality, the more social, cultural, economic, and environmental functions it can perform. So water scarcity is more than just a simple non-availability of water.

When discussing scarcity, we should also give due cognizance to use and ownership. Sexton (1992) has differentiated between *absolute* (i.e. technology-limited) scarcity and *economic* scarcity, the latter referring to economic choices that have created winners and losers. Warner (1992) has noted that the key limit to water availability is redistribution and hence is political rather than technical in nature; and this distinction suggests yet another distinct form of scarcity—*induced*. This supports Homer-Dixon's (1994) resource capture thesis, which we shall address below.

2. Just as the concept of water "scarcity" is subtler than first meets the eye, we will also have to come to grips with the nebulous concept of a "resource." An important point of departure in this article is that an epistemological and conceptual distinction can be made between what we will define as a "first-order" and a "second-order" resource. To our knowledge, Leif Ohlsson (1998; 1999) was the first to systematically analyze resources in this way. In his analysis, a *first-order* resource is any natural resource (such as water, land, or minerals) with which a country can be either well- or poorly-endowed. In other words, a first-order resource like water can be either scarce or abundant; and the *degree* of scarcity and/or abundance is relative spatially, temporally, and in terms of quality. What is stressful in one environment is not a problem in another.

A *second-order* resource, on the other hand, is a social rather than a natural resource. A *social* resource refers to a need (acutely perceived by societies, administrative organizations, and managers responsible for dealing with natural resource scarcities) to find the appropriate societal tools for dealing with the social consequences of first-order natural resource scarcities (Ohlsson, 1999, page 161). This conceptual distinction makes it clear that what is critically important is not so much the availability of the natural resource itself but rather how society adapts to changes in that supply—either by way of (a) long-term increases in water scarcity as a result of population growth and/or climate change, or (b) short-term water abundance in the form of floods.

Recent articles using this distinction depict water management as a series of oscillations between first and second-order resources over time, much like the turning of a screw (Ohlsson & Turton, 1999; Ohlsson & Lundqvist, 2000). Priorities change from supply-sided management (mobilizing more water) through demand-sided management (doing better things with available water), ultimately to adaptive management (adapting to absolute scarcity). Couched differently, Ohlsson's (1998; 1999) second-order resource is another way of looking at Thomas Homer-Dixon's (1995; 1996) concept of "ingenuity." But the importance of this conceptual difference is that it allows the analyst and policymaker to effectively develop coping strategies to deal with the bottlenecks inherent in water management globally. This has particular relevance for an understanding of the problems confronting developing countries.

This conceptual distinction makes it possible to develop a whole range of unique concepts by means of a matrix showing different levels of first- and second-order resources within any given social entity. This is illustrated in Figure 1.

Figure 1. Resource Matrix

Quantitative Aspect of the Resource	Type of Resource: Second-Order (Social Resources)	Type of Resource: First Order (Water Resources)
Relative Abundance	Position 1	Position 2
Relative Scarcity	Position 3	Position 4

Four combinations of first- and second-order resource are possible. For purposes of this article, only the last three of these combinations (those entailing at least one relative scarcity) are relevant:

- *Structurally-Induced Relative Water Scarcity* (SIRWS) is a combination that consists of a relatively high level of first-order resource availability (Position 1) in conjunction with a relatively low level of second-order resource availability (Position 4). Water scarcity in these situations is probable as a result of the inability to mobilize sufficient social resources to effectively manage the problem. SIRWS countries are relatively well-endowed with water, but lack institutional capacity and have other problems that render them unable to mobilize that water (via dams and related hydraulic infrastructure) and reticulate it to the end-user. A logical outcome of this condition would be low economic activity, poor public health, and a general low level of infrastructural development. This condition is clearly unfavorable, and could result in a Malthusian catastrophe if combined with high population growth. But creative and responsible decision-making can still save the day provided that the alarm bells are heeded in time. It is these societies that offer examples of the debilitating effects of Homer-Dixon's (1995; 1996; 2000) "ingenuity gap." Examples include Angola, Congo (DRC), Mozambique, and Zambia.

- *Structurally-Induced Relative Water Abundance* (SIRWA) refers to a combination that consists of a relatively low level of first-order resource availability (Position 3) with a relatively high level of second-order resource availability (Position 2). In other words, water abundance is made possible in a relative sense as a result of the ability to mobilize sufficient social resources to effectively manage the problem. SIRWA countries are relatively poorly endowed with water resources, but use their relative abundance of social resources to develop a set of management solutions that are effective and legitimate in the eyes of the population and therefore sustainable over time. A logical outcome of this condition would be sustained economic growth, good public health, and a high level of infrastructural development even in the face of endemic water scarcity. This condition resembles the Cornucopian argument that is often presented as an alternative to Malthusian collapse. Indeed there are rich examples of the positive impact of Homer-Dixon's (1996; 2000) concept of ingenuity to be found in an analysis of the water sector in many countries. Arguably the best example is Israel, but South Africa occupies a close second in this category.
- *Water Poverty* (WP) refers to a combination that consists of a relatively low level of first-order resource availability (Position 3) with a relatively low level of second-order resource availability (Position 4). WP countries cannot manage the debilitating effects of water scarcity because of their lack of social resources, unleashing a spiral of underdevelopment that results in a gradual decline in almost all developmental indicators. A logical outcome of this condition would be long-term economic stagnation, deteriorating public health, a low level of infrastructural development, and a high probability of social instability and political decay as the black hole caused by a combination of expanding population and a declining resource-base takes hold. In short, this is an example of the classic Malthusian collapse. Clearly this condition is one to be avoided.

3. Finally, "legitimacy" (which can loosely be defined as the popular support by the broad population for any given decision by government) is an important concept for effective water management. For Water Demand Management (WDM) policies to be effectively implemented, a high level of legitimacy is required of the functional agency responsible for water-resource management (Turton, 2000a, page 144); yet that government's craving for legitimacy easily leads to policies that have the opposite effect. In many political systems, intersectoral allocation of water (Turton & Ohlsson, 1999; Turton, 1999; Allan, 2000, page 184) is typically considered only as a last resort because it is so politically and socially risky that politicians generally favor softer (but also less effective) options instead.

When river basins reach closure and all available first-order resources have been allocated, one of the most important forms of management strategy—after all other supply-sided options such as Inter-Basin Transfers (IBTs) and desalination of water have been exhausted—is the allocation of water away from high-consumption but low-yield activities (as typically found in the agricultural sector) to lower-consumption but higher-yield activities (typically found in the industrial and domestic sectors) (Falkenmark & Lundqvist, 1995). There are a number of unintended consequences of this, such as those arising from new economic dependencies and the restructuring of society away from an agricultural base to an industrial base. Whether this will actually happen depends in part on the second-order capacities and structures for change that exist in society. But as the public sector tends to be lead actor and regulator as well as often the formal owner of water resources, a successful adaptation to first-order stress also depends on the relationship between the state and society. A power relationship is legitimate when the relationship can be *justified* in terms of people's beliefs—when there is congruence between power and beliefs, values and expectations (Weber, 1947).

If people already believe in the need for an adaptive response to water stress, and if the government's legitimacy base is strong, a society will be more responsive to regulatory measures aimed at bringing about this adaptation. If these values are not strongly developed, a government perceived as legitimate may well still have the political capital to guide society to a new mindset. However, if a ruling government perceives that it lacks legitimacy, it may not be willing to take the political risk of implementing unpopular policies, even when the society faces an uncontrolled and ultimately unsustainable spiral of water consumption. The state may be tempted to pursue wasteful but popular water projects instead.

The world is filled with examples of ill-considered water projects that have been used to buy political support, otherwise known as patronage. Specific examples range from to pork-barrel projects in the United States, the Pongola-Poort Dam in South Africa, and many instances in India where unsustainable water projects cannot be changed because they are supporting too many jobs and therefore potential voters. This situation is found in several postcolonial states, which started large, unsustainable projects to kick-start economic development. When these aspirations come to nothing, the government starts losing the political capital needed to make social adjustments to water policy that address an eroded and unsustainable resources base. As Ohlsson (1999, page 10) notes, the first victim of people's frustrated developmental expectations is state legitimacy. Incidentally, this is not limited to the developing world. The so-called "pork-barrel projects" in the United States that Reisner (1993) so eloquently describes illustrate patronage in a sophisticated democratic setting.

