Original Article

Integrating Economic Theory into Hydropower Project Evaluation: A Conceptual Review

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Abstract

This study examines the ethical implications of Cost-Benefit Analysis (CBA) in evaluating large-scale hydropower projects, with a particular focus on the challenges posed by traditional utilitarian frameworks. While CBA is widely used for policy decision-making, it often fails to account for distributional equity, particularly among marginalized communities and future generations. This research highlights key shortcomings, including the tendency of CBA to favor wealthier groups due to income-based willingness-to-pay metrics, as well as its failure to incorporate non-market environmental values such as cultural, aesthetic, and ecological considerations. The study also explores the limitations of standard discounting practices that undervalue long-term environmental and social benefits, leading to intergenerational inequity. By proposing a pluralistic approach that integrates utilitarianism, egalitarianism, and environmental ethics, the study calls for a more comprehensive and inclusive evaluation framework for development projects. This approach would not only enhance the fairness and inclusivity of decision-making but also promote sustainability by recognizing the intrinsic value of environmental and cultural resources. The findings suggest that CBA should be viewed as a decision-support tool, rather than a definitive guide, and should be complemented with qualitative assessments, stakeholder engagement, and value-based judgments for better policy outcomes.

Keywords: *Cost-Benefit Analysis (CBA), ethical implications, intergenerational equity, environmental ethics, hydropower projects.*

Introduction

Cost-Benefit Analysis (CBA) is deeply rooted in welfare economics, which prioritizes societal welfare by evaluating whether the benefits of a project outweigh its associated costs (Boardman et al., 2018). The core concepts underpinning CBA include Pareto efficiency, opportunity cost, marginal analysis, and externalities, all of which guide efficient resource allocation in

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investment decisions. One of the foundational principles of CBA is the concept of opportunity cost the value of the next best alternative forgone when a decision is made (Mishan & Quah, 2020). This ensures that scarce resources are allocated where they can generate the most net benefit. Similarly, discounting plays a critical role in translating future costs and benefits into present values, acknowledging the time value of money and societal preferences for immediate benefits over delayed ones (ADB, 2017).

Marginal analysis, another essential element, involves comparing incremental costs and benefits of a project to determine whether additional investments yield positive net returns (Boardman et al., 2018). Related to this are the concepts of consumer and producer surplus, which help assess welfare impacts by measuring the difference between what individuals are willing to pay and the minimum they are willing to accept. CBA also accounts for externalities unintended spillover effects, both positive and negative, that affect individuals not directly involved in the transaction (Hakansson, 2007). By monetizing these impacts, CBA attempts to incorporate all societal consequences of a project, promoting a more comprehensive understanding of its value.

The ontological basis of economics scarcity and choice justifies the need for economic analysis in project planning. Economic analysis helps assess whether a proposed investment is rational, viable, and aligns with national development goals, particularly in contexts where public resources are limited (ADB, 2017). From a macroeconomic perspective, economic analysis evaluates the potential of government investments to enhance national welfare and promote growth. Unlike private financial analysis, which focuses solely on profitability, economic analysis evaluates non-market outcomes, including environmental sustainability and social equity (Hakansson, 2007).

CBA was first systematically applied in the transport sector in the UK during the 1960s and has since expanded to include diverse sectors such as water resource management, energy, forestry, and urban development (Paul, 2000). It serves as a critical decision-support tool by quantifying and comparing project benefits and costs to assess overall welfare impacts. Metrics such as the Economic Net Present Value (ENPV) and Economic Rate of Return (ERR) help determine the feasibility and desirability of investment alternatives.

Although CBA has been criticized for overlooking distributional effects and focusing primarily on efficiency, its use of standardized monetary metrics ensures transparency and comparability across investment options. As Hakansson (2007) notes, integrating both tangible and intangible impacts such as environmental degradation or community displacement can lead to more inclusive and sustainable decision-making. CBA is particularly valuable in public-sector investments, where benefits may not be directly monetized. Welfare economics provides a framework for capturing non-market values and addressing market failures, ensuring that public spending decisions align with broader social goals (Auzannet, 1997). The Asian Development Bank (2017) emphasizes that integrating CBA into all stages of the project cycle from design to post-implementation monitoring enhances accountability and helps prioritize initiatives that yield the highest societal returns. Ultimately, the application of CBA in infrastructure projects facilitates evidence-based policymaking and ensures that scarce resources are deployed to maximize net social benefits.

