Water Demand Management: Potential and Pitfalls

Background Paper

François Molle

IDRC – Arab Water Academy: Water Demand Management

February 2010

Water Demand Management: Potential and Pitfalls

François Molle

Abstract: Water Demand management has received much emphasis from development agencies in the last decade. The concept stemmed from a growing awareness of the externalities of large scale water resources development and of an assumed state of wastage in the use of water by many sectors, notably agriculture. The paper examines critically the scope of the three main water demand management objectives: saving water in water short basins; reducing irrigation demand through pricing; and reallocating water to higher value uses. It argues that the gains that can be achieved through demand management are often overestimated. Because of the closing/closed nature of water short basins, most water-saving interventions result in spatial shifts of water use rather than savings. Water pricing is often proposed as a way to curb water use but its introduction in irrigated agriculture is shown to be problematic. The economic argument for re-allocation to higher value uses is also critically reviewed. Despite the limitations faced by water demand management policies (and the importance of being aware of them), these policies must be pursued -with a full understanding of their implications and limitations- because they are both needed and, sometimes, the only options at hand.

1 Introduction: why is WDM seemingly a new concept?

Several decades of development of large scale infrastructure, which spanned most of the 20th century and came to be known as the era of the "hydraulic mission" spearheaded by powerful hydraulic bureaucracies worldwide (see the October 2009 special issue of *Water Alternatives*), resulted in impressive achievements: these include the construction of 50,000 large dams, the expansion of irrigation facilities up to 280 million ha, and a growing number of large-scale interbasin transfers. This hydraulic mission, however, has gradually been faced with severe negative impacts and corresponding political opposition. The first critique focused on the social and environmental costs of these infrastructures, including around 100 million of people displaced and disruption or the degradation of many rich aquatic ecosystems that formed the basis of people's livelihoods. The second critique has been formulated by resource economists who pointed to the high public subsidies sunk in these investments, the critical maintenance problems that made repeated rehabilitations necessary, and the correlation between the low cost paid by water users and behaviours identified as leading to wastage and inefficiency. A third critique has been directed against the governance of both the planning of water resources development and the management of water. Non-inclusive and nontransparent decision-making have resulted in the implementation of large-scale projects that have overlooked many externalities. Participation and empowerment of concerned stakeholders are seen as a prerequisite to designing well accepted and sustainable investments.

The hydraulic mission era was characterised by an almost systematic reliance on the augmentation of supply. Growing needs, the occurrence of conflicts, the repetition of shortages or crises were invariably responded to by mobilizing, storing, pumping, or diverting more water out of the river systems and aquifers. As long as water was still available to be mobilised there was little talk of other possible responses to water scarcity. Truly, some efforts were sometimes directed at controlling leakage in urban networks because of the higher costs of producing potable water; irrigation canals were sometimes lined in order to avoid high losses by seepage; awareness campaigns were carried out in times of crisis to invite users to reduce their demand. But, all in all, supply augmentation remained the quickest way to satisfy everybody by bringing more water in.

The reasons for such an over-reliance on the construction of infrastructures owe a lot to the convergence of interests of main decision-makers, including local and national politicians, water bureaucracies, private companies and consultants, and development banks (see Molle, 2008, for an analysis of this web of interests). Equity considerations also frequently contributed to fuelling investments in poor or marginal areas, as a means of balancing earlier investments in areas with higher potential. Competition between states in federal context also often fuels a race to the bottom for water infrastructures that are seen as a way to legitimize claims of "ownership" of the resource.

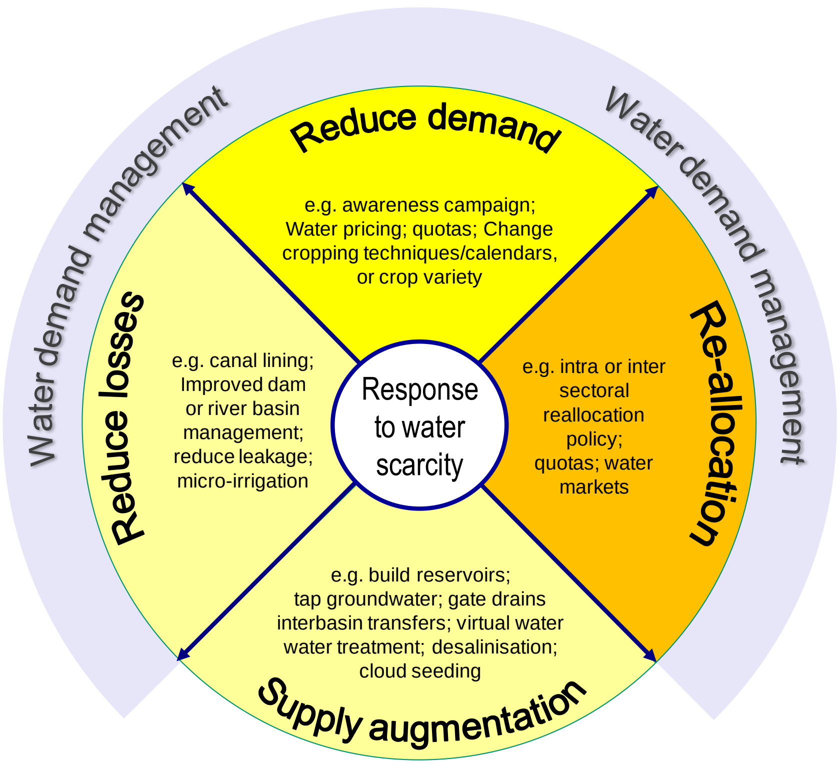
But, with time, opportunities to augment supply have become scarcer and more costly. At the same time, it became common knowledge that the use of water was very often characterized by high levels of losses. In developing countries urban water supply is reported to have losses by leakage between 30 to 40% on average. Surface irrigation is also known to incur heavy losses and one can frequently read the statement that two thirds of the water diverted never reach the plant (e.g. FAO 1998, WRI 1998). Massive supply to irrigation (70% of withdrawals - but probably around 90% of water depletion - at the world level) has also come under criticism in a context of growing competition with urban water supply and needs.

Numerous analysts in the water profession have therefore embraced and popularized the concept of demand management (Hamdy *et al.* 1995, Winpenny 1997; Brooks 1997; Frederick 1993) and made the case that its application would be a primary means to solve the current water crisis. Water demand management (WDM) is defined as a "policy that stresses making better use of existing supplies, rather than developing new ones" (Winpenny 1997), and uses a set of incentives that include pricing, subsidies, quotas, conservation measures, treatment and recycling, awareness raising or educational programs. "Better use" encompasses conservation measures to raise efficiency in use, but also reallocation to uses with higher economic and/or social benefit. For Gleick (2003), such efforts combined with decentralization and participation of water users define a "soft path" approach. This soft path approach has been developed further by a number of scholars who emphasize priority to ecosystem needs for water and reduction of human uses by economic and social incentives (see the collection of papers in Brooks, 2009).

In other words, conventional water supply augmentation is now considered in parallel with three other types of response that, together, come under the label of "water demand management" (figure 1). These three responses are: 1) the reduction of losses in distribution networks and river basins systems; 2) the reduction of the demand by different users, so as to reduce withdrawals from the hydrologic cycle; 3) the reallocation of water according to criteria that reflect societal and/or political priorities at a certain point in time (e.g. giving priority to supplying the poor or sustaining environmental flows, as stated in the South African law for example; or reallocating water to urban uses, considered as bringing much higher economic benefits).

Considering and implementing water demand management has become indispensable. However, there should not be overenthusiasm and misunderstanding over what can be achieved in practice. Constraints to the implementation of water demand management includes the nature of the local political economy, as well as limitations inherent in each of the three pathways mentioned above. These issues are briefly addressed in the following four sections.

