The current use and potential of cost benefit analysis in water sector projects
Dino Ratnaweera\textsuperscript{IA}, Arve Heistad\textsuperscript{IA} and Ståle Navrud

\textbf{ABSTRACT}

The investment needed in global water infrastructure is significant. Infrastructures in water supply and sanitation alone are expected to require USD 6.7 trillion by 2050. These infrastructures must provide investment justifications when seeking funding from disbursement sources, in competition with other services (such as health, education, transport, elderly care etc.). We present a review that identifies monetary valuation gaps in regional and global cost benefit analysis (CBA) guidelines that underpin investment justifications. Case studies of Scandinavian appraisal reports written according to these guidelines indicate an alarmingly low use of monetary valuation on socioeconomic and environmental impacts caused by water sector projects. The findings suggest a need for broader and more accessible recommendations for water sector specific valuation methods. The need to develop a more accessible CBA framework for water infrastructure project managers is theoretically discussed, with emphasis on utilising monetary valuation methods and secondary source data. We identify valuation methods fragmentally discussed in the guidelines that should be adapted and applied, in time and cost-efficient ways, to water infrastructure projects.

\textbf{Key words} | cost benefit analysis, EIA, LCA, total economic value, water infrastructures

\textbf{HIGHLIGHTS}

- Scandinavian water sector CBA appraisals lack monetary valuation of socioeconomic and environmental impacts of water infrastructure projects.
- Our study of 15 CBA guidelines reveal fragmented and conservative valuation practices, possibly causing the low CBA practice rate in the water sector.
- Secondary data sources can be used as quantitative components in a more accessible and applicable CBA.

\textbf{INTRODUCTION}

Most water infrastructures are public entities, fiscally not profitable, environmentally and socio-economically crucial, and depend on disbursements. Therefore, decision makers and funding bodies must be made aware of both the financial, socioeconomic and environmental value of these projects (Sartori \textit{et al.} 2014; Bouzit \textit{et al.} 2018). Cost benefit analysis (CBA) is applicable in most fields and is often a required analysis step by decision makers responsible for awarding disbursements. Although the World Bank, Asian Development Bank, the European Commission (Sartori \textit{et al.} 2014) and others have published CBA guidelines, they somewhat diverge in methodologies and insist on CBA expertise to execute the analysis. Several reports indicate an underutilised rate of use of these guidelines in the

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water sector and point to reasons such as a sector-wide lack of access to experts that execute CBA beyond financial evaluations. Projects suffer from a lack of access to CBA experts, alongside scepticism of both the robustness and need for CBA (Pollak 1996).

CBA is a decision support tool often required by disbursement sources, such as national governing bodies and regional and global financing institutes, to assess the impacts of an infrastructure project to society (Pearce et al. 2006). CBA is not the only evaluation tool; many disbursement programs require qualitative analysis, or a composite analysis of CBA and either a risk analysis or expertise analysis, or an analysis from the perspective of utility to the environment, as exemplified by, for example, Norwegian regulations on impact assessments requiring a composition of monetary and non-monetary analysis (Norwegian Public Roads Administration 2018). However, CBA remains a widely used tool often required in disbursement calls; for example, from the EU Cohesion fund, to express impacts across financial, socioeconomic and environmental impacts with monetary units (Sartori et al. 2014). Across sectors where CBA and other impact assessment and decision support tools are used, literature stresses the importance of integrating social, environmental and monetary aspects when communicating project impacts and values to biodiversity and environmental decision makers (Gómez-Baggethun & Martín-López 2014).

