The Origins and Ideals of Water Resource Economics in the United States

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Abstract

An abbreviated history of water resource economics is reported within the context of coevolving water issues and the emerging institutions of the United States' past two centuries. Notable principles of water economics and their US origins are discussed. Some of the long-standing wisdom of the field is recalled. Landmarks for the founding doctrines of water marketing and efficient water pricing are identified.

1. INTRODUCTION

All the noteworthy concepts of environmental and natural resource economics are exemplified within society's water problems. Depending on the situation, water can be too little, too much, uncertain in demand or supply, depletable, renewable, rival, nonrival, or diminished in its multitude of qualities. The list gets very long. The breadth of public decision making about water is correspondingly wide, offering many management and policy junctures where water economics informs helpfully.

Interestingly, some of the important subfields of economics evolved alongside water economics, with strong motivations for their development fueled in part by society's rising water issues. This includes the overarching field of welfare economics and components such as cost-benefit analysis (CBA) and externality theory (Prest & Turvey 1965). Social choice theory and institutional economics also have strong developmental intersections with water issues.

Landmark innovations in water economics are intertwined with the progress of US water issues, especially during the 1900s. As is observed below, the federal role in water supply development grew very slowly prior to escalating at the onset of the twentieth century and subsequently influencing economic thought. In forthcoming sections, abridged background and context are presented, discussing the 1900s coevolution of water economics with public decisions about water supply development. Emphasis centers upon the federal drive to develop large water projects and the emergent ideas of water resource economics that consequently arose. Although some of the innovations supported political directives to perform original analyses, many of the new ideas are attributable to disappointments in the national push.

The discussion below observes some of the important accomplishments of the water economics field, including policy design for water marketing and pricing. The article concludes with synopses of some of the questions addressed during the 1945–1969 classical era of water resource economics.

2. PUBLIC INTEREST DRIVERS: US HISTORICAL LANDMARKS

By virtue of the influence and remarkable size of the resulting monuments, center stage for water decision making in the United States is commanded by federal reservoir projects. Yet things were very different prior to the 1930s, and since the 1960s the seeds of devolution have been chipping away at the focus on federally built dams. The frontline policy options are quite different now, even though project analysis remains highly germane for proposals such as desalination and infrastructure refurbishment. Costly structural solutions, all of which warrant economic study, continue to be proposed at all governmental levels. Furthermore, ever since the nation's beginning, advancing legal doctrines, changing planning modes, and a diverse set of water policies have also required formulation, debate, choice, and, occasionally, formal analysis (Cody & Carter 2009). Thus, by no means has water decision making been confined to federal projects.

Projects and policies are commonly substitutes, albeit imperfect ones. Throughout the design and adoption histories of structural (project) and nonstructural (policy) measures, the weight of water-related issues has generated many improvements in the capacity to analyze public options. Decision-making processes have become more prescribed, and knowledge has expanded. Yet public decisions often clash with economic recommendations or lag substantially. To grasp the roles of the resulting analysis and policy tools and the progress of economics contributions, it is informative and stimulating to review the historical context.

2.1. Navigation and Flood Control

Almost 200 years ago, a youthful US Army Corps of Engineers (Corps) with an emphasis on military fortifications, especially in proximity to harbor-concentrated populations and commerce, was drawing new responsibilities for making navigation improvements, in the interests of enabling commercial development and more rapid troop deployment (Maass 1951, US Army Corps of Engineers 2008). The rarity of an organized and engineering-schooled body of any kind—the US Military Academy at West Point was established in 1802—generated many surveying and construction-related tasks for the Corps in the 1800s. These included road building, a water aqueduct for the nation's capital, and western exploration (Andrews & Sansone 1983, Rogers 1993, US Army Corps of Engineers 2008). Although the early 1800s saw many privately sponsored or state-sponsored canal-type waterway projects (e.g., New York state's Erie Canal), most of these failed or were federally subsumed, and the emergence of train transport ended the canal era midcentury. The momentous 1824 US Supreme Court case of *Gibbons v. Ogden* granted legal domain over matters of commerce and navigation to the nation (Billington et al. 2005, pp. 13–14), thus permanently assigning special significance to the adjective "navigable," permanently transferring from states specific regulatory powers over navigable water, and solidifying a future role for the Corps in navigation projects.

The Corps developed expertise with navigation efforts (especially river clearing and channel modifications) in the Ohio and Mississippi basins during the nation's early thrust westward (US Army Corps of Engineers 2008). Locks and dams became part of the Corps's repertoire later in the 1800s. Notable floods of the latter 1800s served as the impetus for assigning some flood control tasks to the Corps, which largely built levees to this end. Substantial flooding in 1912–1913 and 1927 brought about the first two national Flood Control Acts (1917 and 1928), with the second accompanied by loosening of the levees-only focus (Holmes 1972, p. 60).

Thus, prior to 1930, the Corps involvement in water policy was project focused and highly targeted to navigation and flood control. Whereas federal interest in multipurpose water projects (e.g., flood control, water supply, hydropower, etc.) was growing in the early 1900s, Corps projects tended to be single purposed. Along the way, the Corps did occasionally engage in 1800s water supply efforts, but the national vision was that water supply was the domain of private enterprise and lower government.

2.2. Urban Water Supply

At the time of the nation's birth and well beyond, the larger US "cities" experienced occasional waves of communicable diseases. In spite of the rudimentary state of scientific knowledge, some wondered if the accumulating street filth and the proximities of water sources (often shallow household wells) to outdoor privies were factors (Blake 1956). Firefighting was also a major public interest given the catastrophic potential of town blazes. Consequently, public interest arose for centralized water supplies. Wooden pipes were the norm for community water systems before and after 1800, yet steam engines were being applied to lift urban water even as the country asserted independence in 1776 (Blake 1956). Because local governments lacked the money to pursue these missions, licensing of a privately operated utility was the main strategy, but problems of public-private coordination and inadequate revenue due to low subscription numbers by townspeople impeded progress (Blake 1956). Eventually, private utilities operating in large cities were usually acquired by city governments to improve and expand service (Blake 1956). Other inducements for public ownership of utilities in the 1800s included the high transaction costs of contracting with private operators (Masten 2011). With little interest from paying customers, wastewater collection—a task now commonly performed by urban water supply utilities—lacked privatized options during this period, and public efforts were meager.[1]

By 1860, 58% of the nation's 136 water utilities were privately held, but only one-quarter of the largest 16 were private (Blake 1956, p. 267). Following a more purposeful path, subsequent private ventures dominated the development of water supply services within the rising interior cities of the United States. Howson (1959) reports that most midwestern utilities were established as publicly licensed, privately owned franchises in the late 1800s. At the conclusion of 20–25-year licenses, most cities took over these utilities and compensated the owners (Howson 1959). Some 4,000 urban utilities existed by 1900, and water rate regulation by state public utility commissions commenced in many states by 1920 (Howson 1959). Public ownership of these systems became favored by a combination of economic considerations: Rate regulation was less rigorous for publicly owned systems, borrowing rules were more relaxed (Howson 1959), and the exemption of municipal bond income from taxation rendered public borrowing cheaper than private borrowing for the same expenditures. (The federal income tax was permanently established in 1913.) In the 1900s western cities such as Los Angeles, San Francisco, and Denver worked to secure water supplies, using their own monies to build dams as well as far-reaching water conveyances, just as major eastern cities had done for shorter distances in the 1800s.

