River basin management and development

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River basins in historical context

In common language, the concept of the river basin pertains to the field of physical geography, and is well established in secondary classrooms: river (or drainage) basins are extents of land that drains all streams and rainfall toward the same terminus, generally a river or the sea, or sometimes an inland water body. River basins are also often called *catchments* in British English, while *watershed*, which in American English designates smaller basins of a few thousand square kilometers, refers to the line dividing two river basins. River basins which drain to an inland water body are called *endorheic* basins, and form large areas of Central Asia and desert regions, like the Sahara or the Arabian Peninsula. River basins can also be seen as nested "rainfall collectors," with small tributaries converging to larger rivers.

Although there are indications of sophisticated knowledge of both river systems and the hydrological cycle by the Chinese as early as the third century BC (with a clear description of how vapor generates clouds and clouds rivers), and despite the refined hydraulic skills of ancient civilizations and later of the Romans and the Arabs, the conceptualization of hydrology remained limited. Land and water resources were in general exploited through piecemeal projects destined for channeling, lifting, storing, poldering, or diverting water in places deemed suitable, based on the characteristics of the land, the understanding of the flow regime, and the available technology.

The clear articulation of the notion of the river basin was probably hindered by difficulties in comprehending the hydrological cycle, most particularly the origin of springs and why and how rivers were flowing despite the absence of rainfall for long periods of time. In 1674 Pierre Perrault, a French geographer, wrote the treatise *De l'origine des fontaines* (On the Origin of Springs), which established a crude water balance of the upper Seine river basin, where he compared the river discharge with "the rainwater that falls around its bed," a calculation which would later be extended by Mariotte to the flow of the Seine through Paris. In 1752, Philippe Buache, a French cartographer attached to the court of King Louis XV, published an essay attempting to describe the structure of continents based on the study of mountain ranges, streams, and rivers which defined a river basin as "the set of all the slopes on which fall the waters that converge to a same river or creek." His theory was rapidly taken up by Gatterer in Germany who improved it and made it the basis of a theory of the division of the world into lands and regions.

Industrialization paralleled by scientific and technological development would subsequently project the river basin as the locus of the human conquest of nature. Ambitious national water projects including irrigation schemes or

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hydropower generation were often discursively rooted in the promotion of the river basin as a natural unit for planning development or organizing societies. The river basin concept, beyond its alleged naturalness, thus came to embody a number of ideologies and was instrumentalized by different constituencies. In the late nineteenth century the concept of a river basin nurtured utopias and political struggles concerning the relationships between central and local power in several countries. In France, the concept was captured by political interests to serve as a weapon against the revolution and centralization, and was supported by the landowning aristocracy who sought to re-establish the pre-eminence of the "local." In Spain, the *regeneracionismo* movement embraced the river basin as a "natural unit" that signaled a natural and harmonious order that was in contrast to the traditional political and administrative divisions inherited from the past; it was used against the traditional landowning elite. In the United States, John Wesley Powell advocated the establishment of self-determined "commonwealths," independent of both capitalists and bureaucrats, organized along hydrographic basins and based on natural resources rather than on the prevailing township and county system.

Although its relation with the basin scale was not always prominent because early developments occurred in the context of a relative abundance of water, irrigation development became the center of water resource development during the second half of the nineteenth century, with enthusiastic private investments in places such as the western United States, Australia, and India often meeting with bankruptcy and calling for public intervention. As a result of this financial failure and given various national objectives, the states stepped in and endorsed the role of (large-scale) developers of water resources. Imbued with the fresh legitimacy of technical marvels and the presumably unlimited power of science, inspired by the colonial deeds of the British in India and the Sudan, the Dutch in Indonesia, and the French in Vietnam, hydraulic bureaucracies were created to take up the challenges of flood protection, large-scale public irrigation, and hydropower generation. These bureaucracies took as their motto the promise that not a single drop of water should reach the sea without being put to work for the benefit of humanity: the "hydraulic mission" was born (Molle 2007).