Figure 1. Response options to water scarcity: supply and demand management



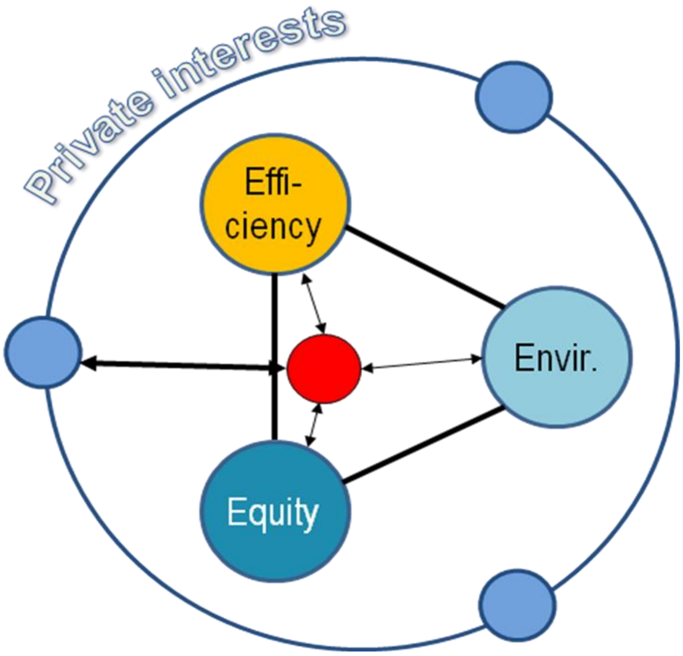
2 WDM and IWRM: the political economy of water management options

The above description of the possible response options at hand takes us to the critical question of how policies are defined and particular responses end up being selected. Two different, or perhaps complementary, approaches can help us respond to this question.

Following the model of representative democracy we can assume that decision-makers - including politicians and bureaucrats - try to select the options that are best suited to meeting societal priorities and collective values, as those embodied in the IWRM framework: the overall efficiency of resource use, social equity, and environmental sustainability. Particular options marked by their incompatibility with one of these three “Es” should be discarded. Public choice theory, on the other hand, emphasises the rationality of decision-makers and the way they take into consideration their personal private interests. These interests may be plainly financial (whether this includes corruption or not) but also frequently include political gains. Typically, it would be unwise to expect politicians to take decisions that would cancel their chance to win in the next coming election. Reality is in general somewhere in the middle: decision-makers surely do take into account their personal gains or losses but they don’t decide in a vacuum. Decision-making is a process that is rarely completely insulated from nonstate actors, whose values and interests will often surface at some point, or from supra-national institutions (e.g. the European Union and its Water Framework Directive). Whether this will be sufficient for these values to be taken into consideration will depend on the overall governance framework, the distribution of power, the political clout of the different constituencies, or the existence of platforms for social learning and reducing the gaps between conflicting interests.

In other words there is a first tension between the three Es and, as a result, between the groups which support objectives associated more closely with one of them; and a second tension between these collective values and private interests - as illustrated by figure 2.

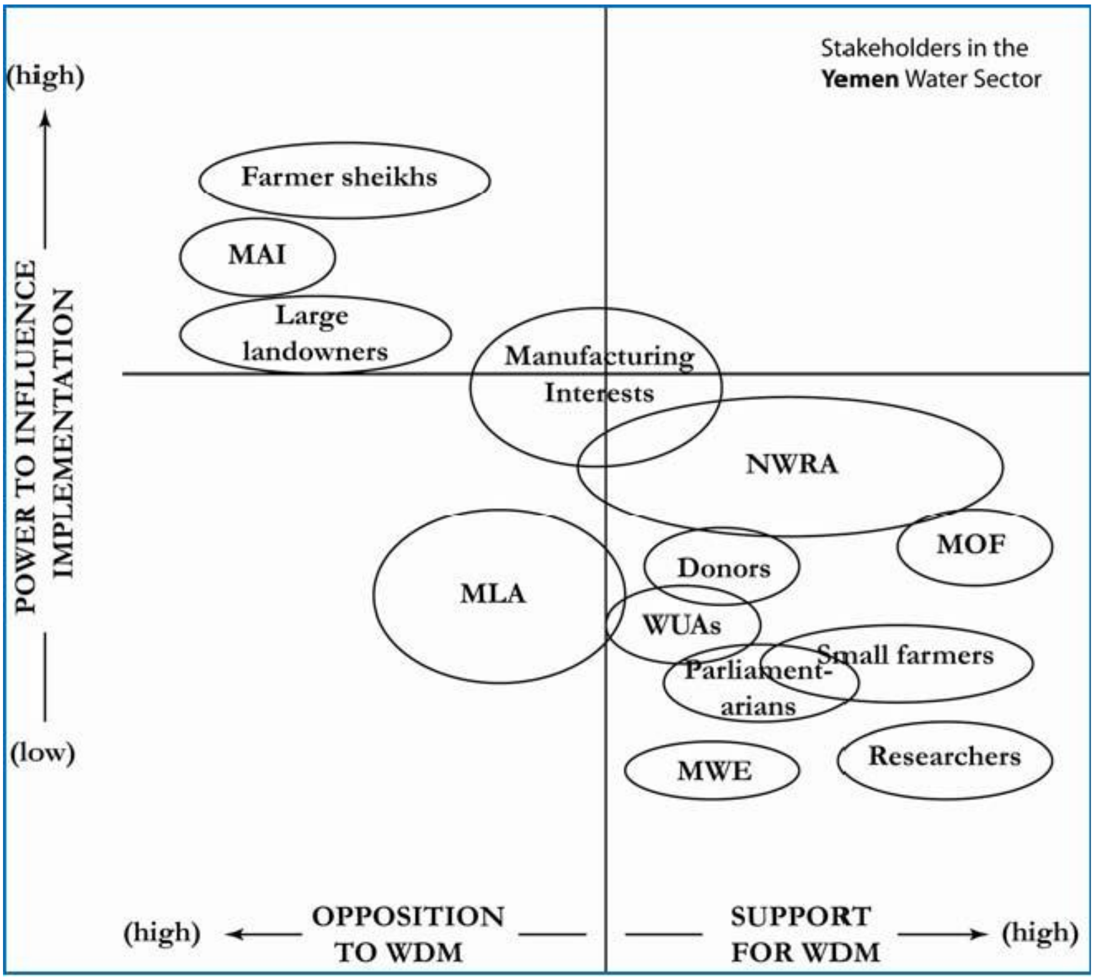
Figure 2. The tension between private and collective values and interests



The distribution of costs and benefits associated with each of the policy response options varies widely: it is obvious, for example, that pricing policies will generally impact on users and generate financial benefits to utilities or the government. But this measure may also carry with it some political costs if it is not well accepted by the population and if there are democratic mechanisms to translate opposition into political pressure or change. Estimation of costs and benefits is not easy but is also made complex by the fact that stakeholder categories often have to be split further. For example some richer urban dwellers may not be concerned by a rise in tariffs while poorer ones will be; some farmers may also not be worried with increased irrigation water prices because they can rely on a well. Likewise governments are not homogenous: the interests of ministries such as the ministries of Agriculture, Environment, Finance, or Water are often not aligned; furthermore, in each of these ministries it is common to find groups with different visions and strategies, some interested in reforms and others in the *status quo*.

Figure 3, for the sake of illustration, shows the mapping of the stakeholders concerned by the implementation of water demand management strategies in Yemen, as a response to groundwater overdraft. The figure illustrates the different interest groups and their respective political power as well as their influence in the policy sector. Some actors appear as both powerful and concerned by the problems, while other have fewer interests at stake and/or less influence.