Management of urban utilities remained a local and state matter until the first Federal Water Pollution Control Act (1948)—now heavily amended and termed the Clean Water Act—initiated federal involvement in water treatment regulation (White 1969, p. 65; Rogers 1993, pp. 97–98). An expensive feature of the many 1972 amendments to this act was the establishment of federal cost sharing for the construction of municipal wastewater treatment facilities.

2.3. Irrigation Water Supply

Western US land development pressures, both from politicians and from landholders, resulted in new demands that would eventually put the federal government in the wholesale water supply business. Homestead policy of the mid-1800s, in which midwestern settlement was promoted by disposing of 160-acre parcels in return for occupying and farming this land, was ineffective in the more arid West in the absence of irrigation water (Bates et al. 1993, pp. 32–34). So, the United States began distributing public waters to landowners too, via the Desert Land Act of 1877 and subsequent

[1] **http://www.sewerhistory.org/chronos/new_amer_roots.htm**.

congressional acts (Andrews & Sansone 1983, pp. 99, 169; Rogers 1993, pp. 48–49). At approximately the same time, a few privately orchestrated land and irrigation developments were succeeding. Notable among these were ambitious 1847–1870s settlements in Utah, Colorado, and California (Coman 1911; Maass & Anderson 1978; Worster 1985, pp. 76–77). Yet many private land development schemes failed in the West, at least in part due to inadequate provisions for irrigation water (see Coman 1911, which appeared as the first article in the first volume of the *American Economic Review*).

These forces led to an incredible surge in irrigated acreage, from 0.25 or 1 million acres in 1880 to 7.5 million acres in 1900 (Institute for Government Research 1919, p. 3; Andrews & Sansone 1983, p. 171). Many of these developments also underscored the utility of cooperative irrigation works (Mead 1903), giving rise to new state laws authorizing the formation of irrigation districts and endowing them with governmental prerogatives such as the power to tax property (Israelsen 1914, Smith 1984).

Another reform of the late 1800s was the christening and spread of a new system of water rights within western states. The prevailing riparian doctrine, a common property regime for water, was found to be unsuited to the West's elevated water scarcities and the desires of western users to transport surface water to nonriparian lands, and the prior appropriations doctrine was born (Andrews & Sansone 1983, pp. 169–170). Western territories and states proceeded to abandon riparian law and to replace it with prior appropriations. Under pure riparianism all streamside landowners share the water resource under soft guidelines constituting unquantified use limits. Among the criticized properties of this system, transactions in water "rights" (loosely speaking) cannot be accomplished apart from transactions in land. The prior appropriations doctrine's precept of "first in time, first in right" would eventually be articulated as formal permits to divert a quantified flow of water with a stated seniority relative to other appropriative rights in a basin. A century later, this institutional innovation would become the basis for expanding a private property solution to water scarcity in which these permits are transacted: water marketing (to be more deeply discussed below).

The federal gifting of land and water was joined by the gift of money in the 1900s, commencing most strongly with the Reclamation Act of 1902. The US Bureau of Reclamation (BuRec) was created by this Act, with the task of producing irrigation works through the use of a dedicated revolving fund. Seed monies were derived from western land sales (Institute for Government Research 1919, p. 21). The original congressional vision was that individual irrigators would sign contracts pledging to return costs over 10 years, thereby recharging the fund for additional projects. Subsequently, Congress lengthened the repayment period first to 20 years and then to 40 years (1914, 1926), commenced appropriating federal monies into the fund (1914), channeled oil royalties from public lands into the fund (1920), shifted contracting from individual farmers to irrigation districts (1922, 1926), capped yearly repayments to not exceed farmers' "ability to pay" (1939), tapped hydropower revenues for irrigation repayments (1939), neglected to assign any interest costs to irrigators, and neglected to adjust repayments for dollar-weakening inflation (President's Water Resources Policy Commission 1950, p. 151; Holmes 1972; US General Accounting Office 1996; Western Water Policy Review Advisory Commission 1998, pp. 4–11). Two results of these intense subsidies were that irrigated acreage continued its dramatic rise in the West and that users of BuRec irrigation water paid less than 20% of the actual costs of the water they received (Wahl 1989, chapter 2).

2.4. An Era of Multipurpose Projects

In the 1930s, the US Congress yielded to the building agencies the high ground for addressing water issues, thereby diminishing nonstructural solutions for several decades. Projects became the key "policies" of the 1900s. All the significant forces pointed in the same direction, with the main encumbrance being limited federal dollars. Engineering skills had advanced sufficiently to take on the huge opportunities presented by unique river sites (Lee 1978). Due to ongoing electrification, hydropower was highly desired, and it was relatively nonrival with other project purposes (Pisani 2002, chapter 8). Voters in beneficiary regions were unified in supporting Congressmen who could win federal approval for subsidized water projects. Early BuRec accomplishments had reinforced irrigation-dedicated constituencies by illustrating what could be accomplished with Washington dollars. The West was like-minded in these pursuits, allowing it to erect powerful political coalitions. The Depression arrived and was answered by the Keynesian New Deal with a very high proclivity to spend money and put people to work on federal civil works projects (Holmes 1972).