CBA has early roots. Historically, we find that the underpinning framework and execution of CBA have been tailored to fit the function of the needs of development policies. Initially, until the 1970s, the traditional approach looked to increase the level of welfare in monetary terms. From the 1970s, the introduction of socio-economic factors appeared, to address equitable income distribution (Rolfe et al. 2015). From the 1990s onward, CBA with environmental externality valuations have been incorporated with more regularity. Today, CBA are used to win disbursements for water infrastructure projects in a funding pool that is limited and competed for by other sectors. Progress reports on United Nations sustainable development goals highlight that after following several years of steady increases, official development assistance disbursements to the water sector declined by two per cent from 2016 to 2017. However, disbursement commitments to the water sector jumped by 36 per cent between 2016 and 2017, indicating a renewed focus by donors on the sector (Guterres 2019). Water infrastructure projects apply for funding from limited disbursement funds in fierce competition with public health, roads and transport, capacity building, energy, resilience, military and education sectors. Therefore, the water sector cannot afford to ignore the non-market benefits of their projects in these competitive appraisal processes. Furthermore, disbursement funding sources and society as a whole cannot afford to continue investing in non-modular infrastructures in the water sector. Investments in water distribution networks and treatment facilities could avoid repeating past mistakes, such as sunk-hole investments that create fiscal backlogs in the future (RIF 2015), by considering the costs and benefits of incorporating flexibility in infrastructure design. Because future operative needs are not fully predictable for water sector infrastructure, Pellegrino et al. (2018) highlight the potential costs when flexibility in operational needs are not accounted for over several sections of an infrastructure’s lifetime. By avoiding costs of non-consecutive rehabilitation needs of, for example, a water pipeline network over its lifetime, the Real Options approach (Marques et al. 2015, 2017) underlines how to monetarily valuate the investment in flexible infrastructure design. These and other fledging monetary valuation methods may be the competitive edge needed for water sector infrastructures to win through in proving their worth through comprehensive impact assessments for hotly competed disbursement funds.

With SDG target 6A, United Nations sets a favourable context to monetarily quantify cost-benefits of new technologies in water infrastructure appraisals. Water infrastructure in the developing world are holistically net beneficial (United Nations 2015), meaning their utility to society is net beneficial if socioeconomic and environmental impacts are also considered against financial costs. Justifying the worthiness of a project in such holistic terms is crucial in both the global and local disbursement context. As a rule, public water infrastructures cannot recover financial investment costs through market revenue streams such as tariffs. In most economies, developing ones in particular, most public infrastructures may appear as sunk cost (i.e. costs not recoverable through other parts of society) if their values are not taken into account (Hussain et al. 2001; Quah 2012). Lagging on identifying the holistic value of projects leads to disadvantages when bidding for disbursement;
not utilising valuation methods that other public sectors apply with relative success arguably leads to water infrastructures not winning funding in competition with these sectors. The infrastructures range across new build, operational, renovational, rehabilitative and decommissioning projects, as summarised in Table 1.

From assessments of reports within its own institute, global financing institute the World Bank identifies that approved appraisals over the past 20 years for infrastructures listed in Table 1 have not substantially attempted to quantify all relevant impacts of infrastructure development in the water sector (World Bank 2010). Other studies reveal that infrastructure costs and direct profits from tariffs and fees aside, several cost-benefits in such investments are commonly ignored (Hussain et al. 2001; Van der Bruggen et al. 2009; Djukic et al. 2016). Even though CBA provides a framework to analyse these impacts, and most institutes provide CBA guidelines, projects in the water sector show tendencies of identifying the total valuation of infrastructure projects as follows: life cycle analyses (LCA) address the cost benefits of specific environmental impacts (Chen et al. 2012); financial analyses address cost benefits of fiscal investments (Van der Bruggen et al. 2009); externalities and other non-market factors that are environmental or socioeconomic by nature are either reduced to single point static values and assumptions, only qualitatively assessed, or not assessed at all. This causes a mismatch in water project lingua franca. As a result, the ability of the end users of these assessments, the decision makers and laymen, to decide between investment options may be reduced when environmental and socioeconomic valuations are not represented in a comparable quantity (Hussain et al. 2001). In comparison to other public sectors, there is a gap in knowledge and willingness to understand the monetary value of externalities and non-market factors from a cost-benefit perspective in water infrastructure projects (Liang & van Dijk 2016). These challenges increase when CBAs rely on secondary sources for monetary valuations, especially when applied from industrial valuation study sites to policy sites in developing economies (Ready & Navrud 2006; Quah 2012).

