COMPREHENSIVE Assessment of water management in agriculture

Research Report 10

Cities versus Agriculture: Revisiting Intersectoral Water Transfers, Potential Gains and Conflicts

François Molle and Jeremy Berkoff

IWMI International Water Management Institute

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and
Jeremy Berkoff

Comprehensive Assessment of Water Management in Agriculture

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Contents

Summary

Water demand management, or making better use of the water we have—as opposed to augmenting supply—is increasingly proposed as a way of mitigating water-scarcity problems. Moving water away from agriculture to uses with higher economic value is one of the main measures widely seen as desirable. Sectoral "allocation stress" is often identified as resulting from four different observations: a) agriculture gets the "lion's share" of all diverted water resources; b) agriculture is not only the main water user but also an activity that incurs by far the largest wastage; c) cities are "thirsty" ; and d) water productivity in nonagricultural sectors is far higher than in agriculture. This apparent misallocation is often attributed to the failure of the government to allocate water rationally.

This report revisits this commonly-accepted wisdom and examines the nature of urban water scarcity, the relative importance of both physical and economic scarcity, and how cities secure funds for the development of their water infrastructure (or fail to do so). It investigates whether recurrent water shortages in cities have anything to do with agricultural water use (or overuse); and assesses whether significant *allocation stresses* warrant the view that *large economic gains* can be realized through reallocation.

A large number of cities worldwide are reviewed and the ways in which they increase their water supply is analyzed. It is shown that, in many cases, augmentation of supply is achieved through transfers of water from agriculture, or from ecological reserves and aquifers. Transfers may be gradual or outright, minor or major, surreptitious or open, above the surface or underground, and with or without compensation, all factors that condition the perceptions and reactions of the general public. If cities eventually tap additional resources, this is often found to happen in a nonsustainable or costly manner. In general, rather than using a narrow criterion of financial costs, cities tend to go for the "path of least resistance," whereby economic, social and political costs are considered in conjunction.

Problems of urban water scarcity are sometimes compounded by the physical environment (arid climate) or by the location of cities in upper catchments where no large streams are available nearby. However, most large cities in the developing world tend to have deficient-to-poor water supply and sanitation facilities, even if there is abundant water in their surroundings. As shown by the debate on financing of water-supply infrastructure, the main issue is "where to find the money?" rather than "where to find the water?" It is shown that urban water supply is a reflection of the local political economy where the "threat from below" (voice of civil society, popular unrest, epidemics, etc.,) the financial and political benefits accruing to the elites and decision makers, and the possibility to tap financial resources (through privileged relations with the central government or international funding agencies) largely determine the level of water services and how these are spatially and socially differentiated.

If city dwellers often have precarious supply and sanitation facilities, there is no strong evidence to show that nonagricultural (notably industrial) economic activities are significantly constrained by a lack of water, both in their daily functioning and in their capacity to expand. Sectoral water allocation may be hindered where formal water rights systems exist (e.g., the prior appropriation right system in the western USA) but much less so where allocation is centrally administered. Contrary to common knowledge, States, when not going for supply augmentation, have consistently given priority to cities and nonagricultural activities, and the large economic gains anticipated for intersectoral transfers appear to be greatly overstated. Agricultural water may have an opportunity cost at the margin, but this margin is usually very thin and transient.

Water-demand management is highly desirable and, in many cases, is a priority for water managers but, though its impact may be significant, its potential is still fairly limited over the medium-term. Transfers of water to uses of higher economic value are occurring and will undoubtedly continue. Rather than minimizing or concealing their effect, planners should acknowledge that highly committed water systems will have to cope with growing uncertainty and fluctuations in supply: contingency planning should allow for short-term transfers, with compensation to those surrendering supplies planned in advance so as to avoid upheavals and water crises. Such transfers neither preclude nor require water markets. But markets have prerequisites that are unlikely to be met in most countries and the alternative of transfers administered and designed through processes of negotiation is likely to predominate. More generally, better access to hydrological data, improved control over hydraulic regulation, multi-stakeholder platforms or other arenas for achieving common goals, and patterns of governance which include empowerment of marginalized social/ethnic groups and representation of all interested parties in allocation and decision making, have the potential for ensuring fairer and smoother reallocation of water.

Cities versus Agriculture: Revisiting Intersectoral Water Transfers, Potential Gains and Conflicts

François Molle and Jeremy Berkoff

Introduction

In a sense all water is used, all water has value: a pristine river as well as a river that has been fully controlled and developed to serve direct human purposes. But as populations expand, human uses increasingly encroach on the values of undisturbed nature, and shifts occur in the intersectoral balance, between nature and human uses and among the differing human uses.

Typically, human communities need small amounts of water for domestic and industrial uses and much larger amounts for irrigated agriculture, at least in dry areas and for paddy rice. This at first poses a few problems. Water is diverted for human uses and environmental impacts are, at least initially, seldom regarded as a problem. Increasingly, however, as irrigation diversions rise, they alter and displace natural uses; and as cities and economies expand, domestic, industrial and in-stream uses also start to impinge on the quantity, quality and timing of water flows, not only for the environment but also for existing and potential agricultural uses. Conflicts among and between environmental and human uses intensify, and mechanisms – some planned, many unplanned – emerge to rebalance sectoral allocations. In many river basins, water resource development has by now reached – or exceeded – its limits; marginal additional sources provide only very costly alternatives; and new projects reallocate water already appropriated for human or crucial environmental use.

Handling these conflicts and the sectoral re-balancing that is implied are a major concern of the literature. Many believe that better use can be made of the resources at our disposal: that water is too often devoted to economically inefficient, low return (usually agricultural) uses and that reallocation to more efficient, high return (usually urban) uses would increase total economic welfare. Others consider that human uses have been satisfied at unacceptable cost to the environment and that this must be redressed. Associated with issues of value are questions related to the mechanisms of effecting transfers to optimize value (however value is determined). What mix of political, administrative and market mechanisms is to be preferred and under what conditions? And how far and in what ways should the resultant mix be regulated to ensure that transfers are achieved in an efficient and effective manner?

Sectoral reallocation is seen by many observers as one pillar of water demand management, defined as making better use of existing available resources, as opposed to supply augmentation options. Significant economic gains are anticipated from a “soft path” approach that includes various conservation measures, technological innovations, and changes in user behavior through education or economic incentives. Reallocation appears as a macro-economic necessity expected to yield gains in aggregate welfare. This report is not

intended to address the whole issue of sectoral allocation. Rather, it endeavors to throw light on important aspects of the discussion regarding transfers of water between rural and urban users under conditions of scarcity. It seeks to address the following questions:

- What is the nature of urban water scarcity? Are there significant differences between physical scarcity and economic scarcity? Are poor Water Supply and Sanitation (WS&S) conditions due to lack of availability of water?
- How, in practice, do cities secure additional water supplies, and how is water transferred from agriculture to cities? What kinds of transfers are commonly found, on what grounds are they decided, what costs are incurred in effecting such transfers, and how do interested parties react to them?
- Are cities – their inhabitants on the one hand and nonagricultural activities on the other – constrained by a lack of water, both in their daily functioning and in their capacity to expand?
- Have recurrent water shortages in cities anything to do with agricultural water use (or overuse)? If so, are there significant allocation stresses that suggest that large economic gains can be realized through reallocation?
- More generally, what is the way forward? And how can we ensure a synergetic rather than an antagonistic rural-urban nexus, with cities obtaining supplies at minimum and acceptable cost to agriculture?

The report is anchored in an annex that examines how cities round the world have in practice acquired water. While direct conflicts between urban and rural interests characterize some of the case studies presented (Ta'iz in Yemen being an extreme example), the empirical evidence suggests that, by-and-large, cities have been able to obtain supplies, often at greater cost than is necessary but without significantly compromising their ability to expand and prosper, even in most inauspicious locations. Where citizens face shortages or any other water problem, the report argues that this is predominantly due to development and financing constraints rather than to water shortages as such. Under conditions of scarcity, any transfers to cities will probably have some adverse impact on agriculture. However, the volume transferred is typically small and, though important social and equity issues arise, it is argued that farmers can often adjust. And where the environment is adversely affected by human impacts, this is predominantly an issue between the environment and agriculture and not between the environment and cities, at least in regard to water quantity.

The section titled "Urban Water Scarcity and Its Links to Irrigation" sets the scene by reviewing what is meant by urban water scarcity and its links to irrigation, investigating its physical, political and economic dimensions. The section titled "Intersectoral Transfers" categorizes different types of transfers and transfer mechanisms. In the light of this typology, the section titled "Intersectoral Water Transfers in Practice" discusses how transfers are effected in practice with reference to the empirical evidence in the annex. The section titled "Are Urban Uses Constrained by Agriculture?" seeks to answer the question: are urban uses in practice constrained by agriculture. And, finally, the section titled "Where Are We Heading?" discusses some ways ahead and the conclusion summarizes the report's main findings.

Urban Water Scarcity and Its Links to Irrigation

Conventional and Alternative Explanatory Frameworks

Economics has been defined as the "application of reason to choice" in the use of scarce resources (Green and Newsome 1992). That water is an economic – i.e., a scarce – good was reiterated at the 1992 Dublin and Rio conferences, and demand management has been widely promoted as a primary means of resolving the alleged water crisis (Frederick 1993; Hamdy et al. 1995; Winpenny 1997; Brooks 1997). Demand management is defined as a "policy that stresses making better use of existing supplies, rather than developing new ones" (Winpenny 1997). It employs a variety of measures, including price incentives, market mechanisms, quotas, subsidies, conservation, treatment, re-cycling, awareness-raising and education. For Gleick (2003) such efforts together with decentralization and user participation define a "soft path" approach. Pricing and markets to balance supply and demand have received particular attention (Rosegrant and Binswanger 1994; Bhatia et al. 1994; Tsur and Dinar 1995; Thobani 1997; Dinar and Subramanian 1997; Easter et al. 1998; Johansson 2000).

Making better economic use of water implies emphasis on its productivity and the economic welfare to be derived from alternate uses. The World Bank's (1993) policy paper remarks that the value of water differs greatly between agriculture and other sectors, "often indicating gross misallocations if judged by economic criteria … Setting prices at the right level is not enough; prices need to be paid if they are to enhance the efficient allocation of resources." Price and market mechanisms are thus not only presented as a means of cost recovery and demand regulation but also as a way to reallocate water towards higher-value uses. Misallocation is held to be a manifestation of poor water management resulting in economic inefficiency. Dinar (1998), for example, holds that: "the potential for economic benefits from allocation-oriented institutional change are not only substantial but also increasing with each increase in water scarcity." Rosegrant and Cline (2002) posit that: "there is considerable scope for water savings and economic gains through water reallocation to higher-value uses." And, Merrett (2003) states that: "in the field of water resources management a widely held *belief* exists that allocation stress is to be found in many parts of the world." The apparent strength of this argument is predicated on four interconnected assertions:

1. That agriculture gets the "lion's share" of all diverted water resources (70% at world level: much more (80–95%) in developing countries);

2. That agricultural use incurs large wastage, typified by ubiquitous statements to the effect that two-thirds of water delivered to agriculture fails to reach the crop or that irrigation efficiency is typically 30-40 percent;

3. That the value of water in nonagricultural sectors is much higher than in agriculture, typically by an order of magnitude; and

4. That cities are frequently water short, the situation varying greatly depending on climate, resource availability, economic development, etc. Reference is made to cities that ration supplies or fail to guarantee water pressure, either permanently or during dry spells, and to urban areas with precarious or nonexistent water supply facilities.

The juxtaposition of these four statements is said to provide a straightforward case that water is misallocated (ADB 2000[1]), with two corollaries. First, responsibility for this is attributed to the State, since it is generally observed that the State allocates water through centralized management. This assumed failure prompts proposals for pricing and market mechanisms as an alternative (Holden and Thobani 1996; Anderson and Snyder 1997; Dinar 1998; Rosegrant and Cline 2002). Second, the contrasting share of water used in agriculture with that in other uses suggests that a relatively limited level of water saving in agriculture would easily make up for the additional needs of the urban sector. This is well exemplified by Gleick (2001) who states that: "The largest single consumer of water is agriculture – and this use is largely inefficient … as much as half of all water diverted for agriculture never yields any food. Thus, even modest improvements in agricultural efficiency could free huge quantities of water."[2]

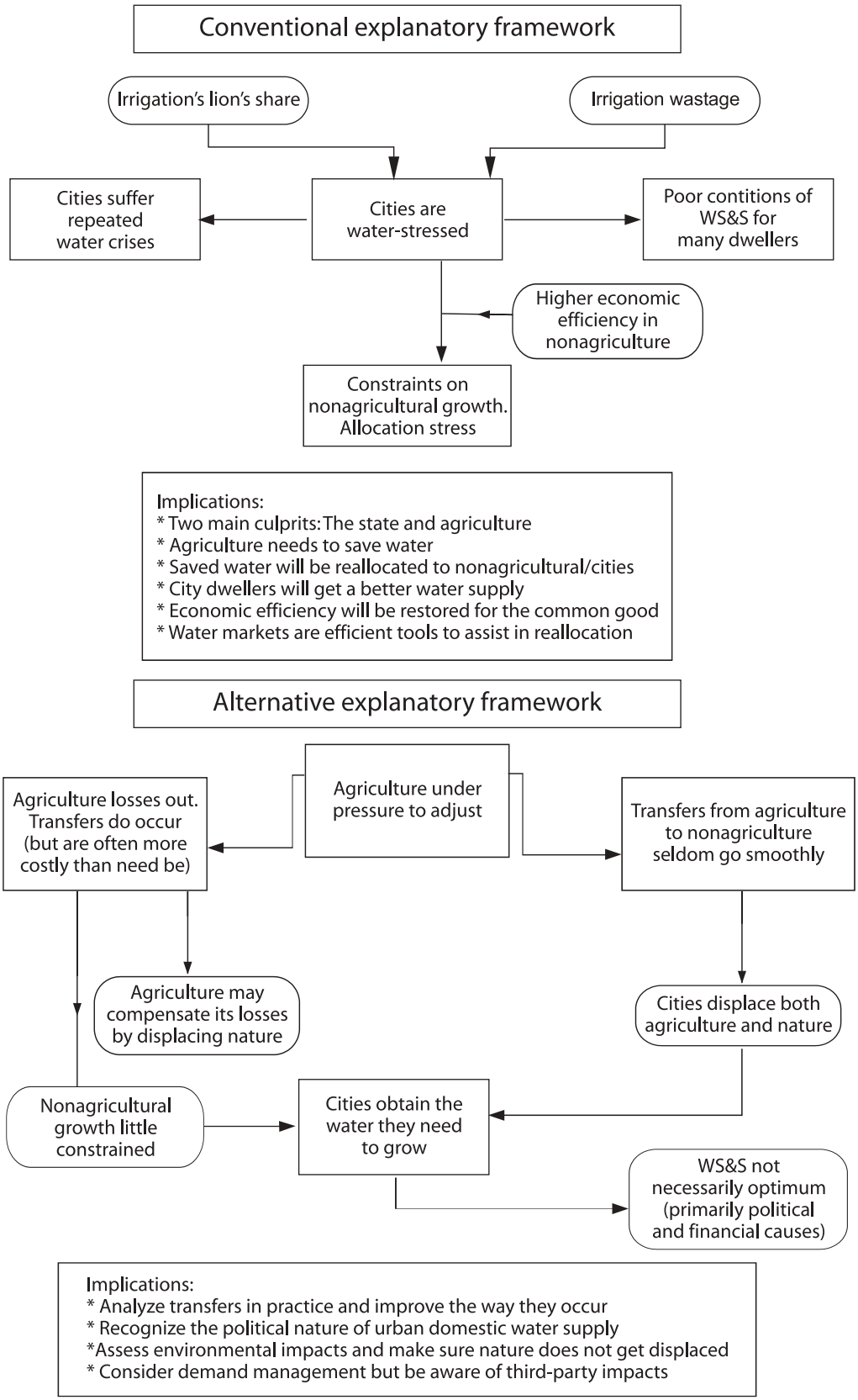
The above four statements imply that urban scarcity is in large part due to excessive use of water in the rural sector and to state failure to reallocate water. In other words, irrigation profligacy and bureaucratic inertia help explain urban shortage. Solutions lie, in part, in demand management in the urban sector but more fundamentally in the improvement of efficiency in agricultural use. Substantial water can be freed and used in higher value uses, reducing the allocation stress for the common good. Water markets may be instrumental in such reallocation and avoid state failure. This line of reasoning is schematized in the upper half of figure 1.

This framework presents us with a riddle: if large economic benefits are waiting to be realized by shifting water out of agriculture through marginal improvements in irrigation efficiency why do reallocation and related improvements seem so problematic? Why have governments failed to recognize these benefits, especially in contexts where urban bias is pervasive? While not necessarily discarding all the tenets of the conventional framework (e.g., irrigation might become more efficient and markets might be effective tools in some contexts), we propose an alternative explanatory framework which critiques some of the causal links implicit in the conventional framework and which shifts emphasis to the political economy of WS&S. Under competition from other sectors, agriculture invariably adjusts and basin efficiency increases; transfers do occur in multiple ways and such transfers keep allocative stress low. Attention is directed to the induced displacement of nature and to environmental costs, and to devising better regulation of these transfers, with emphasis on temporary transfers and issues of compensation. This framework is summarized in the lower half of figure 1.

[1]ADB's (2000) paper "Water in the 21st century" illustrates this view well: "Irrigation is particularly voracious, accounting for up to 80 percent of water demand in hot dry regions … Major obstacles to the rational reallocation of water among users, however, are the legal and regulatory constraints on water transfers and, in many countries, the complex systems of water rights that inhibit the free movement of water as an economic good." Another example of the alignment of agricultural wastage and urban water scarcity is given by the WWC (World Water Commission) (2000): "In many public irrigation systems only 30 percent of water supplied is actually used by plants. This is unacceptable when half of the people of the developing world live on less than US $2 a day—and when more than 1 billion people have no access to clean water and 2 billion lack adequate sanitation."

[2]These points are repeated in countless publications. Winpenny (1997) states that: "The fact that agriculture is such a dominant and, by many accounts, a profligate user of water has led many people to believe that relatively small savings in its water use would be easy to achieve." The International River Network (IRN 2003) considers that there is: "tremendous potential for water savings" and believes that "reducing the water consumed by irrigation by 10 percent could double the amount of water available for domestic supply worldwide." For Simon (1998) "Transferring 5 percent of agricultural water to urban areas would solve urban needs for the next 25 years." See also Schiffler (1998), Postel (2001) and Rogers et al. (2000) who believe that "a small increase in the fees charged for irrigation water … should release sufficient water resources to meet anticipated urban deficits."

FIGURE 1.
Schematization of Conventional and Alternative Explanatory Frameworks.



Some Limitations of the Conventional Framework

Three tenets of the conventional framework are briefly discussed here and some of their weaknesses are shown.

Most water is used by irrigation. To stress that agriculture gets the lion's share implicitly establishes a causal relationship between its large share and the allegedly unfulfilled needs of nonagricultural sectors. But irrigated agriculture is a biophysical process that inherently needs a lot of water. In most cases, if practiced, irrigation requires much more water than other consumptive uses.[3] Moreover, agriculture's share is typically dominant when the needs of other activities – apart from those of the environment – have still to compete for comparable amounts. This has been aggravated by the fact that States have invested massively in subsidized irrigation development for a host of socioeconomic and political reasons.[4] Where other human uses do, in fact, compete for significant amounts, the balance shifts and irrigation almost always becomes the *residual* human use after other needs have been met. To keep with animal metaphors, the lion's share is perhaps better described as the "hyena's share." (In many cases, however, agriculture will compensate for this loss by reusing wastewater [e.g., Israel or Jordan] and/or by displacing nature, which can thus be seen as the ultimate residual *user;* this will be discussed later).

Furthermore, irrigation designs are such that they can often utilize flood flows and other marginal sources that cannot provide the level of dependability required by domestic and industrial users. Irrigation thus typically uses a lot of water at times *when* it has no alternative use. In other cases, irrigation and urban networks are disconnected hydraulically and transfers are either impracticable or the costs of storage and/or integration are prohibitively expensive.

Farmers waste water. Irrigation's dominant share appears consistent with the conventional belief that farmers waste water — are not large consumers (necessarily) squanderers? The alleged wastage in irrigation has been the subject of a large amount of literature, and decision-makers and the media worldwide continue to refer to classical irrigation inefficiency in order to stress alleged mismanagement or to justify interventions of one sort or another. Without entering into the details of this question, it is important to emphasize that waste is relative: if water has no other economic use and, is not scarce, then *wastage* is of little concern other than for any impacts it has on the environment. During the rainy season or in surplus river basins, low irrigation efficiency is thus typically neither here nor there. This is notably the case for supplementary wet season irrigation in Asia, where a large part of the diverted water comes from (excess) runoff that has no other alternative human use.

Even in water short basins, a loss at one point typically flows back to the river or an aquifer and – subject to water quality – can be recycled downstream (Frederiksen 1992; Burt 1995; Keller et al. 1996; Perry 1999; Molden and Sakthivadivel 1999; Molle and Turral 2004; Molle et al. 2004). Efficiency at basin-level is typically much higher than within any individual use. Wasteful practices that result in true losses to the system occur but are not the general rule. Moreover, if real irrigation wastage occurs within a water-short basin, it is usually because of poor internal scheme management rather than because of excessive overall endowment. The issue is thus one of management, not allocation.

