ANNUAL REVIEWS

Annual Review of Resource Economics

Mainstream and Heterodox Approaches to Water Quality Valuation: A Case for Pluralistic Water Policy Analysis

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Annu. Rev. Resour. Econ. 2020. 12:235–58

First published as a Review in Advance on May 15, 2020

The *Annual Review of Resource Economics* is online at resource.annualreviews.org

https://doi.org/10.1146/annurev-resource-100517-023134

JEL codes: B5, D9, D63, Q25, Q26, Q51, Q53, Q57

Keywords

water quality, nonmarket valuation, public goods, ecosystem services, cost-benefit assessment, policy analysis

Abstract

Cost-benefit analyses have largely failed to demonstrate a positive benefit to cost ratio for programs designed to improve and protect water quality in the United States and European Union. At the same time, research from outside economics suggests that water quality ranks among the most urgent environmental concerns and highlights deep social and cultural connections to clean water. Exploring alternative explanations for this apparent water value paradox is essential to informing contemporary rulemaking and regulatory analyses, such as the Clean Water Act and the debated Waters of the United States (WOTUS) rule. I review contemporary advances in mainstream environmental economics relevant to the value of clean water, frontiers that have not yet been integrated into mainstream valuation methods, and pluralistic approaches from sociology, history, and moral philosophy that offer policy-relevant insights but do not fit neatly in cost-benefit frameworks of valuation. The review concludes with recommendations for improved water quality planning and policy in pursuit of a more comprehensive and pluralistic understanding of the value of clean water.

1. INTRODUCTION

Water underpins human well-being and economic development in every region of the world. Water quality affects a broad and diverse suite of ecosystem services, including public health, recreation and tourism, property values, infrastructure, fish and wildlife populations, and cultural resources (Keeler et al. 2012). In 2015, the World Economic Forum declared water crises as the greatest risk affecting the world economy (World Econ. Forum 2015). Public polling in the United States consistently ranks clean water as the top environmental concern in both state and national surveys (Gallup 2019).

At the same time, addressing water quality impairments requires significant public investments and financial resources. Water quality problems are widespread, and the cost of addressing all identified impairments far exceeds available public and private resources. In the United States, approximately 70% of total lake acres and 55% of stream and river miles are impaired, meaning they do not meet quality requirements for designated uses of swimming, boating, or fishing (US EPA 2017). The adoption of the Clean Water Act in 1972 was largely successful at regulating point sources of water contamination. However, nonpoint sources of pollution such as croplands, lawns, and livestock production continue to degrade water quality. Various instruments have been proposed to internalize the externalities associated with nonpoint source water pollution, ranging from nutrient trading schemes to voluntary certification programs. Given the significant investments required to address the scale and scope of water pollution, it is worth asking: Are public investments in clean water worth the cost?

1.1. Is There a Water Value Paradox?

Over US$35 billion is spent annually in the United States to address surface water quality impairments. However, cost-benefit analyses developed by economists have largely failed to demonstrate a positive return on these investments (Keiser et al. 2019). Reviewing 20 studies of the economic benefits of clean water policies from 1985 to 2015, Keiser and colleagues report that the median benefit to cost ratio was 0.37, suggesting that benefits rarely exceeded costs. Economic analysis of the EU Water Framework Directive found that three-quarters of the cost-benefit assessments conducted on projects designed to improve water quality did not have a positive benefit to cost ratio (Feuillette et al. 2016). At the local or regional scale, economic valuation of water-related ecosystem services is significantly less than the opportunity costs of land protection, especially when competing with high-valued land uses such as agriculture (Keeler & Polasky 2014, Kovacs et al. 2013, Noe et al. 2016). At the same time, qualitative and participatory research in the same geographies finds broad support for public investments in water resources and a willingness to prioritize water quality expenditures over other policy objectives (Davenport & Keeler 2018, Fellows et al. 2019, MEP 2017).

Of all environmental goods, clean water offers a unique test of the breadth and validity of how economics assigns value to nonmarket goods and services. The relatively low value of clean water when analyzed through benefit to cost ratios appears to be in contrast to how individuals and groups assess its worth in public polling and survey research. Water quality affects a diverse suite of benefits, not all of which have been integrated into economic valuation models (Keeler et al. 2012). Water quality can be degraded by many different types of contaminants that affect different endpoints, from lakes to rivers to groundwater to coasts, complicating the development of integrated assessment models (Kling et al. 2017). Additionally, public perceptions of water quality are influenced by societal norms, historical and contemporary contexts, and institutions that moderate exposure to water-related benefits and burdens—dynamics that are often absent in methods of economic valuation.

The apparent discrepancy between public preferences for clean water and economic analyses of showing low benefit to cost ratios for water quality interventions may be due to the following explanations, each with important implications for public policy:

1. Economic valuations accurately reflect public preferences and associated welfare gains or losses associated with changes in clean water. Implication: Society should consider shifting resources to other environmental or social goods with a better return on investment.
2. Economic valuations are incomplete because economists have thus far only captured a subset of water-related benefits in value assessments. Implication: Economists should invest in studying a broader suite of water values, taking advantage of new methodologies and data sets.
3. The nonmarket valuation approaches used by most environmental economists have limitations and biases that systematically underestimate the value of changes in water quality. Implication: Policy evaluation for water quality programs should adopt a more interdisciplinary and pluralistic approach that incorporates deliberative and nonmonetary methods of value elicitation.

Economics occupies a privileged position in policy evaluation. The field presents the most well-developed suite of tools to assess the costs and benefits of proposed actions. As a result, environmental economics is often deployed to inform key public policy decisions at local and national scales, including a requirement by the US government to conduct cost-benefit assessments for major rules and regulations at the federal level (Griffiths et al. 2012). The implications of these findings can directly affect the adoption and implementation of policy, as evidenced by the conflicting economic assessments of the Waters of the United States (WOTUS) rule by the Obama and Trump Administrations (Boyle et al. 2017).

These specific examples aside, broad integration of water values into environmental policy making lags behind similar assessments for air quality and carbon pollution, in part because our current understanding of the value of improvements in water quality remains incomplete and contested (Garrick et al. 2017). Combined with persistent critiques about the validity of neoclassical welfare approaches to valuation, the lack of policy uptake raises questions about whether or not the field of environmental and resource economics is up to the task of informing the management of one of society's most precious and threatened natural resources.

1.2. Motivation and Scope

I present a critical appraisal of the contributions of economics with respect to water quality valuation, one that considers a range of critiques of valuation internal and external to the field of economics. I synthesize what can be learned from a pluralistic, multidisciplinary review of the economic valuation of clean water. My engagement is bounded by a pragmatic urgency. The demand for water value information in decisions is present and growing. Therefore, critique should be measured by what better insights or actions it generates that contribute to enhanced social welfare. I aim to not only advance understanding of water valuation but also address persistent limitations of economic valuation that apply to other environmental goods and services.