The beginning of the twentieth century was thus marked by the creation of many hydraulic bureaucracies in different parts of the world. These include the US Bureau of Reclamation (1902), the National Irrigation Commission in Mexico (1926), the Department of Canals in Siam (1902; now the Royal Irrigation Department), the General Directorate of Public Works in Turkey (1914; now DSI), the Inspetoria de Obras Contra as Secas in Brazil (1909; later DNOCS), and the strengthening of many of the corps of engineers that had been created in the eighteenth and nineteenth century in European countries, as well as colonial irrigation administrations in Indonesia, Egypt, and India. But the mission of reducing flood damage or irrigating fields was soon to be enlarged with hydropower and the task of generating electricity, fueled by progress in technology in high dam construction, turbines, and high-voltage transmission lines at the beginning of the twentieth century.

These technological innovations and the many "missions" entrusted to hydraulic bureaucracies were pooled and came to be associated with river basin planning and management, as epitomized in the 1930s by the advent of the Tennessee Valley Authority (TVA), launched by Roosevelt in the aftermath of the economic crisis. River basin development was taken to new heights by combining the concept of *unified development*

(the damming of all the streams of a given river basin to bring the river under total control), the benefits of multipurpose dams (hydropower, flood protection, transportation, irrigation, and other uses), and the idea of regional development (associating water development with other interventions such as reforestation, production of fertilizers, industrial development, etc.). These ideas were soon expanded to the Columbia Basin in the United States which was to become the "battery" of the west coast, with the first concrete for the grandiose Grand Coulee Dam poured in December 1935. Similar large-scale projects and planned development were floated in Stalin's Russia, in a political and parallel contest, where technology, mechanization, and large-scale centralized planning and production processes were part and parcel of a vision of what Josephson (1995) called a "supremely rational society," which would plan massive hydropower plants and canals (e.g., the infamous White Sea–Baltic Canal), as well as "domesticate" rivers like the Volga.

In the postwar period of the 1950s and 1960s, which was marked by the need for reconstruction and to grow food for a world in shambles, grandiose water resources development schemes were soon in high demand. In the United States, the Bureau of Reclamation and the United States Army Corps of Engineers engaged in a sweeping damming of the country's rivers (Reisner 1993/1986) and envisaged megaprojects like the transfer of water from Alaska to Mexico. In the Soviet Union, electricity production, and how it would transform society and the economy (a vision long nurtured by Lenin), received much attention from Stalin who launched the Volta Project – epitomized by the Kuibyshef dam – and the 1948 Plan for the Transformation of Nature. This plan and the later Siberian river reversal project to divert water to Central Asia were echoed by what Shapiro termed "Mao's war against Nature" and its major flood control, canal and hydropower projects in the 1950s. In Spain, Franco undertook the relentless construction of 800 dams (and irrigation schemes) as a way of legitimizing his power and buying support from rural elites. Hydropower development soared in countries like Canada, Norway, and Sweden, where rivers were, in the words of Jakobsson, "industrialized."

In the developing countries, particularly newly independent ones, elites and governments enthusiastically embraced the icons of modernity and development epitomized by large-scale irrigation schemes and dams – in India famously referred to by Nehru as "the temples of modern India." In that, they were supported by either Western countries or the Soviet Union, which had both economic and geopolitical interests in fueling this postcolonial hydraulic mission. Massive investments – most pre-eminently in dams and irrigation systems – in countries with potential rural instability were thought by the United States to be the best defense against the spread of communism. It was in this context that the TVA, marketed in particular by the prophetic tone of Lilienthal's book *TVA: Democracy on the March* (1944), was to become both an icon of modernity and development and a major asset of US overseas development and diplomacy (Ekbladh 2002): in a matter of years the TVA would become the "grand-daddy of all regional development projects," embodying the social engineering drive that Scott (1998) has termed "high modernism," and inspiring a multitude of TVA-like projects in river basins such as the Jordan, Danube, and Mekong, and in countries as diverse as Sri Lanka, Afghanistan, Colombia, China, and South Africa. This further spurred the creation of national water bureaucracies entrusted with river basin planning and the construction of hydropower dams, reservoirs, and canal networks for irrigation.

