1 River Basin Trajectories: an Inquiry into Changing Waterscapes

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Introduction

This book is concerned with 'river basin trajectories', loosely defined as the long-term interactions between societies and their environments, with a focus on the development and management of water and associated land resources (Molle, 2003). A basin trajectory encompasses human efforts to assess, capture, convey, store, share and use available water resources, thereby changing waterscapes and turning parts of the hydrological cycle into a hydro-social cycle (Wester, 2008). It also includes human efforts to deal with the threats posed by particular 'shock events', such as droughts, floods and contamination incidents, and to achieve a degree of environmental sustainability. Last, a basin trajectory includes institutional change and the shifting relations of power that govern access to, and control over, water resources. While this book focuses on human-induced environmental and hydrological transformations, its chapters also show how environmental change impacts on society and influences policy making. This includes the generation and particular social distribution of costs and risks, and shifts in the very conception of, and values attached to, nature.

The idea that the river basin is the 'natural' and most appropriate unit for water resources development and management has strongly influenced water–society relationships in the past 150 years (Molle, 2006; Warner *et al.*, 2008). Late in the 19th century it nurtured utopias and political struggles concerning the relationships between central and local power in countries such as Spain, France and the USA (Molle, 2006). Based on colonial experiences with water resources development in the Indus (van Halsema, 2002) and the Nile (Willcocks, 1901) basins in the early 20th century and the establishment of the Tennessee Valley Authority (TVA) in the USA during the 1930s (Lilienthal, 1944), the river basin became the unit where 'unified' or 'comprehensive' water resources development was to take place. This approach focused on the full utilization of rivers, multi-purpose dams, and wider regional development planning (White, 1957).

With time, and partly in reaction to significant modifications of river systems by hydraulic infrastructure and human water use, the river basin became the pivotal geographical unit for integrated water resources management (IWRM). The aim of this approach is to take into account, and reconcile conflicts arising from, the interactions between surface water and groundwater, water quantity and quality, human use and environmental functions, and scales and sectors of management (GWP, 2000; Grigg, 2008). More particularly, questions of river basin governance, with the vexing issue of cross-scale interaction and integration, came to the fore, as water problems were increasingly recognized as managerial, societal and political (Molle *et al.*, 2007). Watershed movements and river basin organizations (RBOs) of various stripes have emerged to address these concerns.

The choice of the river basin as the management or governance unit is not undisputed. While there is an obvious (physical) logic for working with hydrological units in which the generation and use of water resources are largely coterminous, it is also well recognized that river-basin-based approaches suffer from 'tunnel vision' (Molle *et al.*, 2007). Many drivers and consequences of river basin dynamics can be observed outside the basin, where solutions to local problems may also lie. In addition, even on a physical plane, river basin boundaries may not be relevant, for example in the case of small islands, deltas, flood plains or coastal areas. The occurrence of aquifer systems that are non-coterminous with river basins, or of interbasin transfers, is also frequent and demands consideration of linkages with adjacent basins. Yet all these particular situations can be treated as extensions of the river basin concept, and the influence of external factors can be considered through specific examination of the interactions of a river basin with its physical, economic and political 'environment'.

Water challenges, in the form of scarcity, excess or pollution, can be responded to in many different ways. Although droughts seem to call for dams, floods for dikes, and water pollution for treatment plants, response options are often much broader. Flood damage can be controlled locally by infrastructure (upstream dams, dikes, pumping stations) and also by more careful land-use planning (avoiding settlement in flood-prone areas), efficient flood warning, changes in upstream land cover, restoration of buffer areas, etc. Situations of water scarcity can be responded to in three different ways: supply augmentation (more water mobilized through dams, canals or pumps); demand management (including reducing absolute demand or saving water to expand uses); and (re)allocation (redefining access to a given amount of water) (Molle, 2003). Although the term 'river basin trajectory' may suggest there is a simple linearity in the development of river basins from supply augmentation, through demand management to water (re)allocation (Molden *et al.*, 2005), the chapters in this book show that these three responses occur simultaneously and at different scales.

Technical and economic rationality have long inspired ways to select among available options by proposing various types of sophisticated cost–benefit analyses and other impact assessments. The history of water resources development (and that of public investment in general), however, abundantly shows that 'good intentions are not enough' (Green, 1996) and that these techniques are value laden, prone to distortion, and often justifications of projects that have (already) been decided upon, on political or other grounds (Berkoff, 2002). It also shows that options are never equivalent and that they entail flows of benefits and costs (financial, political or otherwise), and risks that accrue to particular sectors or groups of society. The identification of risks and costs is made more complex by the fact that interventions in the hydrological cycle tend – and increasingly so when pressure on water resources rises – to generate externalities in terms of modifications of the hydrological regime that affect users or residents elsewhere in the basin (Molle, 2007).

The question of political power and decision making – what are the options and who decides – is at the core of the 'shape' of a particular basin trajectory. The distribution of decision-making power and the political clout of different groups of stakeholders in society – in other words a particular power configuration or governance regime – are key to defining allocation or dam management rules, the decision to build another dam, or the establishment of particular water-related institutions. A defining characteristic of river basin trajectories is the political struggles surrounding the ways water is owned, allocated and managed, and 'over the right to define what a water right entails' (Boelens and Zwarteveen, 2005).

One particular and generic aspect of a basin trajectory is the closure of a basin. *Basin closure* occurs when the quantity of water abstracted is too high to ensure regular supply to downstream users or sufficient outflow to dilute pollution, control salinity intrusion, flush sediments and sustain healthy ecosystems at the mouth of the river (Seckler, 1996; Molle, 2003; Molden *et al.*, 2005; Molle *et al.*, 2007). This phenomenon (illustrated in Fig. 1.1) can be transient when it occurs only in a few dry months, and the basin is said to be closing, or almost permanent, when the basin is said to be closed. Basin closure occurs due to the 'overbuilding' of water infrastructure in river basins for the extraction of surface water and groundwater, to the point that more water is consumed by agriculture, industry and humans than is renewably available (Molle *et al.*, 2007). Rivers no longer reaching the sea or contracting lakes are the most visible signs of basin closure, as exemplified by the Colorado River and the Aral and the Dead Seas.

The process of river basin closure induces increased competition between water use(r)s, and water scarcity reaches such a level that the exploitation limits become evident. However, using the term 'water scarcity' to describe situations of water overexploitation is dangerous, as it obscures issues concerning unequal access to, and control over, water (Bakker, 1999; Mehta, 2001). For most people, water scarcity is caused by competition between water uses and by political, technological and economic barriers that limit their access to water, rather than by physical water scarcity. Water scarcity is caused not only by variability in supply (supply-induced scarcity) or increases in population (demand-induced scarcity) but also by the overdevelopment of water resources, the selective entitlement of water rights and resource capture by better-off people, which Homer-Dixon (1999) terms structural scarcity. The design and social control over water technologies such as dams, pipelines and irrigation canals lead to what Vincent (2004) terms designed water scarcity, which influences who gets access to water.

Basin closure and water overexploitation tend to spur water quality decline, intersectoral water transfers, inequitable water allocation and reduced access to water (Molle *et al.*, 2007). The inequality in access to water and the conflicts between the different users of water call for new approaches to water management (Mehta, 2001). The construction of large dams, irrigation schemes, interbasin transfer schemes and groundwater pumps create path dependency and lock-in situations (Sexton, 1990). The socio-ecologies that become dependent on these technologies and the water resource base are formidable and very difficult to reverse (Shah *et al.*, 2003). While the overbuilding of river basins results in a situation that constrains the scope for reducing water use, it also radically alters the role that hydrocracies need to play, from centralized water resource developers to regulators and facilitators of decentralized water governance.

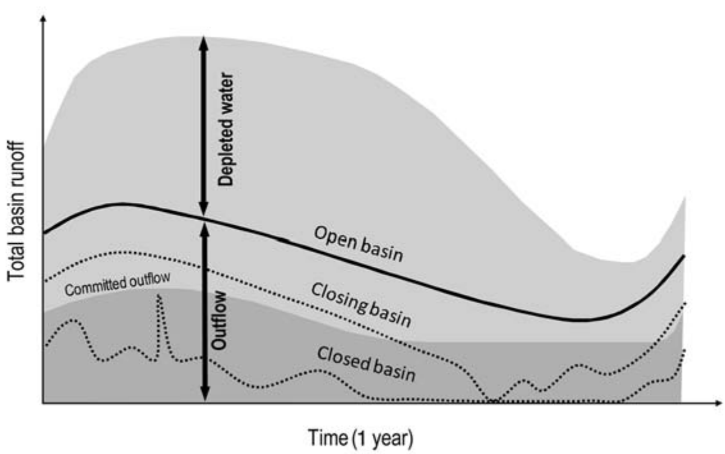

Fig. 1.1. The process of basin closure.