I focus my review on the value of water quality, rather than water quantity, while recognizing they are often interlinked (Brauman et al. 2007, Olmstead 2009). I devote less attention to market values of water or those values that can be internalized via private sector risk assessments (e.g., **https://tool.waterriskmonetizer.com**) in favor of deeper analysis of the values of clean water as a public good that contributes to a diverse stream of benefits.

Section 2 reviews notable advancements in the valuation of clean water mainstreamed by environmental economists. Section 3 summarizes frontiers in economic valuation science that hold promise, yet have not been widely adopted by economists. Section 4 discusses future directions and pluralistic approaches to valuation that go beyond mainstream economics. Section 5 applies these concepts to the valuation process, offering guidance for economists and practitioners conducting assessments of water value. Section 6 explores potential answers to the water values paradox.

2. MAINSTREAM ADVANCES

Contemporary research in environmental economics has made both methodological and substantive contributions to our understanding of the value of clean water. Comprehensive reviews of the economics of water quality and nonmarket valuation approaches are covered in Dumas et al. (2005), Griffiths et al. (2012), Olmstead (2009), and Viscusi et al. (2008). Below, I highlight a few research advances in nonmarket valuation and integrated assessment modeling that are improving the scale, scope, and validity of welfare estimates associated with changes in water quality.

2.1. Nonmarket Valuation and Benefits Transfer

Water quality affects multiple dimensions of human welfare (Brauman et al. 2007, Keeler et al. 2012, Olmstead 2009). Environmental economists have focused on a subset of these values that can be assessed using standard revealed and stated preference approaches, mainly property values, recreational behavior, and avoided treatment costs. Revealed preference approaches address the first two categories of values. In reviewing 48 different hedonic studies, Nicholls & Crompton (2018) find consensus that clean water has a measurable positive impact on property values. Similarly, studies of travel costs demonstrate that visitors are willing to travel further to visit cleaner, clearer waterbodies (Phaneuf 2002, Van Houtven et al. 2014). An exemplary case of a revealed preference approach to water valuation is the Iowa Lakes Valuation Project (**https://www.card.iastate.edu/lakes/**), where researchers have conducted annual surveys of a representative sample of residents on recreational lake usage in order to understand the impact of water quality on visitation patterns over time (Egan et al. 2009, Jeon & Herriges 2010). Survey results were used to estimate the willingness to pay for improvements in individual lakes, and the resulting welfare benefits have been used to prioritize lakes for water quality improvements.

Applying revealed preference to water value has been aided by increasing accessibility of data, including housing transaction data from the real estate website Zillow, aggregated data on water rates from the American Water Works Association (AWWA), and online platforms for disseminating visitor use data (e.g., **https://irma.nps.gov/Stats/Reports/Park/GRPO**). In addition to increased data availability, economic valuation estimates have become more precise as methods have improved, including use of intertemporal panel data, cross-sectional approaches, and quasi-experiments that take advantage of variability in environmental quality (Kuminoff et al. 2013, Mendelsohn 2019).

Stated preference surveys also find consistent evidence of positive willingness to pay for improved water quality, with average annual household willingness to pay varying from \$0 to more than \$200 depending on the magnitude of water quality improvements (Ge et al. 2013, Johnston et al. 2005, Van Houtven et al. 2014, Walsh & Wheeler 2013). Unlike revealed preference, stated preference surveys allow estimation of the monetary values held by nonusers (Hanley & Czajkowski 2019). Stated preference studies also permit measurement of values for water quality changes that do not currently exist, such as a hypothetical policy or program that will reduce water pollution in the future. Choice experiments provide greater opportunity to customize bundles of water-related goods and services and identify site characteristics and demographic factors that explain variation in stated preferences for clean water (Ahtiainen et al. 2015, Brouwer et al. 2010, Latinopoulos 2014, Phaneuf et al. 2013, Viscusi et al. 2008).

Debate continues about the validity of contingent valuation for informing environmental policy analyses (Hausman 2012, Kling et al. 2012). However, emerging consensus about best practices for stated preference methods (Johnston et al. 2017b) is improving the development and interpretation of nonmarket valuation instruments in water policy evaluations and regulatory assessments.

The costs of treatment associated with degraded water represent another stream of value that can be integrated into cost-benefit assessments. There are generalizable damage functions for the costs of water treatment at the household and municipal levels (Keeler & Polasky 2014, Lewandowski et al. 2008). In general, treating contaminated water is relatively inexpensive, especially in urban areas where costs are distributed among many households. Avoided cost analyses typically yield estimated benefits far below costs associated with interventions to improve water quality, such as taking land out of agricultural production or reducing crop yields (Gourevitch et al. 2018, Keeler et al. 2016). Residential surveys report per household willingness to pay of $45 to $60 per month to reduce nitrates in drinking water to a minimum safety standard (Crutchfield et al. 1997), suggesting that the consumer surplus associated with clean water is much higher than revealed through avoided cost approaches.

Benefits transfer of water-related values is needed when time and resource constraints prevent the collection of site-specific data, as is often the case for policy evaluation. Researchers have synthesized multiple water quality valuation studies via meta-analysis and developed meta-regression models for transferring water quality benefits (Johnston et al. 2005, 2017a; Kling & Phaneuf 2018). These models allow users to adjust mean willingness to pay for water quality improvements based on income, demographics, region, water body type, and other contextual factors. Additional advances that can reduce benefit transfer errors and produce more accurate welfare estimates include studies that calibrate preferences to local contexts, ensuring that consumers can afford to pay the amounts indicated by benefits transfer (Dumas et al. 2005, Smith et al. 2002), updating beliefs about the distribution of values using Bayesian probability theory (Phaneuf & Van Houtven 2015), and calibrating stated preference data with site-specific revealed preference data (Haener et al. 2001).

2.2. Integrated Assessment Models

In a review of the value of water quality–related ecosystem services, Keeler et al. (2012) noted that water quality valuation was hindered by a lack of integrated hydrologic and economic models that could translate changes in water quality into economic values. Research has greatly advanced in this area over the last decade. Collaboration with ecologists and hydrologists at project conception means that the variables used as inputs to economic models now better match the outputs of biophysical models, and that biophysical model outputs are translated into indicators of water quality with direct application to human well-being (Keiser & Muller 2017, Kling et al. 2017, Olander et al. 2018). Detailed hydrologic models of changes in water quality are coupled with economic models, allowing researchers to investigate potential trade-offs or complementarities in pollution reduction strategies (Rabotyagov et al. 2016). Advancements in spatial ecosystem services models such as AIRES and InVEST emphasize the importance of visualizing the flows and sinks of benefits so the spatial dynamics and specific contextual interactions with different user communities can be determined (Bagstad et al. 2013, Cong et al. 2020).