[3]Water to satisfy basic food requirement is in the order of ten times larger than our basic need for domestic water, and in the order of 500 times larger than our need for water to drink (Abernethy 2005).

[4]Irrigation has been widely promoted as a tool to deal with food insecurity, rural poverty, unemployment and regional development. Along with its rent-seeking and pork-barrel dimensions, this has frequently resulted in the overbuilding of irrigation systems and the commitment of much of the available water resources (Molle 2004).

In addition to the water balance *per se* there are issues related to design and farmer behavior. In contrast to urban systems, irrigation systems are *designed* for a level of water constraint, if for no other reason than to limit capital cost. This restricts the water that can be diverted during wet periods. Full use can normally be made during dry periods but water is inherently scarce at such times. Design scarcity is aggravated – and scarcity becomes pervasive – as a basin develops and less water becomes available. Irrigation managers and farmers respond to physical scarcity to optimize water's value to them – adjusting crops, practices and calendars, and developing conjunctive use by digging wells and installing pumps (Molle 2004b; Loeve et al. 2003). Except in fully controlled on-demand systems – the exception rather than the rule – the stochastic and varying nature of water supply means that the *hidden hand of scarcity* provides both real time and longer-term incentives for efficient water use. As a radical driver of change, scarcity is typically much *more* effective than any conceivable price mechanism though changes in behavior induced by scarcity are often overlooked. In contrast, urban systems are designed for water on-demand and pricing is critical if water use is to be constrained.

Low water productivity in agriculture. Urban water uses usually have higher value to society than irrigation uses, and this is reflected in the priority typically given to domestic – and often industrial – uses both in practice and in law. But this can be presented in misleading terms, either because water does not really constitute a production factor or because like is not compared with like. According to Gleick (2001), for instance, "supporting 100,000 high-tech California jobs requires some 250 million gallons of water a year; the same amount of water used in the agriculture sector sustains fewer than 10 jobs – a stunning difference." He sees a shift from the latter to the former as providing *tremendous gains in efficiency* as if they were really in competition.[5] A farm laborer cannot readily be transformed into a high-tech worker and, even if this was possible, the market determines demand and supply. Such examples are presumably meant to support the necessity of shifting water out of agriculture. But there is no indication that high-tech industry is ever short of water and it is equivocal to suggest it competes with agriculture. No doubt some industries are significant consumptive users or pollute flows to the extent that they are unusable. But in only a few cases is water a significant industrial cost and it is misleading to express total added value in terms of returns to a single factor.[6] Profit-maximizing industries control water costs as they control the costs of any other item, but in practice industry is driven by other far more important considerations and, if generally profitable, almost invariably secures the water it needs.

These elements suggest that the concepts of allocation efficiency and productivity used in the conventional framework need qualification. The next section examines the causal link between urban water scarcity and agricultural uses by exploring the nature of this scarcity.

Urban Water Scarcity

Two questions are examined here. First, is urban water scarcity due to physical scarcity and what are its financial and political dimensions? Second, how are decisions to develop water supply infrastructures made, and how who pays for water is defined?

[5]Gleick (2003) also uses US GNP, which although "an imperfect measure of economic well-being provides a consistent way to begin to evaluate the economic productivity of water use" and divides it by total water diversions to show how "water productivity" has increased with time.

[6]A concept of productivity that divides gross output value by water volume runs into contradictions. For example, applying better fertilizers can increase water productivity, which is not very meaningful (Abernethy 2005).

Physical and Economic Water Scarcity

Is urban water supply constrained by a physical lack of water? According to Camdessus and Winpenny (2003) "The root cause 'of poor water supply to the population' is our negligence and our resignation in the face of inequality." The "Camdessus Report" is a follow-up of the World Water Vision and reiterates its conclusion that the crux is money, not the physical availability of water. The recurring question is: where are we going to find the money? Not, where are we going to find the water? Likewise, the World Water Assessment Program (WWAP) report does not refer to physical water scarcity as a problem, let alone an agriculture-based one (UNESCO 2003). Anton's (1995) review of water supply in Latin American and Caribbean cities refers to rising cost and distance in mobilizing surface water, the decay and siltation of reservoirs, degradation of urban networks, a lack of incentives for water saving, contamination of surface and groundwater etc., and addresses the financial implications of supplying cities but its conclusions make no reference to a link between agricultural use and the situation in the cities.

This suggests that the root cause is economic rather than physical scarcity, even if the latter may compound the former. Precarious or underdeveloped infrastructure reflects a lack of funds and political will. As stressed by Camdessus and Winpenny (2003) "All governments, agreeing on the importance of water, subscribe to internationally inspired commitments and undertakings. But their spending performance is at odds with their rhetoric: in most countries the water sector is given a disproportionately small share in the budget." The capital needed for infrastructural development varies widely but the central question is – unambiguously – who is to pay?

The loose causal link between physical water availability and actual supply is supported by the fact that water-short cities have often been faced with insufficient supply throughout their history, regardless of size. In 1975, Amman had a population of 600,000 but only 64 l/day available per capita (Darmame 2004). The population has grown threefold since then yet the per capita use has only doubled. Athens's per capita supply at the start of the nineteenth century was a mere 32 l/day. Scarcity has been a recurring feature in the story of Guayaquil's growth in the last 150 years, from 25,000 to 3 million inhabitants (Swyngedouw 2003). São Paulo, Brazil, has faced problems of water supply right throughout its history (Ducrot et al. 2003). Likewise, there is no shortage of large cities in water-abundant regions with deficient water supply and sanitation systems: e.g., Lagos (Olukoya 2004) and Calcutta, with their contaminated sources, dilapidated networks and limited treatment and distribution. Bangladesh is another country with abundant water, yet a total of 2.5 million people in the slums of Dhaka are said to suffer from very precarious provision of water and sanitation (UNESCO 2003).[7] Ho Chi Minh City has quite abundant sources of water, but only 44 percent of the people have piped water connections to their homes and service is intermittent in 25 percent of the service area (McIntosh 2003).

Low per capita supply is often taken as a mark of water scarcity. Numerous cities provide water only one or two days per week, conveying a sense of sheer deprivation. Yet, Amman, for example, with its one-day-a-week delivery, still consumes 135 l/c/day, even if Amman East – the poorer area – uses 75 l/c/day (Darmame 2004). Intermittent supply is at least in part due to a concern for limiting the leakage that would result from constant pressure and is resolved by storage at the household level (Decker 2004). Briscoe (1999) reports that in Chennai, if supply was to increase from about 2 hours per day at 2 m of pressure to 12 hours a day at 10 m of pressure, leakage would amount to about 900 million l/c/day or three times the current total

[7]However, official statistics in Bangladesh report that 99 percent of people in Dhaka have "access to water." This points to the difficulty of establishing consensual standards on what is such access and in defining water supply with all its components of water quality and regularity in delivery. Collignon and Vézina's (2000) survey of ten African cities suggests that official figures are either inflated or correspond to total coverage (all types of supply considered).

supply! Moreover, average values obscure the level of disparities in access to water within the same city, and how this access is linked to affluence. Amman has been noted above. In Chennai, supply is 68 l/c/day but at times of shortage this may be halved and some areas relying on tankers receive as little as 8 l/c/day (Brisset 2003; Weber 2001). In Ahmedabad, 25 percent of the population consumed 90 percent of the water while 75 percent consumed 10 percent. In Calcutta, slum areas received 80 l/c/day, while non-slum areas were supplied 240 l/c/day (UNDP 1998). Phoenix in arid Arizona, with average consumption of more than 1,000 l/c/day, has satellite towns like Paradise Valley where consumption is over 1,600 l/c/day (Copenhaver 2003).

Another issue is the way standards are defined. A figure of 200 – even 275 l/c/day – is often considered such a standard[8] (Salameh 2000). In contrast Gleick (1996) considers 50 l/c/day as a minimal domestic supply, and the Global Water Supply and Sanitation 2000 Assessment Report suggests that reasonable access should be broadly defined as "the availability of at least 20 liters per person per day from a source within one kilometer of the user's dwelling" (UNESCO 2003), a figure also adopted by WHO-UNICEF (2000). Yet, The Hague is managing with 102 1/c/day, Barcelona with 127 1/c/day, Rome with 176 1/c/day, and Moroccan cities with between 70-100 l/c/day (IWA 2004). Malé, capital of the Maldives, relies on desalinated water and consumption is 34 l/c/day though supply is available 24-hours of the day and is reliable (McIntosh 2003). Low figures tend to be associated with less-than-ideal water conditions, but it is often difficult to distinguish between core needs, comfort, superfluity, excess and waste.

Cities in arid settings understandably run out of water in their immediate vicinity and must opt for costly and distant transfers. Indeed, many cities have developed in the *wrong* place and are chronically short of water (Winpenny 1994). Chennai, Mexico City, Las Vegas and Amman, are cities that have mushroomed despite limited nearby water resources. Ta'iz grew between 1986–1994 at 7.9 percent despite being one of the most water-stressed cities in the world. Likewise, even in wet environments, needs may outstrip nearby resources if the city is located high in a catchment, e.g., São Paulo, Atlanta, Kuala Lumpur, Coimbatore and Hyderabad. Though located by the sea, Manila has long resorted to interbasin transfer. New York and Boston[9] both had to go further afield to secure water supplies. Some cities destroy local water sources as they expand, e.g., Bangalore, which has encroached on 181 of its 262 tanks (Aiyar 2003). More generally, cities in developing countries have been unable to keep pace with inward migration (Lundqvist et al. 2003). As population rises physical structures to collect, convey and dispose of water become more costly and financial requirements may be beyond what the cities can afford.

Of course, many cities are faced with intermittent crises. Such crises ,in general, have roots in hydrological vagaries and extreme climatic events but may be compounded by careless management, lax planning, abusive consumption patterns, and the intervention of politicians, whose actions are fostered by a transient illusion of abundance (the 1989-1991 crisis in Athens, in Kaika - 2003, the 1992-1995 drought in Seville, in del Moral - 1998).

In sum, two aspects of urban water scarcity appear to have greater salience, albeit with great variability: the lack of available resources around

[8]Salameh (2000) considers that "it has been established in developed societies that 1,000 m^3 per year, or about 275 liters of water per capita per day are required for domestic purposes, including hygiene, commerce, and reasonable losses in water nets due to leakage." However, the sheer discrepancies in both the standards proposed and the water used in practice in diverse cities show that the debate is not yet closed (see Feitelson and Chenoweth 2002; Meinzen-Dick and Appasamy 2002; Molle and Mollinga 2003).

[9]New York relied on local supplies until 1842, and then brought water from the Croton river basin, 75 km away. Between 1907 and 1927 it transferred water from two creeks in the Catskill mountains, and later, between 1937 and 1965, tapped three upper tributaries of the Delaware river (Fitzhugh and Richter 2004).

megalopolises and the difficulty to catch up with the booming population; the financial aspect of precarious WS&S conditions (especially to the poor), which takes us to the more general question of the political economy of urban water supply.

The Political Economy of Urban Water Supply

The Camdessus Report and other documents (Rijsberman 2004; UNESCO 2003; Rogers et al. 2000; Smets 2004) give varying estimates of the financial resources needed to meet Millennium Development Goals targets or bring urban WS&S services up to standard.[10] Leaving aside the definition of "need" (see above), these amounts are not usually *per se* beyond the financial capacity of consumers, countries and international institutions. The question is rather: are such investments a priority, and who is to pay?

Are WS&S Investments A Priority? Incentives to decision makers include the pressures to do something (push) and the benefits accruing to them (pull). Historically, extension of WS&S facilities beyond the affluent classes in Europe can be attributed not just to technical advances and the hygienist movement but also to the need "to preserve order, cleanliness and a healthy workforce" (Goubert 1986), and to the perceived "threat from below" (Chaplin 1999). As early as the mid-eighteenth century it was argued that "prevention of further environmental degradation was cheaper and more effective for society than continuing with expenditure on poor relief" (Chaplin 1999). Swyngedouw (2003) describes changes in Guayaquil, Ecuador, attributing bourgeoisie response to threats from the urban proletariat to aesthetical and physical-sanitary concerns of the late nineteenth century. Bennett (1995) also describes how widespread public protests in Monterrey elevated neighborhood problems to city problems, which even went up to the level of national concern, thus prompting massive government-funded infrastructure. In contrast, Chaplin (1999) attributes the dreary situation in India to a failure by the upper classes to put pressure on the Government to implement preventive and sanitation policies. Antibiotics and pesticides confine epidemics to slums, while the reservoir of unskilled informal workers leads to the "commodification" of labor rather than to trade unions that fight for better conditions.

When examining positive incentives, it is useful to distinguish between investment in WS&S facilities (pipes, sewers, fixing leakage etc.,) and those that augment supply (reservoirs, aqueducts, tunnels etc.,). The former benefit only the population concerned whereas the latter are more visible, benefit the whole population, and are seen as concrete responses to the looming shortage, thus bringing political rewards as well. Moreover, they provide notorious opportunities for kickbacks; and are supported by line agencies that have financial and/or professional incentives to push for costly investment in increasingly distant transfers,[11] though in other cases utility staff, officials and/or politicians derive informal revenues from water vendors and seek to preserve the status quo (McIntosh 2003; URC 2004 for the case of Karachi).

[10]The Camdessus Report (2003) refers to actual needs of US$75 billion per year, increasing to US$180 billion in 2025. Hecht (2004) estimates that after a peak in the mid-90s, investments have dropped to US$ 8 billion per year.

[11]Shower's (2002) study of African cities shows that primary sources of supply in the 1970s were springs, wells and boreholes. With time, the sources of water have tended to be increasingly distant: Johannesburg draws water from nine rivers, including from the distant Lesotho; Tripoli is now dependent on the 600-km Great Man-Made River that brings fossil water from the Sahara Desert. Between the 1970s and the 1990s dependence upon nearby rivers decreased from 62 percent to 42 percent, while the use of rivers farther than 25 km away increased from 39 percent to 58 percent. Inter-basin water transfers have become commonplace and have increased from 43 percent to 54 percent of river users, while dependence on more than one river increased from 24 percent to 38 percent.

Who will pay represents a second dimension.[12] The privatization debate can be analyzed in terms of the state shifting the burden to citizens; and of multinational operators shifting water supply from the public to the private sphere.[13] If society is receptive to privatization, this can be achieved, as in the UK. Cities in the South are under considerable pressure from aid agencies to privatize their water utilities but outcomes at best have been mixed. Because of the risks involved and the weak financial returns, these long-term investments are unlikely to attract massive private capital (SIWI 2004). If this option is not politically feasible[14], then Public-Private-Partnerships are possible or the money must come from public coffers or foreign aid and loans.[15] Some cities are able to attract funds from donors and financing institutions e.g., due to international subsidies (e.g., EU funds for Athens), to geopolitical context (e.g., Amman), or in the context of broader reconstruction (e.g., Phnom Penh).

The capacity of city managers and politicians to fund investment is closely linked to a city's location within the state/region/nation, both in geographical and in political terms. Capital cities are more likely to get access to public funds. Mexico's federal district has a stronger fiscal basis than the poorer constituent municipalities. While the former benefits from central funds, the latter may be unable to make the investments needed, though these may be eased by political affiliations and/or convergence of interests with the centre (Connolly 1999). How taxes are distributed among administrative layers – central to local government – is key. Saravanan and Appasamy (2001) recount how water supply in colonial Coimbatore reflected a conflict between local bodies and the state government on who should pay. Swyngedouw's study (2003) on Guayaquil shows how the level of investment corresponded to successive cocoa, banana and oil booms.[16] During the oil boom of the 1970s, the State – as owner of the resource – became central to the struggle to release resources to finance city expansion. A similar tale is recounted by Bennett (1995) in her study on Monterrey: evolving relationships between federal and state government line agencies, private-sector interest groups, international banks and the civil society determined whether investments were made or not, who paid for them, and what sources of water were to be tapped. Again, Chennai was promised 142 Mm^3 of water from the Krishna river when the same party (Congress) ruled the three states concerned, a promise only partly fulfilled as political configurations changed (Mohanakrishnan 2003).

Cost allocation for water treatment follows similar patterns. Societies perhaps react more to extreme environmental degradation than to uneven or deficient water supply. Popular

[12]Rijsberman (2004) believes that "a crude analysis concluded that the bulk of both current and future financing comes, and will have to come, from domestic public and private funding, not international financing through development aid. It estimated that 80-90 percent of current funding in the water sector comes from domestic funding, with the bulk coming from public investments" (Cosgrove and Rijsberman 2000; GWP 2000). Financing of water services has been historically varied. Swyngedouw et al. (2002) for example, show that urban water supply systems have gone through four different phases: from small private companies, through municipalization, central state intervention (infrastructure), to an embryonic yet not unchallenged trend towards privatization.

[13]Privatization of utilities in the UK, for example, may have been consistent with the ideology of the Thatcher government but it was made pressing by the huge looming financial burden entailed by the need to overhaul dilapidated old urban networks (Bakker 2000) and to meet the quality standards imposed by EU directives.

[14]For example, Alcazar et al. (2002) show how privatization of water utilities in Lima was eventually forgone by the Fujimori government in the late 1990s because the issue had become a political liability: necessary investments would have sent prices to unacceptable heights, to the detriment of Fujimori's main constituency and without generating cash income for the state's coffers (as in the case of electricity and telecommunications).

[15]The conjunction of the pressure put on development banks to show that their action alleviates poverty, with the setting up of the Millennium Goals for water and sanitation may increase the willingness of the international funding agencies to support a growth in the investment in WS&S.

[16]Convergence of interest between Quito and the coastal bourgeoisie during the cocoa boom, when the city enjoyed exceptional WS&S by the-then standards, was in part broken during the banana boom. Social unrest in the 1950s, along with banana rents and foreign loans, warranted investment but this failed to keep pace with city expansion.

pressure often forces governments into taking remedial actions, as in Brazil and Mexico (see below). In response to public concerns, the US Congress allocated federal funds to cleaning up of a top list of 3,000 contaminated sites (Sampat 2000; Gotlieb 1988). After cases of pollution hit the media, the Government of India funded the Ganga Action Program in the 1980s, although the funding of its continuation was hotly debated (Narain 1999). These examples show that popular pressure can force the state to change its priorities and to face the costs incurred. As a second step, states often try to share or shift costs.

It may appear that the US$50 billion allegedly needed each year to bring water to those still deprived of an adequate supply is an unreachable target. But, it is modest when compared to what is spent on armaments or even on ice cream (Worldwatch Institute 2004). Yet, this might imply that the typical average value of 5 percent of state expenditures quoted for 1993 by Bhatia and Falkenmark (1993) might need to be increased by approximately 10 percent, unless a significant part of the costs is passed on directly to the users. The private-public debate and its evolution and outcomes in different settings mirror the struggles between competing discourses, worldviews and interests. Existing patterns of governance, the emergence of environmentalist-NGOs and other civil society entities, the coercive power of international institutions, the historical background of political struggles, all influence the final distribution of costs and benefits and the viability of particular solutions.

Intersectoral Transfers

This section provides a typology of how water is transferred in practice from agricultural to urban uses. First, a brief categorization of different types of transfer is proposed. We then look at the different types of transfer mechanisms. This provides a framework for the following section, which discusses how transfers occur in practice and some of their consequences.

Transfers Are Happening

Table 1 divides intersectoral water transfers into temporary and permanent transfers, with permanent transfers in turn divided into gradual and outright transfers. Transfers can also be distinguished according to the share of the source of origin that is diverted.

Temporary transfers typically occur during a drought. If the source is large, the impact on irrigation users may diffuse and be unidentifiable. If the transfer is a large portion of the source (often the case during droughts), then temporary allocation directly impacts on a known group of farmers who may have to be compensated for their (temporary) loss. Once the emergency is over, allocations revert to the original pattern, always with the possibility that drought will return sometime in the future. Chennai has bought water from surrounding wells in times of shortage; Seville and Manila have reallocated dam water stocks; and the California Water Bank has mediated reallocation during the 1991-1993 drought.

Gradual permanent transfers. These occur when a source of water already tapped by several users is progressively diverted to the benefit of a city. In such cases, the transfer typically first amounts to a limited percentage of the source of origin and the effects diffuse and are largely unidentifiable since the source continues to provide a large share of water to other users.

Outright permanent transfers. These transfers represent a brutal reallocation of water from one user to another. If the percentage diverted is

TABLE 1.
Examples of Water Transfers.

	Large percentage of the source of origin	Limited percentage of the source of origin
Temporary transfers	Deep wells to Chennai; Transfers to Seville, Manila.	Drought transfers from Krishna river to Chennai; The Californian Water Bank
Permanent transfers A. Gradual transfers	Zanghe reservoir and Northern Plains (China); Jordan river to Amman, and Chao Phraya river to Bangkok.	Irrigation water to Chiang Mai; Krishna river water to Hyderabad; Transfers from *acequias* in New Mexico.
B. Outright transfers	Diversions to Mexico City and from Yangtze to North China; Diversion of the San Juan river to supply Monterrey; Buying out of irrigation dams by Tsingtao and of wells by Chennai.	Transfer from Bhavani river to Tirupur or from the Zayandeh Rud to Yazd; Diversion of Mae Klong river to Bangkok; of Kelau river to Kuala Lumpur and Melamchi river to Katmandu.

limited, for example, 5-10 percent of available supply (as is often the case for large sources), this can be more easily accommodated (Chiang Mai, Yazd, Bangkok, Katmandu and Hyderabad). But if the transfer amounts to a large part or all of an existing source (e.g., the conversion of irrigation reservoirs to municipal use in China) then the transfer is likely to be problematic if no compensation is paid.