This book presents a rich analysis of 11 river basin trajectories. Each chapter provides a historical perspective on river basin development, highlighting the particular set of physical and human features that have shaped basin trajectories. All the authors have faced the double challenge of providing historical depth to their account while, at the same time, combining analyses of both environmental and institutional transformations. Because of the scale chosen, that of medium river basins, it was not possible to include the details of more local processes, such as changes in the management or governance of irrigation systems.

The 11 river basins investigated are mostly located in one country (the Zayandeh Rud in Iran, the Krishna and the Bhavani in India, the Merguellil in Tunisia, the Lerma–Chapala in Mexico, the Yellow in China, the Ruaha in Tanzania, and the Murray–Darling in Australia); other basins include the Olifants (South Africa) and the Colorado (USA) basins, which have their lower tips located in Mozambique and Mexico, respectively, and the Jordan basin, whose study is limited to Jordan. Five basins are located in federal countries (USA, Mexico, Australia, India), where relationships between the federal and state governments appear to be a crucial dimension of basin management and governance. The 11 river basins all face conditions of water scarcity, with a few particularly acute cases (Jordan, Zayandeh Rud, Lerma–Chapala).

This chapter presents general findings and reflections drawn from the river basin trajectories analysed in this book, occasionally enriched by evidence drawn from other basins in the world. It attempts to both identify commonalties and emphasize the specificity of each basin. It starts with a discussion on ideologies and models of river basin management and then describes four widely observed processes related to river basin trajectories. The responses of society to the issues raised by basin trajectories are then discussed. Last, conclusions are drawn.

Drivers of Change and Competing Paradigms

River basin development has long been predicated on an ideology of domination of nature, where 'conquering', 'harnessing' or 'taming' the wilderness were touted as a civilizing mission made possible by science and advances in technology. The development of irrigation was central in wider state settlement policies, whether it was to settle a nomadic population, as in Jordan (Chapter 2) or in Tunisia (Chapter 7), provide jobs after the two World Wars to returning servicemen in Australia (Chapter 12) and South Africa (Chapter 3), break up haciendas and colonize them with a new type of industrious farmer devoted to 'revolutionary irrigation' in Mexico (Chapter 4; Aboites, 1998), or strategically occupy land (as in the USA, Chapter 6; or Israel, Lipchin, 2003). In the post-World War II period, irrigation held the promise of feeding the masses, raising rural income and – in the particular context of the Cold War – enlisting 'development' and food self-sufficiency in the struggle against communism. Projects were churned out based on the expectation of large increases in yields, optimistic cropping intensities, and adoption of cash crops.

The transition from local water control to large-scale water resources development by the state, based on river basins, was intimately linked to the 'hydraulic mission' of the hydraulic bureaucracies (hydrocracies) created in the 19th and 20th centuries. Wester (2008) defines the hydraulic mission as:

> the strong conviction that every drop of water flowing to the ocean is a waste and that the state should develop hydraulic infrastructure to capture as much water as possible for human uses. The carrier of this mission is the hydrocracy who, based on a high-modernist world-view, sets out to control nature and 'conquer the desert' by 'developing' water resources for the sake of progress and development.

The hydraulic mission era, which ended in the 1970s in most affluent countries, was marked by the growth of powerful state hydrocracies, such as in Mexico (Chapter 4), where the logo of the Ministry of Hydraulic Resources was *Por la Grandeza de México* (For the Greatness of Mexico). Many of the senior hydrocrats manning the hydrocracies were educated in the West, notably in the USA, where the Bureau of Reclamation trained 'a new generation of Mexican hydraulic engineers' (Chapter

4) as well as engineers of many other countries, where the export of the TVA model was attempted (see Ekbladh, 2002; Molle, 2006).

The hydraulic mission era was characterized by a massive injection of public money in all countries and 'blatant subsidies and political favours' in the USA (Chapter 6; Worster, 1985; Reisner, 1993). These subsidies were a result of the recognition of the failure of private irrigation initiatives at the end of the 19th century, such as in Australia (Chapter 12), India (Chapter 10) or the western USA (Chapter 6), and also of the overriding political goals attached to irrigation development. In the USA this phase was associated with 'a "private commodity" paradigm, featuring an emphasis on water development and the rights of individual rights-holders' (Chapter 6).

This first phase of agricultural growth and modernization clearly marked the period from 1960 to 1990 in the Ruaha basin in Tanzania (Chapter 8). It was later substituted by a narrative of efficiency, environmentalism and water reallocation during the period 1995–2005. While in the former period, water and land were seen to be abundant, the latter drew from a growing perception of water as a finite supply and concerns over power cuts. A similar shift emerged in most basins, albeit at slightly different times. In the USA, a 'public value' paradigm, emphasizing resource protection, value pluralism, and democratic (i.e. collective and participatory) decision making, took root (Chapter 6). In the Murray–Darling basin (Chapter 12), the water reforms beginning in the late 1980s were also the product of changing ideas about how public institutions should be organized and operated. There was a widespread feeling that decision making could no longer be left to small groups of engineers who had spent their careers dealing mainly with water resources infrastructure. Under the new arrangements, the basin's river system was to be managed to conserve biodiversity and improve sustainability as well as for production. In the Olifants basin (Chapter 3), environmental and social considerations were incorporated into the 1998 Water Law, which triggered attempts at broadening participation of stakeholders and quantifying environmental flows. In China (Chapter 5), the Ministry of Water Resources brought forward ideas for the conceptual transformation of water resource development and management from engineering-dominated approaches to approaches based on demand management and the value of water resources (a shift from emphasis on *gondchengshuili*, engineering water benefits, to *ziranshuli*, broader water resources benefits).

These changes were the result of a change in societal values linked to growing affluence and awareness of environmental degradation. In the Colorado basin (Chapter 6), the national goal of western settlement based on water resources development also created something heretofore missing from the region: an urban constituency drawn to the aesthetic and environmental amenities of the region, supportive of public lands and other collective resources, and emphasizing quality of life over return on investment. As Kenney notes (Chapter 6), the inherent incompatibility of the two paradigms suggests that they have evolved sequentially and incrementally rather than simultaneously. In China, however, the two attitudes are linked to competing philosophies and seem to have always coexisted (Chapter 5): Confucianism and the Naturalist school of thought sought to explain nature on the basis of the complementary cosmic principles of yin and yang and saw man as a natural master of nature. Taoism, on the other hand, saw water as 'the supreme moral example of the stricture to find harmony with "the way" (tao), (…) as an object of contemplation intending to reveal moral truths … something to be admired rather than controlled, … with gardens as a place of contemplation where it was possible to connect with the ultimate realities of nature, and to escape worldly concerns.'

With the growing recognition of the associated social and environmental costs, and also with the decreasing availability of suitable dam sites, the hydraulic mission ran out of steam in most affluent countries in the 1970s (Barrow, 1998). Priority shifted towards water quality and environmental sustainability, setting the stage for a resurgence of the river basin concept in the 1990s. This resurgence was strongly inspired by the ecosystem approach, in which a river basin is seen as an ecosystems continuum and water as an integral part of ecosystems (Marchand and Toornstra, 1986). In many ways, this is a reaction to the construction bias of the hydraulic mission era, but proponents of the ecosystem approach are adamant that 'water resources should be managed on the basis of river or drainage basins in an integrated fashion, with a continued and deliberate effort to maintain and restore ecosystem functioning within both catchments and the coastal and marine ecosystems they are connected with' (IUCN, 2000). In the early 1990s, the centrality of river basins for environmental governance was reflected in the Dublin Principles (ACC/ISGWR, 1992) and the formulation of IWRM approaches, and was later formalized by the European Union in its Water Framework Directive (EU, 2000).

Major Processes at Work in River Basin Trajectories

River basins are very different from one another. However, the 11 story-lines that follow, as well as the wider bibliography on river basin development and management, allow us to identify generic processes that are at work in most river basin trajectories. These are: (i) the overbuilding of river basins; (ii) the overallocation of entitlements; (iii) the overdraft of reservoirs and aquifers; and (iv) the double squeeze of agricultural water use, due to declining water availability and quality on the one hand and rising urban and environmental needs on the other.