The four decades following World War II witnessed massive investments in reservoirs (large dams increased globally from 5000 in 1950 to around 50 000 at present, while irrigated areas doubled from 140 million ha to 280 million ha). All the ingredients of nineteenth-century scientism, hubris, and utopias were alive and well and the hydraulic mission was in full swing, predicated on an ideology of the domination of nature, where "conquering," "harnessing," and "taming" the wilderness were touted as part of a civilizing mission, and rooted in the conviction that water flowing to the ocean was a waste that called for infrastructure to capture and manage the resource in each river basin.

Beyond promises to feed the masses, raise rural income, or meet energy requirements, the development of public irrigation and associated dams was central to Cold War geopolitics as well as to wider national state policies, whether it was to settle nomads (as in the Middle East and Tunisia); to provide jobs to returning servicemen after the two world wars (as in Australia and South Africa); to break up haciendas and colonize them, with farmers practicing "revolutionary irrigation" (Mexico); or to strategically occupy land (as in the United States, Israel, and Sri Lanka). As a result, the hydraulic mission era was characterized by a massive injection of public money in all countries, with associated subsidies and political favors.

In industrialized countries the hydraulic mission started to lose momentum in the early 1980s, with the growing recognition of associated social and environmental costs, and also with the decreasing availability of suitable dam and irrigation sites. A similar trend was observed 15 years later in developing countries, although infrastructure development remains largely unabated in a number of countries. This change was due to the rise of environmental concerns (priority shifting toward water quality and environmental sustainability), the public costs of such water resources development, and increasing criticism from affected groups and the civil society at large. Challenges to conventional river basin development also resulted from the shift from government to governance, whereby water issues came to be considered as societal questions requiring participation from, or co-management with, concerned stakeholders. In the early 1990s these concerns were reflected in the Dublin Principles and the formulation of integrated water resources management (IWRM) approaches, which were later formalized by the European Union in its Water Framework Directive. The directive sanctioned the river basin as the appropriate unit for managing water, partly under the influence of some national models (e.g., France and Spain), and partly as an embodiment of the promotion of basin-centered management by mainstream international organizations. But the appeal of river basins as an organizing principle also came from its "naturalness," as the locus of hydrological processes where the integration of water-related issues, as well as the participation of stakeholders, should be facilitated. The promotion of the river basin as a universal unit for water management has triggered wide discussion and scholarly debates from various disciplines.

Current research agenda

Basin management, modeling, and hydrology

River basin management is a subject of predilection for modelers. Hydrologists and engineers have developed numerous models to reproduce hydrological processes and to study and optimize the allocation of resources. Models, long limited to the study of surface water, have grown in sophistication and now increasingly include groundwater modules coupled with surface

water. However, it often remains difficult to appreciate, for example, time lags and two-way interactions between surface water and groundwater resources, how changes in land use, in particular deforestation, alter runoff and groundwater recharge. Likewise, actual management rules of dams and irrigation schemes, and more generally the change in actors' behaviors at all levels in the face of extreme events, are difficult to model. A growing body of literature is also addressing the evolution of supply and demand in river basins under varied scenarios of climate change. Economists have developed their own models to optimize the economic efficiency of resource allocation within river basins. Despite growing sophistication, these models generally work at a high level of aggregation and are often unable to reproduce local dynamics and to capture the complexity of the interaction between physical and humanz systems.

The question of efficiency in water use within river basins has also been the subject of many works that have emphasized the concept of river basin efficiency, as opposed to local user or system efficiency. They have shown how local "inefficiencies" associated with leaky canals, reservoir spills, return flows from irrigation, or other system "losses" are often the primary source of water for other users or for ecosystems within the basin. Successive reuses of water across nested scales greatly complexify water balances and accounting, and introduce additional and intertwined questions about changes in water quality and energy costs. Although this important work has critical implications for the concepts of efficiency and allocation, it is not always well understood, and reasoning based on conventional point-of-use efficiencies often prevails, partly because of adherence to classic engineering conceptions but also because it provides easy justification for investments in water-saving technologies.