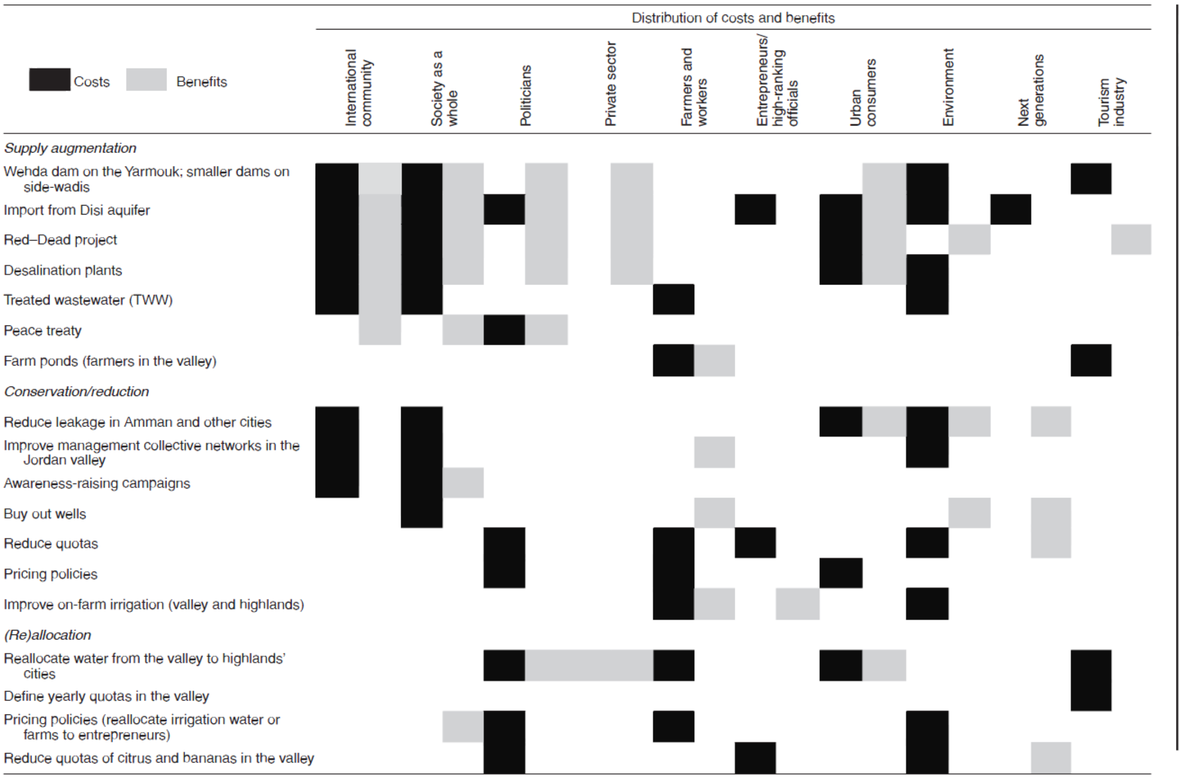
Figure 3. Plotting stakeholders against their political influence and power (source: Zeitoun, 2009)



But WDM includes different policies with different distributions of costs and benefits and which therefore cannot be lumped together. A similar but disaggregated exercise has been made in the case of Jordan, to identify how the various response options to the water crisis perform in terms of costs and benefits to the main interest groups and constituencies (Figure 4). Such mapping exercise helps understand why some options are preferred to others: an option with corresponding benefits accruing to powerful people is obviously more likely to be selected than one which brings costs to them, but its selection will also depend on how they affect other groups and, more importantly, on whether these groups have means to vent their dissatisfaction. The political economy of a particular setting will largely determine the decision-making process: this explains why the policy selected (or the energy and efforts later spent in implementing it) is sometimes at logger heads with, for example, economic rationality. In some cases, power is very lopsided and decision may veer towards options that are not "IWRM compatible".

But this accounting of costs and benefits is often more problematic than thought: the reason is that *interventions* on the hydrologic cycle (under the form of physical actions such as: building a dam, an interbasin transfer, a pumping station, a treatment station, or lining canals and shift from for furrow to drip irrigation) will often have unexpected impacts on users, aquatic ecosystems, and the environment in general. Many of these impacts occur underground (e.g. groundwater contamination) or over a long time span (e.g. salinisation of land). We now turn to these externalities and show how pervasive they are in the water sector, most particularly in water short basins.

Figure 4. Water reforms and stakeholders in Jordan: distribution of costs and benefits (Van Aken et al. 2008)



3 WDM interventions: hydrologic tricks in water short basins

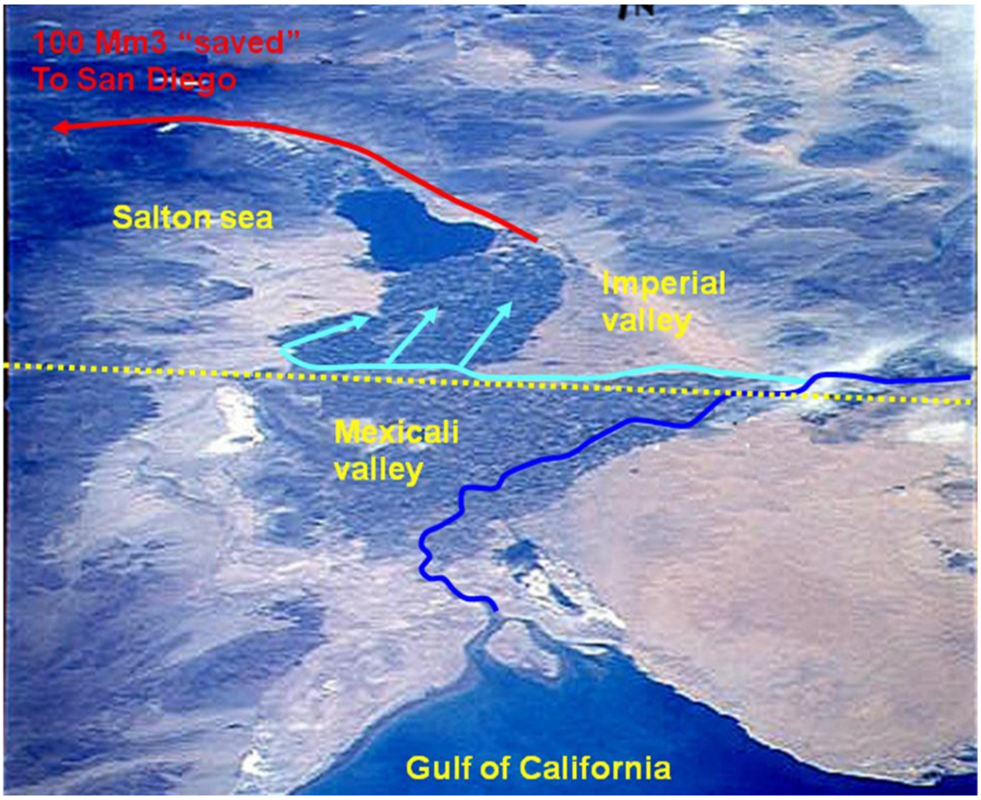
Reducing losses is a prominent part of WDM. This section shows that interventions justified by objectives of saving water through a reduction in losses often amount to reallocation. Third-party impacts of such interventions increased with the closure of the basin, that is, the degree of mobilisation and depletion of its renewable water resources.

Taking river basins as the unit for water management, we may define the degree of closure of a basin by the percentage of runoff that flows out of the basin without being depleted by some use or committed to downstream needs (including environmental services, dilution of pollution, flushing of sediments, or control of salinity intrusion in estuaries)(see Molle et al. 2007). Water short basins are typically basins that are closing, that is, where most or all available resources are depleted, at least during some part of the year. Basins with severe problems of scarcity, such as the Yellow, Colorado, Rio Grande, Nile, Jordan, Amu Darya, Syr Darya, Orontes, Cauvery or Lerma-Chapala, are all closed basins, at least during a large part of the year.

Closed or closing basins correspond to areas with major constraints of water scarcity where water savings are most needed: the *very definition* of a closed basin, however, seems to preclude the possibility of such savings. There has been widespread recognition that focusing on relatively low irrigation efficiency at the on-farm or secondary levels can be totally misleading (Frederiksen 1996; Keller et al., 1996; Perry, 1999; Molden and Sakthivadivel, 1999). By adopting a basin-wide perspective, it becomes clear that what appears as a loss at a given point flows back to the river or an aquifer and is often recycled by other users further downstream, provided there has been limited deterioration in water quality. The degree of appropriation and use of return flows -in other words the intensity of recycling of water within the basin- obviously increases with the degree of exploitation of available renewable resource, or of "closure" of the basin. In closed basins, any decision to further tap existing water (through diversion, pumping from watercourses, drains, or wells) at a given point of the hydrological cycle is almost certain to impact on existing users and/or the environment. What is stored, conserved or depleted at one point governs what is available at another point further downstream (Molle 2003). Whenever an individual, a village or the state taps a new source or increases the abstraction of an existing one, this is often tantamount to a mere reallocation: in other words, one may be almost sure to be robbing Peter to pay Paul, as the following examples illustrate.

The Los Angeles/San Diego urban area is a well-known water-thirsty area that relies of interbasin transfers, particularly diversion from the lower Colorado river. The alleged (and much celebrated) "win-win" agreement between Southern California Metropolitan Water Authority (MWA) and the Imperial Irrigation District (IID), which took place in 1998, includes the lining of the All-American Canal (AAC) by MWA and the usufructory right to an estimated 100 million m^3 (Mm^3) conserved through this intervention and granted to San Diego (CGER 1992). In fact, it is apparent that 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 2000) (see figure 5). From a total canal seepage of 100 Mm^3, 30 Mm^3 are captured by the La Mesa drain (which has been excavated to control the level of the aquifer) and 70 Mm^3 recharge the aquifer. The aquifer is tapped by individual and federal wells that irrigate a total of 19,000 ha, to which must be added 800 ha irrigated by the La Mesa drain. However, because of the increase in salinity estimated at 21.9 ppm/year, it is likely that negative impacts will eventually affect an area of 33,400 ha (Cortez-Lara 2004). The decrease in groundwater resources also renders the future supply of the growing urban areas more critical (Castro Ruiz 2004).