### METHODOLOGICAL FRAMEWORK

Therefore, this paper looks at the current state of CBA by analysing the guidelines available to infrastructure projects seeking disbursements, and by analysing the practical application rate of CBA in the water sector. The paper adopts the methodology from a World Bank internal review of CBA execution in practice (Ward 2009) and extends it to a wider assortment of impact assessment guidelines while maintaining a focus on applicability to the water sector. The use of applying the above methodology to multiple case studies of submitted disbursement proposals extends the methodology underpinning several disbursement guideline reviews (World Bank 2010). Regional and global CBA guidelines are rooted in economic theories, and the general concepts are uniformly agreed: the CBA framework evaluates direct financial, socioeconomic and environmental project impacts from a monetary perspective. The underpinning methodology of CBA is to apply a monetary value to all positive (benefits) and negative (costs) effects for all affected interest groups of the investment options/project alternatives. Benefits and costs of each project alternative are assessed and aggregated over the life length (time horizon) of the project using a social discount rate. The social discount rate is usually. The results are presented in terms of net present value, where a positive value indicates that total discounted benefits exceed total discounted costs. A correctly executed CBA compares investment options with

<table>
<thead>
<tr>
<th>Types of action</th>
<th>Typology of water infrastructure</th>
<th>Infrastructures serving</th>
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<tr>
<td>Construction of new infrastructures to meet increased needs</td>
<td>Water transport</td>
<td>High density urban areas</td>
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<td>Completion of partially built infrastructure</td>
<td>Wastewater collection and water distribution</td>
<td>Town districts and villages</td>
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<td>Improvement of water infrastructure assets</td>
<td>Treatment of primary water</td>
<td>Rural aqueducts</td>
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<td>Improvement or replacement of infrastructure to meet legislation</td>
<td>Treatment and discharge of conditioned sewage</td>
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<td>Water stock infrastructure</td>
<td>Reutilisation of treated sewage</td>
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several scenario alongside a baseline scenario where the project does not take place, known as the counterfactual scenario. A comparison of investment option with the counterfactual scenario highlights the project’s opportunity cost; that is, the utility to society if the project is not executed.

However, the guidelines are not harmonised in its recommendation of monetary valuation methods to assess non-market project impacts. We develop a methodological framework to help identify these differences, and potential knowledge gaps that can substantiate the findings of earlier internal reports by, for example, the World Bank.

Sustainable use of natural resources is recognised as a long-term benefit to society. Decision makers are requesting appropriate and comparative project impact assessment tools to assess environmental (Matthies et al. 2007) and socioeconomic valuation (Norton 1987) alongside financial impacts of infrastructure projects. In this perspective, the total economic value framework highlights monetary valuation methods available for infrastructure project impacts. We evaluate 15 CBA underpinned guidelines by regional and global financing institutes and governing bodies against the valuation method branches that comprise the total economic value framework. This approach identifies the major disbursement CBA guidelines, the content differences, the impacts each institution recommends projects to monetarily value, and how well the guidelines are practiced in reports submitted from a range of water sector projects in Scandinavia. The findings are compared against the categories of the total economic value framework, to identify which valuation methods and type of impacts are most widely underutilised in water sector CBA. Each of these underutilised valuation methods can provide decision makers insights on water projects impacts and will be outlined.

The theoretical framework is best illustrated by the grey box indicating the transition between current CBA practice as identified in literature, and the future of a more holistic, practically applicable CBA in the water sector. The paper will discuss the four tenets to transition an underutilised decision support tool in the water sector to a holistic and applicable CBA. The grey, chequered rectangle in Figure 1 discusses the four tenets of making monetary valuation more accessible; identifying applicable conditions, using relevant valuations, showing decision makers the value in using secondary data, and presenting decision makers assessment data in comparable units and relatable language. The analysis of CBA guidelines and case studies of Scandinavian appraisal reports will reveal current coverage of these four tenets and identify gaps. The aim of this approach is to lay the foundations for tailored CBA guidelines to fit demands for less time- and cost-consuming data sourcing and ease monetary valuation without high dependency on expert insights.