River basin overbuilding and trajectories

Long-term interactions between societies and their river basin environment are sometimes described by the term "river basin trajectories," which examines human efforts to assess, capture, convey, store, share, and use available water resources in the face of changing physical and social environments, as well as how the distribution of decisional and discursive power results in specific water regimes, with particular patterns of distribution of costs, benefit, and risk across space, time, and social groups. Other concepts and approaches within the field of political ecology, such as the *hydrosocial cycle* or the socioecological concept of the *waterscape*, although seldom applied to river basins as such, also emphasize relations of power behind the manipulation of the water cycle.

One commonplace aspect of a basin trajectory is *basin closure*, which occurs when the quantity of water abstracted from the river or the aquifer is so high that it can no longer ensure the supply to downstream users, dilute pollution, control salinity intrusion, flush sediments, or sustain healthy ecosystems at the river mouth (or terminus). This imbalance can manifest itself only during a few dry months (where the basin is said to be *closing*), or almost permanently (where the basin is said to be *closed*). Closure and resulting scarcity can sometimes occur in sub-basins or small catchments, while the larger basin remains open. Rivers hardly reaching the sea, or contracting lakes, are the most visible signs of basin closure, as exemplified by the Colorado or Yellow rivers, the Aral Sea, and the Dead Sea. In some cases, like in the Lerma–Chapala Basin (Mexico), overabstraction of groundwater, and excessive surface water withdrawals can lead to water depletion exceeding annual renewable water.

The natural *interconnectedness* of ecosystems and users across a river basin increases with

basin closure. As the amount of available water is insufficient to dampen or absorb fluctuations in supply and demand, or to dilute salt and pollutants, conflicts and negative externalities increase, posing increasing challenges to regulation and management. What particular actors do at a particular point in space and time (e.g., digging farm ponds, tapping groundwater, harvesting water, lining canals, changing cropping patterns, or irrigation techniques) modifies the circulation of water, salts, sediments, and biota, disrupting the environmental processes and human activities associated with the prevailing water regime. The lack of data on, or knowledge of, both hydrological processes and actors' behaviors often makes it difficult to comprehend, evaluate, or anticipate how the water cycle is altered and what positive and negative social and economic externalities are produced. Externalities travel across space and time and sociopolitical categories of stakeholders. They amount to a constant redistribution of costs and benefits along lines of power that eventually tend to determine who are the winners and the losers between diverse stakeholders. Third-party impacts must be regulated, with the state usually playing a critical role.

Basin closure is generated by the *overbuilding* of river basins, a socially constructed process of overextension of the water abstraction capacity, in general for irrigation. The process is fundamentally driven by the vested interests of politicians, water bureaucrats, private construction firms, and development banks and the powerful incentives they face in sustaining water resources development. Overbuilding is also caused by regional politics and issues of equity, whereby differences in relative wealth between regions are used by poorer ones to claim for hydraulic (and other) investments even if hydrologic and economic conditions should discourage them. In other settings, between federal states (e.g., India) or between nations (e.g., Nile), it is commonplace to see a rush toward infrastructure development in order to lay claim to or to support a prior claim on the shared resource. Supply augmentation options are more attractive to decision-makers because they avoid politically costly reductions in use or reallocation, but are often adopted at the expense of the public purse and environment preservation, with opportunistic, optimistic hydrologic or economic hypotheses that have to be paid for later: overallocated resources, managers having to tap reservoirs' security stocks, helplessness in the face of aquifer overexploitation, and the necessity of reallocating water between sectors by fiat or stealth, in general toward municipal and industrial users and to the detriment of agriculture, the environment, or weaker constituencies.

The overdevelopment of water use infrastructure, principally irrigation schemes, generates water scarcity "mechanically." When most available resources are committed, little slack remains in the stock and fluxes of the river basin, and any disruption caused by hydrologic variability (compounded by climate change) or mismanagement (notably the tendency to overallocate the resource) generates crises that are opportunistically seized by politicians or interest groups to further develop supply. Politicians then often "naturalize" water scarcity and "securitize" the debate by framing and justifying their responses and policies under the cloak of national or food security or other overriding metajustifications. In both discursive and material ways, scarcity is manufactured.