Despite its long-standing application across various sectors, Cost-Benefit Analysis (CBA) often faces criticism for inconsistencies in methodology, underrepresentation of social and environmental factors, and inadequate theoretical grounding in project evaluation frameworks. In developing countries, including Nepal, infrastructure investments such as large-scale hydropower projects are frequently appraised using financial indicators alone, with limited integration of broader economic and social welfare principles. The lack of a comprehensive understanding and application of foundational economic theories such as welfare economics, opportunity cost, and externalities can lead to suboptimal resource allocation and limited societal benefits. Furthermore, variations in the application of discounting methods, marginal analysis, and valuation of non-market impacts reveal a gap between theoretical constructs and practical implementation. This disconnect necessitates a deeper investigation into the theoretical underpinnings, principles, and operational practices of CBA to improve its relevance, reliability, and policy alignment in public investment decision-making.

The primary objective of this study is to critically examine the theoretical foundations, guiding principles, methodological approaches, and real-world practices of Cost-Benefit Analysis (CBA), with a focus on their application in infrastructure project evaluations, particularly in the context of developing economies. Specifically, the research aims to: (1) explore the theoretical constructs from welfare economics and public finance that underpin CBA; (2) assess how key principles such as opportunity cost, discounting, and marginal analysis are incorporated in practice; (3) identify the methodological approaches used to value tangible and intangible project impacts; and (4) evaluate the extent to which CBA practices align with theoretical ideals in recent infrastructure projects. By addressing these objectives, the study seeks to bridge the gap between CBA theory and application, contributing to more effective and inclusive decision-making frameworks in public investment planning.

Methodology

This study adopts a qualitative research design based on a systematic literature survey to examine the theoretical foundations, evaluation principles, methodological approaches, and practical applications of Cost-Benefit Analysis (CBA). This approach is effective in synthesizing existing knowledge to gain insights into the conceptual and applied dimensions of CBA, particularly in the context of large-scale infrastructure evaluations. A structured search was conducted across databases using keywords such as “cost-benefit analysis,” “welfare economics,” “economic evaluation,” “infrastructure appraisal,” “discounting,” and “public investment.” The search focused on materials published between 2000 and 2024, ensuring a balance between foundational theories and recent developments. Sources included peer-reviewed articles, institutional reports and key economic literature. Inclusion criteria emphasized literature addressing theoretical underpinnings of CBA, opportunity cost); core evaluation principles, methodological advancements and practical applications, particularly within developing countries such as Nepal. The selected literature was thematically analyzed and categorized into four domains: theoretical constructs, evaluation principles, methodological frameworks, and applied practices. This process enabled the identification of key trends and gaps, offering a nuanced understanding of CBA's role in economic evaluation and investment decision-making. The literature-based method supports critical reflection on the relevance, strengths, and limitations of CBA in real-world contexts.

Application, history and principles of CBA

Cost-Benefit Analysis (CBA) has emerged as a critical tool for evaluating public investments and policy decisions, particularly in determining whether proposed projects yield net societal benefits. The formal use of CBA began in the 1930s and gained prominence after World War II, largely driven by the necessity to ensure the efficient allocation of public funds in large-scale infrastructure and development initiatives. The methodology was first systematically applied in the United Kingdom’s transport sector during the 1960s, subsequently becoming a standard framework for evaluating public projects and policy interventions (Economic & Labor Market Review, 2008).

Over time, the principles and practices of CBA have evolved to address increasing complexities in public sector decision-making. The Asian Development Bank (ADB) outlines eight core principles of CBA, which include the use of standardized units of measurement, market-based evaluation of benefits, analysis of consumer behavior, valuation of human life, comparative scenario analysis, delineation of specific study areas, and the avoidance of double counting. Recent methodological updates introduced by ADB include refinements to the minimum economic rate of return, valuation of the social cost of carbon, and consideration of regional cooperation impacts. These enhancements are intended to align CBA practices with contemporary development priorities and ensure its relevance across various funding mechanisms and operational contexts (ADB, 2017).