Technically challenging water projects became the norm during the 1930s, especially in the West. The Tennessee Valley Authority (TVA) was authorized in 1933 for the Southeast. Although TVA projects were fewer in number, their scale was similar to that of projects being pursued by the Corps and BuRec. All three agencies continued to formulate and initiate major projects through the 1960s. The embedded subsidies engendered by low cost-sharing requirements, slighted borrowing costs, and other beneficiary advantages meant that this massive construction program redistributed both wealth and people westward as it sped development. Yet pork barrel[2] politics reigned nationwide for water projects, so there were east-of-the-Mississippi projects too, and the total cost of Corps projects exceeded that of the BuRec. By 1949, BuRec had spent $1.5 billion and the Corps had spent $5 billion (nominal) during the same 47-year period (de Roos & Maass 1949). In many situations, project outputs such as water, power, and transportation were in direct competition with private enterprises—often overwhelmingly so and thereby strongly altering the industrial organization landscape (Holmes 1972). Yet court rulings supported federal authority to displace entrepreneurial activity with these activities (e.g., *Ashwander v. TVA*, 1936).

Combined, the three federal agencies noted here have built more than 1,100 dams[3] (476 BuRec, 609 Corps, 47 TVA). The ten largest US reservoirs by volume (three BuRec, six Corps, one TVA) lie in the Colorado, Columbia, and Mississippi River basins.[4] The largest of these ten was the first of them to be built (Lake Mead/Hoover Dam, BuRec, 1931–1936). Three of the ten were initiated in the 1930s and were completed in the 1940s. Four were started in the 1940s and were completed in the 1950s. The remaining two were completed in 1966 (Lake Powell/Glen Canyon Dam, BuRec; the second largest) and in 1975 (a Corps project with Canada). Today, the largest US reservoir is only the thirtieth largest in the world, yet it remains an impressive historical landmark—physically and institutionally—for both the United States and the world.

[2]Pork barrel refers to attempts of legislators to impress their home constituents by spending national monies on local projects, regardless of the national merit of any given project (Hird 1991). Because such national-level decisions normally require approval by a congressional majority, cooperation among legislators is a factor in "bringing home the pork."

[3]**http://www.usbr.gov/facts.html, http://en.wikipedia.org/wiki/United_States_Army_Corps_of_Engineers#Water_resources, http://www.tva.gov/sites/sites_ie.htm.**

[4]**http://en.wikipedia.org/wiki/List_of_largest_reservoirs_in_the_United_States.**

2.5. Filling Up, Moving On

Political pressures and complicit agency interest in multipurpose water projects continued beyond the 1960s with many administratively approved yet unfunded projects. However, new construction starts waned seriously in the 1970s due to complaints about costs and environmental burdens. Early environmental groups further organized themselves to combat the loss of natural ecosystems caused by dams. At the front of this movement, the Sierra Club lost key battles, notably Hetch Hetchy Dam (San Francisco, 1913–1923) and Glen Canyon Dam (BuRec, 1956–1966), but environmental organizations also sharpened their arguments, matured politically, and eventually lodged some wins (e.g., preventing Echo Park Dam in the 1950s) (Bates et al. 1993, pp. 43–44; Billington et al. 2005, pp. 395–99). With the emergence of these public interests came demand for understanding the environment and its values better (White 1969, pp. 45–46) and for representing those values in decision making. As a result, it became accepted practice to include monetized recreational and environmental values in the CBAs of proposed projects.[5]

Other institutions such as the Federal Power Act began to impinge on the dam approval process too, as with the scientifically momentous Hells Canyon case (1967–1969, Snake River, Columbia Basin). Upon complaint and suit by the US Department of the Interior, the US Supreme Court expressed concern about the salmon and steelhead effects of another contentious dam on a special waterway (Krutilla & Fisher 1975). Consequently, economist John Krutilla was instrumental in injecting new information on sacrificed recreational values, thereby affecting project analysis in a unique way (Duffield 2011). In the end, the High Mountain Sheep dam was not built.

During the late 1970s, TVA's Tellico Dam brought about a historic faceoff between the culture of dam building and a new call for protecting endangered species, the Endangered Species Act of 1973 (Andrews & Sansone 1983, pp. 120–21; Plater 2004). Because of the Act, in 1978 the US Supreme Court halted construction of the nearly complete Tellico to protect a small fish—the snail darter. This dam was eventually completed after US legislators from Tennessee won a congressional exemption from the Act.

During the same period, the rising water quality problems of the post–World War II, high-growth nation demanded attention and money, sparking new policy and imposing considerable new federal costs in the form of pollution regulation and subsidized wastewater treatment facilities (Rogers 1993, pp. 11–12). The financial pressure contributed to difficulties in funding more water development.

Executive decisions made by President Carter's administration (1977–1981) provided a defined end to the US dam-building era. Disappointed western factions helped to defeat Carter and place Reagan into office (1981–1989), but during President Reagan's first term, cost-sharing requirements were raised for water projects,[6] CBA rules were reshaped,

[5]Water supply beneficiaries welcomed the introduction of recreational benefits into federal CBA, thereby hastening the change. Not only did recreational benefits improve a project's approval chances, but they further reduced the prospective cost shares to be levied upon local beneficiaries (Banzhaf 2010).

[6]Perhaps this outcome should have been anticipated by water development supporters: Because of anti-TVA statements he made, in 1962 Ronald Reagan was fired from a popular television show he had hosted for eight years. The show's sponsor, General Electric (manufacturer of turbines for the TVA), was responsible for the termination. Reagan's TVA stance helped to launch his political career in California (**http://en.wikipedia.org/wiki/General_Electric_Theater**).

and various federal water-planning efforts were terminated (Andrews & Sansone 1983, pp. 110–12; Waelti 1985).

Since the 1950s, there has been a strong and growing interest in policy reform, i.e., nonstructural measures, as the means to address water issues. Examples are increased attention to conservation ideals, water reallocation, and water pollution policy. State water laws have greatly evolved with these shifts, especially since 1980. Most eastern states have replaced their riparian doctrine with more tangible water permit systems, and western states have increased the transferability of water rights and have raised the standing of instream flow rights (Deason et al. 2001). Federal dam-building agencies have undergone change too, in part by redirecting attention toward water quality and environmental missions—sometimes engaging new projects to undo the results of earlier projects (Polasky 2008). Interest has also risen for project reoperations: modifying the operating rules that specify state- or season-dependent releases from reservoir systems. Reoperations alter the water supply potential, flood preparedness, and environmental effects derived from existing dams and now seem primed to gain very strong attention under a climate-altered environment. In addition, maintaining federally built infrastructure is a rising economic challenge due to agedness,[7] as is the deterioration of reservoir storage capacities due to sedimentation (Rogers 1993, Huffaker & Hotchkiss 2006).