Spatially explicit water quality models, when linked to spatially explicit damage functions, allow analysts to account for heterogeneity in the distribution of economic benefits and costs (Bateman et al. 2016, Keeler et al. 2016, Willemen et al. 2010). Recreation value is rarely a function of water quality alone, for example, because visitation is affected by proximity to population centers, amenities, and access points and preferences for substitute recreation sites. Studies have found that recreationists have inconsistent preferences for water quality, in that preferences can vary over time and depend on baseline exposure to water quality (Smeltzer & Heiskary 1990). While researchers understand water quality benefits to be highly spatially heterogeneous, there is a lack of empirical data to estimate the damage functions for the full array of water quality pollutants across space (Garnache et al. 2016). Assuming a linear constant damage function for changes in water quality ignores both ecological thresholds and diminishing marginal returns to water quality improvements and masks underlying heterogeneity in affected populations and endpoints of interest that may be relevant for prioritization decisions (Keeler et al. 2019). Future work aimed at understanding spatial heterogeneity in costs and preferences of beneficiaries would improve the potential of integrated assessment models to explore spatial patterns in the distribution and value of water quality changes.

Methodological advancements in nonmarket valuation and integrated modeling have enhanced economists' ability to evaluate the efficacy of alternative elicitation formats and improve parameter estimation. However, improved econometrics has not necessarily led to improved policy-relevant insights, such as isolating the value of marginal changes in specific ecosystem services that relate to water quality interventions (Hackbart et al. 2017, Olander et al. 2018). Additional challenges include understanding the generalizability of water valuation estimates, uncertainties in underlying data, models, and assumptions, and a general distrust among the public of "black box" approaches to producing valuation estimates (Laurans et al. 2013).

3. FRONTIERS IN VALUATION

Keiser et al.'s (2019) assessment of the "low but uncertain" economic benefits of the Clean Water Act represents a synthesis of much of the economic research described in Section 3. This section highlights three research frontiers: inclusion of a broader suite of benefits, new sources of data, and insights from behavioral and institutional economics. If included in future welfare evaluations, these approaches are likely to increase the estimated net benefits of clean water policies.

3.1. Missing Benefits? Health Costs, Nonuse Values, and Nonmaterial Benefits

When pollution exposure is linked to impacts on human health, valuation estimates tend to be large, as research on the economic costs of particulate air pollution has shown (Krupnick & Morgenstern 2002). However, epidemiological and toxicological data linking changes in degraded water quality to health impacts are absent or inconclusive for most water pollutants. To date, few economic assessments of water values have integrated data on potential health costs associated with exposure to water pollution in drinking water or recreation. An exception is lead pollution, where researchers have documented how lead in drinking water can negatively affect cognitive function and lifetime socioeconomic achievement (Gould 2009). Data on lead-related costs have been used to evaluate the economic benefits of investments in lead removal in municipal and household water systems (MDH 2019).

The evidence for other common water pollutants such as nitrate remains inconclusive. Elevated levels of nitrate in drinking water are associated with increased risk of some cancers as well as birth defects and miscarriages (Brender et al. 2004, Manassaram et al. 2006, Ward et al. 2018). However, studies have reported positive, neutral, and negative effects of nitrate on cancer incidence, and elevated risks are often associated with specific subpopulations, making it difficult to make generalizable claims. Van Grinsven et al. (2010) proposed a method for calculating the economic costs of increased cancer risk due to nitrate pollution in water supplies in the European

Union, arriving at a population-averaged health loss of €0.7 per kilogram of nitrate leaching based on an assumed increase in risk of colon cancer. This method has since been modified and applied to assessments of the economic cost of nitrogen pollution in valuation assessments in the United States and European Union (Sutton et al. 2011, Temkin et al. 2019). Gourevitch et al. (2018) found that a more comprehensive accounting of the social costs of nitrogen pollution, inclusive of potential health costs due to elevated cancer risk, increased the social cost of nitrogen fertilizer use such that water quality benefits approached the same magnitude of savings as air quality benefits.

The inclusion of avoided health costs is likely to increase estimates of net benefits for water quality improvements, and their absence may partly explain the low economic values for clean water found to date. However, there are reasons to be cautious about this approach. The science linking nitrate and human health is underdeveloped, and there is no dose-response curve for nitrate exposure (or most water pollutants). Therefore, we know little about the shape of the damage function relating increased nitrate to increased health risk.

In addition to health benefits, nonuse values and cultural or nonmaterial values often elude quantification. In a review of cultural ecosystem services, Chan et al. (2012) caution that owing to the intangible nature of values for nonmaterial benefits, analysts cannot assume that they are self-evident and will appear in trade-off assessments or stated preference studies in the same way as instrumental services.

Scholarship on cultural and nonmaterial ecosystem services has demonstrated that expressed values for clean water are deeply tied to stewardship motivations surrounding the protection and restoration of clean water (Peppard 2013, Raymond et al. 2009). A review of watershed payment programs found that values such as "an obligation to future generations" and "pride in and responsibility for taking care of the land" were the most common justifications for participating in water restoration activities and Payments for Watershed Services (Bremer et al. 2018).

Nonmaterial values are difficult to disentangle into their constituent parts, which is needed to isolate marginal values for specific water quality changes (Chan et al. 2011). Researchers know very little about how sensitive cultural values are to changes in water quality or the material status of freshwater bodies (Peppard 2013). Nonmaterial values are also dynamic—humans are not passive recipients of water-related values but active coproducers (Vatn 2009). For example, institutions and technological advancements such as changes in fishing gear can moderate how users interact with the natural environment, leading to shifts in demand for water-related benefits and changing sensitivities to water quality changes (de Oliveira & Berkes 2014).

Beyond nonmaterial values, other categories of water-related values remain underdeveloped or highly uncertain. These include the economic impacts of hypoxia and harmful algal blooms (Rabotyagov et al. 2014) and potential value streams associated with changes in phosphorus and sediment pollution (Garnache et al. 2016, Hansen & Ribaudo 2008). Both biophysical scientists and economists need to develop integrated ecological and damage functions that connect changes in water quality to these endpoints. Further work is also needed evaluating the option value of protecting aquatic ecosystems from water quality changes even for cases where there is high uncertainty surrounding potential welfare impacts of water quality changes. Until these other benefits are included in cost-benefit assessments, economic assessments of clean water are likely to consistently undervalue water protection or restoration programs.