Some transfers are explicit and obvious to observers, not least to the farmers; others are more surreptitious. Diversions through canals or large pumping stations are overt, especially when they correspond to a large share of the source of origin. On the other hand, there may be a long distance between the point of diversion and the downstream farmers/users, and as such, the tributary flows and hydrologic variability blur and mitigate the impact of the diversion. Groundwater abstraction by a city, or re-appropriation of water through gradual encroachment upon irrigated land (e.g., Manila, Lima, Bangkok and Cairo) can pass virtually unnoticed at first but tend to become manifest with time, when they impact on other users (e.g., impact on other groundwater users in the Lerma basin in Mexico, or Ta'iz in Yemen).

A special case is when transfers concern a source of water that still has some "excess flow." Others in the basin are then in a weaker position to oppose a transfer, especially if it can be presented as crucial for economic development or to ensure *equity* between regions. The benefits foregone – not least in environmental uses – are invariably glossed over even if they are already apparent (as in the Piracicaba diversion to São Paulo), or likely to surface in the mid-term (as in the Mae Klong diversion to Bangkok, or Karum diversion to Isfahan and beyond), or may surface in the long run (as in the Melamchi basin to Katmandu).

The different types of transfers, depending on how visible they are and on how much water is diverted, are perceived differently by the populations impacted. Outright transfers are clearly more sensitive and generally involve negotiations and compensation (Tsingtao and Seville) unless the source is not fully committed (Bangkok and Katmandu).

Transfer Mechanisms

These considerations suggest a further categorization based on the mechanisms utilized in their implementation (table 2). The first type of transfers occurs through the transfer of *formal rights* to the use of water. These are typified by practices in developed countries, notably the western USA and other arid regions, but increasingly also in the eastern USA and other developed countries (for instance, in the UK, where traditional riparian rights were modified in 1969 by the introduction of abstraction permits). Formal rights can, in principle be transferred in a

free market with the price reflecting market conditions either in real time, or over a longer period (a season or year), or permanently. Free markets, however, usually fail to account for externalities or third party effects (see section "Are Markets Needed to Relocate Water?") Given government concerns and political pressures from third parties, market sales of formal rights are normally, therefore, only permitted in a regulated market, with the terms of the sale set, monitored and enforced by a public agency. Alternatively, legislation sets out the terms on which transfers are to be made, for instance, by establishing clear priorities at times of drought, or limiting the term of the right so that it can be transferred to a higher value use once the term has expired (as in the UK).

Markets in *informal rights,* in contrast, develop spontaneously without regard to third party or externality effects, sometimes even where, in principle, transfers are forbidden by law (as, for instance, in regard to the terms applicable to the sale of *warabundi* in north-east India and Pakistan). Most informal markets are small-scale and, generally involve farmer-to-farmer sales rather than intersectoral sales. An exception is the conversion of irrigation wells to tanker operations in Amman and some cities in India, which represents a significant case of an unregulated market transaction from agricultural to urban use.

TABLE 2.
Transfer Mechanisms from Agriculture to Urban Uses with Examples (see annex).

	Without Compensation	With Compensation
Formal and Informal Rights		
A. In a free market	Not applicable	Tanker sales in Chennai, Amman and numerous other cities; Traditional Spanish markets
B. In a regulated market	Not applicable	The California Water Bank; Markets in the USA, Australia, Chile etc.
C. By legal means	Limited term rights (UK); Expropriation for environmental objectives (Australia and USA); Change in law (South-Africa)	Expropriation for environmental objectives (USA)
Administrative Decision		
A. By formal decision	Reallocation during droughts in most cities Industries pumping from irrigation canals (Isfahan and Chiang Mai)	Purchase of wells or reservoirs (or water from them), in Chennai, Seville and China. Dam water to Seville; Melamchi to Katmandu. Compensations can also be in terms of technical interventions (lining)
B. By "stealth" by means of management of existing resources	Operation of the Angat reservoir in Manila; Kinjhar lake for Karachi (drought periods); Northern China reservoirs, etc.	
by means of investment in diversions from rivers/reservoirs	New diversions to Hyderabad, Bandung, Karachi, Amman, Monterey, Mexico, etc.	Diversion of Mae Klong to Bangkok*
by means of investment in wells	Out-pumping of agricultural users in Yemen, Mexico, China, etc.	
by means of encroachment on irrigated areas or tanks	Encroachment of tanks in Bangalore	Land purchases e.g., Cairo, Lima, Bangkok, etc.

* *Note:* compensations were minimal (e.g., subsidies to develop water supply schemes for local villages) and granted later, rather than part of the initial diversion plan

Administrative decision has been by far the most important mechanism for transferring water from one use to another, both historically in developed countries and to this day in developing countries. *Formal administrative* decisions are taken by a national, provincial/state or basin entity depending on the functions assigned to each under the constitution or in law. Formal administrative decisions with compensation typically occur where: a) the farmers giving up water supplies are readily identifiable and, b) can bring political pressure to bear on the decision makers. They involve varying degrees of consultation between the interested parties (Seville, Tsingtao, etc.,). Where water is relatively abundant, either seasonally or more generally, transfers are more likely to be made without compensation, being reflected in the priority given to urban uses at times of drought, and over time as a basin "closes."

Direct expropriation is problematic for any government, even an authoritarian one, especially in the context of where the local economy revolves around irrigated agriculture. In a sense it may be "easier" to displace people for the construction of a dam than to dispossess them from the water used for their livelihoods. This is true even if no formal rights are held. In the few cases in which formal rights exist and are effective, expropriation is precluded. The buying of agricultural wells around some cities such as Chenai is an example of outright and total reallocation of minor sources with appropriate compensation.

Negotiations can include financial compensations and/or efforts by the city to reduce its losses or its consumption. El Paso, for example, obtained water from the Rio Grande on condition that it reduces its per capita consumption, recycle sewage water and eliminate leakage (Earl 1996). Dongyang, Zheijang Province, obtained water from a dam managed by Yiwu city but had to increase the height of the dam and line irrigation canals (Liu 2003). The much-celebrated 1998 agreement between the Imperial Valley Irrigation district and the Southern California Metropolitan Water Authority (MWA) included the lining of the All-American Canal (AAC) by MWA with usufruct rights to the 100 Mm^3 thought to be *conserved* passed to Southern California metropolitan area (CGER 1992), though in practice this was at the expense of Mexican farmers.[17] Similarly, the Upper Ganga canal was lined so as to make use of the *seepage losses* for supplying Delhi but proved to be at the expense of well irrigation further downstream. Molle et al. (2004) use an example from Central Iran to show that in *closed basins,* where most or all resources are committed (often overcommitted), conservation measures do not save water but merely reallocate it across the basin, in a way that is not always perceptible (see above).

When formal administrative decisions to transfer water are taken unilaterally, they merge imperceptibly into informal transfers by stealth (table 2). This may occur as a result of investment decisions (as in Hyderabad) or management decisions (as in Manila), or development decisions (as in the occupation of tanks in Bangalore or the conversion of irrigated land to urban use as in many expanding cities). Transfers by stealth by definition do not allow for compensation, although later complaints can trigger some ex-post measures (Mae Klong to Bangkok). But do transfers, in the absence of compensation – whether temporary, gradual or outright – always in essence amount to

[17] "… the so-called "savings" are detrimental to the recharge and quality of the aquifer that is tapped by Mexican farmers on the other side of the border in the Mexicali Valley" (Cortez-Lara and Garcia-Acevedo 1999). Out of 100 Mm^3, 30 Mm^3 are captured by the La Mesa drain (excavated to control the water table) and 70 Mm^3 recharge the aquifer. The aquifer is tapped by individual and federal wells irrigating 19,000 ha, to which must be added 800 ha irrigated from the La Mesa drain. The resulting increase in salinity estimated at 21.9 ppm/year, could eventually affect an area of 33,400 ha (Cortez-Lara 2004). The decrease in groundwater resources also renders future supply to expanding urban areas more critical (Castro Ruiz 2004). This situation of untold reallocation is quite common: the 102 km long canal from Munak to Haiderpur Water Treatment Plant will also be lined and "savings" used to increase supply to Delhi, to the detriment of farmers **(**GNCTD 2003). Reallocation from groundwater users to cities is also occurring in China and between Delicias Irrigation District in Mexico and Texas cities (Pearce 2004).

expropriation? It can be argued that farmers, who typically paid only a small fraction (if any) of the costs of irrigation, cannot object if the state subsequently withdraws a part of the water allocated to them. This has less force once the value of water is capitalized in land prices since it is usually impracticable to recover windfall gains accruing to the initial beneficiaries.

Another argument is that the real costs to farmers of partial "expropriation" may be less than what appears at first sight, given the room for adjustment in many irrigation systems and the fact that the *hidden hand of scarcity* elicits changes in behavior and factor use (Berkoff 2003; Molle 2002). For example, the reduction of the dry season irrigation in the Chao Phraya delta has been paralleled by a significant increase in cropped areas (Molle 2004b); irrigation deliveries in Uzbekistan were reduced from about 17,000 to 13,000 m^3/ha in the early 90s without significant effects on crop yield (Davis and Hirji 2003). Loeve et al. (2003) document cases in China where crop production has increased despite less water being made available for irrigation. Of course, adjustments are possible up to a certain extent and, as basins close, the room for maneuvering decreases.

Distinctions between transfer mechanisms are not always clear-cut. An administrative decision (e.g., to give priority to urban uses) may be justified by reference to priorities set out in the water law that in a sense provide for a generalized right. Transfers by stealth may subsequently be confirmed by a formal decision. Bureaucratic reallocations (with negotiation and due compensation) are akin to transactions in informal rights, and even regulated markets. Even so, categorization both by types of water transfer (table 1) and by transfer mechanism (table 2) provides useful reference in discussing transfers in practice.

Intersectoral Water Transfers in Practice

This section draws a few lessons from the cases reviewed in the annex. It examines the social, environmental and political costs attached to each type of reallocation, and provides hints on how a particular transfer is justified and selected.

Reallocation Stress: Political and Social Costs

In a situation of competition, cities will generally have to re-appropriate water already used, allocated or “owned” (when a formal right exists) by other users, generally agriculturalists or nature itself, and this inevitably generates stress. Such transfers appear to breed political tension irrespective of the mechanism used – whether it’s an unilateral bureaucratic decision, coercion, compensation or even a market transaction. Political stress is generated in proportion to the political clout of the constituencies that stand to lose in the transfer (the water users in the first place and subsequently the surrounding communities). It is obviously more difficult for a city to acquire water used/controlled by entities that have political power: agriculturalists may or may not include powerful landowners and their political weight in terms of votes also varies (e.g., it is strong in India but weak in Malaysia); urban industrialists, in general, command considerable power over politicians. Conversely the cost of doing nothing, or little, is less for politicians when urban populations affected by prevailing poor conditions of WS&S are also voiceless. This is clearly expressed by the Camdessus Report, which states that “with the mass of people not serviced, politically weak or disempowered, it is tempting to postpone spending on maintenance and periodic replacements, likewise on investments with a long gestation period.”

The difficulty of acquiring more water is also dependent on the political structure and administrative boundaries. For instance, a transfer within the same state, region or district – whatever the local structure – is easier to handle than those involving different provinces/states in federal entities. The latter category depends on the respective powers vested in the central government and the states, and also on the clarity of their respective roles. The El Cuchillo dam conflict between Nuevo Leon and Tamaulipas, for example, was compounded by the confusion regarding the legal roles of the federal, state and local governments (Barajas 1999). Interstate conflicts are pervasive for the Ganges, Krishna and Cauvery basins in India (Richards and Singh 2002). Attempts by Chennai to obtain water from the Krishna river were largely frustrated and made difficult by the fact that Tamil Nadu does not even intersect the Krishna river basin. In contrast, small and centralized states, such as Tunisia, Jordan or Israel, which fully control water supply and allocation, can pursue policies of transfer through national "carriers" or "water grids." These countries being arid may create a need for strong centralized control over their (countries) resources.

While there may be obvious economic gains in transferring water from nearby agricultural areas (if any), decisions cannot be based on simple economic criteria only. Societies may place higher value on agriculture because of its importance for food security to rural livelihoods, or for cultural reasons (Meinzen-Dick and Appasamy 2002). Under the ideal conditions of full employment and perfect mobility, people may shift from activities which are extremely water-dependent. In developing countries, however, poor people are often characterized by lack of mobility, skills and economic alternatives. In addition to the social/political stress of depriving an area of its means of subsistence (even if compensation is provided), the social costs of displacing people (migration to slums, increase in urban violence and other social ills) must also be considered. One can easily, for example, point to the higher return of water use in cities such as Sana'a, Chennai or Mexico City (as well as the greater willingness of this population to pay for their use of water), but it may not be feasible to transfer water out of irrigation to higher value use when the bulk of the population in the area of origin lives on agriculture.

The different options (including inaction) have costs and benefits that are distributed unevenly across society and generate specific costs and risk. In sum, decision-making incorporates wider aspects of the local political economy such as social, transaction, political, and sometimes even environmental costs attached to the various demand- or supply-oriented options; the nature of the possible source of funding; the degree of mobilization/pressure by various constituencies; pre-existing customary (or other) rights and water uses (Howe et al. 1990; Howe 1987). Eventually, decision makers tend to follow the "path of least resistance" (Kenney 2004). Although the mere financial costs of water resources development projects are typically rising[18] and are, sometimes prohibitive, supply-augmentation options are often chosen. This shows that the consideration of all the costs and benefits (private or collective) weighed by the relative clout of the constituencies (benefited/affected) leads to decisions which may differ from what a more narrow sectoral rationality might, *prima facie*, suggest to be the way forward.

The path of least resistance may change over time, depending on the shifting political clout of the parties involved, and may even prompt the reversal of decisions that were acceptable at an earlier point in time: the amount of water abstracted by Mexico City in the Lerma basin had to be decreased due to protests; the opposition of the Temascaltepec farmers to the export of water to the capital has also stalled this new project

[18]Bhatia and Falkenmark (1993) and Serageldin (1995) estimate that the financial and environmental costs of tapping new supplies will be, on average, two or three times those of existing investments, because most of the low-cost, accessible water reserves have already been exploited.

(Tortajada and Castelan 2003). Another striking example is that of Los Angeles, which has been forced by lawsuits to restore flows and wildlife habitat in the lower Owens valley and to limit exports from the Mono basin: the amount of water diverted to Los Angeles from these two sources dropped from 620 Mm^3 in 1980 to 370 Mm^3 in the 1990s (Fitzhugh and Richter 2004), resulting, however, in growing diversions from the Colorado river and the Central Valley.

The case studies show that the most traveled paths of least resistance are: 1) stealth reallocations (when they are quantitatively limited with regard to the source or obscured by the nature of the hydrologic cycle); 2) diversion of surface water away from downstream ecosystems; 3) the use/overuse of groundwater (to the detriment of sustainability); and, 4) the development of (costly) resources (partly because they provide financial/political benefits to decision makers). These options are normally selected when/because they are expected to arouse less opposition in the short term, but the assessment of political risk is often uncertain. Although the undefined or open-access nature of groundwater has provided cities with opportunities to tap the resource with ambiguity, it has sometimes generated a backlash as in the case of Jaipur, where farmers clashed with the police after wells were dug in areas adjacent to their lands to supply water to the city (Londhe et al. 2004). Similar examples are provided by Ta'iz, where most agricultural wells ran dry and led to civil unrest, and by Athens, where its use of a well-field in the Yliki lake area allegedly lowered the water table, provoking complaints from nearby small-scale farmers (Kallis 2004).

Water crises are, also, useful events that assist in reducing political costs by increasing the acceptability of certain decisions: droughts are useful events that can serve to obscure human responsibility for water shortage, e.g., due to faulty planning, mismanagement of reservoirs or wasteful distribution and use. They are used to justify technical or political options in line with the agendas of a surprising range of vested interests, from conventional supply-augmentation supporters,[19] to those attached to an ethic of efficiency and management, via neo-liberals advocating privatization and commercialization (Kaika 2003) to, perhaps surprisingly, environmentalists advocating neo-Malthusian concepts of "limits to growth" and sustainability (Bakker 2003). Images of cracked soils and withered crops are used to manufacture consent or passivity around varied plans and strategies as documented in contexts as diverse as Seville (building the Melonares dam, despite environmental impacts) —- (del Moral and Giansante 2000), Athens (Kaika 2003), north-east Brazil (Coelho 1985), Gujarat (Mehta 2001), or California (Nevarez 1996). This explicitly shows that while crises may be used to pass desirable reforms there is no assurance that they will not be used to support business-as-usual decisions, or vested narrow interests.

The creation of wider and more democratic debates often challenges existing interests and raises the political costs of certain options. Pursuing a mere economic logic is likely to be detrimental to equity, but unchecked centralized and obscure decision making may favor costly options that only benefit a few constituencies. Political mediation has to follow a narrow path between public and private interests.

Minimizing Impacts: Forgetting Hydrology

Unsurprisingly, cities do not publicize widely their water projects, minimize their impacts, and avoid talk of compensation if they can find a way to justify increased or new abstractions. The fact that in many cases only a limited percentage of the source is diverted is used to stress the

[19]In São Paulo, Brazil, the current water crisis has allegedly been presented as more severe than it was in reality as a way to justify and press for transfers from the Ribeira river (Assunção 2004).

benign nature of transfers, and the ambiguity between temporary and permanent transfers provides the context for justifying permanent decisions. At times of stress, when the marginal value of water is high, the priority right of the city is made manifest and other uses are curtailed first. Between 1980 and 1996, water supplies to agriculture in the Guadalquiver basin were normal in only 4 years, and fluctuating between 65 percent of requirements to no supply at all (Fereres and Cena 1997) in other years, with a total prohibition of irrigation in 1995 (Martin et al. 1997). In 2001, in the Zayandeh Rud basin, irrigation supply to 120,000 ha was reduced to zero. In Portugal, in the Alentejo region, supply to irrigation was curtailed during the 1993-1995 drought, while municipal and industrial (M&I) use was sustained (Caldas et al. 1997). Amman's supply was hardly impacted by the 2000/2001 drought, while supply to agriculture was severely restricted. All the water from the Angat dam used by farmers can be reserved for Manila in times of drought (McIntosh 2003). In 1991, the California State Water Project cut off supplies to farmers and the Bureau of Reclamation reduced its supplies to the Central Valley Project by 75 percent (Anderson and Snyder 1997).

Less extreme examples come from Thailand, where supply to the Chao Phraya delta in the dry seasons of 1992, 1993 and 1994 was around 50 percent of normal levels, with Bangkok given priority (Molle et al. 2001); and by Coimbatore, where the Pillur diversion making up 3 percent of the average at the Bhavani Sagar dam is planned to be doubled (Lundqvist 1993), implying that in deficit years water to downstream farmers will be reduced by up to one-fourth. When Indonesia was hit with a major drought in 1994, residents' wells ran dry, but supply to Jakarta's golf courses was ensured so as not to impact on tourism. In 1998, in the midst of a 3-year drought, the Government of Cyprus cut the water supply to farmers by 50 percent while guaranteeing the country's annual 2-million tourists the water they needed (Barlow and Clarke 2003). Such situations contrast with the western USA, where cities often hold rights that are junior to those held by irrigators (Colby 1993).

These examples not only confirm that nonagricultural uses almost always get priority but also show that the crux of the matter is not so much the average amount diverted to cities but *what this share becomes at times of shortage.* Unsurprisingly, gradual or small outright transfers are justified based on their alleged limited *average* impact. When a drought occurs and the impact felt becomes critical, it is always possible to naturalize crises, blaming it on climatic change, El Niño, or bad luck. Referring to a dispute over the Bhavani Sagar dam, Tamil Nadu officials stated:" Of course, the land is already (command area} entitled for water, but subject to availability" and lamented that "the rain gods had not been very kind to Tamil Nadu" (The Hindu 2003). More generally, the impact of transfers on existing uses is understandably kept vague. The water, soon to be diverted from the Veeranam tank to Chennai, was officially declared by the government to be "only excess water"—(The Hindu 2004b) but other observers air their concern about availability of excess water, because *in the last 10 years there has not been enough water to feed the Veeranam ayacut* (The Financial Express 08/11/2003). The diversion is supposed to be only during 6 months, but it is not difficult to foresee what will transpire in the dry season if Chennai city runs out of water. Treatment and conveyance infrastructure worth Rs 7,000 million (US$45 million) provides a compelling argument to use water from the tank for the city supply. Likewise, the successive steps of water diversion from the Kinjhar lake to Karachi are presented as not impacting on other water users, despite contrary evidence surfaces at times of shortage.

The denial of hydrologic realities allows the consequences of a transfer to be glossed over. The agreement between the states of Nuevo Leon and Tamaulipas, for example, stipulates that water from El Cuchillo dam is for human consumption of Monterrey, on the condition, at the same time, that the needs of irrigation are "preserved." This wishful thinking surprisingly did not address hydrologic issues in more detail and

it is safe to assume that this omission was purposive.[20] Earlier studies had shown that the water that El Cuchillo would store was indeed already appropriated downstream and, as such, a more detailed discussion would have made agreement impossible. Even with a rough sharing in quantitative terms (a second agreement in 1990 specified that Monterrey would divert 5 m^3/s – and 10 m^3/s in a second phase – while restituting 3 m^3/s of treated return water), the hydrological variability was not considered and it was clear that the first drought (1996–1997) would reveal the underlying conflict i.e., upstream domestic use would likely take precedence over downstream irrigation (Barajas 1999).