Structural solutions have been found deficient for reasons other than cost and environmental damage. Major Mississippi Valley floods of 1993 and 2011 and Hurricane Katrina flooding in 2005 demonstrated that dams and levees can be disappointing substitutes for local floodplain management policy. Indeed, structural systems are argued to sponsor added destruction by encouraging development in the wrong places and of the wrong forms. According to economist Boulding (1964, p. 88), "The truth is that what we call 'flood control' means the eradication of little disasters every 10 years or so at the cost of a really big disaster every 50 or 100 years in any given floodplain. . . . This is largely because we have regarded flood control as a problem in engineering rather than in sociology."

Today, a multitude of forces now point in new directions, with a heightened emphasis on institutional advance through improved policy design and policy choice, as opposed to technological advance and further structural investments. Yet expensive structures continue to be proposed and occasionally undertaken, and public interest in more dams and conveyances perseveres in spite of the highly harnessed water environment of the United States. For all these reasons, the potential role of economics for assessing options remains high.

3. ECONOMICS DEVELOPS AND WEIGHS IN

Within this richly colored backdrop, the emerging science of economics—still labeled "political economy" in the late 1800s—was attempting to establish sufficient foundations to speak decisively about public undertakings such as water resource development. The field of welfare economics, although key to the very existence of political economy as a science, was still in its infancy in the 1930s. Hicks (1939a, 1975), Little, Samuelson, Arrow, and others had not yet pushed forward the concepts of Pigou (1920) and his predecessors to more completely articulate the optimal organization of an economy and appropriate techniques for measuring community welfare change.

[7] **http://www.infrastructurereportcard.org/fact-sheet/dams**.

3.1. Cost-Benefit Analysis

The subfield of CBA existed at this time—Clark's 1935 text is likely the strongest 1930s example—but CBA still lacked key abilities. Thus, formal economic tools for studying available water policies or projects were underdeveloped when the twentieth-century need was peaking. This is not to say that the political establishment was omitting economic claims from debate. Federal arguments suggesting public sector involvement in US water development date at least to 1807, even though the major activity awaited the twentieth century (Boland et al. 2009).

The most-quoted passage in water resource economics was provided by the Flood Control Act of 1936, which famously instituted that federal funding for a given water project is acceptable "if the benefits to whomsoever they accrue are in excess of the estimated costs." Usually, this mandate is implied to have inaugurated CBA for all federal water projects, but in truth the Act emphasized the standard for flood control projects, and "cost-benefit ratios" were already providing guidance in project selection processes (Arnold 1988). More remarkably, "to whomsoever they accrue" responded (inadvertently?) to a pivotal hardship confronting welfare economics at that time. Enamored with the ordinal-only concept of consumer utility initiated by Pareto, economists were reluctant to add money measures of utility changes across different agents, because interpersonal comparisons of this type were normatively unpalatable to economists of the era. To them, it was contentious to add a five-dollar loss incurred by a poor man to a six-dollar gain for a rich man and conclude that the community was better off because of the one-dollar net increase. Different hypothetical compensation tests involving just this additivity were about to be invented (or reinvented according to Chipman & Moore 1978, p. 548n) through the combined contributions of Hicks (1939b, 1943), Kaldor (1939), Henderson (1941), and Scitovsky (1941). In the past 70 years, economists have grown far more sanguine about the normative appropriateness of adding money measures and then asking if the sum or net present value is positive, thereby embedding interpersonal comparisons in social welfare criteria. The post–World War II focus of CBA on water projects and the congressional licensing expressed by "to whomsoever they accrue" may have been contributing factors in this decidedly normative transformation of applied welfare economics.

Pork barrel politics was in high speed by the late-1930s, with Congressmen jockeying to get their pet projects to the front of the funding queue. The availability of money trailed project approvals and generated some congressional interest in a method of culling projects, although legislators had no intention of relinquishing their power to economic metrics. In 1939, the National Resources Planning Board and the US Bureau of the Budget received collaborative duties that "may be said to mark the beginning of formal economic analysis of water projects" (Viessman 2009, p. 21). After World War II, efforts to develop a consistent set of standards for CBA were initiated, capturing considerable attention and drawing the attention of able economists (Caulfield 2000, Hufschmidt 2000). During much of the postwar era, these standards have been advisory rather than required. By necessity, agency economists (often replumbed engineers) were at the forefront of these developments, but academicians became heavily involved in the 1950s. The Harvard Water Program (1955–1972) is a special instance of this involvement (Maass et al. 1962, pp. 10–13; Kneese 2000; Reuss 2003).

Noteworthy published statements of CBA standards for federal water projects are listed in **Table 1**. Recently, proposed revisions to the in-force 1983 rules have been circulated for public comment, and a new document is overdue. Witnessing the stakeholder commentary

Table 1 Major federal documents[a] guiding water project cost-benefit analysis

Year	Title	Source
1950	*Proposed Practices for Economic Analysis of River Basin Projects*, aka the Green Book	US Subcommittee on Benefits and Costs of the Federal Inter-Agency River Basin Committee (1950)[b]
1952	*Reports and Budget Estimates Relating to Federal Programs and Projects for Conservation, Development, or Use of Water and Related Land Resources*, Circular A-47[c]	US Bureau of the Budget (1952)
1958	*Proposed Practices for Economic Analysis of River Basin Projects*, a minor revision of the Green Book	US Subcommittee on Evaluation Standards of the Federal Inter-Agency River Basin Committee (1958)[b]
1962	*Policies, Standards, and Procedures in the Formulation, Evaluation and Review of Plans for Use and Development of Water and Related Land Resources*, Senate Doc. 97	President's Water Resources Council (1962)
1964	*Evaluation Standards for Primary Outdoor Recreation Benefits*, Supplement 1 to Senate Doc. 97	Ad Hoc Water Resources Council (1964)
1973	*Principles and Standards for Planning Water and Related Land Resources*	US Water Resources Council (1973)
1979	*Principles and Standards for Planning Water and Related Land Resources* (revised)	US Water Resources Council (1979)
1983	*Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*	US Water Resources Council (1983)
2012?	*National Objectives, Principles and Standards for Water and Related Resources Implementation Studies*[d]	Council on Environmental Quality (2012)

[a] Abridged from Hufschmidt (2000).
[b] The 1950 and 1958 proposals were not adopted by the agencies for which they were designed due to disagreements primarily regarding the uneven admissibility of secondary economic effects (Caulfield 2000).
[c] A-47 was employed by the President's Office until it was replaced in 1962 by an administratively forged agreement, subsequently distributed as Senate Doc. 97 (Caulfield 2000).
[d] Background for this document and the draft is available at **http://www.whitehouse.gov/administration/eop/ceq/initiatives/PandG.**

that is invited to this process does not quell long-standing worries about the influence of project beneficiaries.[8]