Overbuilding of river basins

The overbuilding of river basins is a socially constructed process that generates basin closure through the overextension of the water abstraction capacity, in general for irrigation. Decision makers are faced with powerful incentives for continued public investments in irrigation infrastructure. Politicians, whether at the local or government level, have long identified iconic, large-scale projects as the best way to build up constituencies and state legitimacy with public funds. Hydrocracies vie to maintain and expand their bureaucratic power (sustained budgets and fringe benefits, upholding of professional legitimacy, etc.). Private consulting and construction firms, often linked to particular politicians/parties, look for business opportunities. Last, development banks and cooperation agencies also have vested interests in maximizing the disbursement of funds (Chambers, 1997).

The overdevelopment of water-use infrastructure, principally irrigation schemes, generates water scarcity 'mechanically'. When most available resources are committed and little 'slack' remains in the hydrological regime of a particular river basin, any substantial drop in available resources below average values is likely to result in shortages for some users. With a growing hydrological variability due to climate change and a tendency to mismanage carry-over stocks in reservoirs (managers being under pressure to generate electricity or to release water at the cost of mid-term reserves and security of supply), the frequency and intensity of such shortages are increasing. Crises result in public outcry, media coverage of farmers with withering crops, newspapers stamped with pictures of cracked soils, and tales of looming disasters. Politicians are prompt to seize such crises to promise more populist projects aimed at tapping more water. New irrigated areas are often necessary to make dam or diversion projects economically more attractive and also to achieve the 'buy in' of provinces or populations that will be affected by new reservoirs or projects. The vicious circle of overdevelopment thus becomes self-sustaining (Molle, 2008).

Augmenting supply maximizes benefits to what has been termed the 'iron triangle' in the western USA (Reisner, 1993; McCool, 1994) and often minimizes short-term political stress, compared with options where supply to existing users must be reduced or reorganized. Logrolling (Chapter 6) is a political behaviour that fuels overbuilding, whereby 'legislators from various jurisdictions all agree to support each other's proposed projects in their home districts. In this way, a project with only local appeal can gain the support of a broad base of legislators.'

The process of basin overbuilding is well illustrated by the case of the Zayandeh Rud (Chapter 9), where each new import of water into the basin is justified by water shortages and accompanied by an expansion of irrigation and out-of-basin transfers. Instead of stabilizing water use in the basin, providing more 'slack' and security to users, whatever additional water is made available is committed to expanding irrigation areas. This process is also illustrated by the Lerma–Chapala basin (Chapter 4) and other case studies from central and north-east Thailand, and from the Bhavani basin (Chapter 11).

Other critical drivers of basin overbuilding appear in our case studies. In the Colorado basin (Chapter 6), the upper states, and later Arizona, partly pursued development as a means of securing their entitlements and claims by effectively diverting water. In the Krishna basin (Chapter 10), as the award (basin-sharing agreement) of 1976 was to be revised in 2000, the states sharing the Krishna water 'engaged in massive development of their hydraulic infrastructure (with serious economic and fiscal damage) to lay claim on water resources and ensure they would be holding a prevailing position when the award would be renegotiated' (Gulati *et al.*, 2005). Politically motivated concerns for regional equity also fuel basin overbuilding. Preventing regional tensions and threats of state implosion under the pressure of independence claims from all three regions of Andhra Pradesh state have been major drivers of infrastructural development in the lower Krishna basin (Chapter 10; Venot *et al.*, 2007). Although irrigation is first expanded in favourable areas, it leads to later claims from other (poorer) regions that they have not only been discriminated against but also need such investments for their development. This often leads to the expansion of costly infrastructure in marginal areas.

Politicians are used to resorting to overriding justifications that close or 'securitize' the debate (Warner, 2008): new projects are indispensable and cannot be delayed because 'poverty demands that we do something', development is needed and requires 'sacrifice', national or food security is at stake, or growing energy needs make the development of hydropower 'unavoidable'. These concerns are legitimate and often truly pressing. But by closing the debate, decision makers also make it impossible to discuss alternatives, to examine in detail the social and environmental costs of projects, and to reveal the frequent absurdity of supply augmentation projects when seen through the lens of investment costs (soon to become cost overruns).

Overallocation of water entitlements

Basin overbuilding is also made possible by the fuzziness or absence of water rights, which means that many projects are, in fact, partly predicated upon water that is already committed to other (generally downstream) areas. Such a problem may occur not only because of uncontrolled expansion of private irrigation, as in the Ruaha (Chapter 8), Lerma–Chapala (Chapter 4), Zayandeh Rud (Chapter 9) and Krishna basins (Chapter 10), but also because of state-initiated anti-erosion works, as in the Merguellil (Chapter 7) and Yellow River (Chapter 5) basins, or even public irrigation schemes, as in the Zayandeh Rud and Chao Phraya (Thailand) basins.

River basins with stricter control of hydrological conditions and definition of water rights and entitlements should theoretically avoid this trap. Experience shows that this is not the case. Overbuilding through private investments is paralleled by an overallocation of water entitlements that creates similar patterns of scarcity. In the Colorado basin, apportionment of water among riparian states has been based on optimistic average hydrological data, without considering either evaporation losses in reservoirs to be built years later (now totalling 2 billion m^3) or native Indian rights. In the Murray–Darling basin, notably the state of New South Wales, licences have been granted despite recognition of the ticking time bomb represented by large contingents of 'dozers and sleepers' who only use their rights occasionally or pay their fees without using water. This has led to a water allocation that amounts to 65% of all entitlements, on average, and to a reduction in security and predictability. In the Olifants basin (Chapter 3), all water was allocated, making it virtually impossible to grant new rights to black communities. In the Lerma–Chapala basin, the 1991 treaty on surface water allocation was based on an optimistic assessment of annual water availability (with two dry periods excluded from the hydrological model underlying the treaty) and no attempt was made to reduce the volumes of water concessioned to water users.

The overallocation of water entitlements is an obvious political expedient to reduce tension, avoid denying access to resources, and satisfy a maximum of existing (or would-be) users in particular constituencies (Allan, 2006). This, of course, occurs at the cost of supply security to all. More recently, over-allocation was made more critical because of prolonged droughts (Murray–Darling, Colorado, Lerma–Chapala), dwindling runoff (Yellow River), and painful expectations of climate change (Murray–Darling). On top of these concerns, preoccupation with aquatic ecosystem health put environment flows on top of the agenda. Attempts to reallocate water to the environment from existing users have been largely frustrated, and this remains an unresolved issue. In the Olifants basin, environmental flows (eflows) have been much discussed but have so far remained on paper. In the Colorado basin, federal laws generally defer to the tradition in state water law of allowing water users to consume rivers in their entirety. Western states now provide some mechanisms for granting water rights to instream flows, but these tend to be very limited in scope, often relying on water rights that are junior to traditional consumptive users. In the Murray–Darling basin, attempts to reduce entitlements to enhance environmental flows have also not been popular, and states have been forced to resort to a (still limited) buy-back of water rights. In the Zayandeh Rud and Jordan basins, the environmental objective of maintaining terminal sinks (the Gavkhuni lake and the Dead Sea) has been simply written off. The Lerma–Chapala (Chapter 4) offers an example of reallocation away from irrigation with the aim of sustaining the level of the Chapala lake, but this objective was mainly dictated by urban supply objectives downstream of the lake.

Overdraft of reservoirs and aquifers

As a consequence of basin overbuilding and/or the overallocation of entitlements, the case studies confirm a widely observed tendency for managers and users to ‘overtap’ reservoirs and aquifers. Reservoirs generally have several purposes but are pivotal in providing interannual regulation and carry-over storage. Storing water allows managers to ensure supply in dry years. Water security, measured as the capacity to withstand a number of successive dry years, is largely dependent upon storage capacity. The Murray–Darling and Colorado basins are famous for storage capacities that are much higher than the average annual runoff: dams can store 2.8 and 3.5 times annual runoff, respectively. Conversely, the lack of storage in basins such as the Ruaha and the Jordan means that users have to face greater irregularity and risk.