Finally, a situation is conceivable in which society may have a latent willingness and ability to adapt, but *systemic* legitimacy (of the political system itself) is sorely lacking. In apartheid-era South Africa, for example, all reform was hampered by the systemic illegitimacy of the system itself, resulting ultimately in a collapse and radical restructuring of the overall political process. A decision-making entity perceived as illegitimate will not receive the necessary popular support, and the population at large will undermine such government policies as a form of civil disobedience. Notably, in the developing world, we find examples of governments and implementing agencies with a low level of accountability and consequently a low level of systemic legitimacy. Instead of initiating reflexive change, these governments and agencies tend either to ignore the water crisis or to deflect it by further squeezing their natural resource bases, often in the form of intensified production (otherwise known as "water mining").

Under such stress, the process that has been called "resource capture" (Homer-Dixon, 1994; Homer-Dixon & Percival, 1996) is especially prone to manifest itself. This occurs when powerful groups in society systematically shift (first-order) resource allocation in their favor over time, usually to the long-term detriment of the group from which the resource base is being captured. Since these powerful groups must gain control over the resource allocation mechanisms in order to gain such unequal access, *structural scarcity* (a highly specific form of water scarcity) ultimately results. A good example of structural scarcity is apartheid-era South Africa, whose "hydraulic mission" effectively mobilized water in order to distribute patronage to the white minority, thereby retaining the support of the white farmers who owned most of the land at that time (Abrams, 1996; Turton, 2000a, page 142).

In international river basins, countries may also try to shift the burden of resource closure (that condition when all of the resource-base has been allocated) to other riparians. Upstream riparians may capture the resource before it reaches the downstream countries, while downstream countries may strengthen their claim to a river's water by leveraging non-water power threats (Warner, 1993). The importance of water is blown out of proportion under these circumstances, and hydrological information may even be classified because of it. This process propels water management into a national security issue in which the resource becomes non-negotiable, forestalling an equitable agreement on its sharing. This "securitization" of water, often an unsatisfactory state of affairs, leads to zero-sum hydropolitical dynamics.

One possible way of accomplishing a desirable de-securitization of the water issue is (a) to develop uncontested data with which to build confidence between riparian states or water users, and (b) to institutionalize the conflict potential that arises under conditions of scarcity. According to Haas (1993), "epistemic communities" may converge around a body of accepted scientific procedure and thus facilitate the creation of a legitimate base for negotiation. The creation of water regimes can therefore be seen as a manifestation of second-order resources within any given regional security complex. Processes of the securitization of data (Warner, 2000) can still obstruct the dissemination and exchange of reliable hydrological information within the emerging regime, however, and act as a mitigating factor. In Israel, for example, hydrological data are classified as secret and is thus not available to the public or other interested parties. This article will later address the issue of whether GIS can enhance openness and data exchange, thereby facilitating confidence building in water-sharing arrangements.

The Population/Water Resource Nexus in Africa

First-Order Type of Analysis

If water resources are relatively finite within any given country, then a doubling of that country's population will cut in half the volume of water available per capita. This calculation is seductively simple, so let us don the eyeglasses of first-order analysis and look at some African countries. Table 1 shows the population data for Southern African and East African countries in Columns 2-6. The population growth over that time period (39 years) is shown as a percentage in Column 7 as calculated by the FAO (2000) database. In general terms, this table gives an indication of how the baseline population, which was arbitrarily taken as being 1961, had grown by 2000. Column 8 shows the water availability expressed in cubic meters per capita in 1998. The World Bank Atlas (2000, page 30) defines water availability per capita as the total renewable water resources of a given country (including river flows) divided by the population and expressed in cubic meters.

Two assumptions (both of which are strictly of a first-order nature) can be made for purposes of analyzing this data. The first assumption is that a three percent growth in population over a 39-year period is high. All of the countries that have a population growth in excess of this have been listed in Table 1 in bold, and their corresponding figures in Column 7 have been highlighted. The second assumption is that, in terms of availability of fresh water, anything above 10,000 cubic meters of water per person per annum is high. Here, too, the countries concerned have been listed in bold, and their corresponding figures in Column 8 have been highlighted. Clearly, these assumptions are rather arbitrary and can be challenged. But it should also be emphasized that (a) these assumptions are relative and not absolute, and (b) they establish a clear split in the data in order that basic trends can be detected (see the following discussion on GIS). As such, they act as filters enabling raw data to be analyzed in some meaningful ways (see Box 1 for a full explanation of the methodology used in this circle).

Table 1. Population Growth (Millions) and Water Availability Data

Southern Africa (SADC Member States)

Country	1961	1970	1980	1990	2000	Growth 1961-2000 (%)	Available m³/cap 1998
Angola	4.8	5.5	7.0	9.2	13.1	2.68%	15,783
Botswana	.49	.63	.90	1.2	1.5	3.18%	9,413
Congo (DR)	15.7	20.2	27.0	37.3	50.9	3.11%	21,134
Lesotho	.88	1.06	1.3	1.7	2.0	2.13%	2,527
Malawi	3.6	4.5	6.1	9.3	11.3	3.20%	1,775
Mauritius	.67	.82	.96	1.0	1.1	1.31%	1,897
Mozambique	7.6	9.3	12.0	14.1	18.3	2.25%	12,746
Namibia	.63	.79	1.0	1.3	1.7	2.73%	27,373
Seychelles	.43	.53	.63	.70	.80	1.49%	n/a
South Africa	17.8	22.0	27.5	34.0	43.3	2.35%	1,208
Swaziland	.33	.41	.56	.75	.92	2.79%	4,552
Tanzania	10.4	13.6	18.5	25.4	35.1	3.22%	2,770
Zambia	3.2	4.1	5.7	7.2	10.4	3.16%	12,001
Zimbabwe	3.9	5.2	7.1	9.8	12.6	3.26%	1,711

East Africa (Nile Basin States)

Country	1961	1970	1980	1990	2000	Growth since 1961	Available m³/cap 1998
Burundi	2.9	3.5	4.1	5.4	6.3	2.16%	561
Egypt	28.5	35.2	43.7	56.3	67.8	2.29%	949
Eritrea	n/a	n/a	n/a	n/a	3.65	2.19% **	2,269
Ethiopia	24.7	30.6	38.7	50.9	62.9	2.43%	1,795
Kenya	8.5	11.4	16.6	23.5	30.6	**3.51%**	1,031
Rwanda	2.8	3.7	5.1	6.9	7.6	2.21%	798
Somalia	2.8	3.6	5.8	7.7	8.7	3.05%	1,730
Sudan	11.3	13.8	18.6	24.0	31.1	2.65%	5,433
Tanzania	10.4	13.6	18.5	25.4	35.1	**3.22%**	2,770
Uganda	6.8	9.8	13.1	16.4	23.3	**3.11%**	3,158

Sources of Data:
Population growth data (Columns 2 - 6) - FAO (2000).
Population growth since 1961 (Column 7) - FAO (2000).
Water availability per capita m^3 in 1998 (Column 8) - World Bank Atlas (2000, page 34-35).
** Eritrea Data calculated from 1993 - FAO (2000).

From this rather crude assessment, an interesting picture starts to emerge. All of the countries that have a relatively low population-growth (i.e. less than a three percent increase in 39 years) in conjunction with a relatively high availability of freshwater are found in Southern Africa and include Angola, Mozambique, and Namibia. Conversely, countries that have a relatively high population-growth rate in conjunction with relatively low water-availability include Botswana, Malawi, Tanzania, Zimbabwe, Kenya, Somalia, and Uganda. Two countries—the Democratic Republic of the Congo (DRC) and Zambia—stand out alone in terms of this assessment, displaying a relatively high population growth rate in conjunction with a relatively high water-availability.

The analysis also suggests that the countries in the first group (low population growth and high water-availability—Angola, Mozambique, and Namibia—have population and water-resource fundamentals that ought to predispose them to a degree of prosperity. But this is not the case. While Angola is richly blessed with a wide range of first-order resources, it remains embroiled in a debilitating civil war; if anything, its resources (particularly oil and diamonds) only fuel the conflict. Mozambique has a seemingly high volume of water resources, yet it too has suffered from a quarter-century of civil war and is in fact a downstream riparian on almost all of the river basins passing through it, making it vulnerable to the whims of upstream states. Namibia is relatively prosperous and politically stable, yet it has a small population and therefore a small tax base—a debilitating factor. Namibia's physical size is massive and its population far removed from water resources, meaning that any infrastructural projects actually have a low number of taxpayers per kilometer of pipeline.