Environmental Impacts of Transfers

While cities gradually displace agriculture, the practice (agriculture) has to adjust and respond to the squeeze. Part of the response comes through an increase in efficiency, notably at the basin level where a greater part of return flows is reused and depleted. In other cases, agriculture comes to use wastewater instead of freshwater. In many cases, however, irrigation compensates this reallocation by taking more water from the environment. The tendency to over-develop irrigation schemes, as manifest in basins where the level of diversion has long caused critical environmental damage on downstream areas (this is epitomized by the example of the Aral sea) is, therefore, compounded by this induced additional pressure. In cases where little agricultural water can be re-appropriated by cities (irrespective of whether this is because of physical unavailability or socio-political reasons), cities will tend to directly "displace nature." Only in basins where a lot of water is untapped (or in periods when river flows are abundant) will abstraction by cities have little impact on other water users. In places where conflicts already occur and where environmental degradation is already sizeable, these will further compound the impact on the environment.

The notion of *displacement* is very much dependent on the viewpoint adopted regarding what should natural flow be and whether "excess water" is an acceptable concept or not. Flood regimes have various important functions such as spreading fertile silt, recharging groundwater, flushing pollution, sustaining ecosystems attuned to them (Hunt 2004). Agriculture in the Ganges delta, as well as the Sunderbans, the world's largest coastal forest, for example, depends on the flood of the Ganges and Brahmaputra (Khalequzzaman 2003). Likewise, fisheries in the Mekong basin, notably in the Tonle Sap, are strongly correlated to the yearly flood. If we consider these functions as essential, it is clear there is no excess water in a basin. At the other extreme, the age-old engineering view that no water should reach the sea if resources were properly managed has proved devastating. The characterization of this degradation and the issue of reconciling production and conservation are major debates, which lie out of the scope of this report. Suffice it to say here that in most basins where significant conflicts occur, and where, therefore, the issues of intersectoral transfers examined here prevail, aquatic ecosystems have already been significantly impacted and that *displacement* is synonymous with further degradation.[21]

While both agricultural and urban uses tend to displace nature, the transfer of water to cities, in general, results in more wastewater being generated, and in turn, having an increased emission of pollutants and contaminants. Cities dispose of 80 percent of the water they divert as

[20]President Salinas' speech for the inauguration of El Cuchillo dam on October 17, 1994 was typical of the way politicians like to frame projects in terms of administrative boundaries rather than hydrological ones, overlooking interactions that will, however, soon surface: Salinas declared that "El Cuchillo dam is a project of Nuevo Leon and for Nuevo Leon, which will solve future water supply" (Barajas 1999).

[21]Cities or industries have long extensively polluted the environment and impacted on ecosystems, fisheries, and biodiversity. Fitzhugh and Richter (2004), for example, describe the historical development of water resources of five major American cities and how this has destroyed, compromised or threatened a wide range of ecosystem services, as well as reduced biodiversity.

wastewater. Only 10 percent of the effluents from cities in developing countries are treated (UNEP 2003; Sadeq 1999; Joyce 1997). Just as drainage has often been the "poor relation" of irrigation in part because it jeopardizes formal cost-effectiveness, disposal or treatment of effluents from the M&I sector has often been a nonstarter. In both cases, *development* was achieved at the cost of the environment and – for the lack of treatment – of the health of populations. The growth of urban/industrial water needs, therefore, impacts not only in terms of transfer of equivalent volumes of water but also in terms of reduction of the stock of usable water by rendering part of it unfit for human or agricultural use.[22]

A good example of this is provided by Janakarajan (2003) and Tewari and Pillai (2003) who describe the impact of tanneries on the Palar river basin, in Tamil Nadu.[23] Tanneries use many toxic chemicals and generate heavy pollution that is passed on to agriculture via surface water and to domestic users via groundwater (Amarnath and Krishnamoorthy 2001). The industries have exhausted all resources and polluted the basin to the point that downstream farmers have refused to use the river. Water in the Damodar river, India, is polluted by coal mines and other industries to a degree that it is unfit even for agriculture (Hardoy et al. 2001). Likewise, in South Africa, effluents from mines have polluted rivers to an extent that the water cannot be used for domestic purposes any longer. When the situation becomes untenable, as in the case of the Huai river basin in China in the 1990s, drastic action may be taken to close down paper industries, tanneries and other polluting sources, and prohibiting farmers to use the contaminated water (Postel 1999).

It must be noted, however, that agriculture activities are now increasingly contributing their own pollution load in turning surface water and groundwater almost unusable for the cities. Seville, for example, cannot use water from the Guadalquivir that flows by because of pesticide and fertilizer residues (Del Moral and Giansante 2000). The cost of agricultural pollution in the USA is estimated at US$9 billion per year (Bate 2002). In many instances, all types of pollution combine to make it unfit for domestic supply. The King Talal dam near Amman was initially constructed to supply the city but it now collects treated wastewater, water that is destined for irrigation; although as many as 13 rivers flow through Jakarta, the degradation of water quality prevents the city from using any of them, and forces it to tap surface sources 78 km away as well as groundwater (McIntosh 2003); a similar situation is found in Chinese cities such as Yingkuo (Bhatia and Falkenmark 1993), Chengdu, where water pollution and silt have forced the closure of two river intakes and thereby compelling the government to invest heavily in the rehabilitation of the watersheds (McIntosh 2003).

As noted earlier, one common way to meet growing needs, or to respond to displacement by cities in the case of agriculture, has been to exploit/overexploit groundwater resources. Tapping groundwater is the easiest solution because it generally relies on individual or corporate investments (as opposed to public ones), it is spatially spread with little need for infrastructure, and it penalizes constituencies that often have

[22]The degree of degradation of water quality has long reached alarming levels (Lundqvist 1998; Butler and Maksimovic 2001; Niemczynowicz 1996; Postel 1999; Barlow and Clarke 2003). Although this situation was already manifest in the post-World War II period in developed countries (Lunqvist et al. 2001) and in the 1970s in developing countries (e.g., Lee 1979) societal responses have been dismal. It is now becoming apparent that our knowledge of the effects of concentrated toxic wastes on human and environmental health is poor and that the number of new chemical substances that are released into the environment far exceeds those that are monitored or researched (Peters and Meybeck 2000).

[23]In the Palar basin these industries contribute to about Indian Rs 50 billion (US$1,052 million) by way of foreign exchange annually, besides employing 100,000 people directly and indirectly (Janakarajan 2003). A similar story unfolded in Tirupur, where the hosiery industry generated Rs 30 billion in 1999, with more than half of the population depending on this industry for their living (Narain 1999; Lundqvist et al. 2003).

little voice (nature and the environment) and the next generations (because of depleted or contaminated resources).[24] That between 1.5 and 2 billion humans in the world, of which one billion urban dwellers in Asia (Foster 1999), almost 99 percent of the USA's rural population and 80 percent of India's population (Sampat 2000), are reported to rely on groundwater for domestic consumption gives an idea of how widely this solution has been resorted to. It is "cheaper" for decision makers to disregard these externalities rather than adopt sustainable solutions, on both financial (the marginal cost of alternative surface supply is increasing) and political grounds (expropriating or even acquiring rights from other users is a painful and troublesome process). While groundwater has offered an easy way out of many urban stalemates, the hidden costs will be increasingly apparent in the next decades, as some of these resources are exhausted or contaminated. Externalities include:

- Reduction in available stocks, drop in the water level and resulting increase in pumping depth and related expenditures. Other users are pumped out. The cone of depression created in Shijiashuang city in China, has rendered groundwater use unsustainable and resulting an increase in the pumping costs to farmers (Kendy et al. 2003).

- Land subsidence in cities like Mexico City (10 m during the last century), Manila, Jakarta, Cangzhou (Page 2001) and Beijing. Subsidence in some parts of Bangkok has reached 20 cm a year and one-third of the city is now under sea level. Subsidence affects not only buildings and roads (Nair 1991) but also the future water storing capacity of the aquifer itself.

- The quality of groundwater almost everywhere. Realization of its extent is increasing in proportion to the number of measures and investigations being carried out. In the USA, a wide range of pollutants have been found to infiltrate into the soil and reach the aquifer: nitrates and pesticides from agriculture and golf courses, petrochemicals from underground storage tanks (gas stations), effluents from metals and plastics degreasing, nuclear, medical and other hazardous waste from landfills, etc., (Sampat 2000). The most significant consequences are health hazards and the reduction in supply available because of degradation of the quality of water resources.

- Salinity intrusion due to the overdraft of coastal aquifers in cities such as Tel Aviv (Swyngedouw et al. 2002), Lima (Masson 2002), Jakarta (Gany 2003), Manila (Fellizar 1994) and Dakar. Salinity intrusion has rendered aquifers increasingly unfit for both domestic and agricultural use.

- The drying up of springs and wetlands fed by groundwater flows that are affected by the lowering of water tables. In Jordan, the overdraft of the aquifer to supply Amman and irrigated crops has dried up the Azraq wetland, a Ramsar site used by migratory birds. Of the world's wetlands 50 percent are said to have disappeared (UNESCO 2004) and these depletions have been mainly due to overexpansion of irrigation.

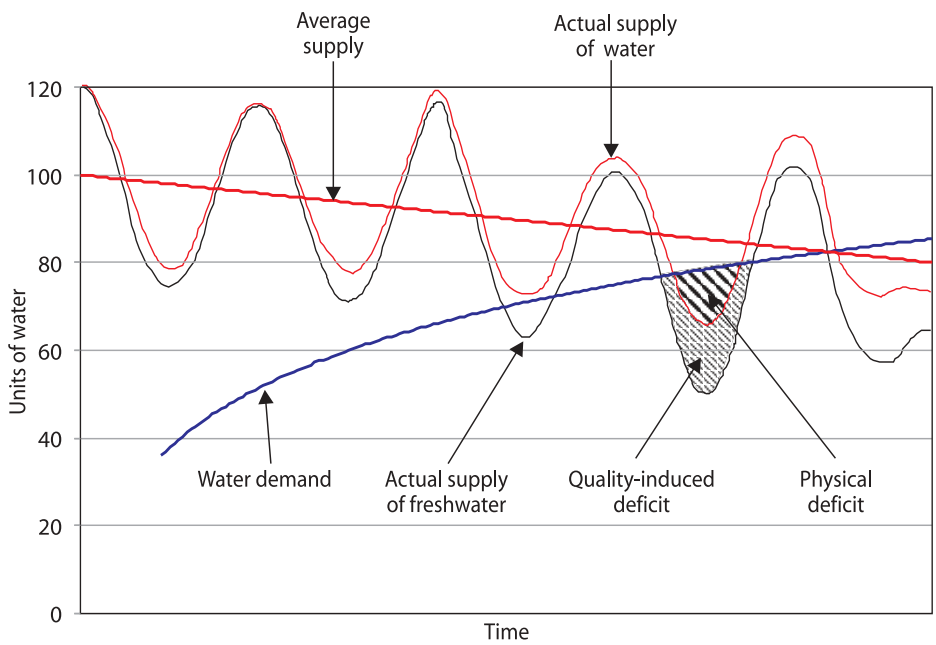
[24]This statement might, however, be cancelled by the probable development of cheaper desalination processes in the near future that could replace the dwindling supply from exhausted aquifers.

Contamination of freshwater decreases the water available precisely at a time when demand is rising. Figure 2 provides a (conceptual) chart that shows the effects of seasonal water scarcity, due to increases in demand and increases in contaminated water that is unfit for consumption.

Average available resources are shown declining (due to abstractions upstream). Quality-induced scarcity, as shown in the chart, does not affect a fixed portion of resources but, rather, increases both with time (growing emission of pollutants) and with physical scarcity (since more water appears as contaminated when dilution is less): the Karum river in Iran, for example, saw its discharge during the drought in the year 2000 being reduced to 20 percent of the normal value and as a result, water became unfit for human consumption. Water was brought by tankers and cargo trains from other regions to supply cities in the lower basin, including Ahwaz, which has a population of about a million, provoking social unrest (Motiee et al. 2001). Moreover, as groundwater use is regulated or declines because of pumping costs or quality problems, pressure is shifted back onto surface water. This is already apparent in Bangkok, where industries have been told to use piped water instead of wells and a similar situation prevails in Jakarta too (Gany 2003).

Societal responses to urban environmental degradation are akin to those regarding poor supply, and the degree of popular mobilization defines the cost of doing nothing (Lundqvist et al. 2001). The experience in developed countries during the nineteenth century has been referred to above. Similar pressures have occurred in developing countries. The inhabitants of Vidisha, on a tributary of the Yamuna river, forced the government to act in reaction to degradation of their river—stench and dead fish (Narain 1999), and community action supported by the media also prompted state action in São Paulo in the late 1980s (Hermann and Braga 1997). A similar story unfolded in the Lerma-Chapala basin, Mexico, in the late 1980s. Lake Chapala, the main source of water for the city of Guadalajara, was seriously threatened by growing biological and chemical water pollution. This generated a public outcry in the state of Jalisco and the administration was eventually pushed to take action and a large-scale sewage treatment

FIGURE 2.
Physical and quality-induced water deficits.



program[25] was launched in 1991 (Mestre-Rodríguez 1997). Generalizing Narain's (1999) observations on India, "what will really happen will clearly depend on the stamina of the people living downstream." Such initiatives are often neither recognized nor supported by government, and may even be undermined or opposed by other interest groups or bureaucratic and/or political interests (Lundqvist et al. 2001).

The overall picture is that if cities have generally found ways to increase their water supply, this has often been in an unsustainable and damaging way, displacing agriculture and nature. Water allocation and use in the different sectors are going to be critically impacted by issues of water quality. Spatial interactions through the hydrological cycle are not defined only by questions of quantity but also increasingly by quality. While environmental qualities are enhanced in some places and for some people, this is often achieved at the cost of deterioration in other places with severe impacts on other groups of people (Swyngedouw et al. 2002). In understanding water problems one must consider how human activities influence quantity and quality of the resource base, and how benefits and costs are generated or shifted both spatially and across social groups.

Are Urban Uses Constrained by Agriculture?

Discussions of urban scarcity generally focus on domestic WS&S services, with little reference to stress undergone by industries. Combining industrial and municipal (M&I) uses because they are often spatially concentrated can be confusing. They are distinct from both a physical and a political-economic point of view. *First,* industries, in general, need secure a continuous supply of high-quality water. They thus tend to exploit deep aquifers where it is feasible. In Bangkok, for example, 90 percent of industries resort to groundwater (TDRI 1990) mostly because the quality of water from the river is too poor (Srivardhana 1994). In Monterrey, when the supply of pipe water became uncertain, industries shifted to groundwater. *Second,* the industrial sector represents an interest group that is affluent, powerful and closely linked to the highest levels of political and bureaucratic apparatuses.

In contrast to industry, domestic users can adjust behavior in case of shortage, and daily allocations may fall below 100 l/capita without causing any major impact other than the reduction of supplies for car washing, gardens, swimming pools, etc. Health impacts may intensify due to lack of treatment capacity in time of shortage (e.g., the 1999–2001 crisis in Isfahan; the 1990s crisis in Chennai) or when supply and sanitation are altogether poor. The deterioration of water quality results in the spread of waterborne diseases (with 2.2 million deaths attributable annually to diarrhea and the lack of safe drinking water, sanitation and hygiene.)[26] Outbreaks of cholera and gastroenteritis were recorded in Chennai in the 1990s (Brisset 2003), and in

[25]This also serves to confirm that the alleged lack of funds is relative to political pressure: "The projects were mostly generated by State and Municipal authorities and funding was raised by federal water rights (a payment similar to tax), subsidies (both federal and state originated), domestic and foreign credits, private sector investments and water supply savings derived from water pricing strategies." (Mestre-Rodríguez 1997).

[26]Altogether, 1.1 billion people lack access to improved water supply and 2.4 billion to improved sanitation (UNESCO 2003). The World Bank (2002) estimates that half of the population in the poorest cities lack access to WS&S. Domestic and industrial pollution have severely impacted Jakarta's water quality and the health of its residents, with diarrhea responsible for 20 percent of deaths of children under 5 years of age (WRI 1996).

South-Africa, epidemics have been linked to the cutting-off of supply to people who could not pay (Marsden 2002; AfroNews 2004).

Many big cities with poor WS&S are fast-growing (La Paz, Hyderabad, Amman and Ta'iz). Simon (1998) notes that: *"Ironically, the areas of the world with the fastest growing populations are also the areas with already severe water problems, and the shortage will get much worse."* This serves to show that lack of water does not hinder expansion although growth outpaces financial capacity to expand supply networks. Such situations often prevail *when* rural-urban transfers are characterized as a *push* process, whereby impoverished rural families migrate to cities out of despair, regardless of the conditions they are likely to face in the cities. This contrasts starkly with the situation in western countries where water is a prerequisite to expansion: many cities in the western USA, for example, require developers to prove their right to adequate provision of water before construction begins (Emel 1990), and others, like in Arizona, have required urban water suppliers to acquire rights as a prerequisite for annexation of new suburban developments to urban water systems (Lund and Israel 1993).

Industrial and other economic activities typically enjoy a secure and predictable supply. The extent to which they are significantly disrupted by sporadic or general water shortage is debatable. Episodic shortages hardly or rarely impact on commercial and industrial activities since they are given priority over other water users. It is only in rare cases that industries are forced to suspend their activities. Recent shortages in the industrial and tourist zone of the Eastern Seaboard, near Bangkok, have been met by a government commitment to implement six interbasin transfers and drill 290 artesian wells for short-term relief. This, however, spurred protests from farmers using groundwater (Samabuddhi 2005).[27] Page (2001) cites a survey of Hebei province by Xinhua agency, which showed "how local officials enforced restrictions on farmers but overlooked those on industry to lure projects from which they could profit." Chan and Shimou (1999) refer to industries in coastal China that are occasionally affected by water shortages, with suggestions that water-intensive industries should be moved inland. In this case, water scarcity is at the basin level and its cumulative impact on downstream areas is what affects industry. In severe droughts, industries using surface water may also be impacted but in such cases supply to agriculture has usually long been discontinued (e.g., Manila in 1997-1998 and other examples given earlier) and domestic use is drastically rationed (e.g., Chennai in 2001, Ramakrishnan 2002a). Even in such cases, it is dubious whether the costs of implementing measures that would decrease the probability of such occurrences would be lower than the losses incurred.

Another question is whether (long-term) *investment* in services or industry is significantly constrained by water availability. This is a matter of debate with little information available. By and large, industries that offer to create jobs and increase business taxes are unlikely to be denied preferential access to municipal water. Alternatively, they abstract groundwater regardless of whether this is sustainable or not.[28] Ramakrishnan (2002a), for example, describes the drastic restrictions on water supply in Chennai but, at the same time, reports that the Chennai Petroleum Corporation's demand for an additional 15,000 m^3/day needed for its expansion project (in addition to the existing supply of 18,000 m^3) has been agreed upon. Except for the fact, that

[27]The Finance Minister is reported to have told senior bureaucrats that their "heads are pledged as a guarantee, since this issue is a problem for the entire country…I don't want to hear again that industries along the Eastern Seaboard are facing water problems, whether it's this year or in any other year."

[28]In Isfahan, for example, while water in the Zayandeh Rud basin is over-allocated, new industries are allocated the water they need: these amounts to an implicit transfer of water out of agriculture (the residual user). Industries (including steel factories) pay a much higher charge per unit of water than agriculture.

highly water-consuming industries such as making aluminum are unlikely to settle in water-short areas (which is, probably, a positive outcome), evidence of significant water-based constraints on investments has still to be documented.

Even so it is widely believed that increased supply to cities could enhance economic output, with scarcity attributed to excessive allocation to agriculture; that physical scarcity is due not to natural conditions but due to available water being locked up in agriculture (see section titled "Urban Water Scarcity"). In the ADB's (2000) view, for example, "Major obstacles to the rational reallocation of water among users … are the legal and regulatory constraints on water transfers and, in many countries, the complex systems of water rights that inhibit the free movement of water as an economic good." Further, Arriens (2004) states that: "the allocation of water to high-value uses is a matter of economic accountability." In contrast, others observe that farmers are "losing out" (Winpenny 1994), urban interests are getting the "upper hand" (Lundqvist 1993), and that "without a doubt, cities will continue to siphon water away from agriculture" (Postel 1999). This suggests that cities eventually succeed in getting the water they need, if necessary from agriculture, and that intersectoral reallocation of water is taking place.[29] If so, why does the literature place such emphasis on the gains from reallocation? One possibility is that the debate is influenced by western USA experience where prior appropriation and concern for third-party impacts has indeed hindered smooth reallocation of the (senior) rights held by irrigators to cities (see annex). This may have been further inflated because some economists advocate markets out of ideological inclination rather than practical experience (Bauer 2004). It is intriguing to see the ubiquity of this argument, even in countries where sectoral reallocation seems to have been handled relatively successfully.