Under pressure from users and politicians, managers frequently release more water in a given year than would be expected if carry-over storage were managed prudently. This increases risk and does indeed generate or magnify crises. The case of the Zayandeh Rud basin (Chapter 9) shows how careless releases in 1999 and 2000 contributed to an exceptional crisis in 2001. Likewise, in 2000, the managers of the Nagarjuna Sagar dam in the lower Krishna basin took a gamble and released all the available water, paving the way for the ensuing crisis (Chapter 10). In the Ruaha basin (Chapter 8), pressure to generate hydroelectricity at the national level also led to lowering of dam water levels beyond what risk management dictated, and to subsequent major power cuts in the capital. In the Lerma–Chapala basin (Chapter 4), the 1991 surface water allocation treaty was based on the assumption that the carry-over storage in reservoirs would increase with time if the treaty was adhered to. Instead, carry-over storage was largely depleted to comply with annual water allocations as river runoff was less than predicted by the hydrological model underlying the treaty.

Overdraft of aquifers is a better-documented and more familiar problem. Almost all basins show a long-term drawdown of water tables. This is particularly worrying in basins where groundwater provides a ‘buffer’ in case of insufficient supply of surface water, such as in the Zayandeh Rud, Lerma–Chapala and lower Yellow River basins. Indeed, as surface deliveries become more uncertain, users develop conjunctive use and turn to groundwater in compensation. In the Lerma–Chapala basin, groundwater-based irrigation also developed as a market response to opportunities for producing vegetables for the USA market. Ten years ago, water tables were dropping at rates that would bring aquifers to exhaustion, but these have been partly replenished by exceptional rainfall. The Merguellil, Jordan and Zayandeh Rud basins are typical cases where aquifers are declining and where authorities have found no way of reversing this process. The Jordan highlands suggest that price-based regulation is illusory and that where enforcement of quotas is not realistic the only solution is buying back wells and controlling further drilling. The Merguellil case illustrates the contradiction between long-term sustainability concerns and the short-term needs of food and income generation, which explains why authorities often turn a blind eye to private drilling and aquifer overdraft (a decline of between 0.25 and 1 m a year since the 1980s).

Reallocation from agriculture to cities (and the environment)

Another lesson drawn from many river basin trajectories is that agriculture – often after a phase of overexpansion due to basin overbuilding – ends up constrained by a double squeeze (see Fig. 1.2). On the supply side, water availability is sometimes reduced by long-term trends due to climate change or otherwise. Predictions for the Colorado basin by 2100 point to reductions anywhere between 11 and 45%, while the Murray–Darling basin expects reductions in mean annual flow in the order of 20–30%. Degradation of water quality is also a trend that contributes to reducing freshwater availability, with some river or drainage water unfit for use in domestic supply and even in agriculture.

On the demand side, the large historical share of agricultural use now collides with urbanization and environmentalism. All water-short basins, although sometimes buying respite by continued supply augmentation, end up facing the issue of water reallocation. It is always politically very sensitive to take water away from existing users to serve expanding urban constituencies; it is even more challenging – in a closed basin – to set water apart for 'environmental use', i.e. to sustain or restore ecosystem health. Figure 1.2 shows how irrigation gets squeezed by these trends in supply and demand and how the variability of freshwater supply induces increasingly severe shortages, which tend to primarily affect environmental and agricultural uses.

The case of the Lerma–Chapala basin (Chapter 4) illustrates how the hydro-social networks constituted around, and by, the hydraulic infrastructure in the basin make it difficult to reduce consumptive water use, even if a range of water reforms are attempted and serious efforts are made to arrive at negotiated agreements on surface water allocation

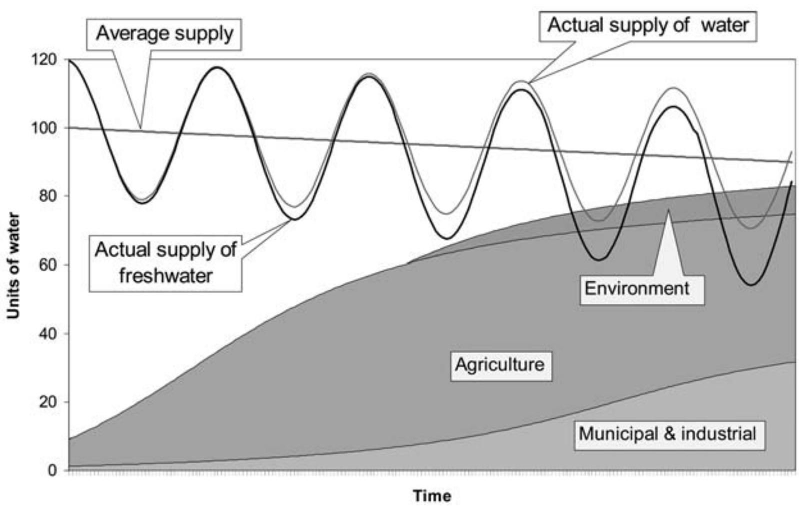

Fig. 1.2. River basin 'double squeeze'.

mechanisms. In the Colorado basin, the recipe of ‘drawing on surplus flows in wet years, transferring water from agricultural to urban users in normal years, and tapping reservoir storage in dry years’ has reached its limits, as storage reached critical lows and transfers faced a series of difficulties. Market mechanisms allow a degree of reallocation to cities, and several direct agreements between urban and irrigation areas can also be noted: San Diego buying water from the Imperial Valley irrigation district (supplied from the lower Colorado), Melbourne acquiring rights to 75 Mm^3 of the lower Murray–Darling in exchange for investments, and Chinese cities in the Yellow River basin transacting with irrigation districts. In other basins (diversions to Amman in the Jordan basin, to Hyderabad in the Krishna basin, to Tirrupur and Coimbatore in the Bhavani basin, to coastal cities in the Merguellil basin), transfers have been decided by administrative fiat. This was also the case in the Lerma–Chapala basin, where, in 1999, because of critically low levels in Lake Chapala and to secure Guadalajara’s water supply, the CNA (National Water Commission) transferred 200 Mm^3 from the Solis dam, the main water source of the largest irrigation district in the basin, to Lake Chapala. A second transfer of 270 Mm^3 followed in November 2001, as lake levels continued to decline.

Keeping water in lakes and rivers is even more challenging. In the Olifants basin, the establishment of environmental flows has remained largely theoretical, with different approaches tested to determine environmental requirements. The gridlock as to how to reduce agricultural use is likely to be eventually eased by constructing a new dam and therefore developing more resources. Such a way out is also visible in the Mexican case (with a new dam on the upper Santiago River to serve Leon city and a new dam on the Santiago River near Guadalajara to supply its urban water) and the Zayandeh Rud case (interbasin transfer). Whenever possible, and often regardless of costs, supply augmentation is still a favoured option, which minimizes political stress but, of course, only buys time and eventually compounds basin closure.

Expectations of reduced supply are taken very seriously in the Murray–Darling basin. The main challenges for the future concern the best way to reduce overall allocation in the basin and, more importantly, to make sure that each state will take its share of the burden. It is no longer merely a question of complying with the 1994 cap on abstraction but of adjusting to significantly reduced allocations for the irrigation sector. The pressure to do this is mostly driven by current environmental allocation concerns, plus the expectation of reductions in mean annual flow in the order of 20–30% by 2100 under a range of climate change scenarios.

Major Societal Responses and Issues

Several major issues, associated with the four processes highlighted above, can be singled out and illustrated by our case studies. One issue concerns the ‘politics of blame,’ which is the way crises are explained, handled and used to justify specific policies and further particular agendas. Other issues concern the actual responses to basin closure, the impact of water scarcity on water-use efficiency and equity, and basin governance.

The politics of blame

Water-related problems (floods, shortages, contamination, etc.) are often accompanied by efforts by stakeholders, managers and politicians to find explanations and apportion blame. The way blame is apportioned to different causes is important because it not only reflects the distribution of power (and the capacity of particular stakeholders to get their message across in the media) but also paves the way for what will be done next, the money that will be spent, and the options that will be favoured. As such, it is an exercise of power.