The second group of countries (high population growth and low water-availability) suggests future Malthusian catastrophes in each country except for Botswana. Botswana is actually one of the most politically stable countries in Africa; it has a functioning multiparty democracy, and its high population growth rate is off a low original population base, so there are not in this case the normal problems related to a rapidly growing population. Significantly, Botswana is also adopting progressive water policy options that include the preference for food security rather than national self-sufficiency. Malawi, Tanzania, Zimbabwe, Kenya, Somalia, and Uganda have all had histories of political instability and economic stagnation, although this is changing for Tanzania and Uganda. First-order types of analysis in these cases are clearly superficial and can be downright dangerous: it is from this type of analysis that the so-called "water wars" literature derives its empirical basis.[2]

Kaplan's (1994) presentation of sub-Saharan Africa as an anarchic, conflict-ridden basket-case has raised suspicion (Ó Tuathail et al, 1998) that such accounts fit certain North American national security agendas. Whatever the agenda, the image of an imploding and chaotic Africa undermines investor confidence in the continent and marginalizes it in policy debates as a lost cause. The Kaplan thesis assumes that water resources are finite, which they are not. Those such as Gleick (1993) who proclaim a "water crisis" only focus on that fraction of precipitation that ends up in rivers, lakes, and aquifers (what has come to be known as Falkenmark's "blue water"). Even in this case, baseline data often unreliable. The remainder either evaporates to the atmosphere, is taken up by vegetation, or percolates into the soil, where it remains as soil moisture and lies unaccounted for in the "water crisis" vernacular. This latter amount (which has become known as Falkenmark's "green water") is so abundantly available in the temperate zones that these areas can export huge quantities of "encapsulated water" in the form of grain to semi-arid zones that are structurally deficient in soil moisture. On the basis of this principle, Allan (1996; 2000) has shown that trade in *virtual water*—the water embedded in cereals—is a viable alternative provided that sufficient foreign currency can be generated to pay for such exports (see Box 2). Allan notes that as much water flows into the Middle

East North Africa (MENA) region as subsidized grain in the form of virtual water as flows down the Nile annually. It is this trade in virtual water that has helped prevent the confidently-predicted water wars (Starr, 1991) from erupting (Turton, 2000b; Allan, 2000).

In addition to ignoring these international economic processes, the water-in-crisis thesis misunderstands the nature of "resources" that are often interpreted in environmentally deterministic ways long since abandoned in geography (Bradnock & Saunders, 2000). Such an analysis simply ignores the capacity of states to develop coherent and

Box 1. Methodology

The methodology that has been used in this article is based on four assumptions, each of which has been arbitrarily defined. The purpose of these assumptions is to act as a type of filter through which raw data can be processed in order to arrive at a conclusion that can assist with the development of a set of core hypotheses. These hypotheses can then be used in other case studies, in order to test their validity, but also in order to refine the underlying concepts and thereby develop new knowledge. This is necessary because the notion of a second-order resource is relatively new and consequently in need of conceptual refinement. These four assumptions are as follows:

- The first assumption is that a 3 percent growth in population over a 39-year period is High, with a growth below this level being considered as Low. This is an arbitrary selection in order to give us a starting point in our analysis. Because of the contested nature of population figures in developing countries, the data from the FAO (2000) is being taken as the legitimate source.
- The second assumption is that in terms of the availability of fresh water within a given country, anything above 10,000 $m^3/cap/yr^{-1}$ is High, with anything less than this value being considered as Low. The data used are derived from the World Bank (2000:34-35) because such data are highly contested in the developing world, and the criterion for the High/Low split is arbitrarily defined in order to give us a starting point for the analysis.
- The third assumption is that a GNP/cap when adjusted to Purchasing Power Parity (PPP) for any given country as defined by the World Bank (2000:42-43) is considered to be High if above a value of US$5,300. Conversely a value below US$5,299 is considered to be Low.
- The fourth assumption is that with respect to the percentage of a national population that has access to relatively safe drinking water as defined by the World Bank (1999), a value greater than 65 percent is considered to be High, with a value below 64 percent being Low.

It must be noted that these assumptions are not ironclad. In reality data is highly contested in the developing world, and these will be no exception, which means that the debate normally degenerates into one about the unreliability of the figures being used. This is a sterile debate; so in order to make some headway in our quest for the development of new knowledge, these four assumptions have been made. They should not be seen as being concrete in any way, but when used in combination form a valid methodology on which the rationale of this article has been based. This methodology enables us to steer a reasonably safe course through the minefield of unreliable data that are a characteristic of the developing world, and it enables us to compare countries in a meaningful way.

Table 2. Comparison of First and Second-Order Resources

Southern Africa (SADC Member States)

Country	First-Order Indicators		Second-Order Indicators	
	Population Growth (since 1961) a (b)	**Water Availability** $m^3/cap/yr^{-1}$ 1998 a (b)	**GNP/cap** US$ Purchasing Power Parity 1998 a (b)	**Access of Population** to Safe Water % a (b)
Angola	2.68% (low)	15,783 (high)	999 (low)	32% (low)
Botswana	3.18% (high)	9,413 (low)	5,769 (high)	70% (high)
Congo (DR)	3.11% (high)	21,134 (high)	733 (low)	27% (low)
Lesotho	2.13% (low)	2,527 (low)	2,194 (low)	52% (low)
Malawi	3.20% (high)	1,775 (low)	551 (low)	45% (low)
Mauritius	1.31% (low)	1,897 (low)	8.236 (high)	98% (high)
Mozambique	2.25% (low)	12,746 (high)	740 (low)	32% (low)
Namibia	2.73% (low)	27,373 (high)	5,280 (low)	57% (low)
Seychelles	1.49% (low)	n/a	10,185 (high)	97% (high)
South Africa	2.35% (low)	1,208 (low)	8,296 (high)	70% (high)
Swaziland	2.79% (low)	4,552 (low)	4,195 (low)	43% (low)
Tanzania	3.22% (high)	2,770 (low)	483 (low)	49% (low)
Zambia	3.16% (high)	12,001 (high)	678 (low)	43% (low)
Zimbabwe	3.26% (high)	1,711 (low)	2,489 (low)	77% (high)

East Africa (Nile Basin Riparian States)

Country	First-Order Indicators		Second-Order Indicators	
	Population Growth (since 1961) a (b)	**Water Availability** $m^3/cap/yr^{-1}$ 1998 a (b)	**GNP/cap** US$ Purchasing Power Parity 1998 a (b)	**Access of Population** to Safe Water % a (b)
Burundi	2.16% (low)	561 (low)	561 (low)	52%
Egypt	2.29% (low)	949 (low)	3,146 (low)	64%
Eritrea	n/a	2,269 (low)	948 (low)	7%
Ethiopia	2.43% (low)	1,795 (low)	566 (low)	27%
Kenya	3.51% (high)	1,031 (low)	964 (low)	53%
Rwanda	2.21% (low)	798 (low)	n/a	n/a
Somalia	3.05% (high)	1,730 (low)	n/a	37%
Sudan	2.65% (low)	5,433 (low)	1,240 (low)	50%
Tanzania	3.22% (high)	2,770 (low)	483 (low)	49%
Uganda	3.11% (high)	3,158 (low)	1,072 (low)	34%

Sources of data for Table 2:
Population growth since 1961 (Column 2) - Column 7 of Table 1.
High/Low Population growth split (Column 2) - Arbitrarily defined as >3.0% is high, <2.9% is low.

Water availability $m^3/cap/yr^{-1}$ 1998 (Column 3) - World Bank Atlas (2000, pages 34-35) and Column 8 of Table 1.
High/Low water availability (Column 3) - Arbitrarily defined as >10,000 $m^3/cap/yr^{-1}$ 1998 is high, <9,999 $m^3/cap/yr^{-1}$ 1998 is low.

GNP/cap 1998 (Column 4) - World Bank (2000, pages 42-43)
High/Low GDP/cap split (Column 4) - Arbitrarily defined as >$5,300 is high, <$5,299 is low.

Access of Population to Safe Water (Column 5) - World Bank (1999).
High/Low Access of Population split (Column 5) - Arbitrarily defined as >65% high, <64% is low

sustainable policy choices with which to manage the problem of water scarcity. It is this type of capability that fits into the category of "second-order resources," which can loosely be defined as the social resources needed to manage changes in the level of first-order natural resource availability—otherwise known as social adaptive capacity—over time.