Figure 5. Reallocation of water to cities in the lower Colorado and impacts on third parties



Congress has lauded the lining initiative at AAC since 1988; the misgivings of the Mexican side have been addressed by stressing that the measure is in accordance with the Colorado compact, which only deals with surface water, and therefore conforms to existing legal arrangements. Focusing only on the American side of the deal allows decision-makers to picture the arrangement as a win-win situation and even to state that the "agreement was possible in part because there are few externalities" (Briscoe 1997). Win-win hydrologic situations in water short basins often have a forgotten, or sometimes conveniently, overlooked "lose" element, especially when surface-groundwater interactions are ignored.

Delhi is a sprawling city that draws its water supply mainly from the Yamuna river, but also from an unknown number of wells. Treated water is to be piped to Delhi, at a time where the capital is reaching 15 million dwellers and consumes 742 Mm^3/year, against a real demand estimated at 1,200 Mm^3/year. Since Delhi has no right on water of the Yamuna, the negotiations on the allocation of the river flow between the concerned states is a delicate issue. A MOU signed in 1994 attributed 725 Mm^3 out of 1200 Mm^3 to Delhi and the Sonia Vihar water treatment plant, inaugurated in June 2002, was to treat 232 Mm^3 from the Ganges river annually. Water is taken off the Upper Ganga canal, which serves large irrigation schemes north of Delhi, stored in a tank, treated and conveyed to Delhi through a giant 3.25 meter-diameter pipeline. In order not to impact on irrigation supply, the canal has been lined to avoid seepage and make use of the "losses" to increase supply to Delhi. It was soon discovered, however, that this seepage was the direct source of supply of hundreds of wells further downstream. This raised protests from farmers relying on groundwater in the vicinity of the canal and emotional statements from social activists who see food security in the area threatened (Shiva *et al.* 2002). This situation can be found in most of India, where use of surface and groundwater has developed to the point that the latter has now surpassed the former. Just like in the Imperial Valley case, redirecting seepage losses to cities was seen as the best way to increase supply without affecting existing uses but the "losses" were eventually found to be already tapped by other users.

Likewise, Molle and Miranzadeh's (2004) case study in central Iran sheds light on the multi-level interconnectedness of water users in a closed basin. The Zayandeh Rud basin covers 41,500 km^2 in the center of Iran. The Zayandeh Rud river originates in the Zagros mountains, where rainfall and snow are rather abundant, and traverses arid areas to empty into Gavkhuni swamp and a terminal salty lake. Flows from lateral valleys, mostly groundwater flows but also superficial runoff at flood times, initially contributed –albeit modestly- to the main river flow. Well drilling, enlargement or extension of qanats, water harvesting structures, small reservoir constructed by the state led to the closure of lateral sub-basins; in the main valley overextension of irrigation facilities, diversion to urban areas and industries, interbasin transfers to other cities increased withdrawals. Return flows come back to the river or replenish aquifers that are, in turn, tapped through wells. Overexploitation of the aquifer by farmers, compounded by the irrigation of "green belts" around the city, resulted in a decline of the water table. All this resulted in lower and more saline flows to the downstream areas (water entering the swamp area is extremely saline, with EC values as high as 30 dS/m during periods of low flow; Salemi et al. 2000) and the partial drying up of the swamp. In such a situation of overexploitation, all the available resources are depleted by beneficial uses, and the overall basin efficiency is close to 100% although irrigation efficiency at the scheme level is only around 50%. On the negative side, although the basin is a "recycling machine" with high overall efficiency, water reuse translates into degraded water quality and increased pumping costs; in all cases changes in management affect return flows and their appropriators. A typical shift of the use and benefit of water from downstream to upstream areas occurs: the tail end part of the basin, which was described by travellers in the 11th century as the paradise on earth, is now partly destroyed by salts and lack of water, and abandoned.

The reallocation problem described above also occurs at a smaller scale. When a farmer has access to a given amount of water (e.g. the water provided by a well) and invests in micro-irrigation, he usually uses the portion of water saved to expand his area, if this is possible (a common situation in arid countries where water, and not land, is a constraint); if he used to be water-short, uptake of water and evapotranspiration by the plant will increase because of improved supply (Burt and Styles, 1999). In both cases the benefits to the farmer increase, but the net amount of water *depleted* by the farmer is also on the rise. While this particular individual may benefit from the change the replication of this situation on a larger scale leads to a significant reduction of return flows (both superficial and groundwater flows, depending on the case), and to a diminution of supply to users who were tapping these flows, as well as to a drawdown of the aquifer.

In Morocco, ambitious plans to transform up to 400,000 ha of public irrigation schemes into micro-irrigation are all likely to backfire in some places, because of their impact on the recharge of the aquifers. Infiltration of water in the gravity irrigated systems of the Haouz, near Marrakesh, accounts for half of the recharge of the aquifer, and this aquifer is overexploited by farmers using wells both within and around the irrigation schemes. A massive shift to micro-irrigation, with the corresponding reduction in diversions transferred to urban areas, would have a dramatic impact on the aquifer.

Similar situations have been observed in various places like Valencia, Spain (García Mollá 2001), where drip irrigation has not reduced application rates, in the Kairouan plain, Tunisia (Feuillette 2001) or in Maharashtra, India (Regassa Namara, pers. com.): different types of micro-irrigation have been introduced and successful farmers have been able to grow cash crops like banana and to expand their cultivated areas. The level of water depleted had thus increased because of crop change, increase in cropping intensity, and expanded area, but all these (private) benefits have come at the (social) cost of an exacerbation of the overexploitation of the aquifer. In such cases, contrary to common belief, which sees micro-irrigation as a water-saving technology, its implementation can also result in greater water depletion.

The evidence is that in closed basins where pressure on the resource makes conservation most needed, there is often little –if anything- to be saved (see the collection of case studies in Molle and Wester, 2009). This statement, of course needs some qualification since there are notable exceptions. Where important quantities of water are lost to sinks it is possible to improve management so as to avoid such losses. This is the case, for example, in the irrigation systems of central Asia, in which large amounts of water collected by the drainage systems end up wasted in the desert. If percolation losses and return flows from irrigation are degraded in terms of quality they might be unfit for reuse and therefore losses by percolation or direct run-off should be minimized. This applies, for example, to the Jordan Valley and in major parts of the Indus basin where groundwater is saline, although saline sinks or lakes are considered to have environmental value. Another caveat concerns the costs incurred by possible successive pumping operations. Users near the coastline also have nobody downstream: according to WRI (1996), 40 percent of cities with populations over 500,000 are located on the coasts and the return flows from these areas cannot be utilized. In practice, wastewater from coastal cities is either treated and reused in peri-urban agriculture, or flows to the sea untreated, where it contributes to controlling salinity intrusion, as in Bangkok and Manila (obviously not an ideal option in terms of environmental management).

These specific cases notwithstanding, closed basins often offer limited scope for significant *real* overall water conservation. This does not mean, of course, the leakage in cities should not be reduced or that management in irrigation schemes should not be improved. But the implication for demand management in general and water conservation in particular is that potential changes in system efficiencies generally amount to a reallocation between users, often with unexpected third-party impacts, and not to real savings.

When constraints/incentives applied to users to reduce abstraction of water are effective, the problem of the impact of reduced return-flows on third parties using these flows must be addressed. Raising water charges to instil awareness of its scarcity is often advocated as a means to regulate abstraction and demand. The following section examines the effectiveness of such policy in surface irrigation.

4 Economic instruments in water use in agriculture: why is irrigation special

Apart from the conservation interventions reviewed in the preceding section, WDM is also concerned with constraining the amount of water diverted/abstracted by users. Several types of incentives are possible, including pricing, subsidies or taxes, campaigns to raise awareness, etc. However, policies often focus on the necessity to raise the price of water, so that users may get incentives to reduce use or to use water in the most economically beneficial activities. Another widely applied and pragmatic method to control use is the definition of quotas or allotments to the different users. This relates to the management of supply rather than to that of demand. This section argues that if WDM through pricing is often effective in domestic supply, it is not the case in the agricultural sector, where defining quotas appears to be more efficient and straightforward.