3.2. New Data Sources: Advances in Nontraditional and Big Data

The explosion of big data generated through remote sensing, social media, and crowd-sourced platforms is expanding the scale and scope of data-driven analyses in fields ranging from ecology

(Hampton et al. 2013) to human behavior (Chatterjee et al. 2019). In economics, big data provides information at a volume and granularity that present both challenges and opportunities for economic theory and applications (Einav & Levin 2014). Data from social media platforms such as Flickr or Twitter can estimate user activity and movement, visitation rates, and population density (Lin & Cromley 2015, Patel et al. 2017, Wood et al. 2013). Content analysis from websites, blogs, or apps can evaluate preferences, user perceptions, social networks, and even property values (Schwartz et al. 2019, Yao et al. 2018). These nontraditional sources offer the ability to evaluate trends at spatial and temporal scales that would not be possible with survey instruments, increasing the number of observations in models and thereby enabling economists to test the generalizability of value estimates.

Data on activity, movement, and preferences can be coupled with crowd-sourced data on amenities through platforms such as Open Street Maps, and remotely sensed data on land use, flooding, and water quality, enhancing coupled social and ecological models at scale (Donahue et al. 2018, Ramadas & Samantaray 2018). Recent remote sensing work has demonstrated increasing skill at monitoring and understanding lake clarity (Feng et al. 2019), measuring suspended solids (Wang et al. 2017), detecting algal blooms (Neil et al. 2019), and identifying and classifying boat traffic (Kanjir et al. 2018). Economists are just beginning to explore how the use of alternative data sources can improve the accuracy and representation of economic models and lead to more inclusive and comprehensive valuation at scale.

Big data also presents numerous challenges. Economists will need to modify econometric techniques reliant on individual demographics to take advantage of social media data, where the number of observations is large but the analyst knows very little about the income, location, or choice set of individual users. Because social media data are not representative of the full population, resulting analysis of user behaviors or preferences is likely biased toward a subset of the population. Social media data or remotely sensed products may not be accessible to all researchers, and not all data providers are fully transparent about the source, accuracy, and potential biases of data they make public. And of course, there are very real privacy concerns about the use and analysis of data on individuals obtained without consent, even if anonymized. Despite these limitations, big data sources offer an exciting frontier in valuation science, especially if they can be applied to water quality analyses in data-scarce regions of the world.

3.3. Beyond the Rational Actor: Behavioral and Institutional Economics

Behavioral and institutional economists caution that the elicited preferences may not accurately reflect the marginal worth of the good in question, but rather the general identity or principles of the respondent (Kahneman & Knetsch 1992). Stated preference studies are subject to known biases, including anchoring, priming effect, and loss aversion, with alternative question framings leading to significantly different elicited willingness to pay (Gregory & Slovic 1997, Ovaskainen & Kniivilä 2005). A behavioral paradigm asserts that preferences are neither completely fixed nor totally fluid, and that research design interacts with social, cultural, and economic context to shape preferences (Bowles 2008).

Designers of contemporary stated-preference surveys have integrated learning from behavioral economics into the design of valuation instruments (Hanley & Czajkowski 2019). These include formats designed to reduce the cognitive burden on respondents and correct for biases such as loss aversion. Additional behavioral recommendations include pretesting the instrumental design to check for comprehension and to detect lapses into heuristics, presenting valuation questions in such a way that the information seems consequential and realistic, and designing choice experiments that allow for more realistic comparisons (Hanley & Czajkowski 2019, Johnston et al.

2017b). Some authors argue that these improvements do not go far enough in addressing exceptions to rational actor theory and advocate for continued innovation in instrument design that is consistent with "social rationality" or "satisficing behavior" theories of welfare (Folmer & Johansson-Stenman 2011). For example, Lindenberg & Steg (2007) advocate for a valuation approach that assumes environmental behaviors are shaped by physical and social constraints where agents have limited information and use heuristics to make and adapt their choices through iterative learning.

If behavioral economics has highlighted inconsistencies and complexities that affect the interpretation of individual rationality, then institutional economics has shaped understanding of the role of formal and informal institutions in shaping values (Berbés-Blázquez et al. 2016). Different institutional framings support different rationalities that affect stated willingness to pay. For example, Dietz & Atkinson (2010) show that elicitation instruments produce different policy rankings if they frame implementation options as polluter pays or beneficiary pays.

Valuation responses are also sensitive to the specification and articulation of institutional contexts as part of hypothetical water quality scenarios commonly used in integrated assessment models (Motew et al. 2019). Institutions define who should participate in environmental assessments, what counts as relevant knowledge, and how information is conveyed and interpreted (Vatn 2009). This influences valuation results because respondents' political worldviews may interact with the choice of payment mechanism (Fourcade 2011, Lamont 2012). Clean water applications of behavioral and institutional research include studies of the role of prosocial messaging on water use (Ferraro et al. 2011) and investigations into the institutional factors that affect participation in water quality protection or restoration activities (Pradhananga et al. 2015).

4. A HETERODOX APPROACH TO VALUATION

The economic valuation of ecosystem services is criticized for narrow conceptualizations of welfare and a static view of the formation and articulation of individual preferences (Wegner & Pascual 2011). Researchers from sociology, history, and moral philosophy have a lot to say about these topics, but their insights have been largely ignored by mainstream economists in part because the focus has been on critique rather than the development of actionable alternatives (Nunn 2020). Heterodox fields of economics such as feminist economics and ecological economics have embraced pluralistic methodologies of valuation, as well as a more intentional focus on issues of rights, power relations, and equality in the framing of environmental issues. In this section, I review the advantages and disadvantages of heterodox frameworks of valuation and preference elicitation.

4.1. Insights from Sociology and Moral Philosophy

The construct of value is defined and interpreted in unique ways across varied disciplinary contexts. Sociologists define values as guiding principles that are relatively stable over time and inform and influence people's beliefs, attitudes, perceptions, and behaviors (Schwartz 1992). Values filter information about the world, shape people's attitudes, and indirectly influence their behavior (Bardi & Schwartz 2003). Economists conceptualize values as a measure of worth that reflects an individual's preferences for changes in the amount or quality of a good or service. Under a neoclassical view, values may be influenced by social context but are best observed at the level of the individual, with net changes in social welfare estimated through the aggregation of individual values. In contrast, sociologists take society and culture as their units of analysis precisely because they believe phenomena are shaped by institutions and social and cultural norms and therefore cannot be understood at the individual level. Individual and collective concepts of value are interlinked, and techniques designed to elicit values under either framing can be supported by well-developed theories of value construction, formation, and articulation (Brekke et al. 2003, Kenter et al. 2015).