Critique of the river basin scale and boundaries

River basins are promoted as the integrative locus of human uses and the environment, the scale at which the resource can be efficiently

managed and allocated, and where participation of actors with a stake in the basin's water should naturally occur. It is therefore not surprising that river basins have been associated with IWRM and promoted as one of its cardinal "best practices." They have also been justified by the alleged necessity to improve "spatial fit," that is, the matching of resources boundary and institutional regimes governing them. A growing scholarship has challenged this prescription. From a management point of view, it has been pointed out that river basin boundaries may not be relevant, for example in the case of small islands, deltas, arid areas, floodplains, and coastal areas; that surface and groundwater interactions need to be considered; that aquifer systems are often noncoterminous with river basins; and that interbasin transfers are also frequent and demand consideration of an expanded scale.

From the government's point of view – with a focus on the structure of power and processes of decision-making – river basin boundaries are problematic in different ways (Norman, Cook, and Cohen 2015). The accountability and legitimacy of organizations or policies based on river boundaries can be weak, and may generate conflicts with the existing layers of sectoral or political administration and agencies.

More crucially, river basins are affected by social or ecological processes which unfold at different scales and spatial units (e.g., climate change, invasive spaces, etc., which therefore have different "problemsheds"), and basin regulations or management practices may intersect in sometimes conflicting ways with other "policysheds," or geographical units in which policies (e.g., on land-use planning, reforestation, urban or industrial development, spatial conservation, or protection areas) are implemented. Thus, there has been a recognition that many drivers and consequences of river basin dynamics can be located outside the basin, where solutions to local problems may also lie. This recognition in particular speaks to the relationships between food production, water, and energy, and has triggered calls for integrating policy thinking at a higher level, through what is commonly referred to as a "nexus" approach.

Hydrologic boundaries are a starting point but often beg to be pragmatically adjusted to particular geographic, administrative, and political realities. Mechanisms to harmonize policies, resolve conflicts of prerogatives, and ensure participation in the coordination of multiple levels of organization and administrative layers need to be established. Coordinating existing state and nonstate actors may therefore be the primary goal, rather than creating a new basin organization. Eventually, the selection of boundaries for water or environmental management, whether of the river basin or otherwise, is a political choice.

Ecosystemic approach and environmental management

Intensive river basin development has resulted in major ecological changes. Dams have radically altered the natural flow regime of rivers and the circulation of sediments; large-scale irrigation schemes have withdrawn and depleted large amounts of water; cities, industries, and agriculture have injected massive amounts of chemicals and pollutants. Although hydraulic infrastructures have provided huge benefits in terms of flood control, energy and food production, or navigation, the dramatic alteration of existing hydrologic regimes in terms of quantity, quality, and timing have often undermined or destroyed rich ecosystems, together with the elaborate human uses that had developed around them.

Dams, irrigation, and pumping schemes have led to the loss of springs or wetlands, to the gradual disappearance and contamination of

terminal lakes or seas, and to the many benefits associated with floods (source of nutrients, recharge of aquifers, support of wetlands and biodiversity, flood recession agriculture, reproduction of fisheries, etc.), which have been severely curtailed.

Not only has development, in most cases, resulted in a shift of benefits from the local population to other, often urban, populations, but the overall economic assessment has sometimes been negative, the loss of ecosystem services and existing productivity used being higher than the benefits generated by the investments, as the cases of the Hadejia' Jama'a floodplain in Nigeria and the Kafue Flats in Zambia famously illustrate.

The necessity to view a river basin as a continuum of interconnected ecosystems in order to understand how changes in one part of a basin affect both water availability and environmental health in other parts of the basin has spurred the development of an "ecosystem approach," defined by the Convention on Biological Diversity as a strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use in an equitable way. It has contributed to raising people's awareness about the diversity of services obtained by people from ecosystems, either directly (fresh water, food, fuel, fiber, genetic resources, recreation, aesthetic experiences, spiritual enrichment, etc.), or indirectly (air quality maintenance, climate regulation, erosion control, regulation of human diseases, water purification, etc.), and has substantially enriched the conception of river basins and the understanding of their management.