Predictably, climatic vagaries or El Niño are convenient scapegoats, which, indeed, often bear part of the ‘responsibility’, but irrigation, its large share of water diversion, highlanders (responsible for deforestation) and pastoralists (associated with overgrazing) are also primary targets. During the second Lake Chapala crisis (Chapter 4), water authorities blamed the desiccation of the lake on the drought and the high levels of evaporation from the lake, although the extractions from the lake by Guadalajara city of at least 240 Mm^3 a year contributed strongly to the decline of the lake. In the Ruaha basin, water shortages experienced in the Mtera–Kidatu hydropower complex (which resulted in power cuts in the capital and other cities) were blamed on upstream irrigators and pastoralists. A series of analyses demonstrates that, despite claims by power-generation authorities, the power cuts experienced from 1992 onwards were largely due to improper dam operation rather than to upstream depletion of water. In 2004, for example, the situation was so critical that the Mtera reservoir was operated by utilizing the dead storage, despite advice to the contrary from the Rufiji Basin Water Office and the ministry responsible for water. This advice was not heeded, resulting in higher risks and showing the economic and political importance of maintaining power generation at any risk and cost.

In the Mekong basin, the floods in the summer of 2008 were used to critique the dams built by the Chinese in the upper basin and the lack of transparency concerning dam releases, although evidence of their responsibility is dubious. Floods in central Thailand or the Ganges basin have also been associated with land management practices by highlanders, although scientific evidence of a correlation is at best weak (Forsyth and Walker, 2008). In the Thai case, accusations have been blended with ethnic stereotypes and conveniently justified expansion of state enclosures (in the guise of national parks, reserves, etc.), afforestation by private companies and, in some cases, expulsion of hill tribes (Walker, 2003).

Whether justified or not, such accusations are active elements of negotiation processes (if any) and/or state decision making. In the Lerma–Chapala basin, the *Grupo de Trabajo Especializado en Planeación Agrícola Integral* (GTEPAI, Specialized Working Group on Integral Agricultural Planning) attempted to strengthen the negotiating position of irrigators in the river basin council. Its strategy was to show that the irrigated agriculture sector was serious about saving water and hence a credible negotiating partner. However, the stigma of irrigation being a wasteful use of water was too strong, and the farmers continued to be blamed for the desiccation of Lake Chapala by urban dwellers and environmentalists.

Conversely, proponents of particular solutions must paint them in a positive mode. The Red–Dead project in Jordan, which proposes to bring water from the Red Sea into the Dead Sea, generate hydropower and desalinate water, and pump part of it to Amman and other cities (Chapter 2), is alternatively painted with environmental (save the Dead Sea), religious (the cradle of three religions) or political (the peace conduit) arguments. Other mega-projects, such as the diversion of the São Francisco in Brazil (Alves, 2008) or the Water Grid in Thailand (Molle and Floch, 2008), also emphasize ‘eradication of poverty’, enhanced rural incomes and abundant water, while typically disregarding costs and investment alternatives.

Responses to basin closure

Basin closure and associated water scarcity, decline of water quality and environmental degradation – as mentioned earlier – give way to three types of responses: supply augmentation, demand management and (re)allocation. It has been hypothesized that these three types of responses occur sequentially along the basin closure trajectory (Molden *et al.*, 2005). While it is true that early phases of basin development are almost exclusively typified by supply augmentation, case studies of closing or closed basins show that – under pressure and in the face of recurring crises – the three options are pursued concurrently.

The blend of options selected depends on the physical, financial and political features of each option. Physical constraints refer to the accessibility of water resources and clearly set a limit to what is possible. Yet such constraints are typically qualified by financial and political considerations, as shown by the interbasin transfers through tunnels in the Zayandeh Rud basin and by the Red–Dead project in Jordan. If the costs of such works are shifted to the country as a whole and/or, partly, to the international community, then they may be eventually realized. Likewise, the acceptance of federal policies in the Murray–Darling and the Colorado basins was strongly linked to billions of dollars of federal subsidies in various guises (e.g. for Land Care groups in Australia, or water diversions and dams in the USA). Interbasin transfers may be opposed by 'donor basins', and imposition by the central government may involve lots of political manoeuvring and arm-twisting, as seen in the current project to divert the water of the São Francisco River in Brazil (Alves, 2008). While in some cases project costs are an impediment, in other cases higher costs may be seen as desirable by unchecked private interests.

While most infrastructural projects are costly, other measures are financially more attractive. Technical improvements or conservation policies, whether physical (e.g. canal lining or retrofitting of home appliances) or not (e.g. awareness campaigns), may be cost-effective. Fine tuning of management may also result in savings. In the Colorado basin, the reservoir operations and shortage-sharing rules were the most debated elements in the recent audit process (Chapter 6). The water level in the dams governs not only the head (hydropower generation) and the flood-control capacity but also the size of the water body and thus its evaporation losses. New rules may better account for hydrological changes and desired levels of security, and better balance priorities (e.g. environment versus human use).

Political constraints refer to the political benefits and costs associated with particular options. Options impacting key supportive or strong constituencies are likely to be discarded. This is clearly demonstrated in the case of the Jordan basin (Chapter 2), where regulation of groundwater use in the highlands and charging for water in the valley (notably in citrus and banana farms) are poised to damage the support of certain tribes and entrepreneurs to the King and the government. In the Olifants basin (Chapter 3), redistributive and participatory policies are adverse to white economic interests and have made little progress. Other types of policies meet with little popular support but they seem to go ahead out of bureaucratic inertia or ideology, as the intriguing case of water-harvesting structures in the Merguellil basin suggests (Chapter 7).

As a result of such complex sets of constraints, responses are often diverse and shifting but more or less efficient. The Colorado basin has seen the emergence of an unusually rich suite of strategies for increasing yields and avoiding (overcoming) limits, highlighted by efforts to eliminate reservoir spills (and associated 'over-deliveries' to Mexico), marketing of water salvaged through conservation programmes, the eradication of water-loving tamarisk and Russian olive trees, weather modification (i.e. cloud seeding), desalination, the proposed importation of water from neighbouring basins, and compensated fallowing of agricultural land. In Jordan (Chapter 2), policies have also mixed all kinds of conservation incentives with supply augmentation (dams, import of groundwater from distant aquifers) and forced reallocation of water (from agriculture in the valley to cities in the highlands).

In the past, the key to positive-sum bargaining in river basins was to expand the available benefits (i.e. water and power) at public cost, with little consideration of environmental and other public values. Today, opportunities for new storage or diversions are limited, civil society at large has gained political space and clout, and decisions are increasingly debated in wider and more contested arenas. Yet this clearly varies from one basin to another, and unilateral state decision making still prevails in many countries.

Hydrological pathologies

The hydrology of closing basins is problematic. Because most flows, including return flows from existing uses, are tapped, there is little 'slack' in the basin hydrological system to dampen or buffer natural hydrological variability, and perturbations thus strongly reverberate on the whole system. The pathology of closed river basins has been the subject of many works, which have emphasized the concept of river basin efficiency, as opposed to local user or system efficiency (Seckler, 1996; Molle and Turral, 2004; Perry, 2007). They have shown how local 'inefficiencies' associated with leaky canals, reservoir spills, inefficient irrigation practices and other system losses are often the primary source of water for other users or for ecosystems.

More generally, interventions in the hydrological cycle generate externalities in terms of water quantity, water quality, sediment load or timing that travel across the basin. These externalities are heightened by the process of closure but are also sometimes difficult to seize or appreciate as they involve time lags and two-way interactions between surface water and groundwater resources. Deforestation in the Murray–Darling basin has altered runoff and groundwater recharge, resulting in the phenomenon of dry-salinity. Afforestation in the upper Olifants basin has reduced natural runoff to the point that forest areas are considered as a water user and forestry companies have to pay fees accordingly. Development of diffuse water-harvesting structures and shallow wells in the Krishna and Merguellil basins has critically curtailed runoff and benefits to downstream water users. In the Zayandeh Rud basin, several hydrological interactions have also been evidenced, including reverted net flows between the river-bed and adjacent aquifers. In the Yellow and Lerma–Chapala basins, reduced river base flows due to groundwater over-exploitation have also been observed.

Unless they save water that goes to sinks, such as saline aquifers or the sea (all ecosystem functions of river outflows being considered), conservation efforts tend to amount to disguised reallocation. This is a zero-sum game, with reallocation from public environmental interests to water users, or from one user to another, merely robbing Peter to pay Paul. The deal between San Diego and the Imperial Valley Irrigation district, supplied from the lower Colorado, is a textbook example of a zero-sum game branded as a 'win–win agreement'. The 100 Mm^3 of water 'saved' by lining the All-American canal and reallocated to San Diego have merely been subtracted from the flows reaching the Salton Sea and replenishing the Mexicali aquifer, on which Mexican farmers on the other side of the border depend (Cortez-Lara and García-Acevedo, 2000; Cortez-Lara, 2004).