Second-Order Type of Analysis

When it comes to second-order analyses, we are confronted with a basic problem. How do we identify and measure social adaptive capacity? How do we know when it exists and when it is absent? These questions are currently the subject of a research project at the African Water Issues Research Unit (AWIRU) (Turton et al., 2000a; Turton, 2002; Turton & Kgathi, 2002). Their answers require a set of indicators of second-order resource presence (or absence). Again, one needs to make certain assumptions in order to gain insight. For the purposes of this article, two key indicators will be used:

- Let us assume that the existence of second-order resources will result in a higher degree of economic prosperity than the absence of those resources, in line with Homer-Dixon's (1995; 1996; 2000) ingenuity thesis. If this is true, then the adjusted GNP per capita at Purchasing Power Parity (PPP) as presented by the World Bank (2000, pages 42-43) can be used as an indicator.
- The percentage of a given national population that has access to reasonably safe drinking water is an indicator of a government's capacity to provide basic services. World Bank (1999) data on these percentages will be used as an indicator.

Table 2 presents these indicators in the following sequence. Column 1 of the table names the country concerned. First-order indicators are presented in Columns 2 and 3. Column 2a shows the population growth rate for that country as shown in Column 7 of Table 1. This provides an indicator of the country's population dynamics over the last 39 years, which is shown as a High/Low split in Column 2b. (See the first assumption in the previous section for a discussion of the criterion for this split.) Column 3a presents the availability of first-order water resources per capita expressed as cubic meters per annum as shown in Column 8 of Table 1. Column 3b shows this data as a High/Low split (using the second assumption that is based on the criterion discussed in the previous section). This provides a crude but useful indicator of first-order water resource availability *assuming that the country can develop those resources*.

Table 3. Classification of Various African States in terms of Proposed Typology

	First-Order Problems	Second-Order Problems	More Complex Problems
	SIRWA	**SIRWS**	**WP**
Southern Africa	Botswana Mauritius South Africa	Angola Congo (DRC) Mozambique Namibia Zambia	Lesotho Malawi Swaziland Tanzania
East Africa			Burundi Egypt Eritrea Ethiopia Kenya Sudan Tanzania Uganda

Second-order indicators are presented in Columns 4 and 5 of the table. Column 4a shows the GNP per capita as US dollars adjusted in terms of Purchasing Power Parity (PPP). Column 4b presents this data as a High/Low split, with the criterion arbitrarily defined as >$5,300 being High and <$5,299 being Low (our third assumption). While this is an unsophisticated way of processing the data, it serves as a filter that shows an ultimately useful relative tendency. Column 5a shows the percentage of a given national population that has access to relatively safe water. Column 5b presents this data as a High/Low split, with the criterion arbitrarily defined as >65% being high and <64% being Low (our fourth assumption). This is also crude, but serves the same purpose of filtering out a general tendency. The combination of these indicators (when subjected to the High/Low filtering process) can then form the foundation of a hypothesis that can later be empirically tested. (Again, see Box 1 for a full explanation of this article's methodology.)

By concentrating exclusively on Columns 3-5, an assessment can be made using the following logic. Suppose one (mistakenly) assumed that first-order resource abundance (an independent variable) naturally predisposes a country to economic prosperity (a dependent variable). One would then anticipate finding a rough correlation in terms of High/Low splits between Columns 3 and 4. A cursory glance at Table 2 will show that this is not the case; so one can conclude that first-order resource abundance on its own is an insufficient condition to guarantee economic prosperity—suggesting that some form of interceding variable is at work. If this interceding variable is expressed in terms of a second-order resource, then a comparison of Columns 4 and 5 reveals that in all cases except one (Zimbabwe) the existence of such resources as reflected by a higher GNP per capita determines the capacity of the government to deliver basic services like the provision of clean water.

Here the logic of Homer-Dixon's (1995; 1996; 2000) ingenuity thesis is relevant. The presence of a higher level of second-order resource translates into a higher level of economic activity, which in turn impacts on the ability of the state to deliver basic services. Botswana offers a revealing insight in this sense. A country with a relatively small population size but a high population growth rate, it faces severe constraints in terms of low water-availability, yet still maintains a high level of service delivery. A similar trend is evident in Mauritius and South Africa, where high levels of service delivery are possible despite severe first-order water constraints. Namibia is also revealing. A small population in absolute terms usually impacts on the availability of water by showing a high potential for development. In Namibia, however, a low level of economic activity (coupled with a small tax base) acts as a severe constraint that is reflected in the country's low level of service delivery. Namibia and Botswana also both lack permanently flowing rivers within their borders, leaving their hinterlands dry and consequently difficult to develop. Both countries also have a relatively small population and consequently a small tax base. (The fact that the GNP/capita indicator is split differently for these two countries is probably irrelevant, given the crudeness of the criterion used and the arbitrary selection of the threshold at $5,300—see Table 2.)

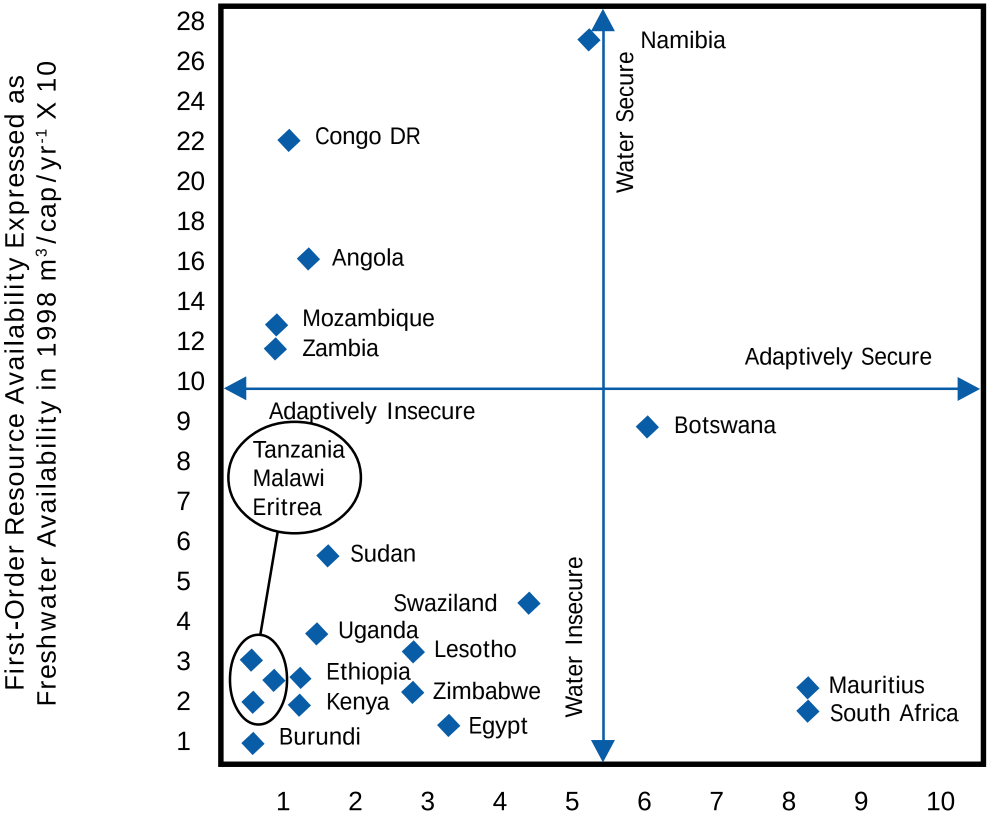
Applying this methodology to Table 2 yields a neat differentiation of cases consistent with the key concepts presented at the start of this article. Particular emphasis is placed on the three conditions: SIRWA, SIRWS, and WP. This typology is presented in Table 3.

Table 3 shows that the typology manifest in the concepts of SIRWA, SIRWS, and WP can be applied to all cases for which data are available—with only one exception. Zimbabwe presents an anomalous situation that does not fit neatly into this framework: it has a combination of low levels of both first- and second-order resources, but a high level of service delivery. While Zimbabwe's current political leadership has had a negative impact on the economy, creating an acute shortage of second-order resources, the country's high levels of service delivery are manifestations of early Mugabe-era achievements. Zimbabwe still has a high potential for development, provided that the negative ramifications of its poor political leadership can be resolved.

The matrix's analysis of Southern Africa yields results that correspond well with each country's first- and second-order resource rating. The three SIRWA cases in Southern Africa are known to be the most prosperous countries in the region. (Should data have been available for Seychelles, then this country would probably also fall into this category.) For these countries, water-related problems are primarily of a first-order nature—namely, the continued search for and mobilization of alternative sources of water supply. The relative economic prosperity of these countries affords them a wide range of options, covering supply-sided solutions (i.e., development of ever-more-distant water resources via IBTs and desalination where appropriate), management of demand, and the importation of virtual water in an attempt to balance national water budgets. Indeed, these countries are enacting all three strategies (Turton et al., 2000b).