This concept has also spurred work in the field of economics, with the development of methodologies for valuing ecosystem services to reveal the hidden costs of interventions and contest cost–benefit analyses and feasibility studies that routinely justify projects by ignoring their negative environmental externalities. They also argue that higher water prices could encourage conservation (thus increasing river flows) and have developed the concept of payments for environmental services.

Environmentalists have also promoted the notion of environmental flow, defined as the flow regime required to ensure the maintenance of particular environmental functions in a river ecosystem. Although the scientific determination of these environmental flows is problematic, and although these flows are often the result of negotiations between different interest groups, claiming a share of the available water for the environment has contributed to the political recognition of environmental requirements, and influenced major policy shifts and regulations such as the European Water Directive Framework. It even gave way to more radical claims, as illustrated by the movement for the removal of dams, which symbolically heralds a nascent paradigm shift.

Basin governance or management models: river basin organizations

The international promotion of the river basin as the natural or adequate scale for water resources management has contributed to the creation and spread of river basin organizations (RBOs). "River basin organization" is a generic term for organizations that come under a variety of names, including agencies, committees, commissions, authorities, associations, administrations, directorates, councils, hydraulic confederations, boards, and trusts. If the diversity of those denominations is partly due to the approximate translation into English of local administration names, it also reflects the historical pathways of the different basins and does make clear from the start that those organizations may sometimes be so different that grouping them under a single

category might actually be misleading: basins may be managed without RBOs, and some RBOs have a very narrow mandate that does not amount to basin management.

Discriminating factors first include the size of the basin (both the problems and the solutions, and how different stakeholders may contribute to them, vary greatly between small watersheds and international river basins) and the mandate of the organization: an RBO may be responsible for any combination of tasks that include construction, maintenance and management of infrastructures, development of basin master plans, allocating water or administrating rights, monitoring and collecting hydrologic or water quality data, law enforcement, fee collection, and promotion of public participation and awareness. But, from a governance point of view, an RBO can be typified, first, by its vertical integration within the state administration and, second, by its horizontal integration with nonstate actors.

Within the state, an RBO can be given all-encompassing powers that include planning, construction, and management, as well as regulation, in which case it will often be an autonomous authority, with prerogatives that override those of line agencies. But it can also be entrusted with a more limited mandates, in which case it will often be located under a particular ministry or department. The idea of integration has also promoted the concept of regulation, where an RBO is often supposed to define the rules of the game (like water quality standards, maximum aquifer withdrawals, user fees, and water rights) by which different sectors, users, and governmental agencies must abide. Unsurprisingly, the creation of a layer of governance at the basin-level results in the redistribution of bureaucratic power and often generates tensions or conflicts with other segments of the bureaucracy, as well as with local administrations. Because of the political difficulties of reshuffling prerogatives, RBOs often end up layered on top of existing institutions rather than replacing or complementing them. The development of a regulatory RBO, often located under the new and weak ministry of environment, is often not well accepted, especially if it threatens sectoral vested interests associated with the planning and construction of infrastructure or with unchecked pollution.

The degree of horizontal integration indicates how nonstate actors, such as representatives from the agricultural or industrial sectors, environmental nongovernmental organizations, and various civic groups, are contributing to decision-making. Nonstate actors can be called on to participate in different ways, from just consultation or participation in basin councils or platforms to representation in executive boards and decision-making, to being the driving force of RBOs that are partly independent from the state (which will be more common in small watersheds).

Integration is often taken as a justification for centralizing decision-making power and internalizing decision-making in a powerful organization, with the frequent risk of combining regulation and operation, and limiting accountability. However, it can be used to promote polycentric governance, where both different levels/scales and the views and interests of state/nonstate entities are expected to be harmonized, with the risks of stalemate by fragmentation of decision-making power and high transaction costs. These patterns of vertical and horizontal integrations define various forms of governance that must be further analyzed and characterized, for example by looking at their efficiency in terms of delivering sustainable or equitable management, the way their legitimacy is built and affirmed, their degree of accountability to society, and their capacity to be financially self-sustaining.