Kendy *et al.* (2003) have also highlighted the hydrological nature of closed basins in the North China Plain, where virtually all annually renewable water is used (depleted) and groundwater tables are falling with agricultural and urban expansion. While water might be used and reused more wisely or reallocated within the basin, little water reaching the sea means that all resources are depleted and that reducing demand can only come from reduced use (i.e. mostly reduced evapotranspiration). With almost no water reaching the sea, it could be argued that the same holds true for the Yellow River in general.

The lesson drawn from all these examples is that the management of river basins becomes increasingly difficult with closure. Arid basins are somewhat easier to manage, in that most of the resource mobilized is stored in a few reservoirs or aquifers, which are potentially amenable to quantification. In basins such as the Yellow or Krishna, where rainfall is more frequent and better distributed throughout the year, supply and demand vary a lot and the spatial and temporal distribution of flows is harder to grasp and control. In all cases, supply augmentation, conservation and reallocation appear to be clearly scale dependent. What is stored or conserved at one point is often a reallocation when seen at a larger scale. Managing such externalities and interconnectedness is challenging in both technical and governance terms.

Adding further complexity to the hydrology of closed river basins is the variability of rainfall. There is no such thing as an 'average' hydrological year, although many treaties on surface water are based on calculations of long-term averages. However, the periods for which rainfall data are available have proven to be too short to calculate robust averages; assuming this is still meaningful in a context of climate change, where the future will not look like the past. In both the Colorado and Lerma–Chapala basins, treaties on surface water were based on calculations of average runoff that later proved to be too high. With climate change it appears that variability in rainfall will increase, further weakening the reliability of estimates of average runoff.

Family/subsistence farming versus entrepreneurial capitalism

As competition increases, water tends to be gradually reallocated towards uses with higher economic value. This is achieved through administrative decisions, negotiations between users, or market mechanisms. An important and ubiquitous question is the allocation of water within the agriculture sector and the fate of irrigated agriculture as water becomes more valuable. Following the Dublin principle on water as an economic good, maximizing aggregate welfare has become a commonplace recommendation, but it is apparent that this principle also tends to conflict with that of ensuring equity or livelihoods for the poorest.

Most basins present a contrast between two broad types of agriculture: the first type is family based, sometimes partly devoted to subsistence agriculture, with limited links to markets and a lack of capital or knowledge, which prevents farmers from intensifying or embarking on more market-oriented and risky ventures. The second type is entrepreneurial, market oriented or export oriented, and owners – frequently absentee owners – often manage their farms through hired managers and labourers. This dichotomy is a simplification and does not do justice to hybrid types of farms: smallholders fully integrated to the market (e.g. periurban vegetable farming in the Merguellil plain) or absentee owners keeping low-value prestige olive tree plantations in Jordan. Yet it is useful in highlighting governments' dilemmas in allocating water and other resources.

Many state policies, indeed, are predicated on transforming the former type into the latter, often with little understanding of the constraints faced by farmers and with optimistic assumptions on how they will respond to 'incentives'. In particular, it is often inferred that higher water prices would trigger a shift towards higher-value crops, an assumption that runs into contradictions since these higher-value crops are already available to farmers; they have not opted for them for good reasons, which are often poorly understood.

The contrast between smallholder and agribusiness agriculture is particularly apparent in the Olifants basin, where discourses on economic efficiency and policies to redress inequalities of the past are at loggerheads. In the Colorado basin, agribusinesses that produce vegetables exported to distant states are indirectly pitted against extensive rearing of dairy cows in Wyoming. In Brazil's São Francisco basin, public irrigation schemes designed to settle poor farmers have been abandoned in favour of wealthy and corporate investors coming from the south and abroad. In the Lerma–Chapala basin, the boom in export agriculture (primarily vegetables) has been fed by expensive groundwater, while support for land reform communities was discontinued in the early 1990s.

In the Krishna basin, two sets of policies have translated into two different modes of access to, and use of, water in different parts of the basin (Chapter 10). Broadly, the first group of policies aims at 'efficiency in development' and concentrates financial and institutional investments on those social groups and areas that offer the highest potential for development. They are the technologies of the Green Revolution, adopted in medium and large irrigation projects, and more recently they have attempted integrating agriculture into agribusiness chains. The second group aims at 'equity in development' and advocates rural development programmes through strong state planning and public investments in remote areas. They are watershed and tank rehabilitation programmes, and minor irrigation projects in upper secondary catchments (Landy, 2008). This need to balance economic efficiency and equity in rural development has been a major driver of the spatial distribution of water use in the Krishna basin over the last 50 years.

Although vegetable and fruit production typically provides higher farm revenues, it tends to be capital intensive and a risky venture that is unfit for smallholders. In any case, this production only makes up 9% of the world's total cropping area and it cannot be expected to displace other grain, oil or fibre crops. Modernization of more extensive farms devoted to such crops is a problem experienced in many countries (including European countries such as Spain and Italy). It is clear that productivity gains cannot be satisfactorily achieved through negative incentives such as pricing but must come through subsidies to help farmers invest and intensify. Adoption of micro-irrigation, for example, is almost invariably made possible by generous public subsidies.

Basin governance

All the hydrological and socio-political complexities of river basin development and management discussed above must be addressed by relevant decision-making and governance structures. Although the establishment of RBOs has become a standard prescription, the diversity of physical and historical contexts militates for a less normative approach (Molle *et al.*, 2007; Warner *et al.*, 2008). However, the belief that a river basin agency should deal with all the water problems in a river basin is deeply rooted in the water sector. This reflects the modernist conviction that strong government agencies staffed by scientifically trained experts should be delegated responsibilities for policy design and implementation in natural resources management (Norgaard, 1994). For hydrocracies, the river basin forms an ideal territorial unit over which they can rule, based on the argument that nature has determined this to be the scale at which water should be managed.

Thus, a central element of river basin trajectories is the process of turning river basins into domains of water governance, a 'scale-making project' (Tsing, 2000) frequently pursued by hydrocracies. However, this process is hidden from view, as recourse is made to the 'naturalizing metaphor' of the river basin (Bakker, 1999). This leads to a neglect or denial of the political dimensions of river basin management, through the reification of 'natural' boundaries, the emphasis on 'neutral' planning and the search for optimal management strategies (Molle, 2006). Frequently, the situation before the creation of new river basin institutions is treated like a *tabula rasa*, while, in effect, many organizations and institutions and the technologies for controlling water are already in place (Warner *et al.*, 2008). The chapters in this book show that the delineation of river basin boundaries, the structuring of stakeholder representation and the creation of institutional arrangements for river basin management are political processes revolving around matters of choice. An explicit recognition of the political dimension of river basin management is necessary so that institutions and procedures may be designed in a more democratic and inclusive manner.

International basins, multi-state basins in federal countries and national basins clearly appear as distinct cases. We focus here on the latter two. Federal countries exhibit a tension between the states overlapping within the basin and the central federal government. States tend to have a large autonomy in managing their water resources, but it is clear that the sum of uncoordinated state-centred interests is unlikely to lead to sustainable river basin management. The case of India shows that states pursue antagonistic expansion strategies that are poorly checked by the existing sharing agreement. Interstate regulation in the Krishna, Colorado and Lerma–Chapala basins is largely achieved through water-sharing agreements and through the management of the main infrastructures by federal agencies.

In Australia, salinity, and, more recently, environmental and drought-related problems, have triggered federal interventions. The institutional challenge is whether a more active and dominant role by central government will deliver arrangements that are better than existing ones. Although the Murray River Basin Commission has been credited with a successful mediation role, negotiated and voluntary water sharing and custodianship of the basin have been slow to react in front of pressing needs and environmental degradation. 'The belief of Federal government is that it has the intellectual horsepower, political muscle and financial resources to succeed where it (and others) believes that the Murray River Basin Commission has failed. This is probably a belief that is common to many central government elites, and their immediate technocracies, and often leads to impatience with detail and the preservation of considerable secrecy and minimal transparency' (Chapter 12).