The analysis of major CBA guidelines from national, regional and global disbursement sources such as governments and financing institutions are assessed against their alignment with the total economic value framework. We also focus on the Scandinavian CBA guidelines, to assess against the multinational guideline standards and if they meet project managers’ expressed need for time efficient, cost efficient and non-dependence on experts to execute CBA. Case studies of Scandinavian water sector project reports underpinned by the analysed Scandinavian CBA

![Figure 1](https://iwaponline.com/ws/article-pdf/21/4/1438/903467/ws021041438.pdf)
guidelines are investigated to explore differences between monetary valued project impacts in guidelines and in practice.

**RESULTS**

CBA guidelines correctly identify that the range of projects utilising the guideline are too varied to provide specific valuation instructions and data source recommendations. End users argue that guidelines lacking accessible and low-barrier databases for data and methodologies are the root for their lower than desirable use rate of CBA. These results present the analysis of 15 CBA or CBA-underpinned guidelines from governing bodies in Scandinavia, regional disbursement sources from various contents, and global financing institutes. The analysis is performed against categories of infrastructure impacts as described by the Scandinavian guidelines: Investment costs; Downstream profitability; Tax costs; Residual value; Avoided illness/death; Visual terrain; Living Environment & Recreation; C = Heritage & Cultural sites; Pollution; Ecosystem.

**Results from analysis of CBA guidelines**

Table 2 reveals that the guidelines disproportionately focus on monetizing impacts (M/dark grey cells) in the financial category. The non-market impact of avoided costs relating to health and illness is largely recommended as a qualitative discussion. Only some institutions recommend a monetary valuation, see the efforts by World Bank, Environmental Protection Agency, Millennium Challenge and the Inter-

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**Table 2** CBA guidelines and their recommended impact analysis methods: monetize, measure in non-monetary units, qualitatively discuss or ignore project impacts

<table>
<thead>
<tr>
<th>Guideline publisher</th>
<th>Financial</th>
<th>Socio.</th>
<th>Env.</th>
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<td>I</td>
<td>D</td>
<td>T</td>
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<tr>
<td>Norwegian Public Roads Adm.</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Swedish Road Administration</td>
<td>M</td>
<td>M</td>
<td>Q</td>
</tr>
<tr>
<td>Danish Road Traffic Authority</td>
<td>M</td>
<td>M</td>
<td>Q</td>
</tr>
<tr>
<td>African Development Bank</td>
<td>M</td>
<td>M</td>
<td>Q</td>
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<tr>
<td>Asian Development Bank</td>
<td>M</td>
<td>M</td>
<td>Q</td>
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<tr>
<td>Inter-American Dev. Bank</td>
<td>M</td>
<td>M</td>
<td>Q</td>
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<tr>
<td>Bank of England</td>
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<td>Q</td>
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<tr>
<td>Green Guide (UK Govt.)</td>
<td>M</td>
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<td>European Council EU</td>
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<tr>
<td>European Bank for Rec &amp; Dev.</td>
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<td>Q</td>
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<tr>
<td>Int. Fund for Agricultural Dev.</td>
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<tr>
<td>Food and Agricultural Org. UN</td>
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<tr>
<td>World Bank (IBRD/IDA)</td>
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<tr>
<td>Envir. Protection Agency USA</td>
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<td>Millennium Challenge USA</td>
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</table>

**Legend:**
- I = Investment costs; D = Downstream profitability; A = Avoided illness/death; R = Residual value; T = Tax costs; P = Pollution; V = Visual terrain; L = Living Environment & Recreation; C = Heritage & Cultural sites; E = Ecosystem;
- M = Monetized; P = Physical Units; Q = Qualitative
American Development Bank. This tendency is consistent across guidelines for socioeconomic impacts, with the exception that some guidelines completely omit referring to impacts on visual terrain, recreational areas and heritage sites (boxes with no letters). The environmental impact factors are recommended to be quantitatively valued more frequently than socioeconomic impacts. However, non-monetary quantification is recommended more often than monetary valuation, as seen by the only appearance of P/light grey boxes in the column for pollution. The Scandinavian guidelines stand out by recommending qualitative valuation; that is, Q/white boxes, on almost all impact categories beyond financial impacts.