Collaborative arrangements for river basin governance are growing, as a result of the failure or limitations shown by models of decision-making restricted to state bureaucracy and experts, of the increasing demand from the private sector, interest groups, and civil society to have a seat at the table, but also of the new emphasis on, and the interest of the public in, restoring environmental quality in line with new values and uses, such as recreation and aesthetics. These factors have been at the root of the surge in the 1990s of the US watershed management movement, which includes over 1000 watershed experiences in collaborative planning, whereby local stakeholders decide the issues and discuss their options, with some technical assistance and funding from both federal and state agencies.

The mandate and prerogatives of an RBO may evolve with time, as a reflection of changes in the problems and challenges, in societal values, and in state–civil society relationships, and of political changes. More generally, these changes refer to the continuous adjustment of governance frameworks to ever-changing context and challenges, a need advocated by scholarship on adaptive management and governance.

The recent work of geographers on the politics of scale and processes of rescaling addresses the social production of scale and its impact on the distribution of power. Here the issue is how actors gain or lose influence as a result of authority being reconfigured around new spatial levels or by virtue of their own ability to work across different scales or levels

Transboundary basins and hydro-hegemony

Scholarship on transboundary river basins examines how water is managed in the 263 basins that cross national boundaries. They represent 60% of total river flows and 45% of the Earth's land surface, while being home to about 40% of the world's population. A first focus is on legal issues, including the 1997 UN Convention on the Law of the Non-navigational Uses of International Watercourses, with its two main principles of "equitable and reasonable use" and the obligation not to cause "significant harm" to neighbors, treaties between two or more countries sharing a river basin, or other institutional arrangements for transboundary river basins on issues such as pollution and navigation (as with the Rhine and the Danube), water allocation (the Indus and the Nile), and joint management (the Mekong and the Senegal).

Despite such arrangements, binding agreements are rare or nonexistent; transboundary management organizations are only given limited power; mechanisms for monitoring and enforcement are lacking; hydrological data remain secretive; and historical political relations between neighboring countries, as well as strong sentiments of territorial sovereignty, make it difficult to ensure equitable and environmentally friendly management.

One way forward has been to respond to the lack of public involvement in interstate water agreements by developing river basin councils, platforms, and forums in which water user representatives discuss plans and allocation issues within a country, like in the Zambezi basin, where a basin strategy has been developed with the active involvement of stakeholder groups in all eight riparian countries. Another way has been to develop the concept of *benefit sharing*, whereby the stalemate in negotiations over water allocation is overcome by introducing other benefits related either to the use of water (e.g., sharing the benefits of hydropower between countries) or to other issues such as trade.

Yet, the topic remains a favorite of political scientists, who have in particular developed the concept of hydro-hegemony to describe

relations of power between countries sharing a same river basin.

Future research directions

This brief review of ongoing scholarship about river basin development and management points to a few questions and areas of research that deserve further inquiry. Modeling approaches and stochastic hydrologic models are crucial to providing information on management options and associated levels of risk, but the study of extreme events must be paralleled by an understanding of policy and political processes that are difficult to model. Although often limited by the availability and quality of data, hydrologic modeling needs to refine the representation of the interaction between surface water and groundwater, and to better take into consideration water quality issues.

Given the baffling diversity of physical river basin environments, the combinations of problems faced, and the multilayered institutional arrangements, more effort should be put into understanding the relationship between the nature of water governance regimes and their effectiveness. More elaborate typologies of river basin organizations and other institutional arrangements should consider the wider historical, social, and political contexts in which these governance regimes emerge and evolve, and provide insight into the administrative configurations which should be favored in a particular context.

These typologies also require a more nuanced understanding of bureaucratic dynamics and reforms, in particular a closer look at the structure of incentives available to different actors and organizations, when the structure of decision-making power is reconfigured to address issues of basin-level environmental management.

More work is needed on the societal and political drivers of river basin closure, as a means of challenging discourses that naturalize water scarcity and water crises or frame them in Malthusian terms. The preference for supply augmentation and capital-intensive solutions results in the generation and compounding of water crises, and is therefore self-sustaining; this preference must be explained by analyzing the social distribution of costs and benefits attached to different policy responses, in particular the convergence of the interests of politicians, bureaucrats, and interest groups.