In the Olifants basin, attempts at establishing a catchment management agency (CMA) have been stalled. Officials initially had high hopes for CMAs as 'the key vehicles to implement the new water management paradigm' (Schreiner *et al.*, 2002), but underestimated the requirements to make the initial consultation process genuinely inclusive, given the highly unlevel playing field, with the large public and private water users well organized to defend their interests (Wester *et al.*, 2003). Similar difficulties had been faced by the Olifants River Forum, established in 1993 to promote cooperation for conservation and sustainable use of the river. The forum was founded by white representatives of large mining firms, Kruger National Park and the Department of Water Affairs and Forestry in order to influence the formation of the planned CMA, with local communities not well represented, and signalled a continuation of the 'white water economy' (van Koppen, 2007).

In the Lerma–Chapala basin, a river basin council was formed in the 1990s, initially only with government representatives, and later also with water-user representatives. However, this council had very few decision-making powers, and was not delegated the authority to approve the budgets of the federal water agency's river basin office. Although proposals to move to a bimodal form of river basin management have been debated since 1992, they have been successfully resisted by the federal water agency during the various revisions of the national water law. While more space has been created for the participation of water users and state governments in river basin management, the federal government remains in control.

In many cases, participatory policies are initiated by government agencies with the implicit intent to keep control of river basin management. The Lerma–Chapala case, however, shows that such processes also create a political space that stakeholders can use to challenge the dominant power of the state. This has not yet happened to a significant degree in the Olifants and Ruaha basins, but could change with time.

The Yellow River Conservancy Commission is another type of RBO where central power seems to be overriding. The Esfahan Water Agency is also an example of centralized water administration that concentrates decisional power. Likewise, little direct representation of users in decision making is observed in the Jordan, Krishna or Merguellil basins. The resilience of civil-engineering-dominated water bureaucracies is clearly one of the main obstacles to change in these water sectors. Their water resources governance structure and policies remain characterized by centralization, hierarchy, specialization in infrastructural planning and secretive, top-down decision making.

As mentioned earlier, with regard to shifting paradigms, ideologies and societal values, water management is – or should be – in a constant flux to accommodate these changes. The Murray–Darling basin provides a good example of where water management is constantly evolving and adapting to changing needs, biophysical influence and public expectation.

Conclusions

The chapters in this book illustrate the diversity of both the water challenges that societies face and their responses to these challenges in varied physical and historical contexts. Although crucial water issues include flood management, urban water supply and sanitation, and pollution control, the dominant process is that of basin closure, whereby available water resources are invariably gradually tapped and depleted beyond the level required to ensure the sustainability of aquatic ecosystems and minimize the conflicts caused by supply variability. With river basin closure the interdependencies among stakeholders, the water cycle, aquatic ecosystems and institutional arrangements increase. These interdependencies manifest themselves in alterations of the water cycle that create positive and negative externalities to different categories of users and the environment. These externalities are not always easy to foresee or quantify and often result in amplified turbulence and greater complexity in terms of water governance mechanisms.

Despite the diversity of contexts presented by the case studies, four generic processes can be singled out. First, the process of overbuilding, which directly fuels the closure of basins, reveals a number of societal and political mechanisms by which the development of water-use capacity and infrastructure tends to outstrip resources and thus to generate 'scarcity'. Second, this overcommitment of resources also affects systems of allocation, whether formal – through a system of rights – or otherwise, which signals that it is politically always easier to downplay hydrological realities by overallocating one 'pie' than by excluding some constituencies (or nature) from accessing it. Third, pressure over resources translates into the 'overtapping' of both superficial (lakes and dams) and underground (aquifers) reservoirs. Fourth, basin closure makes the issue of water allocation critical, and a 'double squeeze' of agriculture is widely observed: the share of agriculture is under pressure from both growing non-agricultural needs and a widening awareness of, and call for, a need to increase environmental flows, since nature, the residual user, bears the brunt of variability in supply.

Indeed, the lack of possibilities to develop new water supplies, and the perception that agriculture is a 'low-value' use of water, lead to increasing intersectoral water transfers: one-way (frequently extra-legal) transfers from agriculture to industry and domestic use, as well as intrasectoral transfers in agriculture to economically higher-value crops and from small farmers to large commercial farmers. Most governments face the need to reconcile the antagonistic objectives of privileging economic efficiency and supporting the livelihoods of the poorest. Plans to transform subsistence farmers into market-oriented producers make light of issues of risk, marketing, and access to capital, labour and information.

The overexploitation of water sources leads to environmental degradation through the destruction of aquatic ecosystems, the depletion of aquifers and the generation of polluted wastewater flows (both industrial/urban effluents and agricultural drainage effluents). In closed river basins, these trends can principally be reversed by consuming less water and making judicious use of wastewater; but creating new 'hydraulic property' (Coward, 1986), even where only marginal and costly solutions remain available (distant dams, interbasin transfers, desalination), is often preferred and, in many cases, pursued in parallel with demand-management options.

Response options are diverse and always in competition. This book clearly shows how politically contested decision making is, both with regard to the selection of these options in general, and to water allocation in particular. The era of water resources development was characterized by a consensus on the desirability of the hydraulic mission, by the need to 'make the desert bloom', and the problems it dealt with could be classified as 'tame', i.e. amenable to solution by construction of hydraulic infrastructure and injection of technology and expertise (Lach *et al.*, 2005). Many problems can now be characterized as 'wicked', with a multiplicity of viewpoints, interests and uses that demand new governance mechanisms. Conventional water bureaucracies or RBOs, which were instrumental in (over)building river basins, need to change their operating paradigms to be able to deal with basin closure.

The chapters in this book show that the cognitive, social and political complexities in closed basins are such that no easy-to-implement blueprints are available to resolve wicked water resources management problems. They take us through very rich and instructive stories that make explicit the deeply political and contentious nature of river basin management, and the need to start from this recognition as a necessary first step for working towards a socially and environmentally just governance of water resources.

References

Aboites, L. (1998) *El Agua de la Nación. Una Historia Política de México (1888–1946).* Centro de Investigaciones y Estudios Superiores en Antropologia Social, Mexico City.

ACC/ISGWR (United Nations Administrative Coordination Council Inter-Secretariat Group on Water Resources) (1992) The Dublin Statement and Report of the Conference. Prepared for the International Conference on Water and the Environment: Development Issues for the 21st Century, 26–31 January 1992, Dublin.

Allan, J.A. (2006) IWRM: the new sanctioned discourse? In: Mollinga, P.P., Dixit, A. and Athukorala, K. (eds) *Integrated Water Resources Management: Global Theory, Emerging Practice and Local Needs.* SAGE Publications, New Delhi, pp. 38–63.

Alves, J. (ed.) (2008) *Toda a Verdade Sobre a Transposição do Rio São Francisco.* Mauad X, São Paulo, Brazil.

Bakker, K. (1999) The politics of hydropower: developing the Mekong. *Political Geography* 18(2), 209–232.

Barrow, C.J. (1998) River basin development planning and management: a critical review. *World Development* 26(1), 171–186.

Berkoff, J. (2002) Economic valuation: why is it often unsatisfactory? And does it matter? With reference to the irrigation sector. Paper presented at the ICEA meeting, 19 June 2002.

Boelens, R. and Zwarteveen, M. (2005) Prices and politics in Andean water reforms. *Development and Change* 36(4), 735–758.

Chambers, R. (1997) *Whose Reality Counts? Putting the First Last*. Intermediate Technology Publications, London.

Cortez-Lara, A.A. (2004) Enfoques encontrados en la gestión de recursos hidráulicos compartidos. El revestimiento del Canal Todo Americano y el Valle de Mexicali: ¿equilibrio estatico de mercado ó equilibrio de Nash? In: Sánchez Munguía, V. (ed.) *El Revestimiento del Canal Todo Americano: Competencia o Cooperación por el Agua en la Frontera México-Estados Unidos*. Playa y Valdez, Mexico City, pp. 273–293.

Cortez-Lara, A.A. and García-Acevedo, M.R. (2000) The lining of the All-American Canal: the forgotten voices. *Natural Resources Journal* 40(2), 261–279.

Coward, W.E. Jr (1986) State and locality in Asian irrigation development: the property factor. In: Nobe, K.C. and Sampath, R.K. (eds) *Irrigation Management in Developing Countries: Current Issues and Approaches*. Westview Press, Boulder, Colorado and London, pp. 491–508.

Ekbladh, D. (2002) 'Mr. TVA': grass-roots development, David Lilienthal, and the rise and fall of the Tennessee Valley Authority as a symbol for U.S. overseas development, 1933–1973. *Diplomatic History* 26(3), 335–374.

EU (European Union) (2000) Directive 2000/60/ec of the European Parliament and of the Council of 23 October 2000. Establishing a framework for community action in the field of water policy. *Official Journal of the European Communities* 43(L327), 1–72.