The five SIRWS cases are all countries that ostensibly have an abundance of water but that lack the institutional, financial, or intellectual capital to translate this into economic growth and development. As such, the type of problems facing these countries are primarily of a second-order nature. Angola and the Democratic Republic of the Congo (DRC) are politically unstable because of seemingly endless civil wars. Mozambique has turned its back on civil war and is seemingly on the road to economic recovery; its institutional capacity, however, is extremely weak, and its high debt burden continues to hamper this recovery. The major floods that took place in Mozambique in early 2000 set the country back significantly economically (Christie & Hanlon, 2001) and also illustrated the government's inability to respond to crisis. Namibia is politically stable, but it has become embroiled in the wars in Angola and the DRC and is starting to hemorrhage precious financial resources that could be used on institutional development instead. Namibia also presents an interesting case in the sense that its first-order type of indicators shows the country to be relatively well-endowed with water. However, this water can only be found on the northern and southern borders of the country and is also difficult to mobilize. Namibia's low population levels also create a false impression by presenting a

Box 2. Turton/Ohlsson Grid



Data Source: *World Bank Atlas* (2000).

The linkage between water availability and development was drawn directly from the pioneering work by Malin Falkenmark, who sought to develop a scale with which to measure what she called "water stress." Her work makes a direct linear relationship between water availability and the capacity for economic development within a given political economy.

Stated simplistically, Falkenmark (1986) hypothesized that water scarcity presents a rigid barrier to economic and social development. She sought to measure this by doing an analysis of various countries in which she found the following: Iraq uses 4,400 $m^3/cap/yr^{-1}$; Pakistan uses 2,200 $m^3/cap/yr^{-1}$; Syria uses 1,300$m^3/cap/yr^{-1}$; Egypt uses 1,200 $m^3/cap/yr^{-1}$; India uses 800 $m^3/cap/yr^{-1}$ and Israel uses 500 $m^3/cap/yr^{-1}$ (Falkenmark, 1986, page 197). By taking Israel as a baseline case, Falkenmark concluded that a realistic level for a developing state is $m^3/cap/yr^{-1}$, as this would allow 100 $m^3/cap/yr^{-1}$ for domestic and industrial use, leaving the remaining $m^3/cap/yr^{-1}$ (80 percent of the total) for irrigation. In the quest to develop a scale based on standard units of measurement, Falkenmark then converted this baseline volume (500m^3) to 2,000 people per "flow unit" of water (one million m^3 of water per year). This lead her to conclude that *more* than 2,000 people per "flow unit" would preclude a region or country from having sustainable economic or social development. While not directly stated by Falkenmark, this notion implied that water scarcity "beyond the barrier" would result in social decay and possibly political instability. The notion also contributed to the "water-

(Continued on page 66)

wars" literature, in which this linear relationship was assumed to mean that countries will go to war over water scarcity at some time in the future.

The analysis seemed intuitively useful at the time, but subsequent research has shown that countries with a large volume of water available to them do not necessarily develop economically. Conversely, countries with a limited water supply (such as Israel, Botswana, and South Africa) are capable of economic development close to or even beyond the hypothetical barrier. In contrast, the concept of the second order resource has proven pivotal in translating water availability into economic development. When second-order issues are considered, how a social entity deals with a scarcity rather than the scarcity itself becomes the critical issue. Thus, emphasis shifts away from the analysis of water availability (as a first order resource) to social adaptive capacity (Ohlsson, 1999; Ohlsson & Turton, 1999) or "ingenuity" (Homer-Dixon, 1995; 2000). Water scarcity itself is seen as a relative thing, with a variety of forms in existence (Turton, 2002).

But what actually is a second order resource? Turton & Ohlsson (1999) developed a grid showing different combinations of first- and second-order resources, and from this they generated some new conceptual definitions. This was refined by Allan (2000, page 324) and used to explain the Middle East North Africa (MENA) water situation. There is a strong need to refine the notion of second order resources further. Five key indicators of second order resources are currently being developed by Turton (2002):

- *GNP/Capita adjusted to Purchasing Power Parity*. This is a crude indicator of potential for institutional development in a given country and allows a rough comparison to be made between countries (as shown in the attached grid).
- The ability to generate data is a direct indicator of *technical ingenuity*. Data are needed to support decision-making, and contested data are often at the root of hydropolitical tension between riparian states in shared river basins.
- The ability of a given country to generate *coping strategies* with which to manage water scarcity is an indicator of both social and technical ingenuity. In this regard, certain *issues* (such as a policy change from national self-sufficiency in foodstuffs to food security) are a key indicator. Food security requires foreign currency with which to purchase "virtual water" embedded in cereals and thereby balance out the national water budget in a "politically silent" way. In other words, water scarcity is actually a local issue rather than a global one if one re-defines the problem. Underlying this is what has been called the "Paradox of Perception" which defines the way that the problem is initially formulated, and therefore also influences the development of a solution from a possible range of options (Turton & Kgathi, 2002). Importing food that has been grown elsewhere can ameliorate localized water scarcities. Since it takes 1,000 tons of water to produce one ton of wheat, importing a ton of wheat effectively imports 1,000 tons of water in an abstract sense. This redefinition can be done without having to admit that water scarcity is a strategically important factor (hence the importance of being politically silent). But in order to do this, one needs to redefine political priorities away from national self-sufficiency in food to *food security* instead. This move, however, is fraught with political risk, as it opens up a new set of political and economic dependencies on the developed countries of the North (see Allan, 2000).
- The *willingness* and *ability* of all role-players to *negotiate* in order to generate coping strategies or develop institutions is an indicator of social ingenuity. It is the ability to gain consensus on hydrological data that builds confidence in otherwise-contested river basins. This also allows the core problem of water-resource management to be re-defined in such a way that the trade in virtual water can become an effective strategy. The Paradox of Perception is relevant in this regard (Turton & Kgathi, 2002).
- Finally, the ability of a given social entity *to sustain institutions once created* is an indicator of both social and technical ingenuity. This article suggests that countries with a higher GNP per capita are more likely to sustain institutions than those with a lower GNP level for a variety of reasons—including the technical ability to generate data on which incremental decision-making can be based.

relatively high per capita water availability, showing the flaws in merely first-order analyses. Zambia is politically stable but has a low level of economic activity. It is also negatively affected by the civil wars in both Angola and the DRC. Should Angola, the DRC, Mozambique, and Zambia manage to solve these problems, they could conceivably become the regional breadbaskets, using their natural resource endowment to balance the regional water scarcity by becoming virtual water exporters within the Southern African Development Community (SADC) (Turton et al., 2000b).

The four southern African WP cases present a complex set of problems indeed. Since there is a relative scarcity of both first- and second-order resources in these cases, their dependence on external aid is likely to grow over time. Lesotho is an interesting case as it is first-order resource poor, yet it is also the source of water for South Africa via the Lesotho Highlands Water Project (LHWP). Water represents one of the few natural resources that Lesotho can exploit (the other being labor and, to a lesser extent, diamonds). So it sells water to South Africa, using the royalties to finance other development projects. Significantly, all of the East African countries fall into the WP category. This suggests that East Africa faces relatively more complex development problems than Southern Africa does.

Some Hypotheses for Testing

The results presented in Table 3 suggest a series of hypotheses that can be tested more exhaustively elsewhere. To review, four such hypotheses are evident:

- In all cases presented, the relative abundance (or scarcity) of the second-order resource determines the outcome.
- For countries with a relative abundance of first-order resources and with a relative scarcity of second-order resources, developmental potential is likely to remain low. This condition can be labeled *Structurally-Induced Relative Water Scarcity* (SIRWS), an unhealthy condition that policy development should seek to counter vigorously.
- For countries with a relative scarcity of first-order resources and with a relative abundance of second-order resources, developmental potential is likely to be high. This condition can be labeled *Structurally-Induced Relative Water Abundance* (SIRWA), a healthy condition to be actively sought as a policy outcome.
- For countries with a relative scarcity of both first- and second-order resources, developmental potential is likely to remain low. This condition can be labeled *Water Poverty* (WP), a debilitating condition that is likely to result in a spiral of social and economic decay over time, with no apparent end in sight short of external intervention in some form. Under these conditions, policy intervention is likely to be exogenous in nature—dependent on third-party involvement.

It would be most illuminating to test these hypotheses by means of a more robust methodology and by using a wider range of indicators. Turton (2002) is developing such a methodology, along with indicators that are applicable to the management of international river basins. These indicators include aspects such as the ability to generate data independently of foreign assistance, and the ability to legitimize that data by means of building consensus among all riparian states. (See Box 2 for more details.) The outcomes of such a venture would be valuable for policymakers and water-resource professionals in the developing world.