If agricultural water use is not a determining factor of the status of urban water supply, then the "lion's share" argument is potentially misleading. The ubiquitous statement that "reducing the water consumed by irrigation by 10 percent could double the amount of water available for domestic supply worldwide" (IRN 2003; WWC [2000] in footnote 2) suggests deceptively that problems of poor WS&S conditions would be solved, and that economic growth would be much enhanced if, only, irrigation were to release a limited portion of "its" water. It fails both to appreciate that reallocation in practice does occur, and to understand the economic and political aspects of urban water supply and scarcity.

Where Are We Heading?

Demand and Supply Management

The literature on demand management or "soft path approaches" (Gleick 2003) to water management often suggests that "doing better with the water we have" will be enough to ease the pressure over water resources e.g., improvements in irrigation efficiency, control of leakage in urban networks, awareness-raising programs, recycling and reuse, pricing of water, etc., are expected to put demand in line with supply. It is beyond doubt that all these measures can have positive outcomes and must be considered as a priority, before going for more

[29]Recently, Rijsberman (2004) also observed that domestic water supply out-competes other uses, "both because the amounts involved are small and because water for domestic purposes is of such high value and clear priority that it takes precedence over other uses."

costly supply augmentation schemes.[30] Successful experience is mainly reported from the industrial and domestic sectors. In the short run, it has been shown possible to reduce urban consumption (typically by around 20 percent, see Bhatia and Falkenmark 1993) through price incentives and retrofitting houses; some cities have succeeded in stabilizing their consumption for some time (Fitzhugh and Richter 2004). However, when tariffs were raised in many Asian cities such as Chennai, Colombo and Manila, no drop in demand was recorded, indicating that demand is price inelastic at these levels of use and prices (McIntosh 2003). Ten years ago, the average level of unaccounted-for-water in World Bank supported projects was reported as 36 percent (Bhatia and Falkenmark 1993); rates of standard losses of 10 percent in efficient cities show that significant conservation can often be achieved, thus obviating the development of new and costly resources, at least for some time (Engen 1999).

Agriculture, although the major water user, has been surprisingly less amenable to demand management. It is now recognized (see section titled "Some Limitations of the Conventional Framework") that local water savings in agriculture often fail to reduce the fraction of water that is depleted and that, in closed basins, they amount to reallocation of water among users through the hydrological cycle (Molle et al. 2004). "Doing better with what we have" also includes raising crop water productivity: ubiquitous calls for changes in cropping patterns overlook that crops with a higher return are not necessarily those with a lower water consumption (e.g., rice in Egypt or Iran) and that diversification is constrained by soil and drainage properties, financial risk, farmers' lack of capital or skills and markets. The potential of water pricing in irrigated agriculture, too, has been grossly inflated and there is now growing recognition that a host of factors limit its impact on behavior. Charging for cost-recovery and to generate funds to maintain the system is no doubt essential, but its potential as a means for eliciting reallocation from agriculture to other sectors is now widely considered as negligible (Savenije and van der Zaag 2002; Cornish et al. 2004; Cornish and Perry 2003; Hellegers and Perry 2004; Molle 2002). The World Bank also recently recognized that the idea of managing the allocation of water resources across sectors through pricing has been illusory (World Bank 2003c; Briscoe 2004). In addition, what this report shows is that the potential economic gains of reallocation – irrespective of the mechanism used to transfer water between sectors – is lower than commonly believed.

These are indications that, however necessary and desirable it may be, demand management under many circumstances is unlikely to yield sufficient gains (Molle and Turral 2004). Saving 20 percent of treated water by reducing leakage in an urban network is desirable, but it will not drastically alter the situation in cities that are growing at 5 percent a year or more (before the 1997 economic crisis water use in Bangkok was growing at 10%, as in many Chinese cities nowadays; see Molle 2004b). While pricing can have an impact on demand in cities, such as Beijing, where use is relatively high, demand management may still have limited impact on the imbalance between availability and potential use in rapidly expanding cities, at least until they start to stabilize as in many developed countries. This should not encourage an excessive focus on supply management, but also recognize that all measures must be considered simultaneously. Even California's water problems (or Colorado's), for example, are addressed through a wide range of measures (Svendsen 2001). Therefore, it is likely that providing water to sprawling cities will require the whole gamut of measures – supply augmentation, conservation, recycling, (re) allocation – at our disposal.

[30]For example, New York's experience suggests that the costs of the watershed protection program are only 38 percent of the cost of a filtration system (Sampat 2000; Postel et al. 2005). Generally, repairing pipe networks in cities is cheaper in terms of m^3 of water supplied available. However, this is not always the case, as some networks are decayed, with no map available, and very dense settlements make work extremely difficult.

Whenever possible, it is probable that interbasin transfers will have to be implemented. As Berkoff (2003) has shown for the North China Plain, it is not only growing cities that beg for additional supply, but also an environment that has been critically damaged, and a stressed irrigation sector. Additional water will help manage and smooth the transition from an agricultural to a nonagricultural-based economy, avoiding or lessening disruptions associated with push-type migrations to cities. This supply augmentation option goes against the idea that demand-management can deal with actual imbalances and that capital-intensive solutions are outmoded. On the other hand, the logic underlying the attractiveness of capital-intensive solutions to elites and decision makers is probably still at work and has not been significantly checked. The resurgence of large-scale diversion plans in Brazil, the Middle East, India, Thailand and China, to give a few examples, might be an indicator of this trend.[31]

Are Markets Needed To Reallocate Water?

Analysts who emphasize the need to reallocate water out of agriculture to nonagricultural uses also tend to be proponents of market-oriented solutions (Anderson and Snyder 1997; Thobani 1997; Rosegrant and Binswanger 1994). They make the case that markets offer a mechanism that both determines the "right" price of transactions and offers compensation to the seller. Small-scale water markets have long existed in many arid countries: the ancient markets and auctioning of water in Alicante, Spain are well known (Maass and Anderson 1978) but, more generally, most of the countless community-based irrigation systems are supplied by springs or qanats (Beaumont et al. 1889; Molle et al. 2004) in the Middle East. And in the North-Africa region it is well-defined individual rights that lend themselves to temporary or permanent transactions. The great majority of the transactions occur in "spot markets": neighbors in a system occasionally swap, lend, borrow, sell or buy water turns in order to fine-tune supply to time-specific individual demands. This also occurs in large-scale irrigation systems when supply is sufficiently predictable and defined in a way (time and discharge) that allows some degree of quantitative estimation (e.g., warabandi in Pakistan and India). More recently, groundwater markets have also developed in South Asia, but they are more akin to the buying of a service than of water itself. At these scales, transaction costs are minimized because users know each other (Reidinger 1994) and can readily communicate, transfers are across short distances and, as such, preclude costly infrastructures or significant losses. Permanent transfer of ownership is also socially controlled and local third-party impacts are more easily identified and taken into account. It is worth noting that such markets have existed for centuries and occur quite naturally, as users soon understand that scarce resources can be more efficiently allocated and used when flexibility is allowed.

The extension of market mechanisms on a larger scale has been much less frequent and more difficult (Livingston 1995). Markets in the western USA (see annex) are limited by constraints that reflect the crucial nature of water for life and the complexity of the hydrological cycle, which invariably generates third-party impacts (Dellapenna 2000; Kenney 2003; Libecap 2003). The Colorado-Big-Thompson system where market transactions have allowed smooth and gradual transfer, partly because trading is occurring only within the system and because the water district holds the right to all return-flows (Howe and Goemans 2003; Libecap 2003). Water markets in Australia remain limited in terms of volume traded, but reallocation has performed reasonably well (Isaac 2002; Turral et al. 2004).

[31]The World Bank also seems to have recently embraced the idea that big projects carry high risks but may also promise high rewards (Briscoe 2003).

Carl Bauer's (2004) comprehensive review of the Chilean experience confirms that, with some exceptions, water markets have been largely inactive, that farmers were uninterested in trading "surplus-rights" or saving water to free up some of it for other uses.[32] The most active basin is the Limari river basin, where significant reallocation between agriculturalists has taken place. Most transactions, however, are short-term reallocation between the irrigators who get their supply of water from the same reservoir. Another successful implementation of transfers has been observed in the Maipo basin, close to Santiago. Alicera et al. (1999) showed that between 1990 and 1997, 4 percent of the water rights held in the upper Maipo and Mapocho basins has been traded (or 7% of non-municipal water), half of these being acquired by municipal utilities. China also started experimenting with inter-provincial trading of water but soon discovered the implications in terms of return-flow and environmental impact (Fu and Hu 2002).

While empirical evidence suggests that water markets have been far less active than expected and have often failed to bear the fruits expected by their proponents, it is worth noting that positive experience is confined to countries (e.g., USA, Australia, Chile, etc.,) with a strong legal, institutional and regulatory background and relatively wealthy stakeholders. Proposals for their adoption in countries where hydrologic data are scarce, physical infrastructure is lacking, and states have weak monitoring and enforcement capacity, are unrealistic. One may question why states that have allegedly failed to allocate water efficiently would be capable of creating the numerous preconditions and safeguards needed to ensure fair and transparent markets (Molle 2004a; Sindzingre 2002). The societal reasons why government agencies perform poorly are the same reasons why privatization and markets are unlikely to succeed or be equitable, notably lack of transparency and accountability, excessive weight of economic interests in political life, and barriers to the regulation of user practices, corruption, etc.

It is beyond the scope of this report to review the arguments for and against water markets. Prerequisites to the definition of water rights have legal, physical and political dimensions that are often overlooked by those who stress the benefits of a formalization of water rights. While mechanisms to allow flexibility in allocation have always developed at a scale where social control and hydraulic infrastructures makes it possible, it is doubtful that fully-fledged markets will constitute a major tool for the reallocation of water in the near future, especially in developing countries (Frederik 1998; Dellapenna 2000; Livingston 1995; Meinzen-Dick and Appasamy 2002; Molle 2004a).

Contingency Planning and Temporary Transfers

Conflicts between cities and agriculture surface primarily during water crises, when the share diverted by the former rises from a low average to a much larger share. This implies that permanent transfers of rights are often not necessary (Savenije and van der Zaag 2002). Agricultural and nonagricultural uses can usually coexist, if shares are expressed in terms of averages. Emphasis should be placed on the design and provision of mechanisms to compensate farmers for losses and deprivation that *will* occur in times of shortage. This is easier to achieve than permanent expropriation of agricultural water, while allowing for a more efficient use of water.

[32]Several authors have also shown that: little provision has been made to address third-party impacts (rights to return flows are not recognized); record-keeping and registration are inadequate; infrastructure is ill-developed; and in-stream uses (e.g., power generation) have not been adequately considered.

It must be realized, however, that the "average discourse" used by the state or by cities to tap other sources precludes, or goes against, the preparation of mitigation measures: since the impact of diversions is obscured by presenting it in average terms (as in Seville, Monterrey and Chennai), there is little incentive to develop explicit contingency plans for dry years, which would shed a different light on the future impact of diversions.[33] Technical agencies, too, are reluctant to engage in debates that reveal that domestic supply is not fully reliable. This fails to raise the awareness of the population that periods of shortage are normal occurrences, and that these occurrences will become more frequent as the basin closes and also the fact, that climate change is likely to compound the situation due to an increase in inter-annual climatic variability. Projections are still routinely based on average values drawn from historical series of hydrologic data even though there is now a general perception that the past is not a good guide to the future (Bakker 2000). More irregularity means that there is a need for more storage and interannual regulation so as to ensure "headroom" in the face of extreme events: the bad news is that this means less water should be tapped on average, compounding pressure on resources.

Drought-management strategies are, therefore, needed to provide an early warning of possible shortages and as a predefined set of actions for different conditions (Frederiksen 1992). If priorities are well-established and transparent information provided, negotiations can prepare for such arrangements and avoid the outcry and political crises that often accompany severe water shortages. The issue should, therefore, be made public and discussed, so that adjustments are planned beforehand and implemented smoothly as necessary. Of course, if local conditions, notably great irregularity of supply and a high demand relatively to the average water available make the occurrence of such compensation schemes too frequent, then there is a case for permanent transfers or supply augmentation.

In developing countries, bulk allocation is generally controlled by the state and reallocation is made easier since no individual rights are held. If rights are held, as in Australia or western USA, then market mechanisms are necessary to allow some of these to be transferred. Market-based options make less sense in contexts where distribution of water to bulk users such as cities, industries and irrigation schemes is centrally operated. Negotiations are more readily achieved on an ad hoc basis if only a few parties are concerned (very often a crisis pits one or two irrigation schemes against one city). The review found that compensation can be discussed and negotiated irrespective of the degree of formalization of rights and of the type of government. What matters is the relative bargaining power of each party. If one party wields too much power then it is likely to override other users while, in the opposite cases, negotiations are more common outcomes. Many Chinese municipalities or states, or cities like Seville, have had to pay compensation in times of drought. Transactions between private and municipal parties can also be mediated by the state, as in the case of the "drought bank" set up in 1991 in California, where networks of canals and pumping stations allowed the reallocation of water among a few (30) big contractors (see Wahl 1993; Teerink and Nakashima 1993).

Participation and Environmental Justice

The displacement of agriculture and nature by growing cities/industries and the contamination of freshwater have heavy social, environmental, and health costs. The magnitude and the distribution of these externalities is very much a reflection of

[33]Similarly, according to White et al. (2001), members of parliaments in the USA are also reluctant to move funds from crisis to drought management because crisis relief is a way to send money home to their constituents.

the governance structure of the society. The "stamina" and the mobilization of the "people living downstream," and the political space offered to disenfranchised groups to voice their concern are paramount. They ultimately not only determine whether externalities are recognized and internalized, but also who pays for that.

A more equitable distribution of benefits and costs is possible when a more inclusive and informed process of decision making on infrastructure development or water reallocation options is observed. A shift from supply-oriented paternalistic development to process-oriented approaches leading to "informed consent" (Delli Priscoli 2004) is materializing, but slowly. Deliberative development enables a better definition of social choice but can only develop in a political configuration where redistribution of power is possible. Because WS&S projects usually involve large outlays of money, decision-making remains largely centralized and technology-oriented. Participatory decision-making is also essential in case of pre-existing customary water rights. Meinzen-Dick and Appasamy (2002) emphasize that beyond the assumed *users* there are a variety of often-disregarded users who derive both direct and indirect benefits and who may be impacted by decisions on allocation (Meinzen-Dick and Appasamy 2002; Meinzen-Dick and Pradhan 2002).

Another lesson from the cases reviewed is that lack of transparency in hydrological data tends to compound conflicts and hinders settlements and negotiations. This is clear in the Kerala case of the Coca-Cola bottling factory and also in Katmandu, where a rather benign river diversion scheme was nevertheless the object of much confrontation. Examples from India (where state data on federal rivers are hardly available) or Central Asia (Wegerich 2004) show that data are crucial to inform participatory planning, which is precisely the reason why they are often not made public by bureaucracies that try to evade scrutiny or accountability.

Urban water management has benefited from users' involvement and participation. A number of innovative experiments have emerged in the past two decades (e.g., Orangi project in Pakistan, Kumasi in Ghana [PSE 1998], Onitsha in Nigeria [Okun 1991], and Pune in India: see also UNESCO 2003, Narayan 1995, Nicol 2000) although these have often been confined to a few success stories and achievements in a broader context have, in general, been limited. Attempts to combine both development and environmental preservation, sophisticated multi-objective and participatory planning (including risk management and social learning) rather than elitist, reactive and deterministic traditional planning have yet to result in "the paradigm shift and the change in mindsets" needed (Vlachos and Braga 2001). A change of focus, from water disposal and treatment to conservation and recycling of resources, is emerging but has yet to materialize on a significant scale.

Environmental justice must become a central concern so as to avoid the situation where water transfers from agriculture, displacement of nature, and the emission of pollutants by cities and industries impact unduly on poor and marginal populations. Little headway will be achieved without participation and political empowerment of the concerned population.

Conclusions

This report has analyzed the nature of urban water scarcity, distinguishing between municipal and industrial uses; and has investigated whether and how cities increase supply as demand grows, and to what extent possible supply constraints are causally linked to agriculture.

Municipal water use. M&I uses tend to be considered jointly. Both have physical, economic and political dimensions but in important respects they are distinct. Urban water scarcity is typically reflected in recurring (short-term) crises that are widely publicized by the media. Many cities have deficient WS&S infrastructure, coverage of networks is partial and part of the population survives with minimal supply. Recurring crises trigger restrictions, transfers from distant sources, and/or a flurry of tanker activity. Intermittent supply of tap water strikes the imagination as a mark of sheer scarcity, although it is often simply a way of minimizing leakage and is often offset by individual in-house storage.

Many cities have difficulties in finding water of adequate quality in their surroundings, signaling a degree of physical scarcity: some have developed in dry areas and have rapidly outstripped nearby resources; others, although located in wet regions, are sited in upper-catchment areas and have to divert water from distant basins. Yet, despite occasional cases of physical scarcity, it is apparent that many water-short cities have been water-short during most of the history of their development, from a population of a few tens of thousands to several million; and that many others are surrounded by abundant water but yet have large parts of their population with precarious access to water supply and sanitation.

Debates on WS&S (e.g., the Camdessus Report) unambiguously revolve around who is to pay for these services, not where water will come from. The underdevelopment of water supply is first and foremost one of economic scarcity, a financial issue, with complex and important questions of political economy on how the provision of public goods is decided and funded. The questions are primarily who benefits and who pays (private versus public, national versus international, federation versus states, nation state versus regional/local entities, users versus general tax payers, poor versus rich, etc.,). In that sense, rather than being merely a question of available capital, the issue translates into political questions: a) Will the processes of democratization and development of civil societies be able to shift the power balance so that basic needs and environmental preservation are given greater consideration? b) Will design, implementation, management and financing arrangements evolve so as to allow the spreading of benefits?

The response to these questions depends on the context and on the capacity and power of decision makers and stakeholders to shift costs and benefits in ways that are politically and/or financially rewarding to them. The struggle for clean water and environmental preservation, therefore, is a political process whereby "who pays what" is defined and, in which public pressure plays a major role. Historians of the Industrial Revolution stress that European urban elites improved WS&S only when they were affected or threatened by epidemics, loss of aesthetic well-being and possible social unrest of the labor force. In contrast, the situation in the South today can also, in part, be linked to a weak "threat from below" and to the limited costs to economic elites by the expansion of slums together with an increase in water use at low levels. That many cities with poor WS&S still grow at the highest rates show that poor water supply is unfortunately not a hindrance, or that migrants are pushed to cities with no other choice.

The proportion of the urban population living in unauthorized areas is typically 30–60 percent, amounting to a staggering 1 billion (Lundqvist et al. 2001). With 80–90 percent of world population growth expecting to take place in cities, it is very doubtful that the financial resources needed to

ensure WS&S facilities to cities will be secured or made available.

Industrial use. While water supply constraints may bring hardship to some urban citizens, it does not appear that they impact significantly on economic investments and industrial development. Industries receive priority in supply due to their economic importance. They may be affected for short periods, in times of severe drought, but this generally occurs after supply to other sectors has been curtailed or even discontinued. In addition, industries widely rely on groundwater (better quality and higher supply security) and are, therefore, partly "de-linked" in the short term from allocation decisions or droughts.

Water-related constraints to industrial investments are yet to be documented, except where arid conditions preclude development of water-intensive industries. Industries are invariably given priority, or granted permits for drilling deep wells, because of the jobs created, the taxes contributed, and the political clout of industrialists. It is doubtful, therefore, that significant increases in water availability resulting from reallocating irrigation water would make a radical difference to economic activity. Contrary to received wisdom on state failure, states do give priority to cities and industries because of the economic logic and elite interests. Transfers *do* occur and the alleged economic benefits waiting to be realized are often much inflated. In other words, opportunity costs of irrigation water are positive – but only weakly positive – at the margin and once urban demands are satisfied these opportunity costs fall to zero. The often stated problem of sectoral allocation as a significant hindrance to economic development is perhaps only a hasty generalization of the situation in western USA (where the prior-appropriation doctrine has tended to lock up water use in low-value uses) to contexts where centralized management has by and large ensured intersectoral reallocation. That investment in nonagricultural activities is only constrained at the margin, if at all, because of effective reallocation/prioritization or supply augmentation, does not mean, however, that this is occurring in an optimal or even a desirable manner.

Cities increase supply by several means. The evidence gathered from the cases compiled in this report shows that regardless of whether cities also engage in demand management programs (reducing losses, increasing prices, etc.,), they seem to be successful in increasing their supply, although ways to achieve this increase are varied, including:

- Increase in supply by constructing new reservoirs on nearby streams.
- Bringing water from distant basins through interbasin transfers (aqueducts, tunnels, pumping stations, etc.,).
- Tapping local or distant aquifers, often in an unsustainable way.
- Diverting water away from agricultural, environmental and other uses.

With the exception of river basins where there is still abundant uncommitted water, these increases in supply tend to have pervasive third-party impacts on existing users when water is taken, rather than traded. They also impact on the environment – although the environment is impacted far more by irrigation – in terms of aquifer depletion, land subsidence, salinity intrusion in coastal aquifers, degraded ecosystems and disappearing wetlands. Clearly, conflicts do not occur only between cities and agriculture but, more critically so, between these two sectors and the environment. Inter-basin transfers have impacts in terms of foregone economic value in the giver basin, and transfers from agricultural use among farmers themselves.