Forsyth, T. and Walker, A. (2008) *Forest Guardians, Forest Destroyers: the Politics of Environmental Knowledge in Northern Thailand*. University of Washington Press, Seattle.

Green, C.H. (1996) Water and economics: what does experience teach us so far? In: Howsam, P. and Carter, R. (eds) *Water Policy: Allocation and Management in Practice*. E & FN Spon, London, pp. 213–220.

Grigg, N.S. (2008) Integrated water resources management: balancing views and improving practice. *Water International* 33(3), 279–292.

Gulati, A., Meinzen-Dick, R. and Raju, K.V. (2005) *Institutional Reforms in Indian Irrigation*. Sage, New Delhi.

GWP (Global Water Partnership) (2000) *Integrated Water Resources Management*. TAC Background Papers No. 4. GWP, Stockholm.

Homer-Dixon, T.F. (1999) *Environment, Scarcity and Violence*. Princeton University Press, Princeton and Oxford.

IUCN (International Union for Conservation of Nature) (2000) *Vision for Water and Nature: a World Strategy for Conservation and Sustainable Management of Water Resources in the 21st Century*. International Union for Conservation of Nature, Gland, Switzerland.

Kendy, E., Molden, D.J., Steenhuis, T.S., Liu, C.M. and Wang, J. (2003) *Policies Drain the North China Plain: Agricultural Policy and Groundwater Depletion in Luancheng County, 1949–2000*. IWMI Research Report 71. International Water Management Institute, Colombo, Sri Lanka.

Lach, D., Rayner, S. and Ingram, H. (2005) Taming the waters: strategies to domesticate the wicked problems of water resource management. *International Journal of Water* 3(1), 1–17.

Landy, F. (2008) *Feeding India. The Spatial Parameters of Food Grain Policies*. Manohar, New Delhi.

Lilienthal, D.E. (1944) *TVA: Democracy on the March*. Harper and Brothers Publishers, New York and London.

Lipchin, C. (2003) Water, agriculture and Zionism: exploring the interface between policy and ideology. Paper presented at the 3rd conference of the International Water History Association, December 2003, Alexandria, Egypt.

Marchand, M. and Toornstra, F.H. (1986) *Ecological Guidelines for River Basin Development*. Centrum voor Milieukunde Rijksuniversiteit Leiden, Leiden, The Netherlands.

McCool, D. (1994) *Command of the Waters: Iron Triangles, Federal Water Development and Indian Water*. The University of Arizona Press, Tuscon.

Mehta, L. (2001) The manufacture of popular perceptions of scarcity: dams and water-related narratives in Gujarat, India. *World Development* 29(12), 2025–2041.

Molden, D., Sakthivadivel, R., Samad, M. and Burton, M. (2005) Phases of river basin development: the need for adaptive institutions. In: Svendsen, M. (ed.) *Irrigation and River Basin Management: Options for Governance and Institutions*. CAB International, Wallingford, UK, pp. 19–29.

Molle, F. (2003) *Development Trajectories of River Basins: a Conceptual Framework*. IWMI Research Report 72. International Water Management Institute, Colombo, Sri Lanka.

Molle, F. (2006) *Planning and Managing Water Resources at the River-basin Level: Emergence and Evolution*

of a Concept. Comprehensive Assessment of Water Management in Agriculture Research Report 16. International Water Management Institute, Colombo, Sri Lanka.
Molle, F. (2007) Scales and power in river basin management: the Chao Phraya River in Thailand. *Geographical Journal* 173(4), 358–373.
Molle, F. (2008) Why enough is never enough: the social determinants of river basin closure. *International Journal of Water Resources Development* 24(2), 217–226.
Molle, F. and Floch, P. (2008) Megaprojects and social and environmental changes: the case of the Thai 'Water Grid'. *Ambio* 37(3), 199–204.
Molle, F. and Turral, H. (2004) Demand management in a basin perspective: is the potential for water saving overestimated? Paper prepared for the International Water Demand Management Conference, June 2004, Dead Sea, Jordan. Minister of Water and Irrigation, Jordan/United States Agency for International Development, Washington, DC.
Molle, F., Wester, P. and Hirsch, P. (2007) River basin development and management. In: Molden, D. (ed.) *Water for Food, Water for Life: a Comprehensive Assessment of Water Management in Agriculture*. Earthscan, London; International Water Management Institute, Colombo, Sri Lanka, pp. 585–625.
Norgaard, R.B. (1994) *Development Betrayed: the End of Progress and a Coevolutionary Revisioning of the Future*. Routledge, London.
Perry, C. (2007) Efficient irrigation; inefficient communication; flawed recommendations. *Irrigation and Drainage* 56(4), 367–378.
Reisner, M. (1993) *Cadillac Desert: the American West and its Disappearing Water*. (Revised and updated). Penguin Books, New York.
Schreiner, B., van Koppen, B. and Khumbane, T. (2002) From bucket to basin: a new water management paradigm for poverty eradication and gender equity. In: Turton, A.R. and Henwood, R. (eds) *Hydropolitics in the Developing World: a Southern African Perspective*. Africa Water Issues Research Unit, Centre for International Political Studies, University of Pretoria, Pretoria.
Seckler, D. (1996) *The New Era of Water Resources Management: from 'Dry' to 'Wet' Water Savings*. International Irrigation Management Institute (IIMI) Research Report 1. International Water Management Institute, Colombo, Sri Lanka.
Sexton, R. (1990) *Perspectives on the Middle East Water Crisis: Analysing Water Scarcity Problems in Jordan and Israel*. ODI/IIMI Irrigation Management Network Paper 90/3f. Overseas Development Institute, London/International Irrigation Management Institute (now International Water Management Institute), Colombo, Sri Lanka.
Shah, T., Roy, A.D., Qureshi, A.S. and Wang, J. (2003) Sustaining Asia's groundwater boom: an overview of issues and evidence. *Natural Resources Forum* 27(2), 130–141.
Tsing, A. (2000) The global situation. *Cultural Anthropology* 15(3), 327–360.
van Halsema, G. (2002) Trial and re-trial: the evolution of irrigation modernisation in NWFP, Pakistan. PhD dissertation, Wageningen University, Wageningen, The Netherlands.
van Koppen, B. (2007) Institutional and legal lessons for redressing inequities from the past: the case of the Olifants Water Management Area, South Africa. Paper presented at the HELP Southern Symposium. CD HELP Southern Symposium. Help in Action. Local solutions to global water problems. Johannesburg, 4–9 November 2007.
Venot, J.P., Turral, H., Samad, M. and Molle, F. (2007) *Shifting Waterscapes: Explaining Basin Closure in the Lower Krishna Basin, South India*. IWMI Research Report 121. International Water Management Institute, Colombo, Sri Lanka.
Vincent, L. (2004) Science, technology and agency in the development of droughtprone areas: a cognitive history of drought and scarcity. PhD dissertation, The Open University, Milton Keynes, UK.
Walker, A. (2003) Agricultural transformation and the politics of hydrology in northern Thailand. *Development and Change* 34(5), 941–964.
Warner, J. (2008) The politics of flood insecurity: framing contested river management projects. PhD dissertation, Wageningen University, Wageningen, The Netherlands.
Warner, J., Wester, P. and Bolding, A. (2008) Going with the flow: river basins as the natural units for water management? *Water Policy* 10(S2), 121–138.
Wester, P. (2008) Shedding the waters: institutional change and water control in the Lerma–Chapala basin, Mexico. PhD dissertation, Wageningen University, Wageningen, The Netherlands.
Wester, P., Merrey, D.J. and de Lange, M. (2003) Boundaries of consent: stakeholder representation in river basin management in Mexico and South Africa. *World Development* 31(5), 797–812.
White, G.F. (1957) A perspective of river basin development. *Law and Contemporary Problems* 22(2), 156–187.
Willcocks, W. (1901) *The Nile Reservoir Dam at Assuân and After*. E&FN Spon, London.
Worster, D. (1985) *Rivers of Empire: Water, Aridity, and the Growth of the American West*. Oxford University Press, Oxford.

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River basin trajectories : an inquiry into changing waterscapes.

In : Molle François (ed.), Wester P. (ed.). River basin trajectories : societies, environments and development. Wallingford, UK and Cambridge, MA, USA : CABI, 2009, p. 1-19.

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