Watkins et al. (2014) emphasized that CBA estimates the monetary value of benefits and costs to a community, guiding decision-making. Boardman et al. (2006) further detailed a nine-step CBA process, which includes identifying project alternatives, measuring impacts, assigning monetary values, and conducting sensitivity analyses. CBA's role in optimizing resource allocation and ensuring fiscal responsibility has solidified its position as a critical tool in evaluating public projects, guiding investments that maximize social welfare and economic benefits. The main principles and features of CBA are as follows:

Cost-Benefit Analysis (CBA) is widely recognized as a critical tool for assessing the economic feasibility of public projects and policies. According to Watkins et al. (2014), CBA provides a framework for estimating the monetary value of the benefits and costs to society, thereby informing and guiding decision-making. Boardman et al. (2006) outlined a comprehensive nine-step process for conducting CBA, which includes identifying project alternatives, quantifying impacts, assigning monetary values, and conducting sensitivity analysis to evaluate uncertainty. CBA's ability to promote resource optimization and fiscal accountability has reinforced its status as a key method for ensuring that investments contribute positively to social welfare.

CBA is grounded in several core principles and features. First, it adopts a “with and without” comparison approach, contrasting outcomes in the presence or absence of a proposed intervention rather than simply comparing conditions before and after. The analysis also prioritizes selecting the best alternative from multiple options, rather than merely assessing the viability of a single project. A defining characteristic of CBA is its societal perspective, which requires that the benefits to society outweigh the associated costs for a project to be considered worthwhile. In evaluating impacts, CBA distinguishes between revealed preferences, typically derived from market prices, and expressed preferences, often obtained through surveys when market data is unavailable. It also emphasizes clearly defined geographical boundaries, ensuring that only the costs and benefits within the specified region or community are included in the analysis.

Boardman et al. (1999) identified three main types of CBA: *ex-ante* (conducted prior to project implementation), *in medias res* (performed during the life of the project), and *ex-post* (conducted after project completion). A fourth type compares the results of an *ex-ante* analysis with those of an *ex-post* or *in medias res* assessment. While *ex-ante* CBA helps determine the viability of a proposed investment, its reliability is limited due to early-stage uncertainties. In contrast, *ex-post* analyses are generally more accurate, though they serve a retrospective function. Studies conducted *in medias res* offer an opportunity to adjust project implementation when outcomes diverge from initial projections.

Prog and Prog (2014) proposed a structured sequence for conducting CBA. The process begins with identifying alternative projects and determining the scope of benefits and costs to be considered. Analysts then catalogue project impacts, select appropriate measurement indicators, and predict outcomes over the project’s lifespan. These impacts are monetized an often-challenging step involving valuation of time, life, and environmental factors. The next step is to discount future costs and benefits to present value, enabling computation of the Net Present Value (NPV) of each alternative. Sensitivity analysis is conducted to examine how results vary with changes in key assumptions, helping to address uncertainty. Ultimately, the project with the highest NPV is typically recommended, although analysts are advised to consider the robustness of the recommendation under different scenarios.

CBA has been extensively applied by governments, international agencies, and donors for evaluating public welfare programs, infrastructure projects, and climate adaptation strategies (Pearce & Nash, 1981). Its systematic approach to quantifying trade-offs makes it indispensable in promoting evidence-based decision-making in both developed and developing contexts.

Watkins et al. (2011) introduced the fundamentals of Cost-Benefit Analysis (CBA), emphasizing that it estimates the monetary value of a project's benefits and costs to determine whether it is socially worthwhile. They outlined eight basic principles to guide CBA application. First, all costs and benefits must be expressed in a common monetary unit to facilitate comparison, representing positive (benefits) and negative (costs) impacts. Second, valuations should reflect actual behavior, such as time savings from improved transportation, using real-life trade-offs people make between time and money. Third, benefits should be measured through market choices, where consumers reveal preferences by purchasing goods up to the point where marginal benefit equals marginal cost.