Results from analysis of case study appraisals

According to Table 2, the Scandinavian guidelines are the most harmonised guidelines in this study. Therefore, they provide the baseline for selection of case studies to study practice rate of CBA in the water sector. The case studies are appraisals written by infrastructure owners, project managers and consultancies to meet disbursement requirements from Scandinavian governments. Predicted financial, socioeconomic and environmental impacts over the infrastructure project’s lifetime are outlined for a variety of water infrastructures, specifically drinking and wastewater treatment plants (DWTP/WWTP), pipelines to and from source and discharge points, and urban flood mitigation measures. The appraisals are all retrieved from open sources, as they are posted on downloadable areas of the client’s websites – all municipal clients in Scandinavia. The case studies are analysed against the same parameters as the CBA guidelines analysed in Table 2.

Table 3 is populated by far less monetized boxes compared to Table 2, revealing that the rate of use of monetary valuation methods in Scandinavian water sector project appraisals is far lower than that recommended by the Scandinavian CBA guidelines. For the financial impacts, the case studies are qualitatively assessing impacts that the guidelines recommend are monetarily valued. This is most noticeable in the category of downstream returns, where the case studies have experts describe potential financial gains and costs to the wider economy surrounding the project area over its lifetime. Noticeably, none of the projects discuss tax impacts, and the rest of the value of the projects is very seldom included in a CBA setting. The socioeconomic and environmental impact factors are largely addressed, to meet disbursement requirements in at least a qualitative way. A noticeable deviance in the results is that some reports provide physical unit valuations of avoided health costs, pollution and ecosystem impacts, even though the overarching CBA guidelines only recommend qualitative analysis. In these reports, these anomalies are due to the appraisals including other impact assessment and decision support tools to supplement the guideline assessment. Impact data collected from life cycle analysis and environmental impact assessments (EIAs) are used to provide these non-monetary valuations (see reports for Göteborg and Lidköpings municipality).

Valuation methods identified by guidelines

Several common theories held by all the CBA guidelines are mentioned earlier in this paper. In contrast, this paper also provides the opportunity to collate the monetary valuation methods that are heavily underutilised by the case study appraisals in practice. This section highlights those methods, and provides a platform to discuss the need to develop their applicability to water sector typologies to a greater degree. Bouzit et al. (2018) explains that ‘two broad basic distinctions are made between the ‘use values’ that individuals derive from using the environmental resources and services’, ‘...and the ‘non-use values’ that individuals derive from such resources and services even if they themselves are not directly beneficiaries of them.’ These valuations are usually categorized into revealed preference and stated preference approaches.

Revealed preference: Estimate the use value of non-market goods and services by observing behaviour related to market goods and services. The hedonic price method applied to the residential property market can be used to estimate individuals’ willingness to pay for environmental qualities of the house, such as traffic noise level. The travel cost method collects data on people’s travel costs (both money and time) and the number of recreational visits they make to, for example, a lake to estimate the current consumer surplus of water-related recreation, which is the recreational use value of the lake.
Stated preference: can estimate the total economic value of non-market public goods and services by directly asking individuals, in questionnaire surveys (often web surveys), their willingness to pay to get a specified improvement in the quality or quantity of a public good. In some contexts, individuals can also be asked the minimum amount they would accept in compensation to get a specified decrement, or not get an improvement, in, for example, water quality.

Use values include direct use, indirect use, and option values. These may be extractive, such as agriculture or fishing, or they may be non-extractive, such as recreational activities, nature tourism, and aesthetic enjoyment of landscapes. Hence, extractive direct use values are strongly related to provisioning services, while non-extractive direct use values are strongly related to cultural services. Indirect use values are associated with regulating services (e.g. soil fertility, water purification, climate regulation, pollination, etc), without entailing awareness about the causal ecological chains that ensure their provision (UNECE 2014).