Reallocation from agriculture is effective. As most analysts observe, agriculture loses out and will be increasingly deprived of water. The impact of this reallocation has been varied:

- Farmers and/or scheme managers have adjusted to growing scarcity by improving irrigation efficiency at farm or scheme level, or by changing cropping patterns.
- Farmers have been pushed into (over) exploiting groundwater, or diverting more surface water to the detriment of nature.
- Farmers have been pushed into using wastewater (or treated wastewater).
- Farmers have been out-pumped (by falling aquifers) or driven out of business by reduced supplies of surface water.

Reallocation of water out of agriculture follows several modes (gradual or outright, minor or major, surreptitious or open, short-term or permanent, with or without compensation) depending on the hydrological characteristics of the source, the definition of rights/allocation, and the power of the cities/state to reorder this allocation. These different modes shape the impact and the response of society to these reallocations.

Mechanisms needed for short-term reallocation. Conflicts between cities and agriculture often only come to the fore in times of shortage, which is due to a combination of: a) a dry spell; b) careless management; and, c) inappropriate consumption practices. Such shortages become increasingly frequent in over-committed basins where no "slack" is available to address the vagaries of the weather, and are all likely to be compounded by climatic change. In a great majority of cases, priority in use is de facto given to urban areas; in some other cases, because rights are fuzzy or ill-defined, because water sources come under different jurisdictions, or because irrigation holds "senior" rights, reallocation (through market-like mechanisms or otherwise) is needed because nonagricultural water demand tends to be inelastic and of higher value. Contingency plans to reallocate water and compensate users in such circumstances need to be prepared, discussed and established in advance, whenever hydraulic connectivity exists. However, there is a reluctance of governments and line agencies to discuss such matters as contingency planning since this would expose the hidden consequences of reallocation. It would also undermine the professional legitimacy of these agencies and faith in their capacity to provide a reliable supply. Nevertheless negotiated drought-management strategies must be established and compensation to farmers made explicit in advance, in order to avoid turmoil and conflicts at times of drought. Such arrangements can often be negotiated between the parties concerned even when the prerequisites to establishing a more complex market for water rights are not met. Indeed, it is observed that compensation for temporary transfers are often negotiated, irrespective of whether rights are strictly defined or not and of the assumed power of the state.

The politics of reallocation. Cities will continue to redirect neighboring water to their own use and to tap increasingly distant sources, sometimes bureaucratically, sometimes through offering compensation and, context allowing, by acquiring transferable water use rights. The option ultimately chosen by decision makers is likely to follow the "path of least resistance" that cities encounter in their search for water. Economists in general, and market advocates in particular, rightly emphasize that, in some cases, expensive interbasin transfers or distant reservoirs are implemented while reallocating nearby agricultural water would be financially (and sometimes environmentally) sounder.

That such choices are made, however, is not merely due to ill-informed decision-making or vested interests, it is also indicative of the fact that buying formal or even informal water rights, and even more so de facto expropriating existing water uses, entail transactions and political costs

that are much higher than usually recognized. To equate "benefit to the society" with the highest return per unit of water is often too simplistic. The view that markets may neutrally reconcile all values and that "once trading water rights becomes a reality, conflict resolution by politics can be eliminated" (McIntosh 2003) is probably naïve and misleading, when generalized. Politics is unlikely to disappear. The western USA shows that even when prerequisites for defining water rights and trading are met, one cannot expect automatic and anonymous transactions to prevail, except under very particular conditions. Irrespective of the benefits of and constraints on markets, case by case transactions are much more likely to remain mediated by political processes of negotiation rather than by impersonal market-like transactions (Colby 1993; Kenney 2003). While *politics* is often construed in a negative sense because of its rent-seeking and pork-barrel dimensions, these aspects must be checked by democratization of decision making and increased public access to data, so that political mediation becomes an effective way of balancing antagonistic interests and world views, rather than a way to further vested interests. Such a process is site-specific and mirrors, among other things, the nature of the physical setting, dominant ideologies, the importance and clout of the civil society, the local political economy and the legal environment.

Degradation of water sources. Unchecked use of water has led to the degradation of resources both in terms of quality and groundwater reserves. This worrisome fact means that, at some point in time, cities will not only have to cater to growing needs but also to find substitutes for exhausted, salinized or polluted sources of water. Environmental degradation constrains supply of water to the cities and is compounded by contaminated wastewater emitted by them. Although treatment of water is one possible answer, only 10 percent of effluents in developing countries are treated and the costs involved are massive. It is, therefore, likely that groundwater depletion, which has so far allowed a large portion of urban water supply, will increasingly generate backlash in future, with pressure shifting back to surface water. Again, the conflict between human use in general, and the environment in particular, is perhaps more critical than that between agriculture and cities.

Allocation stress revisited. The frequent statement that reallocating a minor fraction of irrigation water to cities would suffice to cater to the needs of people with poor water supply conditions is deceptive: both the arithmetic and the causality are erroneous. Much of the water used by irrigation is diverted at times and places where there is no alternative use and a large part of return flows – in water short basins – is reused downstream. Our contention is that the causal association between, on the one hand, the insufficient and precarious conditions of access to water in "thirsty cities," highlighted in times of crises, and, on the other, water scarcity allegedly caused by a wasteful irrigation sector, is largely misleading. Rather than considering that urban masses lack water because it is difficult to take water away from agriculture (generalizing the particular case of the western USA), we argue that transfers do occur and are volumetrically limited, and that the problem (in developing countries) lies elsewhere: not so much in the lack of water per se but, rather, in the *lack* of capital, itself a notion relative to the local political economy and distribution of power in society.

Annex

How Cities Obtain Water: Selected Experiences

The Western USA

Water allocation and rights in the western USA differ depending on the state but are generally based on the prior appropriation rights system that emerged in mining camps in the mid-nineteenth century. To avoid violent disputes between established and new mines, prior appropriation ensured that water once diverted (or "appropriated") from a stream would remain available to the original user (Kenney 2003). The right is absolute but subject to the test of "reasonable use." Diverting more water than is reasonably necessary is considered wasteful and, therefore, not part of the right. Consequently, users are not encouraged to save water as this would generate an "excess" that would legally return to the public domain (Anderson and Snyder 1997). Likewise, users with water in excess of their needs are reluctant to publicize such a situation—even to enter into a market transaction—for fear of losing their right (Green and Hamilton 2000). This "first-in-time, first-in-right" system grants the first settlers "senior" rights (defined as "water duty" related to the area put under beneficial use), whereas later ones are only given "junior" rights on any water (possibly) remaining after the former are served (and their use is, therefore, subject to hydrologic variability). As many of the senior rights are historically held by irrigation districts, this legal system now entails constraints on the reallocation of water to towns (Frederik 1998; Huffaker et al. 2000).

At first sight, it might appear contradictory that problems of transfer occur precisely where private rights have been defined most rigorously and where, in general, trading has been made possible. In fact, a number of conditions are generally attached to market transactions of water. The public trust doctrine, which allows the protection of the public's interest in fishing or navigation, is now extended to incorporate recreation and environmental preservation as well. This inclusion was made to offset the difficulties resulting from the nonrecognition of in-stream/nondiversionary use in the prior appropriation system. The Federal Reserve right doctrine has been used to claim water rights for national parks, federal land and Indian reservations (Livingston 1995). Some states and counties have passed area-of-origin protection laws that prohibit or limit trans-basin diversions in the name of "the public interest," or in order to protect local economies, culture and environment. More difficulties arise when reallocation, transfers and/or infrastructure concern federal rivers or several states. Local, state and federal laws often conflict and transactions or interventions may give way to lengthy court hearings and litigation. Issues of water quality, reliability, timeliness and also of culture and politics bedevil what seems at first sight a simple transaction between willing buyers and sellers.

Market proponents like Anderson and Snyder (1997) dismiss the "water is special" argument, holding that all these conditionalities and overlapping of authorities constrain economic efficiency, engender misallocation and undermine the security of rights. Interpretation of fuzzy concepts such as "public interest," "beneficial use," "wasteful use," and "detrimental to the public welfare" lead to endless and costly court cases. More cautious analysts admit that in closed basins reallocation of water necessarily modifies the hydrological cycle, with frequent third-party impacts on other appropriators and on the environment (Huffaker et al. 2000; Howe et al. 1990; Kenney 2003; Dellapenna 2000; Livingston 1995; Libecap 2003; see Rosegrant and Ringler 1998 for a discussion of possible impacts of water transfers).

Social scientists also warn that in the western USA, water is not just a factor of production but the "stuff of life." Rural counties are doomed to perish without their agricultural base, with a consequent loss of jobs, opportunities and the fiscal base (Oggins and Ingram 1990; Brown and Ingram 1987; Klein-Robbenhaar 1996). Water is a link between people, and individual decisions often have collective consequences. The transfer of a fraction of water rights attached to *acequias* (the traditional communal irrigation systems) to nonagricultural investors in New Mexico, for example, weakens the whole system, in particular with regard to maintenance requirements (Klein-Robbenhaar 1996; NNLMS 2000). Frederik (1998) reports that "when farmers want to sell water to cities, irrigation districts resist, fearing the loss of agricultural jobs that accompany rural water use," while Wahl (1993) acknowledges that "most agricultural water districts have viewed the potential for water transfers only very tentatively out of concern over the security of their water rights and potentially adverse effects on the districts and local communities."

The West (and also some other parts of the USA) encounters severe competition between agriculture, cities and the environment. However, shortage of water in the deserts of Arizona is a relative notion. Phoenix[34] enjoys the supply of the Central Arizona Project (CAP) that brings water from the Colorado river and exhibits a conspicuous consumption rate of over 1,000 l/c/day (still 20% lower than its rate in the mid-1970s)—(Copenhaver 2003). The city displays golf courses that are watered year-round, 200 parks, 50 of which are irrigated, 28 public swimming pools and about 20,000 residents who drench extensive lawns. Even Tucson, which fully depended on groundwater until the recent arrival of CAP water and has water fees twice as high as in Phoenix, is consuming 727 l/c/day, which can be compared with the common average standard consumption of 130 l/c/day in European cities. Some cities like Las Vegas, sited in the desert, with a per capita consumption of 1,200 l/day, defy common sense and need ever more distant transfers to support their growth. Others are situated in wet eastern regions but even so do not escape water problems. Atlanta and Georgia, for example, face problems of water supply (Vaux 2004) but these are mainly due to polluted water sources, delayed maintenance and a decrepit network. Atlanta is located in an upper watershed and draws 85 percent of its water from the Chattahoochee river. It has seen its population increase from 1.3 million in 1960 to over 4.1 million in 2000 (Segal 2003). The struggle for additional resources pits the business community against environmentalists[35] (Wall 2003) and the state legislature banned interbasin transfers in 2001 for fear that Atlanta would divert water away from other poorer parts of the state, which still have available resources (Williams 2002).

State policies have varied in response to changing resource pressures and the rise of environmentalism. In the late nineteenth century there was a fear that speculation and monopoly practices were threatening the public interest and several states, following Wyoming, banned water transfers. The situation has now shifted towards allowing greater use of transfers, an option that is unavoidable in a context where most, if not all, water is already appropriated (Gardner 2003). The complexity of water issues, however, means that ownership and administration of water rights in the West remains in a state of flux (Gardner 2003). A balanced view is given by the report "Water in the West: The Challenge for the Next Century" issued by the Western Water Policy Review Commission (1998). The report sees the voluntary water transfers occurring throughout the West as helpful "to meet the demand for new

[34]"Before they even land, people flying into Phoenix Sky Harbor International Airport can see a 560-foot jet of water bursting from an artificial lake. The jet is listed in the Guinness Book of Records as the highest fountain" (US Water News Online 2003).

[35]Atlanta's proposal to increase withdrawals from the Chattahoochee and Flint rivers aroused controversy because of potential downstream impacts on the rich Apalachicola Bay estuary (Fitzhugh and Richter 2004).

urban supplies and for environmental flows in a manner that is both fair and efficient," but also acknowledges that "water transfers that occur without attention to their potentially damaging effects on local communities, economies and environments can be harmful to ecosystems and social systems that are dependent on irrigation economies."

In a context like the western USA, where individual water rights are defined, water markets or other types of transactions and transfers appear as one of the major options to reallocate water despite the often high transactions (e.g., legal) costs. Since most senior rights are held by irrigation districts, changing demographic and economic conditions warrant a permanent transfer of rights (Frederick 1998; Schiller and Fowler 1999). However, the transaction costs and impediments to transfers must be seen not as useless bureaucratic meddling but as a permanent search for an elusive equilibrium between private and public interests and for a trade-off between people's values (Emel 1990; Brown 1997). Thus the particular experience of the western USA led to a specific system of rights, with its advantages and drawbacks. Prior appropriation means that agricultural activities not only often have priority but also quantitative rights than cannot be circumvented or redistributed. This defines a specific situation of sectoral tension, which is quite removed from the reality of developing countries (and also many industrialized countries), where with few exceptions water is bureaucratically allocated and no formal rights are held.

Europe

Numerous examples can be drawn from the European experience. In contrast to the western USA, for which conflicts between irrigation and urban uses date from the earliest stages of development, water rights in Europe have evolved over time and in only a few cases have significant rural-urban conflicts emerged. Two cases perhaps suffice to illustrate how European cities in arid regions have secured their water.

Athens

Athens provides a good example of a city that had to look further afield for new supplies, while at the same time there was no significant irrigation use in the vicinity from which water could have been diverted. The Marathon dam, the main source of supply, was constructed in 1925. From the late 1950s to the early 1970s several distant sources (the Yliki lake and the Mornos dam, 187 km away) were tapped through aqueducts and Athens enjoyed an abundant water supply until the 1989–1991 drought (Kallis and Coccossis 2002). Heightened anxiety about supply reserves—that were at some point announced to be just enough for 170 days—provided the context to push for supply augmentation (the Evinos dam, and also an infamous water-transportation project by oil tankers which would have benefited private and political interests; see Karavitis 1998) as well as for a demand management program that included raising population awareness, price increases and paving the way for privatization (Kaika 2003). State management and planning of resources has allowed the capture of distant sources with only limited conflicts with agriculture.[36]

Seville

Seville is located in the Guadalquivir river basin, southern Spain, which has a storage capacity that amounts to 84 percent of the annual average runoff. Seville has a population of 1.3 million and receives its supply from reservoirs on right bank tributaries of the Guadalquivir. The main river and the aquifer are too contaminated to serve as sources for domestic supply (Del Moral and

[36]Agricultural producers and local authorities in the area around the Mornos reservoir are complaining against the strict measures that have been applied in order to protect the quality and safety of water in the reservoir. The scheme thus constrains potential agricultural development in the area (Kallis 2004).

Giansante 2000). Despite the relative aridity of the region and the occurrence of about one severe drought per decade (e.g., 1974–1976, 1980–1983 and 1992–1995) the city has enjoyed a rather comfortable per capita supply of between 285 and 425 l/c/day since 1975 (compare this with the end of the nineteenth century when it was no more than 30 to 40 l/c/day [Del Moral 1998]). In the drought years of 1976 and 1994, some transfer of water from the Pintado dam allocated to the Viar irrigation scheme was achieved after much confrontation and paying due compensation to farmers. In the last three droughts, agreements were also reached with the hydropower agency regarding the interruption and scheduling of releases from a dam usually not tapped for the supply of the city (Del Moral 1998). Droughts have been used to stress the existence of climatic risk and the need to augment storage and supply, despite the facts that: a) supply has never been severely curtailed; b) the rate of unaccounted for water is still as high as 36 percent; and c) the shortages owe a lot to careless management of the reservoirs, the delay in implementing supply augmentation plans and the lack of contingency planning (Sillero 1998).

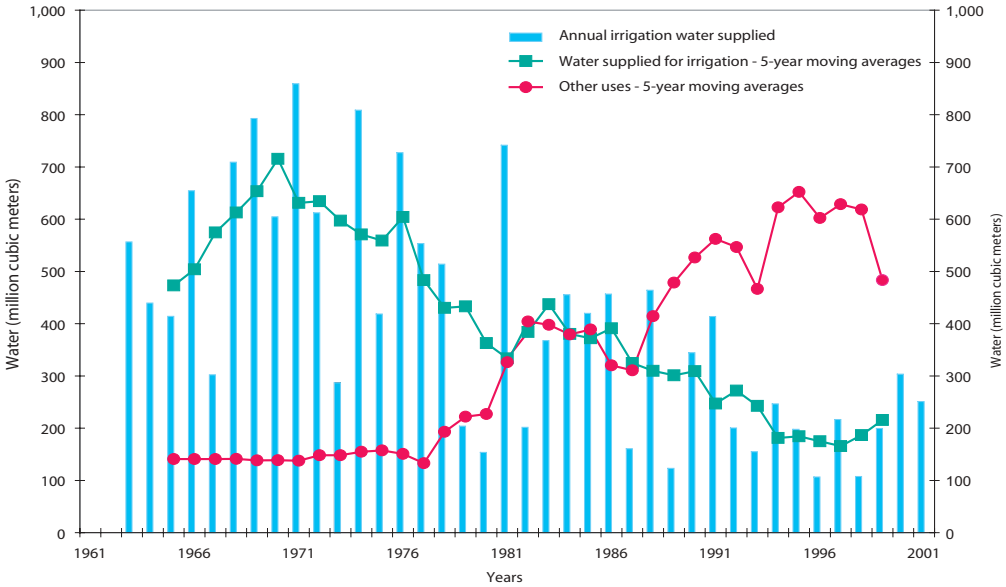
China

Two-thirds of the 600 major cities are said to experience water shortage (Xinhua 2004). But bringing water to these cities has been hindered by rising costs, and failure to keep pace with rapidly growing demands, rather than by agriculture failing to release the water it uses. Indeed, there has been a substantial shift in the balance of water use to nonagricultural uses. Over the past 50 years, agricultural withdrawals as a proportion of total water withdrawals have decreased from a high of 97 percent in 1949 to 69 percent in 1998, and are projected to reach 54 percent in 2050 (Jin and Young 2001). This reflects continued growth in nonagricultural uses in combination with the completion of irrigation development in water-abundant areas, as irrigable land has run out. But on China's northern plains, one of the most severely water-stressed areas in the world, it has also been associated, since about the mid-1990s, with an absolute decline in agricultural water withdrawals. In contrast, domestic and industrial water use has continued to increase at an annual rate of 12 percent and 5 percent, respectively, over the past two decades. Although China has legislated for water rights (GOC 1993), in practice this impressive rebalancing has been achieved based on predominantly centralized policy and allocation mechanisms, with or without the payment of compensation. As Lohmar et al. (2003) put it, the "nation's water policy is becoming increasingly biased toward industry," and the power vested in the Ministry of Water Resources and at Provincial level in practice allows reallocation of water to urban use.

Hong et al. (2001) describe a large irrigation district in Hubei where the proportion of water received by agriculture from the main reservoir declined from 64 to 35 percent between 1990 and 2001 due to reallocation of water to hydropower generation and industrial and domestic uses. The study of the Zhanghe reservoir (Yangtze river basin), by Loeve et al. (2003) provides a good example of transfer out of agriculture. While the reservoir was supplying an average of 600 Mm^3 to irrigation in the 1960s, it now provides only 200 Mm^3, the difference being transferred to hydropower, followed by industry and municipal use (figure 1). Despite this severe decrease in supply, over the same period the cropped area declined by only 32 percent while yields have doubled. This adjustment was made possible by local storage (ponds and small reservoirs), some recycling of drainage water by pumping, the adoption of high- yield varieties of rice, double cropping and water-saving rice growing techniques. Consequently, water productivity has risen threefold (Hong et al. 2001).

In Kaifeng district, in the Yellow river basin, the share of agriculture moved from 87 percent in 1968 to 63 percent in 2000. In absolute terms,

FIGURE 1.
Zhanghe Irrigation System, Hubei, China. Annual water allocations.



Source: Loeve et al. 2003

water use is roughly at the same level as in the late 1960s when the Yellow river was providing 77 percent of total supply. However, the river now only supplies 31 percent, the shortfall being provided by groundwater (Loeve et al. 2003). Indeed, more than 75 percent of the total water use in the Kaifeng City area now comes from groundwater, which has allowed municipal and industrial demand to be met with minimal competition from agriculture (16% of Yellow river diversion in recent years against 4% in the late 60s). However, the cone of depression created by over-pumping is likely to impact on agricultural wells. Surface transfers have been limited but transfers will eventually occur through underground flows.

In Yiwu city (in the Zheijang Province), the municipal government provided the neighboring city of Dongyang US$24 million in construction funds in exchange for a permanent right to a water supply of 50 Mm^3 from one of its reservoirs. The money was used to increase the height of the dam and for conservation measures, principally canal lining (Liu 2003). Another example of transfer for drought relief in 2003 was the purchase by local governments in the Zhanghe basin of 30 Mm^3 of water from five reservoirs located in the Henan Province (Liu 2003). Yet another example is provided by the Tsingtao city in Shandong Province. Despite construction of an expensive surface water transfer scheme from the Yellow river, the City Authorities were able to secure supplies at a lower cost from local irrigation schemes, which were compensated. The transfer project remains unused (World Bank 2002).

As a temporary measure, until the end of this decade when northern China will get about 20 Bm^3 diverted from the Yangtze river via the first phase of the South-North Transfer Scheme, the central government has embarked on a US$2.7 billion program to divert water from Shanxi and Hebei Provinces to Beijing (People's Daily Online 2003). Understandably, such massive re-appropriation has encountered significant opposition from areas releasing supplies and compensation to the areas affected has proven to be essential.