A fourth principle involves the valuation of human life. Though placing a monetary value on life is often controversial, economists argue that such estimates are necessary to inform rational investment decisions. This can be approached by examining how individuals accept increased risk in exchange for higher pay, allowing estimation of the personal cost of life-saving measures. Fifth, CBA must rely on a "with versus without" approach, comparing the expected situation with the project to what would occur without it. This comparison isolates the net impact of the intervention.

Sixth, double counting must be avoided. For instance, a highway improvement may reduce travel time and accident risk, which in turn increases property values. If the enhanced property value is added alongside direct time and safety benefits, the benefits may be overstated. Seventh, decision criteria should be based on net present value (NPV); if the NPV exceeds the present value of costs, the project is considered viable. However, if multiple projects have positive NPVs but funding is limited, a higher discount rate should be applied to better reflect the true opportunity cost of capital. These principles together provide a structured and rational basis for evaluating public investments through CBA.

Approaches to Cost-Benefit Analysis (CBA)

Cost-Benefit Analysis (CBA) is guided by a range of analytical approaches that inform its structure and application in economic evaluation. These include the microeconomic approach, incremental approach, opportunity cost approach, and the long-term perspective approach.

Microeconomic Approach

The microeconomic foundation of CBA is centered on evaluating how a project impacts society using economic performance indicators, particularly focusing on changes in individual and collective well-being. This approach excludes indirect effects on secondary markets and broader macroeconomic outcomes such as changes in fiscal flows or regional development on the grounds that these are often derivative of direct impacts and may lead to double counting if assessed independently. Additionally, the lack of reliable measurement methods for such broader impacts further supports their exclusion. However, these broader implications may be described qualitatively or tested through sensitivity analysis when supported by robust studies (Sartori et al., 2014).

Incremental Approach

The incremental approach in CBA involves comparing the projected outcomes of a project against a counterfactual baseline typically a scenario without the project. Two main components of this approach are: (1) defining the counterfactual scenario and (2) forecasting cash flows. For new projects, this entails estimating all future cash flows that the project would generate. For upgrades to existing infrastructure, it includes the minimum necessary investments to maintain service or implement minor changes. Historical financial data, especially for existing facilities, are valuable in estimating baseline conditions. The difference between the cash flows in the "with" and "without" project scenarios provides the foundation for calculating economic and financial indicators. Careful selection of the counterfactual is critical, as it significantly influences the validity of the analysis.

Opportunity Cost Approach

The opportunity cost approach evaluates the cost of a project by considering the benefits of the next best alternative that is forgone. This method recognizes that market prices alone may not always yield socially optimal outcomes, especially in the presence of market failures such as public goods, externalities, or asymmetric information. Therefore, this approach extends the analysis to include both tangible and intangible project inputs and outputs to more accurately assess the true social value of an investment.

Long-Term Perspective Approach

Many infrastructure and social investment projects have long-term horizons, often spanning decades. Accordingly, the CBA framework must adopt a long-term perspective that incorporates appropriate timeframes, applies relevant discount rates to future costs and benefits, and incorporates risk and uncertainty. Traditionally used in the ex-ante phase (pre-investment appraisal), CBA is increasingly applied during implementation (in medias res) and post-completion (ex post) to evaluate ongoing relevance and performance.

Identification of Project Benefits and Costs

Accurate identification and categorization of project benefits and costs are essential for robust economic evaluation.

Identification of Benefits

According to the Asian Development Bank (ADB, 2016), benefits are broadly classified into incremental and non-incremental types. Incremental benefits are typically based on additional sales revenues or consumer surplus generated when a project reduces market prices or improves service access. In contrast, non-incremental benefits involve the valuation of non-marketed impacts, using methods such as revealed and stated preferences, benefit transfer, or empirical linkages between project outputs and outcomes.