Option values are related to the future (potential) direct and indirect uses of biodiversity by individuals and stakeholder groups. Option value can be understood as a way of framing total economic value under conditions of uncertainty or as the value of waiting for the resolution of uncertainty. An example of uncertainties surrounding the potential future uses and related option value of ecosystems and biodiversity is bioprospecting to discover potential medicinal uses of plants in areas where water infrastructures are

### Table 3

<table>
<thead>
<tr>
<th>Water infrastructure project appraisals that use the national CBA guidelines, assessed for frequency of use of monetary, non-monetary, qualitative or no valuation methods for financial, socioeconomic and environmental impact factors</th>
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<tbody>
<tr>
<td><strong>Report site</strong></td>
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<tr>
<td>Norestrund WWTP</td>
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<td>Bodo WWTP</td>
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<tr>
<td>Søndre Follo WWTP</td>
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<td>Narvik WWTP</td>
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<td>Sørumsand WWTP</td>
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<td>Jøren WWTP</td>
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<tr>
<td>Bjerkreimvassdrag DWP</td>
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<tr>
<td>Sollihøgda DW supply</td>
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<tr>
<td>Blombackens WWTP</td>
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<tr>
<td>Lindholmen WWTP</td>
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<td>Gothenburg flood measures</td>
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<tr>
<td>Mariestad WWTP</td>
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<tr>
<td>Angens WWTP</td>
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<tr>
<td>Transport to Sjölanda WWTP</td>
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<tr>
<td>Sjölanda and Källby WWTP</td>
</tr>
<tr>
<td>Telegrafholmen WWTP</td>
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<tr>
<td>Bodalen WWTP</td>
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</tbody>
</table>

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- **V** = Visual terrain; **L** = Living Environment & Recreation; **C** = Heritage & Cultural sites; **E** = Ecosystem;
- **M** = Monetized; **P** = Physical Units; **Q** = Qualitative
planned to be developed, which involve the question of whether or not any particular organism will prove to be of commercial use in the future (UNECE 2014).

Impacts generated on project users due to the use of a new or improved good or service should be included as project benefits in an economic analysis. Willingness to pay estimated for the use of the service should capture the shadow price of this outcome. Examples of (positive) non-market impacts: savings in travel time; increased life expectancy or quality of life; prevention of fatalities; injuries or accidents; improvement of landscape; noise reduction; increased resilience to current and future climate change; reduced vulnerability and risk, and so on.

Several impact factors relevant to water sector typologies, as listed in Table 1, exist underneath these monetary valuation approaches. There is a common notion that ‘non-market’ benefits are difficult, and as a result are ignored in traditional economic analyses (Lavee 2011). Several socioeconomic valuation methods exist to quantify the value of externalities of water infrastructures. However, the guidelines inconsistently and sparsely highlight these valuation methods. The following impacts should be recommended for CBA appraisal such that environmental and socioeconomic externality valuations are not ignored by decision makers.

Human health impacts: Projects can have on-site (indirect use), downstream (direct use) and off-site (non-use) impacts on human health. A water infrastructure, as described in Table 1, can have adverse impacts and positive benefits on users as described by the following categories, alongside impacts on other life as well.

Noise: Any increase or decrease of noise emissions affects activities and health. This is mainly relevant for infrastructures crossing or near densely populated areas.

Air pollution: Emissions of localized air pollutants such as nitrous oxide, sulphur dioxide, or small particulate matter and so on from water infrastructures have negative impacts on human health, generate material damage and loss of crops and affect ecosystems.

Greenhouse gases emissions: projects can emit greenhouse gases into the atmosphere either directly; for example, fuel combustion or production process emissions, or indirectly through purchased electricity and/or heat. Emissions have a worldwide impact due to the global scale of the damage caused, thus there is no difference in where the emissions take place. Some projects may lead to reduction of emissions throughout their life cycle, providing a positive externality.

Soil contamination: this is caused by the presence of human-made chemicals or other alterations in the natural soil environment, typically as a consequence of industrial activity, agricultural chemicals or improper disposal of waste, possible impacts from water infrastructures.

Water pollution: water pollution is the contamination of water bodies, such as lakes, rivers, oceans, aquifers and groundwater. This occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds.