The valuation context serves to signal which frame of thinking a respondent should use when answering valuation questions. If a survey uses a "consumer framing," then the respondent is more likely to respond through the lens of their individual utility function. If a survey uses a "citizen framing," then we expect respondents to use their own notion of a social welfare function (Brekke et al. 2003, Sagoff 1998). Using a "we" orientation in a value instrument, such as "what are we as a society willing to pay," activates social norms and consideration of values about what is best for the community or society (Kenter et al. 2015, Soma & Vatn 2014). People also express different preferences when given information about the intended use of a natural resource or public good by beneficiaries (Yaari & Bar-Hillel 1984). For example, respondents may be willing to pay more for clean water if hypothetical visitors are using a water body for a spiritual or cultural practice, rather than say, committing a crime. If social norms and institutions can modify people's preferences, then the analyst must consider whose welfare changes should be used as the baseline to evaluate the welfare changes of others and whether the goal of valuation is to modify preferences or satisfy existing preferences even if they lack full information (Nurmi & Ahtiainen 2018).

Some researchers have advocated for either replacing individual preferences with alternative conceptualizations of welfare or including these in addition to more traditional approaches. Sen (2005) argues that economists should expand welfare models to include the influence of factors beyond constraints, beliefs, and preferences to include "sympathy" and "commitment." According to Sen, individuals are not always self-interested and may act in ways that decrease their welfare for the sake of others or for the sake of their moral commitments (Hausman et al. 2016). In collaboration with philosopher Martha Nussbaum, Sen proposed a theory of well-being based on "capabilities" and "functionings" (Teschl & Comim 2005). A capabilities approach to environmental policy evaluation seeks to assess the extent to which a policy makes people more or less able to achieve defined components of well-being, including "control over one's environment," "affiliation," "play," and "bodily health" (Holland 2014).

Scholars have identified lists of key rights and capabilities, including access to clean water, which could form the basis of alternative instruments for preference elicitation and trade-off assessments (Holland 2014, Raworth 2017). Liu & Opdam (2014) operationalize this approach with a representative group of stakeholders who are tasked with ranking different dimensions of well-being that relate to specific ecosystem service values in the Netherlands. Participants allocated a limited number of points among competing objectives in order to prioritize future management actions (Liu & Opdam 2014). A remaining (but significant) challenge is determining appropriate minimal thresholds of water-related rights and capabilities across multiple dimensions of water quality, biophysical endpoints, and populations of beneficiaries.

4.2. Challenges of Inequality in Valuation Assessment

Poorer households have budget constraints, and the assumption of diminishing marginal utility of income suggests that gains in environmental quality should count more when they accrue to lower-income communities. However, cost-benefit assessments that rely on willingness to pay are subject to ability to pay and can therefore privilege the preferences of the wealthiest individuals (Wegner & Pascual 2011). In response, equity or distributional weights can be used to adjust welfare estimates according to income. In climate accounting, equity weights have been used to adjust estimates of climate damages based on income levels in developed and developing countries. The results of cost-benefit assessments of climate change are substantially higher than unweighted estimates, suggesting that assumptions about individual and regional income distribution can greatly affect resulting damage assessments of environmental policies (Anthoff et al. 2009).

Application of equity weighting outside climate economics is rare. I was able to find only a single study applying equity weights to water quality benefits. Nurmi & Ahtiainen (2018) applied equity weights to results from a contingent valuation survey that assessed willingness to pay for improved marine water quality in nine countries bordering the Baltic Sea. They found that equity-adjusted benefits exceeded unweighted benefits estimates by approximately 30%. Analyzing equity weights also identified important institutional considerations, including efficiency gains from a policy allowing intergovernmental transfers of responsibilities and resources in addressing water quality problems.

Water quality problems are unequally distributed, with poor and minority communities bearing more of the burdens associated with degraded water quality and white, affluent communities having the means to invest in avoidance behaviors or to relocate to areas with higher-quality water (Deitz & Meehan 2019). The unequal distribution of water benefits coupled with rising income inequality presents a strong case for broader implementation of equity weighting in environmental cost-benefit analysis. Analysts should consider the implications of alternative weighting schemes (inter- or intraregional approaches) and the relative income elasticity of preferences for different types of water quality benefits—from luxury goods, such as recreational boating, to subsistence fishing or access to drinking water (Drupp et al. 2018). Importantly, the decision not to use equity weights is itself one with normative implications about whose preferences receive greater weight in environmental policy analysis.

In addition to the unequal distribution of water quality benefits and harms, inequalities can be reinforced through institutions and processes of environmental valuation. Having a voice in the mechanisms by which values are elicited and representation in the institutions that design and implement environmental policies are also important mechanisms to address environmental injustices. Environmental programs associated with negative equity outcomes can erode public trust, reduce stakeholder participation, and undermine conservation objectives due to rule breaking or sabotage (Berbés-Blázquez et al. 2016). Explicit consideration of equity in environmental economics necessitates a commitment to understanding what matters to all people—not just those in power—and the creation of opportunities for residents to articulate their own desired environmental futures.

Social scientists with training in power analysis, political economy, and ethnography can help identify the relevant social and historical contexts that shape individual preferences and bring valuable perspectives to the design and implementation of value assessments. For example, vastly different life experiences, including disenfranchisement or disempowerment, can mediate and affect preferences about the environment. If individual preferences are shaped by historical and social circumstances, then the interpretation of welfare estimates should account and potentially adjust for biases in elicited preferences among beneficiary groups (Hausman et al. 2016). Thus far, there has been little scholarship on how historical and social contexts shape individual values for changes in environmental quality. Teschl & Comim (2005) found people in underserved areas where the lack of access to clean water has become normalized may exhibit resigned adaptation, valuing clean water less because "they are used to getting by without it" or think change is "out of their reach." More research is needed to understand how past experiences shape contemporary preferences and how these insights can improve the design and interpretation of valuation instruments.

4.3. A Deliberative Toolkit for Value Elicitation

In contrast to monetary cost-benefit assessment based on the elicitation of individual preferences, deliberative approaches to valuation rely on structured deliberations between small groups of stakeholders to rank priorities, assess trade-offs, and negotiate values. Based on theories of deliberative democracy, deliberative methods rely on informed discussion, negotiation, and learning that can activate social values (Bunse et al. 2015, Kenter et al. 2015, Spash 2007). Specific methods vary, but a focus on participation, iteration, and consensus seeking is the cornerstone of a deliberative approach to environmental valuation (Jacobs et al. 2018).