Urban studies focusing on water and sanitation issues have produced a substantial body of scholarship in the field of critical geography. Insights from urban studies need to better fertilize, and to be integrated into, studies on river basin dynamics and governance, and vice versa. More generally, studies of river basins provide an opportunity for multidisciplinary work integrating approaches from hydrology, economics, human geography, and policy studies, among others.

Multisectoral or nexus approaches also have the potential to refine understanding of the systemic complexity of resource use and economic activities, although it is unclear whether they can substantially influence sectoral policies and practices.

Last, the transfer, operationalization, and adaptation of river basin-based management or governance reforms in different contexts must be accompanied and scrutinized. Critical work on the ideologies, interests, and social mechanisms that sustain the reproduction and dissemination of particular practices and policy models is needed. Europeanization, for example, and the application of the European Water Directive Framework provide an opportunity to assess the confrontation of uniform policy guidelines

with the diversity of environmental and human contexts.

SEE ALSO: Governance and development; Irrigation; Political ecology; Water resources and hydrological management

References

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.

Josephson, P.R. 1995. "'Projects of the Century' in Soviet History: Large-Scale Technologies from Lenin to Gorbachev." *Technology and Culture* 36(3): 519–559.

Molle, F. 2007. "Scales and Power in River Basins Management: The Chao Phraya River in Thailand." *Geographical Journal*, 173(4): 358–373.

Norman, E.S., C. Cook, and A. Cohen, eds. 2015. *Negotiating Water Governance: Why the Politics of Scale Matters in the Governance of Water?* Farnham, UK: Ashgate.

Reisner, M. 1993. *Cadillac Desert: The American West and Its Disappearing Water*. New York: Penguin Books. (Original work published in 1986.)

Scott, J.C. 1998. *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*. New Haven: Yale University Press.

Further reading

Barrow, C.J. 1998. "River Basin Development Planning and Management: A Critical Review." *World Development*, 26(1): 171–186.

Huitema, D. and Meijerink, S., eds. 2014. *The Politics of River Basin Organisations: Coalitions, Institutional Design Choices and Consequences*. Cheltenham, UK: Edward Elgar.

Kemper, K.E., W. Blomquist, and A. Dinar, eds. 2006. *Integrated River Basin Management through Decentralization*. Berlin: Springer.

McCully, P. 2001. *Silenced Rivers: The Ecology and Politics of Large Dams*. London: Zed Books / New York: St Martin's Press.

Molle, F. 2008. "Why Enough Is Never Enough: The Societal Determinants of River Basin Closure." *International Journal of Water Resource Development*, 24(2): 247–256.

Molle, F., and P. Wester, eds. 2009. *River Basin Trajectories: Societies, Environments and Development*. Wallingford, UK: CABI. http://www.iwmi.cgiar.org/Publications/CABI_Publications/CA_CABI_Series/River_Basin_Trajectories/9781845935382.pdf (accessed April 6, 2016).

Newson, M. 1997. *Land, Water and Development: Sustainable Management of River Basin Systems*, 2nd edn. New York: Routledge.

Svendsen, M. 2005. *Irrigation and River Basin Management: Options for Governance and Institutions*. Wallingford, UK: CABI. http://www.iwmi.cgiar.org/Publications/CABI_Publications/PDF/Irrigation_and_Basin_Water_Management.pdf (accessed April 6, 2016).

Teclaff, L.A. 1967. *The River Basin in History and Law*. The Hague: Martinus Nijhoff.

Wengert, N. 1985. "The River Basin Concept as Seen from a Management Perspective in United States." In *Strategies for River Basin Management*, edited by J. Lundqvist, U. Lohm, M. Falkenmark, 299–305. Dordrecht: Reidel.

Zeitoun, M., and J. Warner. 2006. "Hydro-hegemony: A Framework for Analysis of Trans-boundary Water Conflicts." *Water Policy*, 8(5): 435–460.

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