Building on the recognition of water as an economic good in the 1992 Rio and Dublin Conference, many economists and development banks have promoted the use of prices and markets as a way to regulate water demand and to put it in line with available supply (Tsur and Dinar 1995; Bhatia *et al.* 1994; Thobani 1997; Dinar and Subramanian 1997; Johansson 2000). The argument is that if the price in irrigation is almost nil, farmers will be encouraged to use a very large quantity before its marginal productivity becomes zero, consuming much more water than accepted standards and needs. This is explained to the layman by the parallel drawn with domestic supply: if tap-water is free, we might leave our tap on continuously or our neighbor might water his lawn lavishly. Conversely, if the water rate is set high, we will try to control our tap and reduce our monthly bill. These examples are familiar to the point of banality. A cursory perusal of the literature shows that the correlation between water wastage and underpricing has become axiomatic, as epitomized by James Wolfensohn (2000) who stated that “the biggest problem with water is the waste of water through lack of charging”.

Recently[1], however, a readjustment of the hopes that had been placed in economic instruments in general and pricing in particular has taken place. Tellingly, perhaps, the word “pricing” is absent from the Bonn conference 27 recommendations for action, issued in December 2001, and the use of economic instruments in managing water is not referred to in the 2002 Stockholm statement “Urgent action needed for water security”. More significantly, a recent policy document from the World Bank admits that “pricing promotes efficiency and conservation… but [that] there are few successful examples because of the economic and cultural difficulties of putting a value on a natural resource” (Pitman 2002). In 2003, the Bank’s new water resources sector strategy (World Bank 2003)

[1] In 1986, however, FAO and USAID (1986) already found that "water charges policies are unlikely to have any significant impact on the efficiency with which each individual farmers use water except in those extremely rare cases where at the same time: a) water is scarce, 2) the irrigation system delivers water on a demand basis (response to ad-hoc requests); c) water deliveries are measured."

acknowledges the “yawning gap between simple economic principles… and on-the-ground reality”. Analysts have pointed to several constraints and shortcomings, both at the theoretical and practical levels (see Small *et al.* 1989; Perry *et al.* 1997; Sampath, 1992, Savenije and Van der Zaag 2002, Bosworth *et al.* 2002 and the collection of papers in Molle and Berkoff, 2007a, available on the web). Some of these arguments are reviewed briefly here (see Molle and Berkoff, 2007b for more details).

The impact of prices on water use is conditional upon having a direct relation between the volume used and the cost to the user. The problem of metering is well known as the major objection and constraint to the application of pricing as a tool to change water use practices. For historical, technical, and administrative reasons a very small portion of irrigation schemes in the world have volumetric measuring devices at the individual level. Even in the European Union, this case is quite rare, although it has been ubiquitous in Australia for more than 40 years. Historically, irrigation has developed based on tapping plentiful water and quantitative aspects were not a great concern. In addition, in contrast with piped networks, installation of measuring devices in surface irrigation networks is often not easy, nor are measurements trusted when they are carried out. Such structures are easy to tamper with and the transaction costs of enforcing, monitoring, and collecting information are clearly beyond the capacity of most irrigation agencies in the South. Despite the principle that pricing “applies only when water charges are levied volumetrically - an exceedingly rare situation in the developing world”, Svendsen (1993) notes that “the argument is frequently invoked as though it applies to all allocative situations.”

In the absence of volumetric pricing, many analysts have remarked that the argument that prices “keep [the] farmer aware that water is not a free good, but [that] it has been provided at high cost and must not be wasted” is in fact likely to yield the opposite result, with farmers’ determined “to get as much as possible of the thing for which they have been taxed” (Moore 1989; see also Davis and Hirji 2003).

A second major constraint to the effectiveness of pricing on conservation is the fact that at low prices the elasticity of water use in irrigation is very low or nil. In other words, when the cost of water is, say, 1-5% of farmers’ income, significant relative increases will not affect behavior (assuming that the charge is volumetric). This is both common sense and confirmed by empirical evidence and modeling exercises (de Fraiture and Perry 2002; Abu Zeid 2001, Malla and Gopalakrishnan 1995; Perry 1996; Gibons 1987; Ogg and Gollehon 1989; Berbel and Gomez-Limon 2000).

The conclusion of most authors is that actual water charges have no impact on behavior (nor would they have if they were volumetrically based), and that raising them –tenfold or more- to find a degree of elasticity is economically and politically impossible. In the great majority of cases, even if charges were raised to cover full O&M costs (a very rare instance in the South) they would still be too low to have significant impact, in particular where water is rationed. Given the sensitivity of pricing issues, it is unreasonable to imagine that charges will ever be significantly higher than O&M costs because the government would have a hard time justifying that it charges users more than the actual cost of providing water. It is unrealistic to imagine that many governments would take the economic and political risks to define fees at deleterious levels, well above O&M costs, only for the sake of ‘encountering elasticity’.

Another argument is whether losses in irrigation schemes are due to farmers. Only the losses incurred at the farm level can be reduced by a change in farmers’ behavior (irrespective of whether this is induced by prices or not). In large-scale gravity irrigation schemes, these losses amount commonly to 50-70% of the water delivered at the head of the network (Davis and Hirji 2003). Depending on several factors, such as system layout, soil types, topography, and management, the share of these losses varies. For the case of the Mula Canal in India, Ray (2002) estimated that farmers as a whole receive only 30-35% of the amount of water diverted from the reservoir. This means that whatever improvement in management that farmers make concerns no more than one third of the water released, which drastically reduces the potential overall impact of such improvements. Regarding farmers' practices themselves, there is a crucial point which is generally ignored by analysts who paint farmers as the main culprits for the wastage of water. A large part of the losses is due to poor system management, that is, to the mismatch between supply and demand that results in excess flows at some points of the scheme and insufficient flows at others. These losses are due to poor management and scheduling or to inadequate design and poor hydraulic control structures (Meinzen-Dick and Rosegrant 1997). These causes remain largely independent of the users themselves; they relate to system management and even if farmer were to reduce farm-level diversion this would not automatically result in savings at the system level.

Setting substantial water charges and system-level savings are possible only if supply is –if not on-demand-, at least predictable and assimilated to a service. As Small (1987) aptly observed, "it is likely that once this prerequisite exists, the amount of "wastage" will be greatly reduced, thus lowering the potential efficiency gains from any subsequent attempt to introduce water pricing" at the level of the farmer. The final balance between losses in farmers' fields and in distribution varies considerably and requires proper investigation and description before policy measures are introduced for conservation.

Last, there is a major implicit contradiction between the existence of water scarcity and the alleged evidence of lavish or wasteful use of water. Tap water may be wasted because it is abundant (at an individual level) and because the possibility to "leave the tap open" exists and does result in wastage. The same may happen in irrigation schemes (the farm turnout is left open and allows continuous and free flow to the paddy fields, for example) but this is generally observed in schemes that are not water short. An irrigation scheme located in a water short basin is likely to receive water based not on farmers' demands or needs but on available supply. In such conditions water will generally be distributed by rotations, excess return flows will be limited, and supply will often fall short of the potential demand. In many situations of water shortages, users don't even know when they will be given water and in which quantity; they take whatever water is made available to them and this has little to do with the price they pay. Thus, the reasoning suggesting that profit-maximizing farmers are led to increase their use of water until its marginal product is zero does not apply simply because sufficient water is not available to users without restriction. Domestic and irrigation supply cannot be treated in the same fashion and generalizing theory across the board is misleading.

Exceptions to this can be found in contexts where distribution of irrigation water is akin to tap water. A good but rare example is the Canal de Provence, in Southern France. Another exception is the case of groundwater, where users have access, in the short term, to more water than they need and where the cost of abstraction is often quite significant. In such cases, there are incentives both to grow crops for which water requirements are lower (but only if this entails no reduction in net income) and also to save water at the plot level. Farmers who pump groundwater generally do not waste much water at the plot level because of the costs incurred (Bos and Wolters, 1990) but again, this rule has significant and widespread exceptions, as discussed by Shah *et al.* (2004), when the cost of energy (rural electricity supply and sometimes diesel) is very cheap or free.