Identification of Costs

Costs must also be differentiated between incremental and non-incremental components. For incremental inputs, their value is determined by marginal cost reflecting the capital required to meet increased demand. For non-incremental inputs, the opportunity cost is represented by the value of the input if allocated elsewhere. Beyond this classification, costs must be disaggregated into specific categories including capital costs, contingencies, working capital, depreciation, interest during construction, transfer payments, externalities, sunk costs, and system-related costs.

Economic Valuation of Benefits and Costs

Economic analysis aims to measure the social opportunity cost of a project by comparing its economic benefits and costs, while adjusting for market distortions and societal impacts (Ocneanu & Cristian, 2014). Unlike financial analysis, economic evaluation includes externalities, public goods, and broader social effects. It begins with financial cash flows and makes necessary adjustments such as removing taxes and subsidies or adding shadow prices to reflect true economic value. These adjustments ensure that input and output valuations are based on what society is willing to pay or forego, rather than purely on market prices which may be distorted by monopolies, tariffs, or regulation.

Stages of Economic Analysis

The ADB (2016) outlines four primary stages in economic analysis: identifying gross benefits and costs, expressing them initially in financial terms, adjusting these values for economic relevance, and comparing the adjusted totals. The European Commission (2014) further elaborates this process through the following components:

Transformation of Market Prices into Accounting Prices: Market prices often do not reflect the social value of resources. Shadow pricing such as shadow wages is used to correct for labor market imperfections. Fiscal adjustments, including the treatment of taxes and subsidies, are also necessary to avoid misrepresenting costs and benefits.

Monetization of Non-Market Impacts: Environmental and social impacts such as landscape aesthetics or noise can be monetized using willingness-to-pay techniques. These factors are critical in evaluating the true societal effects of a project.

Updating Estimated Costs and Benefits: Time-sensitive adjustments using social discount rates are required to calculate the present value of long-term costs and benefits. This reflects the societal time preference for resources and returns.

Calculation of Economic Performance Indicators: Key indicators in economic analysis include the Economic Net Present Value (ENPV), Economic Internal Rate of Return (EIRR), and the benefit-cost ratio. These metrics, adjusted for distortions, serve as benchmarks for determining project viability. Projects with negative ENPVs or EIRRs below the social discount rate are generally not recommended unless they yield significant non-monetary social benefits (European Commission, 2014).

Key Concepts in Cost-Benefit Analysis

Harve and Jowsey (2004) identified core concepts fundamental to CBA including present value, discounting, opportunity cost, shadow pricing, net present value (NPV), and internal rates of return. These principles underpin the economic rationale for project evaluation and ensure comparability across time and alternative uses of resources.

Government Decision-Making and Resource Allocation

Public sector investment decisions are complicated by the fact that goods and services are often provided at zero or subsidized prices. Consequently, governments must consider both short-term fiscal impacts and long-term sustainability. Objective decision criteria, such as those provided by CBA, are essential for rational resource allocation. As public sector involvement in economic activities expands, the need for decentralized and transparent decision-making becomes more pronounced (Harve & Jowsey, 2004).

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Application and Steps of Cost-Benefit Analysis (CBA)

Cost-benefit analysis (CBA) serves as a critical tool for evaluating the efficiency of resource allocation in both private and public sectors. In the **private sector**, financial CBA is commonly applied to justify investments in technology and equipment, estimate life cycle costs, ensure cost-effective regulatory compliance, and assess hidden costs and intangible benefits. It also demonstrates how leasing and outsourcing can reduce expenditures and how quality improvements influence returns. In contrast, **public CBA** is used to determine the societal value of programs and policies. Applications of CBA vary across countries and sectors, primarily in the types of impacts considered as costs and benefits, the accuracy of financial projections, and differences in discount rates (Kirama, 2010). While private CBA typically focuses on profitability, public CBA emphasizes social welfare, and its principal use is expected in the public sector (Harve & Jowsey, 2004).

Basic Steps of CBA

Watkins et al. (2019) outline the following nine fundamental steps in conducting a cost-benefit analysis:

Step 1: Specify the Set of Alternative Projects

Identify feasible alternatives, including the current situation (the counterfactual). Compare the net social benefits of the proposed project with those of the best alternative.