Advocates for deliberative methods base their argument on both procedural and substantive grounds. Procedural benefits are well documented in the literature and include capacity building, improved learning, dialogue, and awareness and an increase in the perceived legitimacy of outcomes or recommendations (Kenter et al. 2015). Deliberation produces a record of concerns and values that can help stakeholder groups and public entities craft more effective communications campaigns that tie into expressed social values/norms (Bunse et al. 2015). Interaction and debate improve value formulation and articulation, which lead to more informed choices, especially for complex problems or contexts with high degrees of uncertainty about future outcomes (Wilson & Howarth 2002). Substantive benefits such as increased public consensus or realized changes in actions taken are less evidenced but are also noted in the literature (Kenter et al. 2015).

Lienhoop et al. (2015) and Jacobs et al. (2018) review how deliberative methods have been applied to environmental values. Citizen juries, market stalls, participatory modeling, and deliberative multicriteria analyses all utilize some kind of public forum to encourage deliberation and knowledge exchange, coupled with an assignment of social weights, policy recommendations, and/or a monetary valuation. Deliberative monetary valuation combines a deliberative forum such as a citizen jury or market stall with a stated preference or choice experiment where values can be expressed as individual payments or aggregated totals for society (Lienhoop et al. 2015, Lo & Spash 2013). Hybrid approaches take advantage of sophisticated online platforms for value elicitation that allow for an increased number of respondents and control for statistical representation (Gregory et al. 2016). Qualitative methods such as charrettes, narrative prompts, and visual tools have been found to be particularly effective at eliciting social and emotional values for the environment (Satterfield 2001).

By virtue of their design, deliberative methods are time and resource intensive and typically can only involve a small number of participants (see online methods described in Gregory et al. 2016 for an exception). This may be appropriate for local- or regional-scale problems but is harder to justify when the decision context is associated with larger spatial scales and more diverse constituencies. Some methods require participants to reach consensus on a monetary valuation of an environmental change, for example, in the form of an agreed-upon tax or payment scheme that will be applied to a larger population. Other methods use aggregation weights before or after deliberation to scale elicited benefits to a population of interest. In either case, the analyst needs to be transparent about the method of participant selection and how value estimates from small groups are applied to larger populations (Lienhoop et al. 2015, Spash 2007). Their small size also means that deliberative processes are subject to manipulation by vested interests and open to coercion and strategic action (Vatn 2009). Forcing consensus on values means there is potential for political or power dynamics to corrupt participatory ideals of value pluralism and open debate. Advocates for deliberative processes note that effective facilitation, framing, and enforcement of ground rules can mediate some of the risks of manipulation or group think (Kenter et al. 2016).

In summary, deliberative approaches offer an alternative to the individual consumer model of economic valuation where social welfare is evaluated based on aggregated willingness to pay for water quality changes. Deliberative methods provide time for respondents to increase their understanding of complex environmental issues and activate more reflexive and socially oriented value frames. Lienhoop et al. (2015) recommends deliberative methods when the values at stake are unfamiliar or are primarily cultural or nonmaterial in nature. Vatn (2009) groups valuation contexts into categories based on assumed rationality (consumer versus citizen), value commensurability, complexity, and temporal and spatial scale, noting that deliberative methods are better suited to situations with high complexity and broad social implications.

Application of deliberative approaches to environmental value assessments remains relatively siloed in ecological economics and associated fields. The field would benefit from further collaboration between mainstream and heterodox economists, who would compare methods and insights across alternative valuation approaches. Water-related ecosystem services that range from egotistic to altruistic value orientations offer a unique opportunity to compare the value of water-quality policies and programs generated by different methods across varied contexts.

Heterodox scholars recognize valuation as a social process, embedded within culture and therefore affected by social norms and other forms of political power. Whereas mainstream economics marginalizes issues of equity and distribution, other social sciences lean into these issues and offer important and consequential insights on the impacts of institutions, power imbalances, and inequality on the formation and articulation of preferences. Comprehensive information on projected welfare changes due to environmental investments is critical to policy analysis and getting the best return on public investments in public goods. Theory and methods from beyond economics deserve a closer look for their contributions to our understanding of values and valuation.

5. THE VALUATION PROCESS: A PROPOSED FRAMEWORK FOR PLURALISTIC, COMPREHENSIVE VALUATION

The process of valuation will influence the outcome of valuation, with subsequent effects on policy analysis and decision making. The economist makes numerous decisions in the framing, design, implementation, and interpretation of a valuation study. These decisions have consequences and yet they are rarely interrogated for their impact and give a false sense that economic studies are objective and neutral in their conclusions about important natural resource management contexts. In this section, I provide a framework to guide the selection of valuation methodologies that encourages more reflective and comprehensive environmental valuation.

5.1. Diagnose the Decision Context

Effective policy-relevant valuation depends upon a clear articulation of the decision context that it is meant to inform. There are three questions researchers should consider at the scoping stage of a valuation assessment: (*a*) Whose values are to be counted? (*b*) What water quality–related values or ecosystem services are at stake? (*c*) Why is valuation information needed (**Figure 1**)? Answering these questions requires the analyst to make explicit the assumptions that are relevant to the selection of valuation methodologies and the application and interpretation of end results. These assumptions are present in all economic studies, but not often elevated and debated for their potential theoretical and practical significance.

5.1.1. Who: identify the relevant population. Valuation assessments may target specific subpopulations (e.g., recreational anglers who visit a particular lake) or a representative population within a defined spatial boundary (e.g., statewide population of water users and nonusers). Initiatives that affect water quality may have benefits downstream beyond the study area of interest. In this case, the analyst should consider if nonresident values are also of interest even if nonresidents do not bear the costs in the form of higher taxes or increased fees associated with a proposed policy or program.

Decisions about defining the relevant population in a primary study or benefits transfer application can be challenging. Without a clear justification, unit benefit values are often arbitrarily

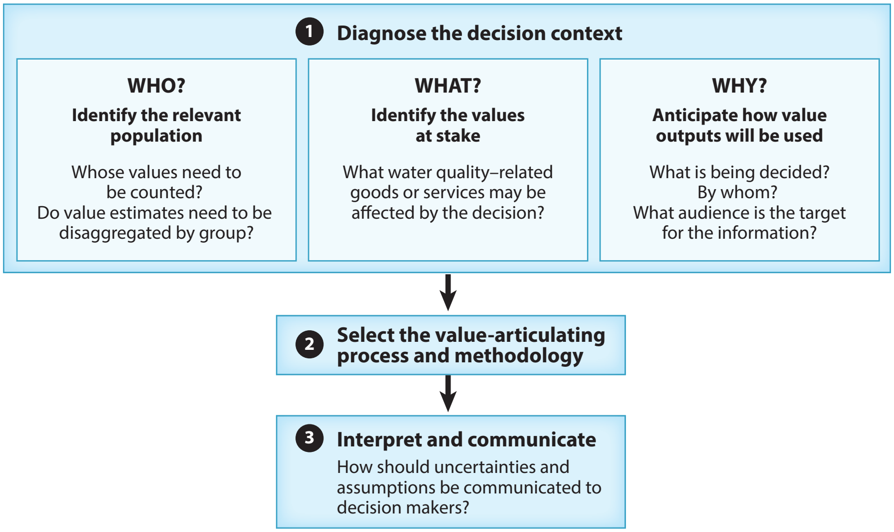

Figure 1

The process of economic valuation should be grounded in a clear articulation of the populations of interest, the types of values or ecosystem services at stake, and the decision context and audience for the information. These questions should inform the selection of the appropriate valuation methodology and the interpretation and communication of results.