GIS as a Management Tool—Just a Matter of Representation?

The previous detailing of population and water scarcity nuances in the developing world has laid the groundwork for an assessment of the role of technology in general—

and Geographical Information Systems (GIS) in particular—in managing such problems. Is GIS a helpful tool for gauging population growth and water stress, or is it a manipulative device for representing the world in the image of the powerful? This is an issue of increasing relevance, meriting far greater attention outside the world of geography and water resource management. It is particularly relevant to the developing world.

Since its inception in the developed world in the 1960s, remote sensing has been a growth industry, becoming a highly popular representational tool to locate three-dimensional data. Yet critics such as Pickles (1991) charge that GIS tends to be used unreflectively—those who use it are not alert enough either (a) to the assumptions underlying their technology of choice, or (b) the implications of its use. This criticism is necessarily bound up with value issues and ethics. Like any map, a GIS representation of the world imposes a set of values on its users. The answer to a research question is dependent on the assumptions underlying that question. Thus, if the question is whether GIS can shed light on water and population stress, this not only implies the assumption that there is a question of stress but also that this stress could lead to problems.

For example, knowledge constructs like "water wars" (most famously coined by Joyce Starr) and the "population time-bomb" express the pessimistic Malthusian perspective. These constructs have not gone unchallenged, and as a result the doomsayers seem to be beating a retreat—see, for example, ICRC (1998), in which Tony Allan argues that it is the "optimists" who are right (although he deems them dangerous, as they promote complacency about real challenges to be met). This debate highlights the need to take solution-capacity into account as much as problem-potential.

If stress is the ratio of challenge to coping capacity (Lazarus, 1966), then coping with stress may involve reducing the challenge (needs) or increasing the coping capability (adaptive capacity). Fortunately, revised projections on population growth and a greater understanding of virtual water—one example of the adaptive capacity introduced above—provide a more optimistic view. One such view is Allan's dictum that the pessimists are wrong but useful, while the optimists are right but dangerous (Allan, 2000). Researchers should therefore be careful both to point out what they believe and what information they rely on to back up those beliefs.

It is important to realize that GIS is an information management tool rather than a data-gathering tool. What emerges from a GIS exercise in itself does not say anything about the policy issue that gave rise to the exercise in the first place. As a consequence, the "garbage-in, garbage-out" principle applies with a vengeance to GIS. For example, a researcher might attempt to gauge the world's level of urbanization by the amount of light its cities emit. The larger the dots on the world map, the bigger the urban population. Yet this analysis would make sense only if the level of energy use is equal across the globe, which it obviously is not. There are striking differences between per capita energy use in Sana'a, Yemen and Cape Town, South Africa; as a consequence, Yemen fails to appear on some urbanization maps (Allan, personal communication, 2000).

The phrasing of the research question, the data input, and the criteria for assessment all matter, because each impacts on the overall construction of the knowledge that we seek to build. A good example is early warning in famine policy. In many emergency situations, food may well be available, but the mechanisms of exchange (entitlements) by which people have traditionally gained access to food have ceased to function (Sen, 1981). In these cases, famine is caused not by a failure of supply but by a failure of meeting effective demand (Hutchinson, 1998).

The concept of the "water barrier"[3] is a relevant application of these observations on the nature of questions to be asked to the water sector. The renowned Swedish hydrologist Malin Falkenmark (1990) introduced the concept as a practical rule of thumb, but eventually she almost came to regret coining it (Falkenmark, personal communication,

1995) as the water sector began to interpret it as an unassailable rule. While the water barrier is a handy device to show how many countries may be mining their way into future misery, its subsequent uses ignored other factors such as second-order resources. The concept of the "water barrier" in itself provides a useful, confrontational view that underscores an alarmist agenda about the state of the water resource, intended to awaken governments to the unpleasant realities of current trends in the available water stock.

Falkenmark intended the "water barrier" to provide a guide to the minimum water requirement for an average human being, which she calculated at 1,700 $m^3/cap/yr^{-1}$ (Falkenmark, 1989). The concept was soon enshrined in policy documents as a hard and fast rule, unfortunately reinforcing existing platitudes that assume water is recovered, handled, and distributed everywhere in a uniform way, thereby ignoring institutional, cultural, and economic differences. This problem is common for analyses in which first-order resources are the sole focus of attention. A meat-eating, industrial-consumer society such as the United States has a rather different water-demand pattern than a vegetarian, self-sufficient nomadic tribe living on a bottle of water a day. Local water scarcity is also only a problem for an area when non-native people either want to, or have to, live there. One consequently needs to take into account first-order natural resources, second-order social resources, and the settlement pattern of people if the problem of water resource availability is to be adequately understood. Taking data as absolutes can easily lead to non-adaptive conclusions (Geldof, 1994), which are clearly unsatisfactory.

GIS and Social Context

The issue of social context is also critical in appraising the validity of a particular technological application. Social context suggests (as did the first section of this article) that there are different types of scarcity. Sexton's (1992) concept of "economically-induced scarcity" and Warner's (1992) "politically-induced" scarcity both hint at an underlying mismatch between the water wealth offered by nature and the actual amount of water available to specific groups and individuals in society. Ohlsson's (1998, 1999) differentiation between first-order and second-order resource scarcity is also a dynamic concept; it addresses response to stressors (such as drought, floods, and famine) rather than viewing scarcity as frozen in absolute terms in a particular moment in time. Countries that are poorly endowed with water resources are not necessarily in trouble if they have adaptive capacities and mechanisms that are either in place or capable of mobilization before the debilitating effects of absolute scarcity become a limiting factor. A country that has found ways to use ingenuity—what we would call its "water IQ"— will not always result in economic stagnation and political instability.

Conversely, a country that is seemingly on the safe side of the "water barrier" does not necessarily have reasons for complacency. On the basis of this insight, Ohlsson (1998; 1999) has endeavored to rank countries according to proxy indicators of social scarcity, guided by the UNDP's Human Development Index. As a result, we now have proxy indicators for second-order scarcity that can be developed further if found to be useful—see, for example, Sullivan et al. (2000). Yet one must bear in mind the "proxy-ness" of the indicators that are being used in this work. Even if one managed to refine the method to a high level of mathematical sophistication, there is still the question of reliability of inputs from official statistics.

In the above examples of the use of GIS in policy-relevant science, it was the *interpretations* of geographic information that were at issue rather than the input. Unfortunately, interpretations are in many instances where the trouble begins. In a country where an aggressive hydraulic mission is bent on mobilizing more water as a foundation for socioeconomic development, experts tend to rely on a positivist approach to knowledge —"objective" and precise science, dominated by experts and high technology and excluding lay knowledge and "fuzziness." An example is the science of hydrology. While hydrology claims to be based on hard data and uses mathematical logic, poor data quality in the form of short time-sequences (coupled with the problems of extrapolation) ultimately yield gross distortions of reality. Another example is flood forecasting, in which cost-benefit assessments on flood protection are made despite lacking adequate time series to justify their extrapolations (Green & Warner, 1999). Politically rational processes are less orderly and predictable than hard science—emotions, values, hard-nosed opportunism get in the way. The measurement of such processes does not lend itself to the use of concrete numbers, so such processes tend to play havoc with this purported objectivity, with potentially deleterious effects on knowledge-building.

It should be noted that the GIS experts with whom we have interacted are often well aware that GIS is not a miracle toolbox but an instrument that necessarily reflects the biases of its filters and the project's aims. While the GIS community should perhaps display even greater receptivity to acknowledging the shortcomings of GIS, it is fair to say that policymakers are equally responsible when they receive information that reflects their biases.

The technical ability with which societies are able to handle their water-resource base is paramount.

Securitization of Water

Water resources are often securitized in semi-arid countries, especially when those countries have a strong hydraulic mission and face closure in shared international river basins (Turton, 2001). Securitization is the elevation of an issue above normal politics in light of the perceived national security interest, legitimizing extraordinary management measures (Buzan et al., 1998). As a result, in political settings such as Israel, Portugal, and Turkey, domestic scholars have found it frustratingly difficult to get access to essential water data because the government considers such data too sensitive to release. Like water, information can become scarce if perceptions of threat to the national interest prevail. During the Oslo negotiations, Palestinians had to rely on Israeli water maps that were open to varied interpretation, thereby undermining confidence in the process. Drawing on Buzan et al's (1998) work on security strategy, this phenomenon may be called the securitization of information (Warner, 1998). The securitization of information often makes official statistics rather dubious, particularly in the Middle East.