Step 2: Decide Whose Benefits and Costs Count

Define the scope of analysis local, national, or global based on the stakeholders involved. Decisions on standing are context-dependent and particularly complex for transboundary impacts.

Step 3: Catalog the Impacts and Select Measurement Indicators

List physical effects as benefits or costs and identify suitable units of measurement. Only include impacts that affect individual human value, ensuring a causal link between the project and outcomes.

Step 4: Predict the Impacts Over the Project's Life

Estimate the magnitude and duration of each impact. This step is more challenging for long-term projects with complex inter-variable relationships.

Step 5: Monetize All Impacts

Quantify impacts in monetary terms using individuals' willingness to pay. Non-market values, such as life or biodiversity, pose challenges for monetization.

Step 6: Discount Future Benefits and Costs

Apply a discount rate to reflect the time value of money. The discount rate is typically determined by a central agency and varies by country.

Step 7: Compute Net Present Value (NPV)

Calculate the net present value (NPV) by subtracting the present value of costs from the present value of benefits. Choose the project with the highest NPV, while recognizing that not all alternatives may have been considered.

Step 8: Perform Sensitivity Analyses

Test the robustness of results to variations in key assumptions and inputs. Focus on variables with the greatest uncertainty or impact.

Step 9: Make a Recommendation

Recommend the alternative with the highest NPV while incorporating insights from the sensitivity analysis.

Economic Valuation Techniques in CBA

A range of valuation methods is available to capture both tangible and intangible impacts within a CBA framework. These techniques vary in complexity and applicability.

Other Cost-Based Approaches

These methods estimate values based on costs incurred to avoid, mitigate, or substitute environmental damages.

Replacement Cost Method

Estimates the costs of repairing or replacing damaged environmental assets. Effective for physical assets but limited for unique or non-replicable entities like cultural heritage sites.

Relocation Cost

Uses costs associated with relocating assets due to environmental damage as a proxy for value.

Opportunity Cost

Measures the value of benefits forgone when choosing an environmentally beneficial alternative, such as designating a wetland instead of developing the land (IDB Policy Directive B.9).

Valuing Environmental Amenities

Environmental goods like biodiversity or recreation are often unpriced. Several indirect methods can assign monetary value to such benefits:

Hedonic Pricing (Property Value and Wage Differential Approaches)

Analyzes how environmental quality affects market prices, such as housing or wage premiums for risky jobs.

Travel Cost Method

Uses visitor expenditures to derive a demand curve and estimate the consumer surplus associated with recreational sites. This "revealed preference" method is widely used across developed and developing countries (Hanley & Spash, 1993).

Contingent Valuation Method (CVM)

Uses surveys to elicit individuals' willingness to pay for hypothetical environmental changes. CVM is especially useful for estimating non-use values like existence or bequest values (Carson, 2000).

Benefit Transfer

Applies valuation estimates from one context to another when time or resources are limited. Although practical, this method can introduce significant uncertainty (Johnston et al., 2015).

Cost-Effectiveness vs. Cost-Benefit Analysis

While CBA is ideal for valuing both costs and benefits in monetary terms, it may not always be feasible or desirable. In such cases, **cost-effectiveness analysis (CEA)** can be used as an alternative. CEA identifies the least costly way to achieve a specific outcome but does not assess whether the benefits outweigh the costs.

Cost-Benefit Analysis and Ethical Concerns

Ethics concerns itself with what is morally right or good, spanning both Western and Eastern philosophical traditions. Western thinkers like Descartes, Locke, Berkeley, Hume, and Kant laid foundational ethical principles, while utilitarianism, advanced by Bentham and Mill, serves as a key underpinning of neoclassical economics and CBA. Utilitarianism advocates for maximizing collective benefit, but its neoclassical form focuses on individual utility maximization, which may result in overall societal welfare under certain conditions. In contrast, egalitarianism, as proposed by Rawls (1971), prioritizes the well-being of the least advantaged members of society. This view opposes elitism, which Nietzsche (1886) aligned with the success of the most privileged.

Environmental ethics distinguishes between instrumental values those useful to humans and non-instrumental or intrinsic values, which ascribe worth to nature independent of human use. When the environment is recognized as possessing intrinsic value, it demands moral consideration, extending ethical concern to ecosystems, animals, and even geological features (Booth, 1994).