All these points, to which can be added the difficulties to measure and monitor use, and to recover charges, explain why there is hardly any case in the literature that demonstrates that charging for surface irrigation water is instrumental in saving water. Charges may have other important functions, such as cost recovery, but this is a different matter. This stands in contrast with the emphasis put on WDM in the literature and policy-making. In fact, evidence from many countries, including those with both volumetric management and water scarcity like Israel, Jordan, Iran, California, Italy, France, Spain or parts of Morocco, suggests that supply management is adopted in the great majority of cases (see a review of those cases in Molle and Berkoff, 2009): in practice quotas, reasoned according to the characteristics of each locale, appear as the easiest and most efficient means of reducing consumption. Regulation through prices would be tantamount to putting financial pressure on users and eliminating those who have less financial capacity and capital to adjust. Such a mechanism is obviously politically very unattractive. Quotas, or reasoned reductions in supply, have two great advantages: first, they ensure a degree of transparency and equity in the face of scarcity; second they are directly effective in bringing use in line with available resources. Adaptation by users is made easier if supply is gradually, rather than abruptly, decreased and if supply – even if reduced - is predictable. When water is pressurized and metered like in an urban network, a combination of quotas and sharp increases in prices beyond it appears as a good option (as observed in a few cases in southern Europe). In conclusion, pricing mechanisms cannot be implemented in irrigation schemes with poor facilities; in more modern or better performing schemes it will be somewhat easier to achieve improvements in management, after which the potential for reducing demand by pricing will be much less.

5 Reallocation and its equity dimensions

Reallocation of water is the third main option of WDM. Water can be reallocated within agriculture, or between sectors, by shifting water to some particular use that is granted priority based on specific criteria. These criteria can be based on equity, as with the case of the reserve in South Africa, but they are generally based on economic efficiency. Enhancing economic water productivity, measured in dollars of output per cubic meter of water, drives many projects and policies.

Many countries have established policies to encourage diversification and the cultivation of higher value crops (in the MENA region, Morocco is a case in point). Crops grown for export markets have often received priority. There is an obvious economic benefit for the national economy as a whole to produce higher value rather than low value crops. Public irrigation schemes often encompass a diversity of farming systems, ranging from subsistence agriculture to higher value export crops. The different cropping systems are sometimes observed side-by-side and this spurs public policies to help modernise farms that grow cereals or other crops held as low value crops.

Economic growth, structural change and urbanization fuel demand for high-value products such as fruits, vegetables and meat (Rao *et al.*, 2004). But although the value of agricultural exports has risen dramatically, cereals continue to occupy in excess of 50% of the cultivated area worldwide, and fruits, vegetables and related high-value crops are confined to less than 7.5%. No doubt this share will rise but market demand remains the limit and these crops often remain confined to entrepreneurial farmers able to assume the capital costs and risks of high-return commercial agriculture. Access to groundwater greatly reduces water related risks, but financial strength, entrepreneurship and access to credit and market information are still all required. Market volatility generates income instability (Hazell *et al.*, 1989; Quiroz and Valdés, 1995; Combes and Guillaumont, 2002) and most poor farmers cannot be expected to incur such risks, even if market volatility can sometimes be moderated by state interventions.

In addition to financial and marketing risk, crop choice is governed by a host of other well- identified factors. These factors include i) labour constraints, ii) lack of capital, credit or desire to get indebted,

iii) lack of information on market demand, quality requirements, agricultural techniques and agrochemicals, or adequate skills etc., iv) land tenure uncertainty that hinders investments and adoption of perennial crops, v) drudgery and health risk, vi) soil, drainage or climatic constraints, vii) high marketing costs due to poor transportation means (World Bank, 2005a; Delgado, 1995) and lack of infrastructure (cold storage trucking, refrigeration etc.) (Barghouti *et al.*, 2004), viii) the (un)reliability of irrigation supply and possible water quality constraints (Burt and Styles, 1999), and last but not least, ix) farmers' strategies, including food security considerations and many ageing farmers with exit strategies and no desire to take risk with new ventures, or to face increased drudgery.

These constraints, and above all the finite outlet of markets, limit the scope for reallocation of water to crops with higher water productivity. In practice, the shift to higher value crops is often associated with an overall change in the type of agriculture, that is, adoption of micro-irrigation and capital intensive farming. Because of the risks and constraints mentioned above such a shift needs to be carefully studied and accompanied by adequate public policies. (In practice the promotion of micro-irrigation, for example, usually comes with government subsidies between 50 to 100%).

It must also be noted that high water use does not always imply low profitability and *vice versa*. 'Thirsty' crops with high returns include bananas (e.g. Jordan), rice (e.g. Egypt, Iran), sugarcane (parts of India) and qat (Yemen). Alfalfa may consume a lot of water but does not have to be low-value, e.g. when in rotation with cereals. Above all, paddy is seldom grown *because* water is free or cheap (Falkenmark and Lundqvist, 1998) but in response to numerous environmental, social and other factors, in addition of its attractive price. Crops with lower requirements may well not increase farmer incomes (and *vice versa*) and the impact on water productivity is far from self-evident. When high-value crops are also more water-intensive higher prices may cause an increase in total demand for water, a phenomenon Dinar and Zilberman (1991) have called 'the expansion effect.' In sum, the objectives of farmers (per ha income), managers (reduce demand), or economists (water productivity), often do not coincide, although policies sometimes posit otherwise.

It must also be noted that water reallocation may also occur between different types of farms, when there is a competition for land, water, or labour, for example when rich farmers outcompete small farmers by depleting groundwater resources through deeper and bigger wells. The equity implications of reallocation are then laid bare.

This also applied to the allocation of water among economic sectors, for which a similar reasoning is held. The World Bank's 1993 water policy and resource economists in general have disseminated the idea of the need for reallocation from low-value to high-value uses. This could be done by considering the opportunity cost of water when pricing it. The need for specific policies designed to ease reallocation is based on the assumption of an "allocation gap". Rosegrant and Cline (2002) posit that "there is considerable scope for water savings and economic gains through water reallocation to higher-value uses", while 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" (emphasis added). The World Bank's (1993) policy paper states that "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 of reallocating water towards higher-value uses and economic sectors.

There is overwhelming evidence at the world level that the allocation gap is small or nil (see Molle and Berkoff, 2009): indeed it is widely observed that cities, industries, tourists and golf courses get the upper hand both in times of shortage and in terms of long-term sectoral water allocation. Water is generally reallocated by a central decision of the state, although there are cases where market mechanisms can be found. This reallocation is sometimes politically difficult and cities prefer to overexploit aquifers or surface waters to the detriment of the environment. Reallocation is never effectuated through the use of administered prices but, rather, through a political *fiat* that embodies and heralds the economic and political pre-eminence of the city.

Acknowledging the 'yawning gap between simple economic principles… and on-the-ground reality' that has prevailed for decades, the World Bank (2003) reconsidered the issue and singled out two main reasons for this gap: the impossibility 'to explain to the general public (let alone to angry farmers) why they should pay for something that doesn't cost anything to produce,' and, second, the fact that 'those who have implicit or explicit rights to use of the resource consider (appropriately) such proposals [price hikes] to be the confiscation of property' (see Molle and Berkoff, 2007b). Intersectoral reallocation remains an important issue but quite independent from administered water pricing. It is not so much the lack of reallocation that poses a problem and incurs an economic loss - indeed reallocation does occur and the assumed gap is overemphasised- but, rather, the mechanisms for allocating water that matter: market mechanisms offer the substantial benefit to provide a monetary compensation to would-be sellers, against mere desappropriation; but their possible negative consequences (concentration of wealth, speculation, etc) must be addressed by adequate control mechanisms.

6 Conclusions

Nothing in the preceding discussion is meant to deny the need for more efficient management and regulation of water use. The examples given in this paper, however, illustrate that conservation in water-short situations is often tricky, sometimes counterproductive, and frequently amounts to reallocating water. This reallocation is often invisible because it occurs through complex surface and underground hydrological fluxes, and because it is masked by the inter-annual variability of supply. Even the introduction of micro-irrigation, commonly held as a water-saving technology, has been shown to commonly lead to increased water depletion and thus to alter water depletion patterns and allocation. Changing scale draws us from a mere question of cost-effectiveness of water-saving technology into a wider and thornier question of water allocation, rights to abstract water, and regulation of its use. Failure to recognize this point leads to further third party impacts and environmental degradation, since the most likely results of focusing on local efficiency rather than on basin allocation are growing scarcity for downstream users; the mining of aquifers; and the reduction of low flows below sustainable thresholds. Thus, interventions that may seem justified in view of a local cost-benefit analysis, in reality have negative impacts on other parts of the basin and are likely to be both inequitable (as they alter the pattern access to water) and economically flawed (when externalities are taken into account).