The 1940s–1960s urgency of project analysis and the dearth of established methods deemed that this be the classical era of water resource economics. The need for compilations

[8] **http://www.whitehouse.gov/administration/eop/ceq/initiatives/pandg/comments.**

of methods and the breadth of the subtopics caused much of the work to appear in texts and governmentally sponsored reports instead of in journals. Pivotal academic works of the classical era included books that remain commendable readings today: Eckstein (1958), Krutilla & Eckstein (1958), McKean (1958), Hirshleifer et al. (1960), Maass et al. (1962), and Bain et al. (1966). As these works questioned and designed measurement techniques for project analyses, they also brought attention to policies capable of substituting for projects. The classical period can be said to have ended prior to the excellent text by James & Lee (1971). For targeted reviews of project appraisal methods, readers should consider the Boland et al. chapter (2009) as well as Young & Haveman (1985).

3.2. Rule Bending

An idealized interpretation of CBA is that these analyses check the excesses of rent seeking and political influence[9] so that only worthy projects can be built. Two obstructions limit this view. First, the metrics of CBA are incomplete, even though CBA involves an inventory of project effects that is larger than the mere estimation of these metrics. Indices such as benefit-cost ratios and net present value include only monetized project effects, so unmonetized effects[10] are separately described in CBA, and the highlighted economic indices are acknowledged to be partial measures (Griffin 1998). "Intangibles are likely to mar the neatness of any analysis. . . ." (McKean 1958, p. 58). This incompleteness of economic measures generates a slackness in the commendations of CBA, thereby inviting politicized, more-subjective choice to finalize prioritizations. As any given proposed project yields both positive and negative effects, only some of which are aggregated into composite economic metrics, latitude persists for politicized forces to override a mere economic metric. Given the incompleteness of economic measures, this latitude is not a bad thing in principle, but it does leave the door open for fulfilling the biased desires of special interests.

Second, political mechanizations are prone to resist when their desired actions are reined by economic facts and analysis. Since 1936, the federally endorsed rule set (when there was one) has mostly had a recommended status rather than a required status. In the same vein, few states in the United States require CBA for state-sponsored water projects, thus maximizing political discretion and limiting decision information. During the important pre-1970s period when major federal projects were still being approved and funded, the agencies employed different benefit assessment methods, with the treatment

[9]Political rent seeking is strongly enabled in the case of nationally funded water projects, due to the wide dispersion of costs (small for any one taxpayer) and the narrow incidence of benefits. Within this setting, special-interest groups can lobby effectively because of weak opposition; agency bureaucrats can enjoy greater power and rewards with larger budgets, more employees, and an approving clientele; and legislators can improve their reelection potential and legislative status (Rucker & Fishback 1983). More recently, the aligned force of these three groups in broader, not-just-water contexts is sometimes termed an iron triangle to underscore the solidarity, strength, and effectiveness of the coalition.

[10]The range of evaluated impacts can be especially rich in water project circumstances. Not only is there the ordinary array of nonmarket inputs and outputs, such as recreational, aesthetic, and environmental goods, but there are a wide range of special considerations. Among these are risk impacts such as flooding potential and water supply shortfalls; cultural impacts such as the inundation of archeological sites or the displacement of native people; and social effects such as those on national security, poverty, or energy/food self-sufficiency. Established CBA protocol for US water projects is to assemble information on all such potential effects as part of the decision-making process. For this reason, there are two long-standing "accounts," "Environmental Quality" and "Other Social Effects," for compiling these prospective impacts. See US Water Resources Council (1983).

of secondary economic effects and discounting being most controversial. Both are discussed below. Overall, the period teaches us that if a hurdle such as the 1936 Flood Control Act criterion threatens to become sturdy, it can be undermined through misapplications and reinterpretations of CBA's guiding principles. Ultimately, when the builders are also the analysts and are in a position to succumb to their biases, CBA may become a lever of political desires, as bureaucratic application of the tool is twisted to elevate favored interests.

Abuses in the execution of water project CBAs has taken many forms. Under the proproject orientations of legislators and building agencies, tendencies are to underestimate costs and to overestimate benefits. Whereas cost underestimation can be accomplished with optimism and omissions, benefit overestimation may require greater zeal and ingenuity. Reviews of the classical era identify many instances of dubious analysis (Marshall 1964, 1966). These proclivities are not peculiar to the United States (World Commission on Dams 2000; Flyvbjerg et al. 2002, 2003; Scudder 2005).

In spite of its shortcomings and occasional misuse at the hands of agencies, it is reasonably argued that CBA "still serves a worthwhile purpose *to restrain the abuse of economic arguments in the political process*" (Ciriacy-Wantrup 1964, p. 10). This concise statement seems remarkable for its contemporary applicability, and it stands as an admirably modern candidate for the central objective of cost-benefit analysts. For this to succeed, the execution of CBA needs more isolation from political and bureaucratic influence than was witnessed during the classical era.

3.3. Nonstructural Policy

"For the next several decades, the most important question related to water resource development is that of institutional design rather than engineering design" (Ostrom 1993, p. 1,907). Thus, at least one Nobel economics laureate believes that policies are more promising than projects. Economists have emphasized two policy tools for application to society's water resource problems. Each of these is the emphasis of forthcoming subsections. Water marketing addresses water scarcity at its most base level—where it occurs in rivers, streams, and aquifers. Here, transferability of property in natural, in situ water provides a predominately nonproject option for growing sectors to acquire water. The second tool addresses scarcity at the processed water level by utilizing full-cost water rates. When rates charged to the clients of water utilities and water districts can be improved to signal not just accounting costs but opportunity costs as well, socially appropriate levels of water use and conservation can be achieved. This combats the standard practice of excluding raw water value from water rates. For example, municipalities commonly calculate water rates so as to recover the value-adding costs of converting raw water to delivered tap water, but the scarcity value of in situ water is excluded.

For reasons of its breadth and nonspecificity to water scarcity issues, a third area of policy advance is not reviewed here. These policies are associated with water quality problems. Externality policies, such as effluent incentives, nonpoint-pollution instruments, transferable permits, and cap-and-trade strategies, are set aside, even though water quality issues contributed to these advances.

3.3.1. Water marketing. Where transferability of private property in water is legally permitted, there is a nonstructural avenue for growing sectors to satisfy their water demand.