If there are instances where such reallocation was hindered by the resistance of rural entities[37], the overall numbers suggest that urban development ends up getting the upper hand. Even where water shortages are extreme, as in Tianjin city, water has placed few constraints on economic growth, which has been extraordinarily rapid and has even exceeded that for the nation as a whole. Conflicts are generally resolved by increasing the authority of higher-level administrative units so that the unit of decision-making is broad enough to internalize the conflict (Lohmar et al. 2003). In other cases, Water Bureaus with competency and authority across sectors mediate the allocation adjustments, mitigating their impact with additional conservation and/or supply-augmentation measures, sometimes also compensating farmers.

Whatever the mechanisms employed, urban uses have generally secured the supplies that are needed to underpin rapid economic growth. Rising urban demand has been met by supply augmentation, conservation measures, interbasin diversions and transfers from agriculture.

South-east Asia

Thailand

In Thailand, the growth of the Bangkok Metropolitan Area (BMA) generated a rise in demand from 0.46 Mm^3/day in 1978 to approximately 7.5 Mm^3/day in 2000, a sixteen fold increase over 22 years (Molle et al. 2001). This demand has been met by increasing the share of the Chao Phraya river flow allocated to the city (up to 45–50 m^3/s) and by using groundwater. There are no reliable data on the exact volume extracted from the aquifer but it is generally estimated at 3 Mm^3/day in the BMA.[38] A total of 95 percent of the water used in the manufacturing sector comes from underground water (Christensen and Boon-Long 1994). Future demand will be met from the adjacent "water-rich" Mae Klong basin via a canal[39] with a planned capacity of 45 m^3/s, which will be reached in 2017. This indicates, first, that the priority given to Bangkok has been readily translated into an increased diversion of surface water (to the detriment of irrigation since the amount available in the dry season is reduced); and, second, that the impact of the shift has been mitigated by allowing industries to mine deep aquifers (at the cost of land subsidence and sustainability; see Nair 1991, Das Gupta and Babel 2005). Supply augmentation will allow Bangkok to satisfy future growth in demand. In parallel, it must be mentioned that conservation programs have been undertaken that aim to reduce unaccounted-for-water in the reticulated system from the current level of 40 percent. With 33,995 factories in Bangkok and its surrounding provinces (Bangkok Post 1999), and around 10 million inhabitants, BMA's growth has hardly been constrained by water.

The city of Chiang Mai, too, has developed its water supply by appropriating canal water from nearby irrigation schemes. These provide 50,000 m^3/day of the city supply (corresponding to 70% of its supply), at the cost of reduction of supply to irrigated areas, with an additional 30 percent coming from the Ping River. Water flowing in the main canal of the Mae Taeng irrigation system

[37]Lohmar et al. (2003) report the case of a factory that had to close because it failed to win priority of allocation over existing agricultural activities. Page (2001) reports that a riot erupted in the eastern province of Shandong after officials cut off water supplies from a reservoir used to irrigate crops.

[38]The Department of Mineral Resources (DMR), for the late 1980s, reports on a total of 9,000 wells extracting 1.3 Mm^3/day. JICA estimated 2.9 Mm^3/day, based on consumption standards by category of factory, and TDRI (1990) concluded that they are probably about 3 Mm^3/day (compared to a safe yield of 1 Mm^3/day [Bangkok Post 1999]).

[39]This transfer has met with the opposition of residents of the Mae Klong basin (Pongsudhirak 1994), especially when a water shortage was experienced in the late 90s. However, the basin has two large storage dams, which, on average, are said to have a surplus of 30 percent (Kositsakulchai 2001). They can thus readily handle the diversion provided the dams are properly managed. More recently, the population in the basin has received some implicit compensation through the funding of rural water schemes in some villages.

that follows the western boundary of the valley has been gradually tapped by innumerable houses and by the city of Chiang Mai. Likewise, around 5–10 percent of the water controlled by the Mae Kuang dam, on the east of the valley, is now transferred to the city, prompting complaints from irrigators who are already water-stressed in the dry season, when only one-third of the area can be put under cultivation.

Malaysia

Malaysia's urban and industrial development has generated an annual growth in water demand of 12 percent in recent years (Abdullah 2005). The city of Kuala Lumpur (KL) has a population of 1.4 million and relies entirely on surface water. KL's rivers have their sources in the Klang river basin (in the neighboring state of Selangor), which supports 1,500 major industrial premises (Abdullah 2005). All residents in the city receive 24-hour piped water, and per capita consumption is only 132 l/day. Despite high rainfall runoff that feeds KL's four main reservoirs, these can no longer meet the rising water demand and as a result water shortages have occasionally occurred, notably in the dry season. In 1997/1998, El Niño caused *severe* water shortages. Lack of rain and high demand have depleted water sources and caused rationing in parts of KL and the Klang valley. As the agricultural water use in the basin is almost negligible, little reallocation was possible. In response to water shortages, an interstate project to transfer water from Pahang state to Selangor state has been considered. The project includes a dam and the transfer of around 1.5 Mm^3 per day through a 45-km tunnel from the Kelau river in Pahang to the Langat river in Selangor. The diversion plan is opposed by NGOs, which stress that the water systems in KL and the state of Selengor have leakage losses of 40 percent of supply and wasted around 1 Mm^3 of water per day in 2000 (FOE 2003). Activists also stress that the Kelau dam would damage the Kelau river ecosystem and require the resettlement of indigenous people and 150 Malay farmers.

Philippines

Manila is another megacity that has continued to expand despite an apparently constrained water supply. It presents an interesting case not just because 97 percent of the city supply is derived from a single source—the multipurpose Angat reservoir and the related Ipo dam—but also because the Philippines has since 1976 had a formal system of water entitlements based on that of the western USA ("first-in-time, first-in right," see above) that, in principle, requires reallocation to be formalized together with the payment of appropriate compensation to those deprived of their formal rights. The Angat dam is managed by the National Power Corporation (NPC) though power is now generated only as a by-product of releases to Angat-Maasim irrigation scheme (for which the National Irrigation Administration [NIA] holds the original water right of 3.1 Mm^3/day) and Manila (for which the Metropolitan Waterworks and Sewerage System [MWSS] holds an original right of 1.9 Mm^3/day) — (NWRB 1996). NIA has been unable to utilize its full entitlement due to lack of development, flooding of low-lying areas and, though denied by NIA, loss of irrigable land to urban sprawl. Under the 1995 Water Crisis Act, therefore, MWSS received an additional 1.4 Mm^3 from NIA's unutilized right and the provisions of the Water Code were strengthened to give Manila clear priority at times of drought. Supplies to Angat were augmented in 2000 by the trans-basin Umiray-Angat Diversion Project, bringing MWSS's total supplies up to about 4 Mm^3/day. Further projects are planned to take this figure to 8.9 Mm^3/day by 2024 (Bumatay 2003).

The supply to Manila is vulnerable to climatic variation because of its dependence on a single source that also serves other users. Manila has secured its needs by a mix of reallocation, refurbishment and new projects, and this may well have been more costly than if more of irrigation's Angat entitlement had been formally reallocated to Manila. Despite NIA denials, further reallocations might be possible without adversely affecting irrigation as urban sprawl encroaches

further on agricultural land. As it is, disputes invariably occur at times of drought with NIA basing its case on prior rights and MWSS on its legal primacy at times of scarcity. While the institutional mechanisms for reallocation are in place, they are insufficiently potent or detailed, notably relating to compensation, to be generally accepted. In practice, each drought becomes a crisis that requires political intervention, resulting in rationing not only for irrigators but also for domestic consumers. The solution seems to be a detailed compensation package agreed in advance that anticipates, rather than responds to, a drought (Young et al. 1996; McIntosh 2003). Even then, reallocation from Angat has limits since supply variability to Manila would increase as its share of this single surface source rises. Increased variability will ultimately prove unacceptable and other sources will become essential.

In addition to the problem of periodic shortages, dissatisfaction with MWSS's performance led to the privatization of the distribution system in 1997. This change, however, has not been an uninterrupted success. Severe financial and contractual problems have led to heated legal disputes, which resulted in one of the two concessionaires seeking early termination. Water is costlier, the service poorer and pollution more severe than they might have been prior to the change (privatization). Moreover, industries have installed boreholes to guard against shortage, leading to saline intrusion and subsidence. Despite these deficiencies, it is claimed that overall daily water production rose from 3.1 to 4.1 Mm^3 between 1997-2002, the population served rose from 7.2 to 9.4 million, average water availability increased from 16 to 19 h/day and the delivered supply rose from about 150 to 180 l/c/day (JBIC 2003). During the drought of 1997-1998, supply to 30,000 ha of irrigated land was suspended for two seasons and supply to the city fell by 34 percent and availability to 4 hours/day (Espinueva 2003). With high levels of non-revenue water persisting, important areas remain poorly served and periodic shortages are likely to continue. Manila remains dependent on a single source and has to resort to increasingly costly and distant interbasin transfers to augment its supply. Even so, there is little evidence that Manila's economic expansion has been or will be significantly constrained by its water supply.

Indonesia

Kurnia et al. (2000) describe the case of the Ciwalengke irrigation system, in the Bandung district, which has seen its water gradually diverted by local factories. These industries have used a large array of legal and illegal measures to tap water and have been little challenged by local farmers or the administration. This can be attributed, in part, to the social and political power of the factory owners. It also reflects the inappropriateness of the legal dispositions, the mixed feelings of farmers who also benefit from the job opportunities offered to their children and higher prices for their land, and the limited bargaining power of Water User Associations. Other river diversions for the supply of the Bandung city are also reported to have been implemented without any consultation with the farmers. Jakarta city has overexploited its groundwater resources and, is now forced to expand supply by constructing more dams in neighboring (or sometimes distant) basins (Gany 2003).

South Asia

India

Chennai (Madras). Chennai is a text-book example of how large cities located in water-short areas resort to multiple means to access water, though it still has one of the lowest levels of per capita consumption in India if not in the world (68 l/c/day) with a supply limited to 3 h/day on average (Brisset 2003). Chennai is mostly

supplied from four tanks (Poondi, Cholavaram, Red-Hills, and Chembarambakkam)[40] and groundwater (55%) derived from well-fields in the Araniyar-Kortalaiyar basin and coastal aquifers as well as from wells operated by municipal corporations and from the 200,000 private wells in the city (Krishnakumar 2001). In 1976, Tamil Nadu reached agreement with Maharashtra, Karnataka, and Andhra Pradesh on a supply from the Krishna river via the Teluguganga canal, a project envisioned since 1957. The project encountered numerous technical, financial and political problems (Mohanakrishnan 2003; Nikku 2004) and water from the Krishna only reached Tamil Nadu in 1996. Ever since, supply has been erratic and during the following 6 years it amounted in total to no more than was supposed to be delivered each separate year (1.4 Mm^3) under the agreement.[41]

Emergency measures taken during the drought that started in 2000 and still assails the state include pumping water from the Neyveli aquifer and transporting it by lorry; purchasing water from private agricultural wells in the vicinity of the city (and buying wells themselves); transporting water by tanker from the Chengalpattu-Kolavai lake; bringing water from the Mettur reservoir in the─_Cauvery river basin, by rail; and installing bore-wells and tanks to supply water to slums (Government of Tamil Nadu 2001). Other longer-term measures taken since the 1990s include: a) construction of dams on the Kortalaiyar river to recharge aquifers; b) renovation of networks to limit losses; c) renovation of tanks and development of water harvesting to increase local storage and recharge; d) construction of two treatment plants in the north of the city and reuse of wastewater; e) desalinization through a battery of reverse osmosis plants; f) use of both municipal and 2,000 private tankers for distribution; and g) provision of rainwater harvesting systems to new buildings (Ramakrishnan 2002b; Nair 2001).

Chennai is in the process of completing a 230-km long pipeline to bring water from the Veeranam dam in the Cauvery river basin. It also envisages diverting water from Pallipalayam, also in the Cauvery basin and 400 km away, as well as from rivers that are already in an extreme state of scarcity (Government of Tamil Nadu 2001). This is despite the fact that Cauvery is the most water-constrained major basin in India and has been the subject of a longstanding dispute between Tamil Nadu and Karnataka. Moreover, all such diversions will impact on irrigation, notably in the deltas that lie at the tail end of the river systems.[42] Well-fields supplying Chennai have pumped out a number of farmers as well as local water supply systems, like in Palayaseevaram (Rodrigo 2004), which once had a water supply 24 h/day and now receives water of poor quality, and that too only 1.5 h/day. There is no mention of compensation being paid to the affected farmers other than in the case of the direct diversion from farm wells in the vicinity of the city.

Coimbatore. Coimbatore, also in Tamil Nadu, has imported water from the western Ghats in Kerala since the 1930s. In the early 1990s, it implemented a diversion from the nearby Bhavani

[40]Cholavaram and Red-Hills were used earlier for irrigation but were tapped by the British, while farmers reverted to rainfed agriculture. Poondi was built by the British for domestic use only, while Chembarambakkam is a large tank that is still used for irrigation. Its capacity will be increased in order to store water diverted from the Krishna basin (Sakthivadivel 2004; The Financial Express 2003; Nikku 2004). It is worth noting that irrigation rights of the areas under the Cholavaram and Red-Hills were duly acquired in the 1960s.

[41]The scheme was designed at a time when Krishna river water was not as (over)committed as today. Farmers located along the 400 km of the transbasin diversion—an arid area with a historic grievance against the more favored Krishna valley—employ illegal means (breach of canal, pumping) and political pressure to get their share of water. Farmers in Andhra Pradesh, notably in the increasingly deprived Krishna delta, oppose the diversion of water to a state that is outside the basin. Several agricultural areas are to receive water from the Teleguganga canal and it is doubtful whether Chennai will ever get more water than during the last 6 or 7 years (Nikku 2004).

[42]Supply augmentation plans are designed "to prevent rainwater running off into the sea by constructing check dams, reservoirs, percolation tanks, etc., to store surplus water in Koratalaiyar, Cooum, Adyar and Palar rivers." There is hardly any surplus in these rivers and water will directly or indirectly be taken from irrigation. Likewise the 180 Mm^3 to be taken from the Veeranam tank are unlikely to correspond to "excess water," as it is claimed.

river, a tributary of the Cauvery, despite the preexisting use of this water for irrigation below the downstream Bhavani Sagar dam (Lundqvist 1993).

Hyderabad. A survey by the World Bank and the Confederation of Indian Industries concluded that Andhra Pradesh (AP) had the third best investment climate among major Indian states and another survey rated Hyderabad as the top destination for IT-enabled service businesses among eight Indian cities (World Bank 2004). While AP's economy as a whole has grown at a rate slightly below the national average Hyderabad's economy has grown much more rapidly than the average growth rate of all Indian cities. The population has been increasing at 3.84 percent per annum during the last 25 years and is expected to rise up to more than 7.5 million by 2015, taking it from thirty-first to the twenty-second largest city in the world (van Rooijen 2004; United Nations 2002).

Hyderabad is located in a drought-prone area and, despite recent economic success, water supply has fallen behind demand. Per capita supply is little more than 90-100 l/c/d (including non-revenue water) and rationing is pervasive. The major water source has been the Godavari river basin (Manjira river tributary), supplemented by overexploited groundwater. More recently, Phase 1/1 of a major new project drawing water from the Krishna river and involving a 400-m pumping head has come on stream, delivering an initial 0.205 Mm^3/day and increasing supply by 31 percent over the 2001 total of 0.66 Mm^3. By 2021, when Phase III/3 is scheduled for completion, the project should deliver 1.23 Mm^3/day (450 Mm^3/yr), almost trebling total supply and, independent of any other projects, augmenting per capita supplies to perhaps 150 l/c/d if population growth remains at 3 percent per annum (GOAP 2004; van Rooijen 2004).

While the Godavari river is relatively in surplus, and the multipurpose Singur dam has exploited unutilized flows, the Krishna river is now getting overcommitted in the dry season (with recurring shortages in the lower basins since 2000) and is disputed by three states. The Krishna Tribunal allotted 22.6 Bm^3 (or 39%) of the 75 percent dependable flow to Andhra Pradesh (AP) so that in 2021 Hyderabad should account for no more than about 2 percent of AP's dependable share. Nevertheless diversion from Sri Sailem LB canal to Hyderabad is located upstream of the 0.9 million hectare (Mha) Nagarjunasagar and 0.5 Mha Krishna delta irrigation projects. As development proceeds, not only in AP but also in Maharashtra and Karnataka, these tail-end systems will face declining supplies, especially during dry years. No mention was made of Hyderabad Water Supply in the Tribunal's report because Hyderabad was not an issue at that time (1976), yet it can be expected to receive priority at times of shortage, with the tail-end irrigation systems unlikely to receive any compensation as their supplies dwindle.

Visakhapatnam. Visakhapatnam has been identified as one of the key regions for development in Andhra Pradesh. Many industries and mega infrastructural projects are planned in the region, in addition to the existing industrial park that includes Visakhapatnam Steel Plant, NTPC Power Plant and the Parvada Industrial Development Area. These industries as well as the city draw water from two major sources of water, the Yeleru and the Raiwada reservoirs, which are also used by farmers. The Vishakhapatnam Industrial Water Supply Project envisages capacity augmentation of the existing 153 km long Yeleru Left Bank Canal (YLBC) system that presently delivers about 180 Ml/day of water from the Yeleru reservoir to Visakhapatnam Steel Plant (VSP). The demand in the immediate future is estimated at 260 Ml/day (2006), which in the long run would increase to 600 Ml/day (Business Line 2003). The solution eventually adopted is to build a pumping and diversion scheme from the Godavari river to increase supply into the tank. The cost of that investment (Rs 3,000 million) is to be partly borne by the industrial group. This example shows that a costly solution has been preferred to the political costs attached to expropriation of local

FIGURE 2.
Water pipes (from the Krishna river to Hyderabad; from Disi aquifer to Amman).

farmers, in this case because it is to be largely paid by private interests and also because the impact of the abstraction of water from the Godavari is more dispersed and less visible, although likely to be significant in times of drought.

Kerala. A much publicized example of conflict between industry and agriculture is that between a Coca-Cola plant in the Pallakad district, Kerala and surrounding farmers. The uncontrolled abstraction of groundwater by the bottling company has depleted the aquifer, dried up several open wells and bore wells and turned the quality of water from nearby wells unfit for consumption (Surendranath 2003). An area of 250 hectares of wet paddy land was reported dry. While the respective impacts of the factory, the past drought and the development of bore wells for agriculture are still a matter for contention, it must be noted that the matter was made worse by the lack of transparent information on the effective use of water by the factory.[43] The Government of Kerala, based on the critical drought situation in the region, ordered a ban on groundwater use from February to June 2004.

Delhi. Delhi is also trying to catch up with the demand of a sprawling and rapidly expanding city. It can access only about 6 percent of flows in the Yamuna river due to upstream diversions by the states of Uttar Pradesh and Haryana (GNCTD 2003). The Sonia Vihar water treatment plant, which is to treat 0.635 Mm^3/day (232 Mm^3/yr) from the Ganges river, was inaugurated in June 2002. Treated water is to be piped to Delhi, at a time when the capital is approaching a population of 15 million and consumes 742 Mm^3/yr, against a real "demand" estimated at 1,200 Mm^3/yr. Water is taken from the Upper Ganga irrigation canal, which has been lined to avoid seepage, raising protests from farmers relying on groundwater in the canal's vicinity and emotional statements from social activists who see food security in the area threatened (Shiva et al. 2002). Although lining is intended to "save" water it is apparent that the operation amounts to a seemingly invisible reallocation of water from well users to the city.

[43]While estimates based on pumping capacity are 0.8 million liters per hour, factory officials claim they abstract only 0.3–0.6 million liters per day.

Nepal

Katmandu. In Katmandu, the water supply system covers less than 70 percent of city residents with 3 to 4 hours of water supply during the monsoon, and 1–2 hours on alternate days during the rest of the dry season (Bhattarai et al. 2002a). To alleviate this shortage and satisfy growth in demand and population, water is to be transferred from the nearby Melamchi river. The project plans to divert 62 Mm^3/yr to Katmandu city's drinking water network through a 26.5-km tunnel. This new supply is drawn from a neighboring surplus basin and its impact is expected to be limited to 75 rice farmers and 15 water mill owners during the driest months (Bhattarai et al. 2002a; 2002b). Katmandu is thus in a position to satisfy its needs with little impact on rural areas (but how to compensate the affected farmers and mill owners remains an issue). Despite low indices of water supply, the problem is one of high cost and economic scarcity rather than of sectoral competition.

Pakistan

Major cities such as Lahore and Karachi use both underground and canal water. Urban and industrial sprawl coexist with *katchi abadis* (squatter settlements) in which 50 percent of the population live and where riots for lack of water supply have already been observed (Kamal et al. 2004). With 43 percent of supply unfiltered, 60 percent of effluents not treated, 7 percent only of the 1.1 million consumers paying bills, thriving water theft,[44] very high coastal pollution and no untapped water sources at its disposal for future growth are severe problems Karachi is faced with (URC 2004; Ercelawn 1999).