Ethical Failures of Cost-Benefit Analysis

From a utilitarian perspective, CBA encounters ethical limitations regarding intra-generational and intergenerational equity. It also struggles to address interspecies justice due to its emphasis on instrumental over non-instrumental values.

Intra-generational Inequality and Wealth Bias

CBA tends to favor the wealthy due to its reliance on willingness-to-pay (WTP) as a proxy for utility. Since WTP is income-sensitive, individuals with greater wealth exert more influence on outcomes, regardless of actual welfare impacts. For example, in a society with shared natural resources, such as a forest valued differently by wealthy and poor communities, CBA may disproportionately prioritize affluent preferences (Hausman & McPherson, 2008).

Intergenerational Equity

To address intergenerational concerns, the Krutilla-Fisher model proposes incorporating increasing environmental good prices and adjusting production benefits through a "double discount" mechanism (Krutilla et al., 1975; Hanley et al., 1991). Intergenerational CBA explicitly integrates future generations (Kula, 1988), accounting for present-biased preferences through techniques like the multigenerational net present value model (Padilla, 2001, as cited in Saez et al., 2007). Tools such as intergenerational discount factors further extend CBA's reach into long-term equity planning (Sumaila et al., 2005; Saez et al., 2000).

Ethical CBA and Pluralism

A pluralistic approach considers diverse ethical perspectives, critical in addressing complex societal issues and sustainability challenges (Castle, 1993). Zerbe (2007) recommended ten ethical guidelines for CBA, emphasizing expert judgment, the incorporation of religious and cultural values, and the direct integration of ethical considerations into CBA rather than through indirect discount adjustments.

In Nepal, storage-type hydropower projects present ethical and practical complexities. Using Hanley and Spash's (1993) framework, CBA entails defining project scope, identifying significant impacts (both market and non-market), monetizing outcomes, applying discounting, and conducting sensitivity analyses. Non-market effects, such as environmental changes, are often evaluated using shadow pricing or revealed preference methods.

Pros and Cons of CBA

Despite its utility in quantifying societal preferences, CBA faces criticisms for inadequately compensating affected groups and failing to reflect diverse value systems. For instance, in hydropower development, CBA may downplay aesthetic and ecological concerns. Mitigation measures rarely yield proportional welfare gains, and public willingness to pay for such efforts is limited. These shortcomings necessitate integrating CBA within broader decision-making frameworks that better capture externalities and site-specific complexities (Mattmann et al., 2016).

Discussion

This study highlights the multifaceted ethical considerations that must be addressed when applying Cost-Benefit Analysis (CBA) to large-scale infrastructure projects such as hydropower development in Nepal. Traditional CBA, rooted in utilitarian philosophy, prioritizes aggregate welfare maximization. However, this approach has significant ethical limitations, particularly concerning intra-generational equity, intergenerational justice, and environmental sustainability.

The reliance on willingness-to-pay as a measure of value introduces systemic bias, favoring wealthier populations whose preferences are more heavily weighted due to their greater purchasing power. This can result in decisions that disproportionately marginalize low-income communities, particularly those who rely on common resources such as forests and rivers for their livelihoods. Consequently, CBA may perpetuate or exacerbate existing socioeconomic inequalities rather than mitigate them.

Intergenerational concerns are also insufficiently addressed in standard CBA frameworks. By heavily discounting future benefits and costs, traditional models risk undervaluing the long-term environmental impacts of hydropower projects. Alternative models, such as the Krutilla-Fisher approach and intergenerational discounting mechanisms, have been proposed to correct these imbalances by giving more weight to environmental goods and the welfare of future generations. These tools offer more ethical approaches to evaluating sustainability trade-offs, especially in projects with long-term ecological implications.

Environmental ethics introduces further complexity by distinguishing between instrumental and intrinsic values of nature. While CBA can account for instrumental values through shadow pricing and revealed preferences, it struggles to capture non-market and non-instrumental values such as cultural significance, biodiversity, and landscape aesthetics that often influence local opposition to hydropower development.