This is an easily oversimplified option. As all human, diversionary uses of water redirect water from its prior course, rather than "consume" it in a strict sense, all transfers of water rights have strong potential to affect people who are not party to the exchange. When someone consumes a regular commodity like an orange, it is destroyed in use, and one person alone receives its functionality. If the orange is transferred to a different person, someone other than the seller destroys it. Because the orange does not subsequently flow from either trader to other potential users, no other people are affected by the two-party agreement.

Water is a perplexing commodity to manage because of its flow character; it flows through our bodies, our production systems (e.g., irrigation and manufacturing), and our environment. Although externalities, such as return flow effects upon a basin's other users, abound for water trade, and some water uses are nonrival, thereby weakening the applicability of the first theorem of welfare economics (invisible hand) doctrine, economists have heavily advocated water marketing. Thus far, US water marketing occurs only in the western states, and even in these states it is not ubiquitous.

Intrasectoral applications of water marketing did not await the approval of economists, however, as market practice was already supported in a few locales where transfers were allowed. For example, some western irrigation districts have long used transferable shares of their corporate stock and, by extension, shares of their water that are amenable to internal, primarily intrasectoral exchange. Teele (1927) wrote insightfully about the economic gains that can accrue to water transferability among irrigators. He also explored the merits of self-interested transactions versus public administration in achieving the greatest agricultural production from limited water, and he saw advantage in the former.

Yet for intersectoral transfers—most notably irrigation-to-urban or irrigation-to-environment transfers—marketing is a more recent phenomenon, having arisen mainly in the latter decades of the 1900s. During the classical era of water economics, prior appropriations water rights had limited transferability between sectors in most states. Literature espousing intersectoral trade originated in the 1950s. Milliman (1956) provided an early discourse on the practicality and service obtainable from a system of transferable water rights. He understood that prior appropriations served "to eliminate a large part of the commonality feature" intrinsic to the riparian doctrine and was therefore a much better platform for exchange (Milliman 1956, p. 430). Ciriacy-Wantrup (1955, 1956) also wrote about transferability opportunities in western water rights. In Milliman's subsequent 1959 treatment, he dealt with a number of important deficiencies in the practice of western water law: "Although suited to transferability, the doctrine of appropriation, as presently interpreted, places a number of limitations which interfere with sale or exchange and introduce undesirable rigidity" (p. 51). At that time, most instances of water transfer involved either land transfer or the internal trade of irrigation district stock shares because water rights were inadequately severed from land properties. Economists began asking for this separation, together with the removal of prohibitions on water right transferability, because they saw the economic waste intrinsic to the old system. Part of these losses were the very large costs and environmental harms of new projects, so calls for marketing reflected strong concern about the economic merits of more projects.

The legal community continued to maintain that courts were able arbiters of best water allocation and that no market-based transferability was needed. Fifty years ago, economist Mason Gaffney and legal scholar Frank Trelease had an interesting debate over restrictive marketing practices of that time (Gaffney 1961, 1962; Trelease 1962; Johnson et al. 1981). Inertia favored continuance of the existing system in that proirrigation, prosubsidy, and proproject interests believed that the legal and project-building systems were working reasonably well. Legal traditions based on case law and court precedents can enlist water attorneys as the guardians of antiquated rules, and it becomes difficult for the gatekeepers of law to visualize advantages in marketing (e.g., Neuman 1998).

Terry Anderson (1983a,b) and others led a renewed charge in the 1980s seeking relaxation of the institutional constraints obstructing water marketing. Several facets of appropriative doctrine were and are problematic, and these vary by state. Among the arguably unfortunate characters are the appurtenance of water rights to land ownership, prohibitions upon transfer, the use-it-or-lose-it principle, the necessity of continued demonstration of beneficial use, state-sanctioned sectoral priorities, and the necessity of diverting water to establish original ownership (Milliman 1959, Gardner & Fullerton 1968, Johnson et al. 1981, National Research Council 1992, US General Accounting Office 1994). Although all these rules are limiting within a modernized appropriative rights doctrine embodying quantification, seniority, and transferability (including subdivision) of rights, they die slowly at the hands of rising scarcity and do not succumb to the words of economists.

Yet as water is not destroyed in use—human use simply changes water's place, time, and qualities—any reallocation is prone to affect third parties, some positively and some negatively, so the externalities of water trade are highly significant issues. These externalities moderate the promise of marketing in that two-party agreements do not automate the achievement of economic efficiency (Gardner 1990). Consequent contributions from the literature of economics are available for the matters of return flow externalities (Hartman & Seastone 1970), instream flow rights and surface flow constraints (Anderson & Johnson 1986, Colby 1990a, Griffin & Hsu 1993, Gillilan & Brown 1997, Murphy et al. 2009), the spatially defined pattern of water value along a watercourse (Chakravorty et al. 1995, Weber 2001), defining groundwater rights and severing them from land rights (Smith 1977, Gisser 1983), appropriations doctrine and water market performance with respect to uncertainty in water availability (Burness & Quirk 1979, 1980; Characklis et al. 2006), and the high transaction costs of water marketing due to externality management (Young 1986; Colby 1990b, 1995). The set of water marketing instruments has expanded to include not only permanent sales of rights but also leases or spot markets, banks operated by public authorities, and dry-year options (Michelsen & Young 1993, Howitt 1998, Pulido-Velazquez et al. 2004). Transfers have become sufficiently common to provide transactional data of different types that enable econometric study of the value of water (Goodman & Howe 1997, Brown 2006). Because water is not particularly mobile between basins as a consequence of the high capital and energy costs of its transport, these market values can vary greatly across locations.

3.3.2. Full-cost rate making. Scientific advance in the water pricing arena was preceded by the general public utility literature (Berg & Tschirhart 1995). Although the principles are long established, adoption of full-cost water rate policies remains very weak, and progress is now complicated by the growing public application of increasing block rates, which assigns opportunity costs unevenly and therefore inefficiently across customers (Griffin & Mjelde 2011). Thus far, full-cost pricing of water has achieved mainly theoretical attention because rate making in the United States is lightly regulated by state governments. Rate design occurs at the local level, where city councils rule and higher water rates are politically distasteful regardless of their economic merit.