When water has been elevated to a national security concern, projects promoting water development become undebatable. The persistence of this phenomenon has given rise to a concept known as the "sanctioned discourse," whereby a select elite determines what may be said about water-related development projects and by whom. Both in Turkey (the multi-dam Southeast Anatolia Project or GAP, on the rivers Euphrates and Tigris) and in Egypt (the Tushka project, which seeks to irrigate Egypian desert land by means of a spillway), criticism of pet projects has been taken as criticism of the state (Warner, 2000).

Abd al-Aziz Ahmad, a senior Egyptian official in the State Hydropower Commission, generated a series of now-famous reports that raised questions about the long-term sustainability of the Aswan High Dam (Waterbury, 1979, page 120); he subsequently met with ostracism in Egypt. Bureaucratic politics (Allison, 1999 [1971]) provide yet another and especially distorting element in this respect. Large organizations such as governments tend to form what Eric Wolf has labelled the *tributary social organization* (Wolf, 1990). Government bureaucracies, for example, form a tributary system that collects resources to finance public works: just as water flows from a tributary stream into a lake, wealth (through taxes and interest payments) flows towards those bureaucracies or departments that create new projects. Control of water then becomes the institutional ability to develop new projects (Johnston & Donahue, 1997). Concomitantly, the way to seek rapid promotion within the dominant organization becomes the completion of a successful project; and often the grander such projects are, the better they are perceived by gate-keeping elites. This dynamic favors the alignment and suppression of negative information; under such circumstances, any statistics generated by powerful water boards are not necessarily reliable, and consultants are under pressure to conform to the wishes of the bureaucracy (Brichieri-Colombi, personal communication, 2000).

Thus, as the output of GIS depends both on the input and the questions underlying it, GIS represents the world in a way that reflects those interests. Depending on what gate-keeping elites want to show, they can manipulate their computer images to highlight and represent their image of reality. The selection of such filters is a key passage point that is easily overlooked in evaluating GIS. Commercial applications of GIS can all be used to accumulate a plethora of personal information building up to detailed demographic profiles, and the intelligence community has always used data from civilian satellite systems in carrying out its security mission (Morain, 1998). Technologically advanced countries can spy on less well-endowed countries to see where strategic resources (such as water, oil, or natural gas) are without them necessarily being able to return the favor.

When we admire GIS data, therefore, we need to consider *whose* reality the shiny GIS material represents.

GIS as a Reductionist Tool

Apart from the influence of interests, there is a fundamental issue at stake regarding the way the world is analysed. At the philosophical, epistemological, and ontological level, GIS represents a Western tradition of decomposing the world into minutiae rather than integrating it holistically. Conventions such as the Convention on Climate Change require countries to collect data according to a certain model that (a) brackets in countables prioritized by the developed world, and (b) brackets out non-countables such as cultural and religious values as well as common-law institutions. The unified approach on measuring vulnerability to climate change proved much more compatible with countries like the Netherlands than islands in the South Pacific, which not only find it harder to come by physical and economic data to fit into the system, but also have raised the issue of different norms such as communal ownership of resources. Forcing them to adopt a framework reflecting Western-oriented values may well mean the non-appearance of local values in the comparative data, which will make it harder for them to bargain for specific compensatory and rehabilitating measures.

Also, just as school atlases of yore listed each colony's raw materials, GIS can be used to pinpoint the last exploitable energy and water reserves and, in so doing, promote their capture. A transferred technology may not conform to indigenous values held by beneficiaries. This disconnect becomes ever more salient as GIS technologies develop into a must-have for the developing South. To keep up, the developing countries seek access to the same reality-transforming technology that they see in the developed world. The use of GIS is now universal in the West, but close allies such as Egypt also benefit from the latest American technology. Yet poorer countries, or those less sympathetic to Western-style capitalism, may be left out: for example, peoples without officially-recognized states (such as the Palestinians) cannot legally buy remote-sensing images, which puts them at a distinct disadvantage. The same issue of availability and access is consequently not just relevant for water, but also for information tools like GIS.

There is also the issue of whether a country that is the subject of GIS analysis can actually do anything with the results that the technology yields in the first place. When floods hit Mozambique in February 2000, flood-warning technology was well in place in the region, but Mozambique did not seem to benefit from it for lack of a working knowledge infrastructure. Thus, no matter how promising epistemic communities are (such as those that involved in global warming and regional-knowledge building), strictures such as those of communication, representation, and logistics may prevent the development of an effective regional water security regime for Southern Africa.

GIS as a Management Tool

Thus far, this article has mainly pointed out serious questions about much of the current use of GIS. But we should not overlook the possibilities GIS opens up if it is used mindfully. The aim should be to make GIS a more *varied* toolbox for understanding the world. The technology lends itself to control *and* resistance strategies—both between countries and between state and society. Like the Internet, the increasing affordability of GIS could, with time, democratize the technology into a tool for use by those with only a reasonably powerful computer. From controversial dams in India to river-deepening and widening projects in the Netherlands, from illegal industrial pollution to covert military operations, researchers who pool resources should be able to parse potentially distorted official statistics and get the "real" numbers. And, in this regard, GIS could promote the democratization of science for policy in general. Fortunately, the ever-falling cost of GIS also allows previously-silenced critics to turn the tables and break the monopoly of information use by elites.

What Turton & Ohlsson (1999) have called the "second transformation" starts with new voices on the scene, such as civil-society groups consisting of NGOs and community-based organizations. While underestimated at first as being irrelevant and repressed, these voices have increasingly started to be integrated into government, particularly where institutional government capacity is weak. In this role, such voices provide a chance to mobilize the second-order resources that some countries may lack by mobilizing untapped knowledge and governance capacities and bridging the ingenuity gaps. The social and environmental consciousness that these advocates express has started to challenge the approach of those still enthralled by a "hydraulic mission" (Reissner, 1996).

In the light of these developments, hailing GIS as the return of positivism would be to paint too simplistic a picture of a changing reality. It would make more sense to try and convince those who work with GIS that theirs is one knowledge among many—such as the traditional knowledge systems of many local water users in the developing world. Interestingly, noted natural scientists for some time now have been advocating the involvement of non-experts in policy debates to help decide on contested value-laden policy problems as well as those surrounded by a great measure of uncertainty (e.g., Funtowicz & Ravetz, 1983). Bringing in "lay" (non-expert) voices and rationalities, perceptions, and emotions as considerations for policymaking (Geldof, 1994) will be perceived by some as a striking blow to the positivist outlook. However, this article advocates: (a) promoting the adaptation of GIS systems such that they allow for a diversity of questions to be raised; and (b) making GIS a tool that can also be operated by those of limited means or those seeking to promote an alternative, counter-hegemonic agenda. The difference between availability and actual access is also a crucial one. GIS can be especially helpful in showing not just the location and distribution of people, but by showing the physical infrastructure or "pipelines of power" (Turton, 2000a), thus showing how hydraulic structures can be developed to ensure differential access to water.

When second-order resources are mobilized in sufficient quantities and in sufficient time, the pitfalls of rapid population growth can be averted.

But the mainstream GIS community is confused by these criticisms, and dialogue towards progress on these issues has so far been painful and generally non-productive. As Schuurman (2000) notes, GIS experts have problems coming to terms with the *language* of GIS critics. Social science can also do its bit by phrasing its arguments in language that is intelligible to those who have been trained in the natural sciences. Fortunately, a new generation of engineers and physical geographers seem to be more sensitized to these questions than their predecessors were. One example is Initiative No. 19 of the University of California-Santa Barbara's National Center for Geographic Information Analysis' (NCGIA) Initiative, in which critics of GIS work together with their GIS-savvy peers (Schuurman, 2000). But we will need to do much more—ultimately redesigning engineering, geography, and social science curricula in a cross-disciplinary way so that the next generation will learn to speak multidisciplinary languages understandable to a wider audience.

Key Questions

Despite the debate over the values and shortcomings of GIS, it remains an important tool in the water availability/scarcity debate. With that debate in mind, it is now possible to focus attention on answering four critical questions.

Question 1. *Will there be enough water to support regional populations in the future?*

The African cases presented (even those characterized here as "low") almost all show an alarmingly high rate of population growth when compared to trends in the developing world. The doubling and even tripling of populations over the 39-year period for which data have been selected is cause for alarm. In terms of first-order analysis alone, this phenomena represents a significant reduction in the availability of water per capita over time—ranging from half to a third over the period. When second-order resources are mobilized in sufficient quantities and in sufficient time, however, the pitfalls of rapid population growth can be averted. Second-order resource management therefore becomes the key management issue, relevant to water resource managers, aid agencies, and foreign policy practitioners alike.