A pluralistic approach that integrates diverse ethical perspectives can enhance the comprehensiveness and legitimacy of CBA. Scholars have emphasized the importance of embedding ethical judgment within the analytical framework, rather than treating it as an afterthought or adjusting solely through discount rates. Ethical pluralism is particularly crucial when decisions involve competing interests, deep uncertainties, and irreversible environmental changes.

In hydropower planning, these ethical limitations become especially salient. While CBA provides a structured, monetized view of trade-offs, it must be used as one component within a broader decision-making framework. Incorporating stakeholder values, addressing site-specific externalities, and integrating long-term ecological and social concerns are essential steps toward more just and sustainable infrastructure development.

Conclusion

The analysis reveals several ethical limitations of traditional Cost-Benefit Analysis (CBA), particularly in the context of large-scale infrastructure projects such as hydropower development. Traditional CBA, rooted in utilitarian principles, emphasizes the maximization of overall welfare. However, this approach often neglects distributive justice, systematically underrepresenting the preferences of marginalized or economically disadvantaged groups due to income-based valuation methods like willingness-to-pay (Hausman & McPherson, 2008). As a result, intra-generational inequality is perpetuated, with policies frequently skewed in favor of the affluent, who possess a greater capacity to influence valuation outcomes.

Furthermore, CBA faces significant challenges in addressing intergenerational equity. Conventional discounting practices tend to devalue long-term environmental impacts, thus marginalizing the interests of future generations. Revised models such as the Krutilla-Fisher algorithm attempt to address this by acknowledging the increasing scarcity and rising value of natural resources over time (Hanley et al., 1991; Krutilla et al., 1975). Despite these efforts, the inclusion of future generations in economic evaluations remains insufficiently addressed in mainstream CBA applications.

Another critical shortcoming lies in CBA's inability to account for non-instrumental environmental values. The framework traditionally prioritizes human-centered, market-driven outcomes, overlooking the intrinsic worth of ecosystems, biodiversity, and natural landscapes. This exclusion limits CBA's ability to evaluate ecological and cultural dimensions essential to ethical environmental assessment (Booth, 1994). In this context, ethical pluralism emerges as a necessary approach, incorporating diverse moral perspectives such as egalitarianism, environmental ethics, and intergenerational justice. This broader ethical lens fosters a more comprehensive and inclusive evaluation of development impacts (Castle, 1993; Zerbe, 2007).

The study also highlights limited public willingness to pay for conservation, which further constrains the utility of monetary compensation mechanisms in mitigating environmental degradation. In hydropower projects, while positive externalities such as reduced greenhouse gas emissions are evident, public valuation of environmental losses often remains insufficient to justify comprehensive protective measures (Mattmann et al., 2016). This underscores the need for broader societal engagement and the integration of non-market values into project evaluations.

Overall, CBA should be regarded not as a definitive decision-making tool but as a supporting mechanism within a larger decision framework. Given its methodological and ethical constraints, it must be complemented by stakeholder engagement, qualitative judgments, and ethical considerations to ensure socially and environmentally responsible project outcomes.

Implications

The findings of this study underscore the need to rethink and reformulate the application of Cost-Benefit Analysis (CBA) in evaluating large-scale development projects, particularly in environmentally sensitive and socioeconomically diverse contexts like hydropower development in Nepal. The utilitarian bias inherent in traditional CBA frameworks fails to account for equity across income groups and generations, thereby risking policy decisions that may reinforce social disparities and environmental degradation. This study suggests that incorporating ethical pluralism drawing from utilitarian, egalitarian, and environmental ethics into the evaluation process can lead to more inclusive and just decision-making. Additionally, the limitations in capturing non-market and non-instrumental values call for expanded methodologies that integrate qualitative assessments and participatory approaches. Policymakers, planners, and development agencies must therefore treat CBA as one component of a broader, ethically grounded decision-making framework rather than the sole determinant of project viability. Doing so can enhance the legitimacy, fairness, and sustainability of infrastructure investments, particularly in resource-dependent and ecologically vulnerable regions.

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