Ecosystem degradation: new infrastructure projects can deplete water sources, increase habitat fragmentation and contribute to deterioration of biodiversity, loss of habitats and species. The economic costs come in the form of lost services when an ecosystem is degraded and loses its functions.

Landscape deterioration: this usually involves a loss of recreational or aesthetic value.

Vibrations: infrastructure construction and operation related vibrations can affect the quality of urban life and can interfere with certain production and consumption activities.

**DISCUSSION**

**Illustrating the gap between CBA potential and case study practice rates**

Figure 2 is weighted with colours to indicate the practice rate of valuation methods observed in the Scandinavian water sector case studies, where green/horizontal lines indicate commonality, orange/diagonal lines indicate low use, and red/chequered boxes indicate no practice rate. By adopting Barbier’s (1989) total economic value framework to the results of CBA practice in Scandinavian reports, this colour chart highlights the lack of quantitatively assessing non-use values of building water sector infrastructures. In fact, the only widely applied analysis is the financially oriented market analysis, which assesses labour, manufacture and operational costs. Thus, Figure 2 underlines the lack of monetary valuations performed in areas of socioeconomic and environmental impact compared to an already limited set of guideline recommendations.
Figure 2 highlights the lack of quantitatively assessing non-use values of building water sector infrastructures. In fact, the only widely applied analysis is the financially oriented market analysis, which assesses labour, manufacture and operational costs. Figure 2 underlines the lack of quantitative valuations performed in areas of socioeconomic and environmental impact. Since the total economic value tree suggests valuation methods to identify the monetary values of these under-assessed impacts, the red and orange branches need to be the focus area for future research aiming to create a more tailored CBA for the water sector with valuation methods that are practically applicable by water sector managers.

Valuation methods needed to bridge knowledge gap

The lowest tiers in Figure 2’s total economic value framework allows for discussion of improving the applicability of methods listed in the boxes which needs most re-work for the water sector, namely the red and orange boxes. There is an array of valuation methods that are widely used in other public sectors which can be applied to water sector infrastructure projects; shadow prices are a collective term for valuations of non-market factors that still have a value in society. Shadow wages for the labour market, willingness-to-pay surveys for aesthetic disamenities, travel cost methods for loss of recreational value areas, value of statistical life, value of life years and morbidity impact values (e.g. either valued directly such as coughing days from air pollution or indirectly in terms of changes in quality adjusted life years) for impacts on human health, surveys on existential use values, unit transfers for the loss of biodiversity, cultural and heritage sites, dose response methodologies for, for example, loss of flood risk barriers and so on, are important valuation techniques when converting non-market factors to monetized costs and benefits (Navrud 2002).

Secondary source data for monetary valuation

Many of the above-mentioned valuation techniques can be unavailable to many or most water infrastructure project managements. Particularly in terms of 0 of non-market impacts, experts and first-hand data which can be proprietary and/or hard to find are often required. There are repositories of such valuations made for non-market impacts on a variety of scenarios, populations, environments and infrastructures, which with adjustments and coefficients could be applied to secondary sites. Navrud & Ready (2007) highlight that the size of a policy site as well as the context of the source site plays a part when accounting for the applicability of benefit transfers as both

Figure 2 | Total economic valuation tree, adopted from Barbier (1989), combined with findings from rate of use of monetary valuation methods in Scandinavian appraisals of water infrastructure projects as listed in Table 2. Green/horizontal lines = high, orange/diagonal lines = low use, red/chequered boxes = no use. The full colour version of this figure is available in the online version of this paper, at http://dx.doi.org/10.2166/ws.2020.364.
unit values and as value functions. They argue that the value function is a more robust approach, as long as the differences between the study and the policy site is small and the implicit assumption is accepted that that two individuals in different countries will have the same willingness to pay if they have the same income.

When secondary source data are retrieved correctly, it can save time and costs for the analysts, with acceptably low potential transfer errors. Brouwer (2000) concludes that ‘when the alternative is no value estimates at all’ international data that are secondarily sourced for project impacts are useful approaches.