Karachi. Karachi uses 5.5 Mm^3/day, which is almost totally coming from the Indus or its tributaries (McIntosh 2003). A new project (K-III) to divert an additional 0.45 Mm^3/day from Kinjhar lake is in its completion stage. A director at the Karachi Water and Sewerage Board (KWSB) declared that "the drinking water supply will not be affected due to lack of water in the Indus river, as the level of the Kinjhar lake was being properly maintained to keep up the flow of water stream into the Kinjhar-Gujo canal for supply to Karachi." Yet, recent reports state that the Kinjhar lake level has declined to its lowest level and only supplies water to Karachi through the Kinjhar-Gujo canal. All other canals are closed to ensure water supply for Karachi (Hi Pakistan 2004). Similar competition exists in respect of the Hub dam, which provides, on average, 195 Mm^3 to irrigation and 455 Mm^3 to Karachi. A further project (K-IV) is to divert more water from Kinjhar lake and exploration of groundwater resources is also planned (Government of Sindh 2003). As a result of cumulative diversions of the Indus, the delta is now becoming a wasteland, and seawater intrusion is now well established in some areas (Kamal 2001).

Middle East and North Africa

Iran

Isfahan. The population of Isfahan in the Zayandeh Rud basin rose from about 45,000 in 1966 to a current level of about 1.5 million. It has secured water and sustained its growth, including activities like a steel industry, by augmenting supplies through trans-basin diversion from the Karum basin and, at times, implicitly reducing supplies to agriculture (Murray-Rust and Droogers 2004). The resources of the basin are now piped to cities outside of the basin, notably Yazd (78 Mm^3/year) and, in the future to Kashan and Shahr Kurd as well (Mourid 2003). The development of the city is hardly constrained by lack of water. Industries providing jobs get the water they need, paying for water at a much higher rate than agriculture they (industries) qualify as priority clients of the Isfahan Water Authority. In times of

[44] "Water theft in Karachi is an organized crime. It exists in many ways. Stealing water by puncturing main siphons outside Karachi's limits, inserting illegal water connections from lane-level lines, obtaining water from the connections of bulk consumers and using high-powered suction pumps are a few common forms of water thefts" (URC 2004).

drought, water supply to agriculture is curtailed. While its (agriculture) share is around 78 percent in a normal year it was reduced to zero in 2001, which was the last year of a critical 3-year drought.[45] Despite scarcity at the basin level, with all resources already committed, green belts, extensive lawns along the river and other vegetated areas continue to expand in the city. In 2001, urban interests demanded and obtained releases from the main storage dam to ensure sufficient water under the city's magnificent ancient bridges in order to meet the interests of the tourist industry. In short, while by and large an oasis, Isfahan could acquire the increasing supply it needs, partly because of expensive interbasin diversions through tunnels, and partly by relegating agriculture to the use of groundwater (which now makes up to 50–60% of its total supply).

Jordan

Amman. Domestic water supply in Amman is intermittent and the city has a long history of water shortage. The King Abdullah Canal in the Jordan valley was initially constructed for irrigation and diverts an average of 150 Mm^3/yr from the Yarmouk to the Jordan valley. The Deir Allah pipeline was constructed in the mid-1980s to lift 45 Mm^3/yr of water over a height of 1,200 m, from the canal to Amman. Part of the return flow is treated and returned to the valley in compensation. Following an agreement with Israel on limited additional flows from the Jordan system and the construction of the Unity dam on the Yarmouk, a second pipeline doubling the transfer to Amman will soon become operational. In addition Amman is to receive water from the (fossil) Disi aquifer, located 350 km further south, which is (over) exploiting groundwater. The urban sector currently pumps about 145 Mm^3/yr (plus 30 Mm^3 from distant aquifers) against 130 Mm^3 used in highland agriculture, together greatly exceeding the annual usable recharge of approximately 153 Mm^3 (Courcier et al. 2005).

Reallocation from agriculture occurs both where water is under government control (e.g., transfers from the valley) and also in a less formal way where it is under individual management. About one-half of highland agriculture is highly productive and grows cash crops which are sold in the Gulf countries, but the other half supports unprofitable olive trees (Venot 2004). Many have advocated reallocating this water to municipal and industrial (M&I) use (Schiffer 1997) so as to avoid more expensive options such as tapping of the Disi aquifer. However, this may overlook the cost of conveying scattered sources to urban centers and political objections to nationalizing private wells. Piping these scattered sources of water to Amman could be very costly since most are located close to the Jordan-Syria border. In practice, a spontaneous market solution has emerged, whereby well water is transported to the city by tankers and sold to areas with poor water supply.[46] The number of wells converted to city water supply rises at times of drought and, so long as shortages persist, tanker water will continue to be supplied. Moreover, if the true costs of Disi water, for instance, were to be charged, there might well be a continued market for tanker supplies at a competitive rather than at a premium rate.

The spectacular growth of Amman (e.g., due to the influx of refugees in 1948-1967 and from the Gulf after the first Gulf war) seems to have been little constrained by lack of water. Supply lags behind since new sources cannot be accessed as fast as population increases, but a wide range of solutions have been adopted including: extension of delivery networks, transfers out of agriculture (with recycling of wastewater), drilling of wells, transfers from distant aquifers and

[45]Agriculture had to rely solely on groundwater, wherever this was possible. Isfahan, however, also suffered as the water quality of the river badly degraded, with impact on health reported in newspapers.

[46]Ironically, while this reallocation embodies principles of economic efficiency and private-sector initiative, this transfer has been prohibited because of the competition it creates with the water utility under reform and privatization.

reservoirs, desalination and repeated actions to limit leakage. Conventional wisdom associates Amman's shortage with the fact that agriculture still consumes 70 percent of the Kingdom's waters. A thirsty city is contrasted with an alleged wasteful agriculture. But is agriculture really wasteful? Transfers from the valley are limited by pump capacity. Even so drip and other modern technologies are spreading rapidly both in the valley and on the plateau. And is the city really thirsty? Lack of water in the capital is ingrained on people's mind by the fact that "people in Amman get water only once a week." But despite this gloomy image, most people do get water all the time by the simple expedient of storing it in-house on the day(s) they are supplied. This is akin to a rotation schedule in irrigation, which by no means entails that crops do not get adequate supply. Average supply is 135 l/c/day (Darmame 2004), which is a reasonable standard for an arid country. Amman is hilly and it is hard to regulate pressure; its network records 72.000 bursts a year (Decker 2004). The main reason for rotational supply is the poor state of the network that would entail a huge increase in losses (already at 30-35%) if it (supply) was maintained (under pressure) fully and permanently.

Rather than a city being in thirst as a result of water use in agriculture, Amman is, on the contrary, an example of gradual reallocation of regulated waters from agriculture to other uses. This reallocation, however, is determined by market pressures and feasibility. Recent water crises have shown that agriculture is, in effect, the residual user. In the dry years of 2000 and 2001, irrigation quotas in the valley were reduced, summer crops prohibited and 1,000 hectares of farmland "rented" to be left fallow, while no restrictions were imposed on Amman. Agriculture still retains the larger share of water in percentage terms but only because other uses have not grown sufficiently. Once water in the Yarmouk is regulated by the Unity dam, the valley will depend almost exclusively on blended treated wastewater and semi-saline water.

Morocco

Planning has been effective in increasing supply and sometimes rebalancing water availability across basins. Since 1995, river basin agencies have been set up to develop master plans in a more participatory manner. The growing needs of cities have, therefore, been mainly satisfied through augmentation of supply and conveyance infrastructure (and even desalination), since quotas per cultivated hectare are already at a minimum (Lahlou 2004). This, however, has shifted pressure onto the groundwater resource, especially at times of shortage, when domestic use and water for animals are given priority. The increase in supply has, therefore, largely served to dampen the competition between cities and irrigation. The efficiency of the latter is being enhanced by the fixing of quotas, and by intensive reuse and recycling, notably through pumping from the aquifers.

Tunisia

In Tunisia, water policy is based on the concept of interregional integration and equity. Regions are partly interconnected through a network of pipes that redistribute water from water-rich (mostly the north) to water-poor regions, and from agriculture to cities/tourist resorts (CNRS 2003), and occasionally back again to agriculture (use of wastewater for agriculture near Tunis). Urban water charges are averaged and homogenized out of a concern for equity. In such a system, reservoirs in the north that had been initially constructed for irrigation purposes have been gradually shifted to urban supply. The shortfall has been partly compensated for by development of groundwater. Irrigation use still amounts to 80 percent of the total supply of water. However, 60 percent of the water used in agriculture is groundwater (Treyer 2002). In the case of Tunisia, therefore, urban supply has been given clear priority and reallocation centrally imposed and managed.

Yemen

Water use in Yemen is estimated at 3.4 Bm^3, 35 percent higher than the renewable resource (2.5 Bm^3) — (Kohler 2000), but the situation is much worse in some localities. The extraction rate in the Sana'a area, for example, is believed to be four times higher than the sustainable yield (Ward 1998). It is estimated that there are about 45,000 private wells in the country (although some estimates are considerably higher) and about 200 drilling rigs (Ward 1998) with largely uncontrolled activities. In other words, despite providing significant short-term benefits to rural populations, the pump revolution has gone awry. The current water crisis is the result of several internal factors (population growth at 3.5%, *modernization* of agriculture through tube-well technology in the 1970s [Milton 2001; Ward 2001], subsidies for oil and pumps and protective measures for *qat* production) as well as external factors (absorption of a population of 1.2 million expelled from Gulf countries after the first Gulf War, mostly in the agriculture sector, and the supply of cheap groundwater-extraction technologies). In the longer term, interbasin transfers involving high pumping costs may have to be considered if a residual agriculture is to be preserved.

Sana'a. The population of Sana'a was 135,000 in 1975 and is now about 1.4 million, after periods where the city grew at an annual rate of 11 percent (against 3% for the country)— (El-Hamdi 1997). A total of 13,000 wells (70 of which are state-owned) supply water to the public resulting an abstraction of─_around 250 Mm^3/yr in the Sana'a basin, against a recharge of 100 Mm^3. Water comes from both shallow aquifers and the high-quality Tawilah deep aquifer, of which─_80 percent is used in agriculture (World Bank 2003a). The city is in a "long-term competition" with agriculture, in that it mainly uses the Tawilah (fossil) aquifer that is being depleted by largely uncontrolled agricultural use. The strategy adopted is to improve irrigation efficiency and increase recharge of the alluvial aquifers so as to relieve pressure on the Tawilah aquifer. However, unofficial water transfers are pervasive via tankers to agricultural wells to domestic users (World Bank 2003b). Indeed, about two-thirds of all water supplied in Sana'a comes from private sources (two private distribution networks and tanker trucks).[47] Open discussions of rural-urban transfers are highly sensitive, following the conflicts in Ta'iz (see below). The World Bank is supporting a set of realistic supply and demand management programs designed to "allow time for a gradual shift to a less-water-based rural economy" (World Bank 2003a), hoping that in the long run water rights and well metering will be in place, paving the way for stricter regulation and water markets. This particular case illustrates an arid context in which a city *cannot* increase its supply because transfers from other basins (or desalination) are economically and socially impossible, and where the common solution of resorting to groundwater is made difficult by a *regime* of open access and groundwater mining. Conflict with agriculture is thus indirect, transfers are partial, and the lack of regulation or water rights prevents proper management of resources. Yet, it must be noted that though per capita consumption in Sana'a is limited, nothing prevents the city from increasing its supply. The crisis is in terms of sustainability and regulation but, in the short term, the supply situation of Sana'a is only partly explained by agricultural use.

Ta'iz. It is one of the most water-short cities in the world with only 36 l/c/day. In the early 1980s, new wells to supply Ta'iz were dug in the prime agricultural zone of Wadi Al-Haima, which is 20 km away from the city. Most of the agricultural wells went dry, incurring drastic declines in farm incomes and deep resentment among the local population. By the late 1980s, the situation had degenerated to such an extent that troops had to be sent to quell the strife and restore law and

[47]Per capita consumption in 1992 in areas served by public water supply was about 120 l/day (including 35 percent that was unaccounted for), against 35 l/day for areas dependent upon private suppliers, because of the high cost of water.

order. Continued abstraction and further drilling were secured through direct negotiations between community leaders and the president of the country.[48] More drilling in the Habir area met violent opposition from local dwellers. This re-appropriation of groundwater only delayed the crisis that was to strike the city in 1996 (Riaz 2002).

Latin America

Mexico

Lerma-Chapala. Lerma-Chapala is a closed and overexploited basin, since the aquifers are constantly falling due to the abstraction of water by both cities and agriculture. Most urban wastewater is now reused for irrigation. However, the level of water in the Chapala lake, at the lower extremity of the basin, is also declining, impacting on its tourist, recreational and ecological value (Scott et al. 2001). The 1991 interstate treaty allocated 7 percent (240 Mm^3) of the average basin inflow to Guadalajara city to the detriment of agriculture. While this share appears limited, in years and months of water shortage cities become the priority users by law, and this right turns out to be very significant. In 1999, for example, while 240 Mm^3 were released to the lake and to Guadalajara city, Alto Rio Lerma Irrigation District had to reduce irrigated area from 77,000 to 20,000 ha without compensation (Scott et al. 2001).

Monterrey. Monterrey in the north of the country provides an example of a city that is located upstream and extracts water from a reservoir (El Cuchillo), significantly and gradually reducing water supplies to farmers in the downstream state of Tamaulipas (Flores-Lopez and Scott 1999). The dispute between upstream areas (the state of Nuevo Leon and supply to Monterrey) and downstream areas (Tamaulipas state and irrigation areas) has been fueled by the fuzziness of the agreements signed by the two states (Barajas 1999). Hydrological interactions and issues of dam management have been overlooked and it became clear that the El Cuchillo dam effectively captured the water that used to flow to a reservoir further downstream (Marte Gomez) which, in turn, was supplying downstream irrigated areas. Irrespective of the legal disputes and political struggles that have unfolded since the commissioning of the dam in 1994, the likelihood is that Monterrey Metropolitan Area, the main industrial center of the country, will not only keep its priority use of the dam but also increase its diversions in the future in order to keep pace with its high growth rate (Barajas 1999).

Mexico City. Mexico City provides another example of a city that grows despite insufficient water supply (Torres Lima et al. 2000). Because of its high elevation, interbasin transfers or pumping schemes are costly and the city relies on groundwater for 70 percent of its needs. Overexploitation (45 m^3/s against recharge of 25 m^3/s) has resulted in land subsidence (on average 10–40 cm/year, with a cumulative drop of 10 m in one century), a declining aquifer (1 m/yr) and its pollution (WRI 1996), rendering water unfit for irrigation by downstream farmers (Haggarty et al. 1999). A discharge of 19 m^3/s (600 Mm^3/yr) is diverted from the Cutzamala basin via a system that includes seven reservoirs, pumping to a height of 1,100 m, and 21 km of tunnels (Tortajada and Castelan 2003). This massive transfer has had a serious impact on the local population and induced hydrologic effects in the area around Toluca, with the overexploitation of the aquifer and the drying up of surface water, including three lakes (Wester personal com.). Further diversion of water from the Temascaltepec basin (5 m^3/s) through this system is planned, but this project has so far been met with fierce resistance from the farmers

[48]The communities affected received a package of public goods (Riaz 2002), and the local Sheikh drilled three deeper wells for his family (Mohielden 1999); but implementation of the agreement (exploitation of new wells, in particular) experienced substantial delays caused by spirited opposition from rural residents (Ward et al. 2000).

of this very productive valley (Tortajada and Castelan 2003; Legorreta et al. 1997).[49] The second major transfer includes tapping of groundwater, which has been previously tapped in the Lerma basin by a field of 230 wells. Its discharge of 14 m^3/s was reduced to 6 m^3/s because of environmental impacts and social conflicts, induced by a reduction in agricultural productivity and the reversion of some irrigated land to rain-fed agriculture, without any compensatory measures. Despite the escalating financial and environmental costs, continuing supply augmentation seems to receive more attention than demand management: the importation of 14.2 m^3/s from the Amacuzac basin is also now being considered (NRC et al. 1995). This would necessitate the construction of a dam with an inundation area of 67 km^2, a 160-km long aqueduct and pumping to a height of 1,825 m, with corresponding energy consumption estimated at 5 percent of total national power production.

Average water consumption in Mexico City Metropolitan Area is quite high (297 l/c/day), even when 40 percent of losses are taken into account. This value, however, conceals a drastic variation from up to 600 l/c/day in richer areas, to 20 l/c/day in poorer parts of the city. Despite calls for demand management, water remains highly subsidized (5% of cost to supply water is recovered through taxes), payment erratic and service precarious (Castelan 2001).

Peru

Lima. In 2000, Lima received 8 m^3/s from groundwater and 21 m^3/s (out of which 9.2 m^3/s for industries) from the Rimac river, that is 84 percent of its discharge (Peru 2004). Another 6 m^3/s from this river went to 4,000 hectares of nearby irrigated land. In times of drought, the law stipulates that domestic use has priority and irrigation is reduced. When shortage is severe, the city too has to rotate supply. A plan to bring 7 m^3/s from the eastern side of the *Cordiliera* through 44 km of canal and 10 km of tunnel is estimated to cost US$330 M (Lama 2000). Additional trans-Andean diversions from the *Rio Mantaro* are expected to add 32 m^3/s (16 m^3/s in a first phase), as a way to meet projected demand until 2025 (Peru 2004). Some water is also to be drawn from the Chillon river, north of the capital. A long-term decline in supply is feared because of the dramatic recession of glaciers in the Andes (Masson 2002). Groundwater overdraft has drawn aquifer levels down by 15–30 m between 1969–1992 and led to contamination by saline intrusions and urban/industrial return-flows (La Touche 1997).

Unaccounted-for-water amounted to 43 percent (two-thirds being leakage, one-third being non-billed use) and only 75 percent of the population is connected,[50] receiving a surprisingly high average of 236 l/c/day (with variations from 567 to 105 l/c/day between rich and poor areas) —Alcazar et al. 2000). Sanitation is poor, as shown by the cholera epidemic of 1991. Although the problem seems to rest more with the urban sector itself, Holden and Thobani (1996) consider that Lima "suffers water supply problems while nearby irrigation districts allegedly waste[51] abundant water" and that water markets would be a way out. In the late 1970s, Lee (1979) observed that urban expansion had affected around 10,000 ha of agricultural land and that water use for irrigation had decreased from 11.2 to 9.3 m^3/s. In fact, Masson (2002) recently reported that agriculture had declined from 23,000 ha in the

[49]Tortajada and Castelan (2003) note that, in line with earlier interbasin transfers in Mexico (Tortajada 2002), the Environmental Impact Assessment of the project did not consider the social impact of the diversion.

[50] "About a third of those without connections relied on standpipes or group taps, another third on water vendors and the rest on other sources such as wells" (Alcazar et al 2002). Masson (1991) also reported that less than 25 percent of the 21,000 industries listed in 1988 were registered as water users.

[51]This waste is not substantiated by any reference but is hard to envision since irrigation has seen its part decreased in times of drought and only the city's sewers discharge to the sea in the dry season. Percolated water is also recycled through (over)pumping of the aquifer.

late 1960s to 6,100 ha in 1986 and had now virtually disappeared! As the city expanded and water became increasingly scarce, good-quality agricultural land was both converted to brick making and transformed into urban areas. No compensation was offered to farmers for the water transferred but their land probably fetched a high price. The same process is now affecting the neighboring Chillon valley (Masson 1991).

Brazil

The Metropolitan Region of "*São Paulo*" (RMSP) is home to 18 million people and includes 39 municipalities (Porto 2003). It is located in the Alto-Tietê catchment and, while it receives an average of 1,400 mm of rainfall each year, the city has been facing water shortage since the nineteenth century, as the development of the water supply system has always fallen behind the population growth (Ducrot et al. 2004). In the 1970s, the Cantareira system, an interbasin transfer bringing 33 m^3/s from the adjacent Piracicaba basin, allowed a relatively abundant supply. While, at the time, this diversion had limited impact on the then underdeveloped communities in the basin of origin. The subsequent development of the Piracicaba basin reveals how transfers can hinder or preclude long-term development in giving-basins (Braga 2000), prompting complaints from the latter and claims for financial compensation (Lobato da Costa 2003). Earlier diversions from the Alto-Tietê, through the Billings reservoir to the coastal area for the purpose of energy generation, are now restricted to the flood period in order to avoid compounding the pollution of the river (Porto 2003).

Further competition over resources will translate into growing pressure onto the Alto-Tietê river itself, which is expected to provide 5 m^3/s after two new dams are built (Ducrot et al. 2004). The flow of the Alto-Tietê is roughly appropriated by industry, agriculture and domestic use in similar proportions and reallocation to urban use is likely to occur to the detriment of agriculture. Competition for land and water, low water quality and uncertain economic profitability favor capital intensive and high-tech agriculture and tend to displace smallholders with less capital. During the last few decades, urbanization and insufficient sanitation facilities have led to the degradation of the quality of surface-water resources (Ducrot et al. 2003). The contamination and degradation of water quality make it unfit for use and translates into quantitative losses of potential supply. Public outcry, however, has forced the state of São Paulo to take action and to design the Alto-Tietê Project, launched in 1991 with the goal of treating 50 percent of the total wastewater by 1996 (Hermann and Braga 1997). Challenges ahead include conservation of water quality in the upper catchment and in reservoirs, reduction of water use in agriculture, control of groundwater abstraction and negotiations with neighboring basins such as the Juquiá, Jaguari, Itatinga e Itapanhaú basins, from which transfers are envisaged (Porto 2003).

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