Full-cost water pricing is the water-based manifestation of marginal-cost pricing—economists' ideal for signaling consumers and achieving the greatest aggregate net benefits in an economy. Hotelling's (1938) seminal article on marginal-cost pricing observes the application to water: "Another example is that of water in a dry country; if demand exceeds supply, and no enlargement of supply is possible, a charge must be made for the water sufficient to reduce the demand to the supply" (p. 249). This notion has been extended to situations in which water supply is not strictly limited because additional capture/storage projects can be constructed, but the next least costly water supply expansion is economically unwarranted or delayed in light of prospective benefits. To ration available water while denying uneconomic projects, it is necessary to incorporate marginal capacity costs in volumetric water rates (Turvey 1976). Failure to include opportunity costs in rates is the root of "the perpetual 'water crisis' in many of our cities" (Davis & Hanke 1971, p. 13). The constant cycle of supply enhancements sans charged opportunity costs ensures that demand regularly exceeds supply, urging populist calls for additional supply increases and perpetuating the process. This issue remains central to contemporary policy. For example, it seems doubtful that the recent wave of US desalination plants would be economically viable under marginal-cost-pricing doctrine. Because desalinated water has high marginal costs (Zhou & Tol 2005), urban rates reflecting these marginal costs and delivery costs will often lower quantity demanded to a level that can be supplied without the desalination facilities.

The story of 1970s rate controversies in Tucson, as told in *Saving Water in a Desert City* (Martin et al. 1984), includes enlightening discussions of economic concepts as well as contrasts to actual decision processes. Martin et al. also juxtapose marginal-cost pricing with the sanctioned procedures of the American Water Works Association—the professional association of water utility managers.

Other important opportunity costs are also candidates for inclusion in water rates, depending on the source of water and its relative scarcity (Griffin 2001). For surface water supplies, the marginal value of natural (raw, unprocessed) water should be present in rates. For depletable water, as in many groundwater scenarios, marginal user costs should be explicitly incorporated (Moncur & Pollock 1988, Pitafi & Roumasset 2009). The public utility concept of "two-part tariffs" is especially pertinent for water rates, given that utilities and districts commonly charge both a flat fee and a volumetric fee when computing water and wastewater bills. Economic theorists continue to champion application of the flat fee to achieve revenue neutrality while using a marginal-cost volumetric fee to advance water use efficiency (Martin et al. 1984, Sibly 2006, Grafton & Ward 2008).

4. CONTRIBUTIONS TO PROJECT ANALYSIS

We conclude this review with briefs on five important areas of project-related contributions originating within the classical era of water resource economics. Some of these methods and perspectives remain worthy of fuller appreciation and better implementation within contemporary water policy analysis. Omitted below is attention to nonmarket valuation methods, due to the breadth of the area and its regular application to nonwater resources (Champ et al. 2003). It bears remembering that such assessments were originally invited into the CBA process for US water projects.

4.1. The Depth of Marginalism

When one is performing idealized project analysis, it is incomplete to inquire whether a predefined project passes a benefit-cost test. Marginalism ideals stemming from the calculus of economic efficiency apply to a variety of project design features and questions (Eckstein 1958). These include size (e.g., pipe diameter, dam height), project segments, components (e.g., boat docks, generating turbines), purposes, and project timing. For each of these individual decisions, it is important to inspect marginal benefits relative to marginal costs.

Moreover, the alternative-costs approach is not a legitimate method of benefit measurement unless the posed alternative is truly marginal in that it will be adopted in lieu of project construction (Steiner 1965, Young 2005). Understanding of this principle continues to be deficient within the rhetoric of water planning, in which it is commonly stated that if project X is not built, then $Y in economic losses (alternative costs) will occur—failing to observe that other policies can/will intervene successfully so that the $Y loss is well overstated. Usually, an additional error here is the inclusion of secondary economic effects in Y (discussed below).

The corollary of legitimizing alternative costs only when posed alternatives are marginal is to require that project benefits be gauged relative to all truly marginal alternatives (Griffin 2008). This elevates the CBA standard so that the with-project scenario is compared with a without-project scenario that includes efficient policy strategies such as appropriate pricing, thereby offering some protection against the use of costly projects as Band-Aids for inefficient local or state water policy.

4.2. Secondary Effects in Dispute

Project boosters, including agencies, are often unabashed in claiming as many benefits as imaginable in their promotions (or as many possible losses due to the absence of a project). During the 1950s, the credibility of counting a water project's secondary economic benefits as a strict benefit was heavily investigated because the BuRec was adding percentage markups to direct benefits to represent the benefits of projects to local economies (Margolis 1957, McKean 1958, Hufschmidt 2000). Interestingly, no such markups to project costs borne by the wider nation were applied. Then, the vernacular of "induced by" and "stemming from" benefits represented what we currently regard as potential welfare impacts on "backwardly linked" and "forwardly linked" industries from the directly affected industry (e.g., irrigated agriculture) (Ciriacy-Wantrup 1964; James & Lee 1971, pp. 166–67).

Whereas such linked welfare effects may exist and are presumably positive in the locale of the project, they are difficult to estimate properly (Margolis 1957), and it is critical to target net welfare effects from the perspective of the project's accounting stance. For federal projects it was repeatedly deemed appropriate to apply a federal accounting stance, but BuRec procedure did not adhere to this 1950s-established doctrine.

Multiplier-styled analysis, as is supported by input-output (I-O) modeling tools, usually fails to illuminate net effects because of its focus on gross economic activity, although the tool can be refined to perform better (Kelso et al. 1973). Even when these I-O enhancements are undertaken, or more advanced general equilibrium welfare measurement techniques are utilized, similar inquiry is reasonably extended to the investigation of secondary economic costs exterior to the local economy. When we ask where project monies are coming from and what these monies were doing before they were diverted, we find that they too were generating secondary benefits. Only when a prevailing condition of unemployment of resources persists might such cost-side secondary effects be reduced. Consequently, "when there is full employment, there really are no secondary benefits at all" (McKean 1958, p. 158). In addition, for conditions of prevailing labor unemployment, water projects are argued to be poor remedies because they take years to plan and the added employment is confined largely to the construction period (Ciriacy-Wantrup 1964).

Maass (1966) offered a more sympathetic perspective by arguing, "There is no such thing as a secondary benefit" in that if Congress wishes to redirect resources to a particular locale by building a water project there, then that is a primary benefit in the eyes of Congress and therefore warrants inclusion in decision-making metrics (p. 210). Haveman's (1967) sharp rebuke maintained that such analysis has no place in CBA (see also Maass 1967). Commencing with the 1973 rule set known as the "Principles and Standards" (**Table 1** above), local effects have been countable within a specific account distinct from the main National Economic Development account of CBA. The secondary economic effects account (Regional Economic Development) has a small role in decision making because it impacts no selection criteria, yet its presence does offer a pressure release for boosterism. In the interests of "restraining the abuse of economic arguments in the political process" as counseled by Ciriacy-Wantrup (1964), it continues to be sound practice to rely on local interests and the media to tout secondary benefits while these amounts are excluded from CBA tests.