The path forward

A more holistic CBA is highlighted, because traditional CBA often only utilise one or two of the three pillars of sustainability (financial, socioeconomic and environmental) it has the capacity to valuate and analyse (Hoogmartens et al. 2014).

The proposed framework in Figure 3 applies other widely used impact assessment methods in the water sector (LCA and EIA) and third-party software to feed valuation methods across all branches of the total economic value framework and CBA, and enables a more holistic CBA of water sector infrastructure projects. A valuation framework for the water sector is suggested for further study, along the lines of the holistic CBA valuation (Lam et al. 2018) developed for the food waste sector. It builds on other attempts at building valuation techniques and unit value libraries for valuations of public goods. Many techniques are still developed in other fields and applied by borrowing in the water sector.

The tenets needed to facilitate the transition from current CBA practices to more applicable and holistic CBA use in the water sector can be addressed if the theoretical observations from this discussion are incorporated in future research. The tabulated results of both guideline and appraisals highlighted the need for a tailored guideline that details applicable conditions for relevant valuation methods of water infrastructure impacts. The correctly designed guideline can save water project managers costs in terms of time needed to correctly execute CBA. This action may also help project managers remove themselves from dependency of valuation experts potentially external to the project staff. The listing of the most under-utilised valuation methods and impact factors, and the recommendation of trusting the use of secondary data sources instead of sourcing primary data for each project, can heavily reduce project costs to retrieve relevant data. Finally, the wide portfolio of CBA guidelines all underlined the need for a uniform project impact language to facilitate impact comparison. Instead of permitting sub-par CBA to pass as approved appraisals, financing institutes stand to gain from providing more detailed and valuation method-specific guidelines to help water project owners execute correct CBA to its full impact assessment potential.

CONCLUSION

The current use of CBA is in many ways defined by the application of CBA guidelines in project appraisals that project owners submit to win disbursements. The development of these guidelines by disbursement sources such as financing institutes and governing bodies at the national, regional and global scale are reviewed to identify potential knowledge gaps. The main findings include quantifying the gap between the plethora of innovative and applicable monetary valuation methods and the limited few included in most CBA guidelines. Internal reviews from the authoring
institutes of some of these guidelines reveal tendencies in water sector appraisals to contain sub-standard CBA, yet they are accepted for disbursements. These reports further reveal that impacts of socioeconomic and environmental nature are perennially under-quantified, or not assessed at all. As a result, this paper studied the composition of 15 CBA guidelines that quantified how recommendations for monetary valuations are lopsided towards financial impacts. There is a conservative approach among most of the guidelines towards recommending monetary valuation methods for socioeconomic impacts, especially when considering the plethora of valuation methods the total economic valuation tree suggests for application. Environmental impacts are largely recommended to be quantitatively valued, particularly pollution impacts in the form of physical units. There is also a notable difference in impacts recommended for quantification between the global institutes’ CBA guidelines and the nation-specific Scandinavian guidelines. The Scandinavian guidelines recommend qualitative assessments on almost all socioeconomic and environmental impacts. Therefore, they represent the guidelines that stand to develop the most to reach the potential monetary valuation capacity of a CBA. The review of water sector appraisals in this paper revealed a very low application rate of CBA principles on all impact parameters, except investment costs and benefits. This was found to largely relate to direct capital and operational expenses over a project lifetime, and not any non-market impacts. The guidelines contained a diverse, yet fragmented catalogue of valuation methods with intermittently detailed description of application methods regarding data collection and applicable conditions for various infrastructures. This paper collated the least reported valuation methods in the guidelines that are relevant to the least studied impact factors in the case study appraisal. The development of guidelines that specify how to source secondary data to execute time and cost-efficient monetary valuation methods specific to impacts from water infrastructure projects was discussed as the path needed in future research. The guidelines all recommended the communication of infrastructure projects to decision makers in a uniform unit. While monetary valuation and CBA is not the only way to impact assess water infrastructure projects, this paper suggests developing the CBA to a more applicable and accessible decision support tool as the CBA and its incorporated total economic valuation provides an optimal framework to communicate impact in monetary units to decision makers.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

REFERENCES


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