Acknowledging that the scope for real water savings in water short basins is limited does not mean that efficiency in use is not an issue. Use in the domestic and industrial sector, for example, is amenable to real savings in that wastewater is often not reusable and, in addition, often degrades the quality of river flows. When water is treated, such savings are all the more economically beneficial because of the costs incurred in restoring water quality. However, sticking to the common perception that water use in agriculture is overly wasteful is likely to lead to ill-conceived interventions. Failing to recognize that water management is to be addressed at the basin level, more so when scarcity is severe, perpetuates misunderstanding about water problems and inspires flawed responses. The ubiquity of the image of conventional irrigation as a backward practice, marred by efficiencies of 30-

40% among both officials and technicians is puzzling and daunting. It takes no account of the remarkable adjustments that users faced with water scarcity have made in the last two decades (Molle et al., 2010), not least the pump revolution that has allowed conjunctive use, access to aquifers, and recycling of water.

Water pricing, heralded as a crucial means to reduce water consumption, has been oversold. A host of reasons explains why there are so few, if any, convincing cases where high prices have curbed the use water in large-scale surface irrigation. Rather than raising prices to deleterious levels, a both socially and politically unattractive option, it is observed that the reasoned rationing of supply through quotas is generally a more viable solution. In any case, irrigation schemes with individual volumetric metering devices (and on-demand supply) are the exception rather than the rule.

Using water in a productive way may be considered as a collective objective. Within agriculture this means that higher value crops should be favoured. Public policies, which seek to foster a shift away from low value crops often overlook the constraints attached to the different existing farming systems, notably the risk attached to unregulated markets: under-capitalised or indebted farmers cannot afford to adopt capital-intensive agriculture without substantial support. In all cases the ceiling to high-value crops and diversification is fixed by market demand. It is also worth noting that some cash crops are also water intensive: therefore there is a disconnect and often an antagonism between objectives of land productivity and income maximization, water productivity, and sustainable use of water resources that is insufficiently recognized. As for increasing water productivity through intersectoral reallocation, there is little room for administered prices and the potential for economic gains is overstated: reallocation does happen, generally through central state decision, but this does not mean that this allocation is done in a way that fully takes care of externalities and induced costs. Market mechanisms offer an alternative to state reallocation that ensures financial compensation but most existing institutional settings do not allow for such a mechanism.

In summary, water demand management options are very much desirable in order to achieve conservation or reduction in demand that allow for a more sustainable use of water resources, as opposed to continued reliance on increasingly costly supply augmentation options. Yet such policies must be designed with caution, taking into consideration, in particular, the complexity of hydrology and farming systems, rather than promoting ready-made technological fixes or economic recipes. With less emphasis on ideology or dogmatism and more attention to site-specific conditions and constraints, decision-makers will design sounder policies, while often discovering the uncomfortable truth that policy options have a more reduced potential than usually believed or hoped for.

References

Abu-Zeid, Mahmoud (2001) Water pricing in irrigated agriculture. *Water Resources Development* 17(4), pp. 527-538.

Barghouti, S., Kane, S., Sorby, K. and Ali, M. (2004) *Agricultural Diversification for the Poor. Guidelines for Practitioners.* Agriculture and Rural Development Discussion Paper 1. World Bank, Washington, DC.

Berbel J. and J.A. Gomez-Limon (2000) The impact of water-pricing policy in Spain: an analysis of three irrigated areas. *Agricultural Water Management* 43, pp. 219-238.

Bhatia, R., Cestti, R., & Winpenny, J. (1994) *Policies for water conservation and re-allocation: good practice cases in improving efficiency and equity.* World Bank Technical Paper, World Bank, Washington, DC.

Bos, M.G. and W. Walters (1990) Water charges and irrigation efficiencies, *Irrigation and Drainage Systems* 4: 267-268.

Bosworth, B.; Cornish, G.A; Perry C.; C.J.; F. van Steenbergen. 2002. *Water charging in irrigated agriculture; lessons from the litterature*. HR Wallingford Ltd. Wallingford, UK. OD145.

Briscoe, J. 1997. Managing water as an economic good. Rules for reformers. In Kay, M.; Franks, T.; Smith, L. (Eds.), *Water: Economics, management and demand*. London, UK: E & FN Spon. pp. 339-361.

Brooks, D.; Brandes, O.M. and Gurman, S. 2009. Making the most of the water we have: the soft path approach to water management. Erathscan: London.

Brooks, D. B. 1997. Water Demand management: conceptual framework and policy implementation. In Brooks, D.B.; Rached, E.; Saade, M., ed. 1997. Management of water demand in Africa and the Middle East: Current practices and future needs. IDRC.

Burt, C.M. and Styles, S.W. (1999) *Practices in Irrigation Impact on Performance.* FAO Water Report No. 19. Rome.

Castro Ruíz, J.L. 2004. El revestimiento del Canal Todo Americano y la oferta de agua urbana en el valle de Mexicali: escenarios futuros. In Vicente Sánchez Munguía (Coord.) *El revestimiento del Canal Todo Americano: la competicion o cooperacion por el agua en la frontera mexico-Estados Unidos*. Mexico: Playa y Valdez.

CGER (Commission on Geosciences, Environment and Resources). 1992. California’s Imperial Valley: a “win-win” transfer? In “Water transfers in the west: efficiency, equity, and the environement. The National Academy of Sciences.

Combes, J.-L. and Guillaumont, P. (2002) Commodity price volatility, vulnerability and development. *Development Policy Review* 20 (1), 25-39.

Cortez Lara, A.A. 2004. El revestimiento del Canal Todo Americano y el Valle de Mexicali: ¿equilibrio estatico de mercado ó equilibrio de Nash? In Vicente Sánchez Munguía (Coord.) *El revestimiento del Canal Todo Americano: la competicion o cooperacion por el agua en la frontera mexico-Estados Unidos*. Mexico: Playa y Valdez.

Cortez Lara, Alfonso y María Rosa García Acevedo, M.R. (1999). “The lining of the All-American Canal: The forgotten voices*”. Natural Resources Journal*, 40(2): 261-279.

Davis R. and Hirji R. (Series eds) (2003) *Water Conservation: Irrigation.* Water Resources and Environment, Technical Note F2. World Bank, Washington, DC, 27 pp.

De Fraiture, C. and C. Perry (2002) *Why is irrigation water demand inelastic at low price ranges?* Paper presented at the conference on irrigation water policies: micro and macro considerations, 15-17 June 2002, Agadir, Morocco.

Delgado, C.L. (1995) Agricultural diversification and export promotion in sub-Saharan Africa. *Food Policy* 20 (3), 225-243.

Dinar A and Subramanian A. 1997. *Water pricing experiences: an international perspective*. World Bank Technical Paper No. 386. Washington DC: World Bank.

Dinar, A. and Zilberman, D. (1994) Economía de las tecnologías modernas de riego: lecciones de la experiencia Israelí. *Revista de Estudios Agro-Sociales* 167(1), 155-183.

Falkenmark, M. and Lundqvist, J. (1998) Towards water security: Political determination and human adaptation crucial. *Water Resources Journal* 198, 12-28.

FAO. 1998. Six-million-dollar-programme launched to help farmers to grow "more crop per drop". http://www.waternunc.com/gb/fao1gb.htm

Feuillette, S. 2001. *Vers une gestion de la demande sur une nappe en accés libre: exploration des interactions resources usages par les systèmes multi-agents. Application à la nappe de Kairouan, Tunisie Centrale*. Ph.D. diss., Montpellier: Université de Montpellier II.

Frederick, K. D. 1993. Adaptive responses to climate change: Demand management. In Ballentine, T. M.; Stakhiv, E. Z. (Eds.), Proceedings of the First National Conference on Climate Change and Water Resources Management. Alexandria, VA, USA: Institute for Water Resources. pp.IV/54-60.

Frederiksen, H. D. 1996. Water crisis in developing world: Misconceptions about solutions. *Journal of Water Resources Planning and Management*, 122(2):79-87.

García Mollá, M (2001) *Análisis de la influencia de los costes en el consumo de agua en la agricultura valenciana. Caracterización de las entidades asociativas para riego*. Unpublished Ph.D. Thesis.

Gibbons, D. C. (1987) *The economic value of water*. Resources for the Future, 101 p.