4.3. Allocating Joint Costs

Large portions of the costs of multipurpose water projects serve joint purposes. A dam can contribute to water supply, flood control, hydropower, recreation, and other products. Federal participation in water projects and the federal requirement for some level of cost sharing by beneficiaries promoted inquiry into methods to apportioning joint costs to specific purposes. Ransmeier's (1942) investigation of the cost-sharing policies and options of the TVA is highly regarded and is cited outside of the water arena. Other studies investigate the relations among cost-sharing methods and CBA and the optimal pricing of project outputs (such as irrigation water and electricity) (Ciriacy-Wantrup 1954). The James & Lee text (1971) inventories multiple methodological alternatives and overviews some critiques. During the classical era the allocation method known as separable costs–remaining benefits achieved strong endorsements and became favored within agencies because of its attributes.

4.4. Discounting in Dispute

CBA of water projects during the 1950s and 1960s focused a lot of attention on the choice of discount rate, which is not surprising given the importance of this single parameter. Although the more recent matter of climate change has drawn strong, renewed attention to the matter (Nordhaus 2007), much of the prior debate peaked during the classical era of water economics. The matter is too extensive to review satisfactorily here. The debate supported a spectrum of social discount rates ranging from "something less" than observed, riskless market interest rates to a doubling of these market rates (Prest & Turvey 1965). The former, labeled generically as the social rate of time preference, embodied the alternative arguments for why private agents undervalue the future in their personal intertemporal transactions and, therefore, why observed market rates are too high for public use (Marglin 1963a,b). The social-opportunity-cost-of-capital argument found all public investments to be at the expense of private opportunities to spend or invest, multiplied by lost tax revenues on diverted private funds. Hence, if corporate taxation and personal income taxation amount to 50%, the social opportunity cost of capital is twice observed market interest rates.

During crucial parts of the post-1936 period, dam-building agencies did not apply the same discount rates in their analyses. Critics maintained that the agencies were using very low discount rates to artificially overstate project appraisals (Krutilla 1966). Practically, the matter was laid to rest in an unsettling way while arguably achieving a reasonable compromise among opposed factions. In 1968 the US Water Resources Council raised the discount rate from 3.25% to 4.625% and established the annual revision process that remains in force today (Holmes 1979). Each year the average yield on US-issued securities is computed. If this average differs from this year's federal discount rate for analyzing water projects, next year's discount rate (which is used for the full planning horizon of projects under investigation) is revised in the direction of the average yield, with a maximum change of 0.25% (US Water Resources Council 1968). Whereas the resulting nominal discount rate includes an inflation component, the project-building agencies perform the rest of their CBAs using real prices. The long tenure of this inconsistency is among the more interesting features of federal analysis.

4.5. Hydroeconomic Modeling

Motivated by questions about optimal river basin planning, the classical era of water resource economics spawned hydroeconomic modeling during the 1950s. The intricacies of human relations with complex water flows rejected, in many situations, the economist's standard practice of layering economic studies on top of available knowledge about physical systems. Such settings often "defy so neat a division of labor between engineering and economics" (Maass 1962, p. 5) and urge collaborative analysis. Taking maximum advantage from the new availability of computers, participants created the centerpiece of the Harvard Water Program—the landmark text by Maass et al. (1962)—which laid the foundations of hydroeconomics and explored a number of its empirical issues. In this same vein, economists helped to marry economics and groundwater modeling to investigate issues such as groundwater allocation and depletion while respecting hydrologic realities (Burt 1966, Bredehoeft & Young 1970).

Among other capabilities, hydroeconomic models can contribute to CBA by perturbing a net-benefits-maximizing model with the addition of a proposed project. Due to the decline of dam building and reduced federal interest in basin-level integrated planning, the practical impact of hydroeconomic modeling was weakened after the classical era (Kneese 2000), although economists continued to participate in these studies and advance knowledge. Today, the field's potentials persist, and academic interest continues to grow (Harou et al. 2009). Because the basin-level objective functions driving these models do not match actual decision processes in that US water allocations are not centrally planned, a continuing challenge is to frame and present such models so that policy-relevant information can be generated.

5. CONCLUSIONS

Today, professional and popular literatures warn of intensifying water scarcities. Three fundamental forces are at play: demand increases that are population driven, supply losses stemming from groundwater depletion and pollution, and heightened volatility in excess demand due to climate change. The consequent scarcity problems are too severe to be rectified by technology advances or infrastructural installations.

Water economics will have to redouble its contributions, largely through repeated applications of existing tools. Whereas additional refinements in theories and methods as well as further improvements in policy design are achievable, much of the proven contributions of water economics remain underutilized in modern water planning. To improve social welfare, it will be necessary to correct these deficiencies, and it will be helpful for economists to be unified in these efforts. To do so, we shall have to foster respect for the foundational principles of water economics. These ideals provide a platform that grounds the field and guards against the reinvention of wheels.

Some of these principles extend to project analyses. Much of this framework emerged during the classical era of water economics. To select economically fortunate and timely projects and to identify good policy strategies, considerable guidance is already in place. Some of the traditions of our economist predecessors are to rail against poor social choices by exercising these methods carefully. Clearly, the developed principles of water economics identify many conflicts with popular thought about preferred solutions (e.g., favoritism of more dams and opportunity-cost-omitting increasing block rates). On top of this, politicized leadership carries biases and lacks full information, thereby jeopardizing public sector choices. Among other things, it should be remembered that secondary economic benefits have limited relevance, project benefits are prone to overestimation by agencies, and environmental values such as instream flows should be accurately considered. Moreover, the economic vision of water demand is a viable basis for computing project benefits. Dynamics and optimal timing of both water use and water projects are also important perspectives.

On the nonstructural/policy side of the ledger, incentives matter and marginalist ideals can support better behaviors. Novel policies can be successful, and they can outperform projects. The opportunity costs of both water and infrastructural limitations matter more than ever. To marshal improved conservation adoptions, consumers should face better water rates—ones that do not omit water value. This will require a major transformation of customary urban utility practices. Water marketing can contribute too. This requires additional legal revisions, yet externality management attributable to water's flow character will continue to be troublesome for the institutional design of property rights and markets. Water economics will have a strong role in all these endeavors.

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