multiplied by the number of inhabitants living close to a water body or study area, which can penalize regions with lower population densities. Aggregate willingness to pay can be highly sensitive to decisions about the population selected for an analysis of benefits (Feuillette et al. 2016).

Analysts should also consider the appropriate frame respondents should adopt when responding to a valuation prompt. Does the valuation assessment aim to capture values of the current population, or are the policy options in question distant and enduring such that respondents should be prompted to consider the well-being of future generations? Framing also affects the activation of social norms, prompting respondents to adopt perspectives of either individual consumers or a more socially oriented rationality (Vatn 2009). Finally, the analyst should consider whether it is useful to be able to disaggregate water values among different beneficiary groups—for example, to assess the equity or distributional consequences of a proposed policy or program (Daw et al. 2011).

Whether explicit or implicit, these discussions of whose values are valued in the context of decision making have implications for the design of valuation instruments and the interpretation and application of study conclusions.

5.1.2. What: identify the values at stake. Clean water affects a broad suite of ecosystem goods and services, including use and nonuse and material and nonmaterial values. Water quality itself is not an ecosystem service, but rather a contributor to multiple dimensions of human well-being, defined by unique endpoints, beneficiaries, and implications for welfare (Keeler et al. 2012). Water-related values can be organized along a continuum spanning egocentric values that relate to direct material self-interest, pleasure, or comfort; altruistic values that relate to cultural or social considerations; and biospheric values that relate to nonhuman or natural systems (**Figure 2**). Identification of the types of values at stake is closely linked to the identification of relevant populations of

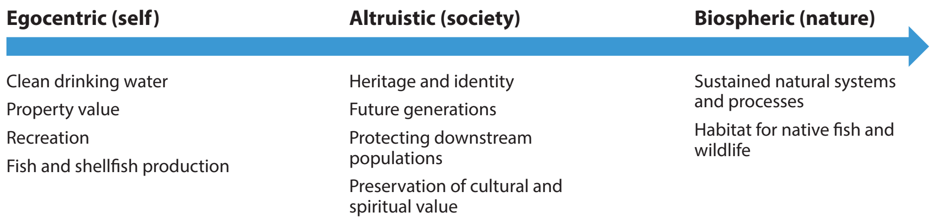

Figure 2

Typologies of values based on Schwartz (1992) and Bouman et al. (2018), with associated water-related values identified under each category.

beneficiaries as discussed above. Different constituencies will prioritize different values, and these preferences for water-related goods and services may not be known at the study outset.

Instrument design is often disconnected from the types of water values under consideration. Discrepancies between value estimates derived from willingness to pay and those derived from willingness to accept in stated preference instruments are most notable in goods that evoke moral or emotional sentiments (Biel et al. 2011), underscoring the need for analysts to consider how the goods in question should affect methodological design. Value instruments may be designed to capture a narrow set of values (e.g., property values) or aim to capture material and nonmaterial values, including intrinsic values that relate to the existence or health of natural habitats and wildlife. Water-related values also differ in their level of complexity or familiarity. Near-term, proximate, and instrumental values, such as changes in property values, are easier to communicate and place a lower cognitive burden on respondents. More complex, uncertain, or distant values included in the altruistic or biospheric categories may be unfamiliar to respondents and therefore require a study design that allows for reflection, iteration, and the consideration of relevant cultural or social norms (Vatn 2009).

Not all water-quality interventions will affect all water-related values to the same degree. For example, a streambank stabilization program may affect sediment loads and fish habitat but have minimal impact on drinking water quality. Consultation with biophysical scientists can identify the likely magnitude and direction of ecological responses to proposed policies or programs and this information should inform the design of hypothetical scenarios illustrating program impacts. Interdisciplinary consultation on the selection of relevant values at stake can also identify key sources of uncertainty, the existence of thresholds or feedbacks, and the level of familiarity of the target population with specific water-related values of interest.

5.1.3. Why: anticipate how value outputs will be used. Valuation exercises cannot be divorced from the contexts they aim to inform. Information on the value of clean water can be deployed in a variety of decision contexts, ranging from raising awareness, prioritizing among competing actions, accounting for the benefits or costs of proposed rules or regulations, developing instruments or mechanisms for resource governance, and settling legal claims (**Figure 3**).

Raising awareness of the value of water in order to influence a campaign or legislative agenda does not necessarily require monetary values or a detailed cost-benefit assessment. In evaluating social policies or prioritizing the allocation of scarce resources, decision makers may be more interested in understanding a diversity of values across different groups or sectors, especially where cultural, stewardship, or relational values for water have been identified as important.

The intended audience for a valuation study may be distinct from the decision makers in charge of implementing a water quality policy or program and different still from the population of beneficiaries who stand to benefit from water quality improvements. Understanding

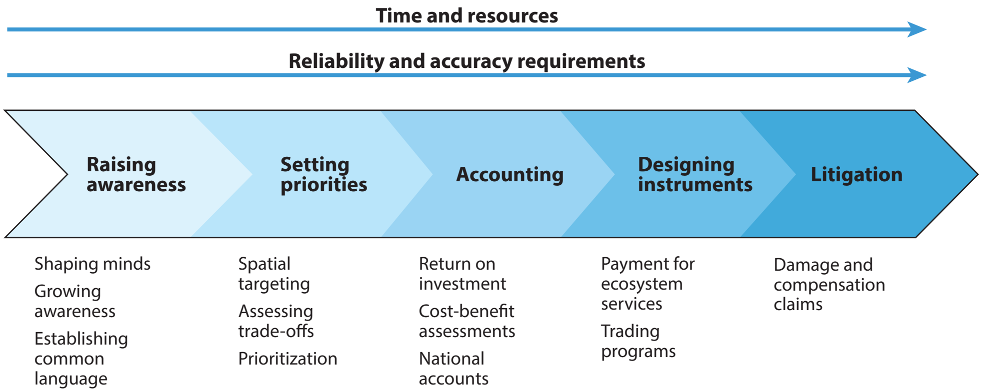

Figure 3

Valuation information may inform a variety of decisions ranging from raising awareness to litigation. As the need for quantitative rigor and accuracy increases, so do the time and resources needed to complete the valuation assessment. Not all decisions require complex models or monetary valuation. In many cases, qualitative data, relative values, or improved education and awareness are all that are needed to inform decisions. Figure based on Gómez-Baggethun & Barton (2013).

the decision context and relevant end-users for a valuation process is best achieved through a process of codevelopment, where decision makers, stakeholders, scientists, and economists work together to scope project objectives, codesign research, and build collective understanding of the assumptions embedded in valuation studies. There is a well-developed literature on best practices in coproduction (Wyborn 2015), although there is limited evidence of this approach being used by economists, with few exceptions (Irwin et al. 2018).