SIRWA countries have a wider range of options available to them and are likely to manage water scarcity more effectively than SIRWS countries. SIRWA countries have the problem of mobilizing more water, so the issue of "running out of water" (another flawed concept that is often used in first-order analysis) is more relevant to them; but given their capacity to adapt, they are likely to implement coping strategies in time to avert a disaster. Virtual water trade is likely to become more important for these countries, raising the issue of increased vulnerability to global grain price fluctuations, increased dependence on erstwhile colonial powers, and other strategic considerations. SIRWS countries, in contrast, do have the problem of developing the water resources that they naturally have. WP countries are likely to face catastrophe after catastrophe with crisis management being the norm, so they are less likely to maintain social, economic, and political stability. Water scarcity is therefore likely to become a critical developmental constraint, with its debilitating effects unevenly distributed within WP countries and potentially exported regionally in a domino-effect of instability.

Question 2. *Can Geographical Information Systems (GIS) technology be used to map water resources and future population growth?*

Clearly GIS is a powerful management tool with enormous potential. There are a number of pitfalls, however, as discussed above. First, as noted in the introduction, political legitimacy and accountability are generally low in the developing world. Under such conditions, resource capture by the economic elite is increasingly likely. A powerful tool like GIS can therefore become an instrument of manipulation and political control rather than a water-management support platform. The impact of this should not be underestimated.

Second, while GIS represents an information management tool, it is not a science (Wright et al., 1998). As such, its effectiveness is hampered by the type and quality of data that originally available for input. In SIRWA countries, the likelihood of adequate primary data (coupled with the existence of sufficient intellectual capital and institutional capacity with which to collect, store, process, interpret, and share that data) is such as to generate optimism about GIS's applicability. For those countries, GIS is thus likely to become a powerful management tool in the future, and in many cases this trend is already evident. For SIRWS countries, the lack of substantial second-order resources is likely to mean that institutional development will be low and intellectual capital will be scarce; as such, the prognosis for the success of GIS in these cases is dubious. The same holds true for WP countries.

Third, the issue of North/South dependency becomes relevant. In the case of GIS, the technology is developed in the industrialized North and selectively exported to the developing South, possibly exacerbating the existing maldistribution of global power and creating new forms of marginalization and dependency.

Question 3. *Has the question now become one of managing demand for water rather than supply?*

There is no simple answer to this question because it is dependent on a series of other issues—such as (a) the capacity of a state to negotiate with riparian states in shared river basins, along with (b) the ability to develop the institutional capacity necessary for developing effective coping strategies. In this regard, the Turton-Ohlsson typology presented in this article provides a useful framework for unpacking these issues. There are at least three necessary conditions for demand management to succeed:

- There must be sufficient institutional, intellectual, and administrative capacity in order to generate viable water-demand-management (WDM) solutions in the first place. Similarly, there must be the capacity to meter water consumption, bill users accordingly, collect payment, and sanction those who do not pay. All of these aspects are second-order-resource in orientation.
- There must be a high level of political legitimacy if WDM policies are to be supported by the general public.
- There must be a culture of payment for water services received. This also implies that there must be general acceptance of water as an economic resource.

For SIRWA countries, the prime management issue is about doing more with less. Under these conditions, WDM is likely to become an important component of a management strategy; however, as Gilham & Haynes (1999) have demonstrated, it is unlikely to be the sole solution. Where WDM is implemented, political legitimacy is likely to be severely tested. In Zambia and in Botswana, for example, attempts by the government to introduce charges for water (which was culturally seen to be a gift from God) are placing strains on the political system. The challenge under these conditions is therefore to develop the right mix of culturally-appropriate and politically-acceptable supply- and demand-sided solutions. Supply management will always remain important, with a shift of emphasis away from large water-transfer schemes to more sophisticated desalinization and water recycling systems. It is therefore simplistic to assume that a hard transition will occur from supply-sided to demand-sided management. In reality, both elements are needed in an effective water-resource policy, but with a shift in emphasis between the two over time toward the management of demand.

The second-order scarcities in SIRWS countries are likely to inhibit the development and implementation of viable WDM strategies. Popular support for WDM is unlikely in these cases, and civil disobedience can be expected to actively undermine such policies. The lack of institutional capacity in SIRWS cases is also likely to mean that water meters are not installed, billing capacity is likely to be non-existent, and legal sanction for non-compliance lacking. Clearly under such conditions the prognosis for success is low. The same holds true for WP countries.

Question 4. *How will WDM be achieved?*

Since the key management issue revolves around second-order resources, three elements are likely to be crucial:

- On the structural side, institutional development is important. Such institutions should: (a) be adequately staffed; (b) have sufficient data processing and sharing capabilities with which to develop and monitor solutions; and (c) be adequately funded in order to ensure sustainability. It is critical for demand-management institutions to meter water consumption, generate bills and collect monies due, and prosecute those who adopt a non-compliant posture.
- On the social side, there needs to be a culture of payment and a high level of support for the decision-making bodies. A cultural acceptance of water as an economic resource that has value and should be paid for is critical.
- On the political side, there needs to be unconditional support by politicians. Without this support, the overall credibility of the management process will be under-

mined. If politicians continue to promise free water to potential voters, then WDM strategies will be compromised.

Current research underway at the African Water Issues Research Unit suggests that three components are necessary to manage water demand, at least in an African context. The first of these is *accessibility to water*. Where water is inaccessible, its use is low and the time taken to fetch it is high. These dynamics change when water becomes more readily available and convenient to use. This means that the second component of any given demand management strategy is *pricing*. As water becomes more readily available, people are willing to pay for the resource. Demand can be managed through an innovative tariff structure such as that currently used in Durban, South Africa—but this is only effective if adequate access to water has already been established and if people's attitudes to the use of water have changed. The third component is, consequently, *education.* Education must target a wide spectrum of audiences—from water users up through the water supply chain to the political level. If politicians continue to offer free water as a means of securing votes, demand management is doomed to fail! An important end-goal of the education process is to change the attitude that water is a free good, in keeping with the Dublin Principles (ICWE, 1992) and World Water Vision (Cosgrove & Rijsberman, 2000).

Conclusion

The development and sustainability of second-order resources determine how well a society can manage a resource such as water. Typically, this type of resource is in short supply in the developing world. Hydropolitically-related foreign policy initiatives are likely to fail if this subtle but important nuance is not taken into consideration. Many cases of aid dependence result directly from an attempt to stimulate development in the absence of any recognition of the importance of second-order resources. Similarly, applications of modern technology such as GIS is likely to fail if second-order resources are not taken into account. Where correctly applied, however, GIS is likely to become a powerful and equalizing management tool of the future. The strategic significance of some of these nuances is important, given the impact of the 2001 terror attacks on New York's World Trade Center and the Indian Parliament. The foundation of this strategic significance derives from the fact that there is a correlation between (a) countries that have the potential to export terror, and (b) the existence of WP as defined in this article.

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Notes

[1] This distinction is not a clinical one, however, because many other criteria could be used. Even in this case, there are still overlaps. Tanzania, for example, falls into both classifications.

[2] The "water wars" argument suggests that, as a country's uncontrolled population growth erodes its available water resources, conflict potential in that country will increase to the point where war over water is inevitable (Turton, 2000b, page 39). By relying on so-called "hard" primary data (population and water availability), this linkage results ultimately in a teleological argument. In reality, this so-called "hard" data are not hard at all; it involves a high level of generalization combined with specific assumptions. For example, U.S. Census (2000) lists Angola's population in 2000 at 10,145,000, while the UN (2000) World Population Data reports a figure of 13,134,000. At best, such data are broad generalizations only and should not be regarded as being the final word on the issue.

[3] The "water barrier" was defined by Falkenmark (1990:181) as a conceptual "barrier" that was set at 2,000 people per standard "flow unit," consisting of one million cubic meters of water per year. Falkenmark considered any figure above the water barrier to make any form of economic development virtually impossible given current technologies.

Subsequent analyses have shown difficulties in universal application of the water barrier. Israel, for example, seems to be capable of surviving at a figure well beyond that set by Falkenmark. South Africa is approaching the barrier and also seems set to survive the transition. These anomalies have given rise to new explanations, leading to the concept of second-order resources. In the cases where states can survive beyond the water barrier, they all have high levels of second-order resources.

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