Gleick, P. H. 2003. Global freshwater resources: soft-path solutions for the 21^{st} century. *Science*, Vol. 302. Nov. 2003, pp. 1524-1528.

Hamdy, A., Abu-Zeid, M., Lacirignola, C., 1995. Water crisis in the Mediterranean: Agricultural water demand management *Water International*, 20(4): 176–187.

Hazell, P., Jaramillo, M. and Williamson, A. (1989) *How Has Instability in World Markets Affected Agricultural Export Producers in Developing Countries?* Working Paper. Agriculture and Rural Development Department, World Bank, Washington, DC.

Johansson R C. 2000. *Pricing Irrigation Water: A Literature Survey*. World Bank, Washington, D. C. 80pp.

Keller, A., Keller, J. and D. Seckler (1996) Integrated water resources systems: theory and policy implications, Research Report 3, IWMI, Colombo, 15 p.

Malla, Parashar B. & Chennat Gopalakrishnan (1995) Conservation effects of irrigation water supply pricing: case study from Oahu, Hawaii. *Water Resources Development*, Vol. 11, No. 3, pp. 233-243.

Meinzen-Dick, R. and M. W. Rosegrant (1997) Water as an economic good: incentives, institutions and infrastructure, in *Water: Economic, Management and Demand*, Melvyn Kay, Tom Franks and Laurence Smith (eds.).

Merrett, S. (2003) The urban market for farmers' rights. *Irrigation and Drainage* 52, 319-326.

Molden, D.; and R. Sakthivadivel (1999) Water accounting to assess use and productivity of water. *Water Resources Development* 15(1/2): 55–71.

Molle, F. 2003. *Development trajectories of river basins: a conceptual framework*. Research Report No 72, Colombo: IWMI. http://www.iwmi.cgiar.org/pubs/pub072/Report72.pdf

Molle, F., Berkoff, J. (eds.) 2007a. Irrigation water pricing: the gap between theory and practice. CABI: Wallingford, UK and Cambridge, MA, USA.

Molle, F., Berkoff, J. 2007b. Water Pricing in Agriculture: Mapping the Debate in the Light of Experience. In F. Molle and J. Berkoff (Eds.) "Irrigation water pricing: The gap between theory and practice", Chapter 2. Comprehensive Assessment of Water Management in Agriculture. CABI: Wallingford, UK and Cambridge, MA, USA.

Molle, F., Wester, P. (eds.) 2009. River basins: trajectories, societies, environments. Cabi: Wallingford, UK and Cambridge, MA, USA.

Molle, F., Wester, P.; Hirsch, P. 2007. River basin development and management. In Water for food, water for life: A Comprehensive Assessment of Water Management in Agriculture, Chapter 16. edited by David Molden. London: EarthScan, pp. 585-624.

Molle, F.; Berkoff, J. 2009. Cities vs. Agriculture: A review of intersectoral water transfers. *Natural Resources Forum* 32(2009): 6-18.

Molle, F; M. Miranzadeh. 2004. *Robbing Yadullah's water to irrigate Saeid's garden: Hydrology and water rights in a village of central Iran*. Research Report. Colombo: International Water Management Institute. Forthcoming.

Molle, F.; Venot, J.-P., Lannerstad, M.; Hoogesteger, J. 2010. Villains or heroes? Farmers' adjustments to water scarcity. *Irrigation and Drainage* 58(2010): 1–13.

Moore, M. 1989. The fruits and fallacies of neoliberalism: The case of irrigation policy. *World Development* 17 (11), 1733-1750.

Ogg, C.W. & Gollehon, N.R. 1989. Western irrigation response to pumping costs: a water demand analysis using climatic regions, *Water Resources Research*, 25(5), pp. 767-773.

Perry, C. J. 1999. The IWMI water resources paradigm: Definitions and implications. Agricultural Water Management, 40(1):45-50.

Perry, C.J. (1996) *Alternative to Cost Sharing for Water Service to Agriculture in Egypt.* IIMI Research No. 2. International Irrigation Management Institute, Colombo, Sri Lanka.

Perry, C.J.; Rock, M. and David Seckler. 1997. *Water as an economic good: a solution, or a problem?,* Research Report 14, IWMI, Colombo, 17 p.

Pitman, George Keith (2002) Bridging troubled water: assessing the World Bank water resource strategy. World Bank Operations Evaluation Department. Washington DC: The World Bank.

Quiroz, J.A. and Valdés, A. (1995) Agricultural diversification and policy reform. *Food Policy* 20(3), 245-255.

Rao, P.P., Birthal, P.S., Joshi, P.K. and Kar, D. (2004) *Agricultural Diversification in India and Role of Urbanization.* Markets, Trade and Institutions Division. International Food Policy Research Institute, Washington, DC.

Ray, Isha (2002) Farm-level incentives for irrigation efficiency: some lessons from an Indian canal. Draft.

Rosegrant, M.W. and Cline, S. (2002) The politics and economics of water pricing in developing countries. *Water Resources Impact* 4(1), 6-8.

Salemi, H.R., A. Mamanpoush, M. Miranzadeh, M. Akbari, M. Torabi, N. Toomanian, H. Murray-Rust, P. Droogers, H. Sally, A. Gieske. 2000. *Water management for sustainable irrigated agriculture in the Zayandeh Rud Basin, Esfahan Province, Iran.* IAERI-IWMI Research Report No 1.

Sampath, R. K. (1992) Issues in irrigation pricing in developing countries. *World Development*, Vol. 20, No. 7, pp. 967-977.

Savenije H H G and van der Zaag P. 2002. Water as a economic good and demand management: Paradigms and pitfalls. *Water International*, Vol 27 (1) 98-104.

Shah, T.; Scott, C.; Kishore, A.; Sharma, A. 2004. *Energy-Irrigation nexus in South Asia: improving groundwater conservation and power sector viability*. Research Report No 70. Colombo: International Water Management Institute.

Shiva, Vandana; Jafri, A.; Jalees, K. 2002. *Ganga is not for sale*. http://www.inmotionmagazine.com/global/vshiva2.html

Small, L. (1987) *Irrigation Services Fees in Asia.* ODI paper 87/1c, London, 14 pp.

Small, L. E.; Adriano, M. S.; Martin, E. D.; Bhatia, R.; Shim, Y. K.; Pradhan, P. (1989) *Financing irrigation services: A literature review and selected case studies from Asia*. Colombo, Sri Lanka: IIMI. ix, 286p.

Svendsen, M. 1993. The impact of financial autonomy on irrigation system performance in the Philippines. World Development, 21(6):989-1005.

Thobani M. 1997. Formal water markets: why, when, and how to introduce tradable water rights. *World Bank Research Observer*; 12(2), August 1997, 161-79

Tsur Y and Dinar A. 1995. *Efficiency and equity considerations in pricing and allocating irrigation water*. Policy Research Working Paper 1460. The World Bank. 40pp.

Van Aken, M.; Molle, F.; Venot, J.-P. 2009. Squeezed dry: the historical trajectory of the lower Jordan river basin. In *River Basins Trajectories: Societies, Environments and Development*, edited by F. Molle and P. Wester, pp. 20-46. CABI: Wallingford, UK and Cambridge, MA, USA.

Winpenny, J.T. (1997) Demand management for efficient and equitable use, in Water: Economic, Management and Demand, Melvyn Kay, Tom Franks and Laurence Smith (eds.).

Wolfensohn, James D. 2000. Press Conference, Washington, DC, April 12, 2000.

World Bank (2005a) *Shaping the Future of Water for Agriculture. A Sourcebook for Investment in Agricultural Water Management.* Agriculture and Rural Development, World Bank, Washington, DC.

World Bank. 2003. World Bank water resources sector strategy: Strategic directions for World Bank engagement. Washington, DC, USA: World Bank.

WRI (World Resources Institute). (1996). *World resources 1996-97: A guide to the global environment—The* urban environment. Washington DC: WRI, World Bank and Oxford University Press.

WRI. 1998. World Resources 1998-99: Environmental change and human health. A joint publication by the World Resources Institute, the United Nations Environment Programme, the United Nations Development Programme, and The World Bank. http://population.wri.org/pubs_content_print.cfm?ContentID=1315

Zeitoun, M. 2009. The Political Economy of Water Demand Management in Yemen and Jordan: A Synthesis of Findings. Water Demand Management Research Series. Regional Water Demand Initiative in the Middle East and North Africa. IFAD, IDRC: Cairo.