5.2. Select the Appropriate Methodology

Selection of the most appropriate valuation methodology should follow from reflection on the population of interest, types of water-related values, target audience, and potential application of valuation results. Economic literature describing the results of valuation studies rarely provides a detailed justification for their selection of methods, so there is room for improvement here.

Traditional cost-benefit assessments are most suitable for decision contexts where the potential benefits or costs of water policies are familiar, respondents are well informed about potential consequences, and the distribution of income or ability to pay is relatively equal across the population of interest. In contexts where policies will affect public goods that are difficult to measure, where consequences are likely to be lasting, serious, and highly uncertain, where policy choices raise other moral questions about issues such as equity, or where there are big differences between the wealth of those who favor a policy and those who oppose it, then alternative methods that allow for deliberation, activation of social norms, and disaggregation of benefits across different groups are warranted.

The objectives of environmental policies often extend beyond efficiency to include goals such as minimizing pain or human suffering, addressing or mitigating historic inequalities, and protecting human rights. In these cases, a valuation strategy should integrate a plurality of methods, drawing expertise from diverse disciplines, to provide the most comprehensive assessment of trade-offs resulting from policies or programs.

5.3. Implement and Interpret

Research from social psychology and behavioral economics underscores how the implementation of valuation instruments can affect the formation and expression of preferences. Values are not independent from the means of value elicitation, including instrument design, framing, and the selection of representative publics. For deliberative forums, facilitation and ground rules are instrumental in ensuring that participation is representative and the potential impacts of coercive or manipulative behaviors are minimized.

Interpretation includes sensitivity analyses, decisions about aggregation and value commensurability, the visualization of trade-offs or distributional considerations, and the communication of uncertainties. Making these assumptions explicit and carrying implications all the way from instrument design to application to policy will improve transparency of value estimates and clearly identify whose values are represented in any resulting policy analysis.

6. SYNTHESIS AND CONCLUSION

If we agree that economics is the study of trade-offs and the allocation of scarce resources, then the mandate of environmental economics is much broader than assessments of individual preferences in pursuit of maximum efficiency. Moral, ethical, and normative dimensions of environmental valuation are critical to understanding how to make complex choices in an uncertain world. Ethical choices cannot be addressed only through technocratic methods, but require open deliberation about interests, motivations, and values. Complex problems of social choice and the allocation of public resources are riddled with trade-offs over competing values and objectives. A robust policy assessment requires comparisons among individuals and groups, acknowledgment of historical context and social norms, and stakeholder awareness of the uncertainties and potential biases embedded in economic models and methods.

The discipline of economics primarily adopts an ahistorical approach, with minimal exploration of how historical factors affect contemporary economic outcomes (Nunn 2020). There is some evidence this is changing as the scholarship of economic historians has become more influential in research on economic development (Nunn 2020) and citations of work in political science, sociology, and psychology are on the rise in economic journals (Angrist et al. 2020). I would like to see this trend extend into environmental economics. My collaborations with historians have made clear how understanding coupled with environmental and social histories of watersheds is extremely relevant to both the design of valuation instruments and the evaluation of future environmental policies (Keeler et al. 2020).

6.1. Resolving the Water Value Paradox?

This review identifies several explanations for the apparent disconnect between past studies showing a low economic value for clean water and perceptions of water as an invaluable public good. While we cannot discount past cost-benefit assessments that have found low monetary values for clean water policies, I believe the other two explanations for the paradox presented in the introduction—missing benefits and limited and biased models—are supported by this review.

Assessment of a more comprehensive suite of water values, including health costs, nonuse values, and relational values, will likely increase benefit assessments for clean water interventions. Applying equity weights where the population of interest has known disparities in income and the benefits of environmental policies are regressively distributed will also likely increase value estimates for clean water. Continued integration of learning from behavioral and institutional economics will improve the design and implementation of value assessments and increase confidence in the validity of conclusions. Finally, integration of big data and other nontraditional data sets may mean modifications to econometric models but could meaningfully expand the scale and scope of valuation methods.

Research on nonmaterial ecosystem services demonstrates that individual preference-based methods of value elicitation are poorly suited to evaluate social and cultural values and will require alternative approaches. Scholarship from moral philosophy and sociology advocates for a broader definition of welfare that includes rights, capabilities, and commitment as objectives for policy implementation. There is also a growing call for more intentional consideration of equity and distributional impacts in economic research, beyond equity weighting (Raworth 2017). Accounting for historical context, power relations, and the unequal distribution of benefits and costs necessitates a pivot away from aggregate approaches that seek to maximize efficiency at the expense of equity.

Economic valuation of environmental goods and services will always be imperfect. Assessing the value of clean water is especially challenging given the diversity of material and nonmaterial values at stake, the varying temporal and spatial scales of water quality changes, and the complex social and biophysical interactions that govern changes in water quality and impacts to human well-being. Economists have made great progress in articulating the value of clean water, and this progress must continue as the urgency and scope of water quality problems grow. Future progress can be aided by an expanded economic toolkit, inclusive of traditional and heterodox approaches, that elevates the distributional consequences of environmental decisions and increases the legitimacy of economic valuation.

DISCLOSURE STATEMENT

The author is not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review.

ACKNOWLEDGMENTS

Steve Polasky, Terin Mayer, and Kelly Meza Prado were instrumental in scoping the manuscript and developing the core arguments. Terin Mayer reviewed literature on behavioral and institutional economics, and Kelly Meza Prado reviewed literature on cultural and nonmaterial benefits. Special thanks to Hillary Waters and Daniel Hernandez for reviewing early drafts and to Rachel Hauber and Lindsey Krause for fact checking and reference formatting. This research was supported by the Environment and Natural Resources Trust Fund and the Legislative-Citizen Commission on Minnesota Resources.

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