

Equity and Benefit- Cost Analysis

Post-Workshop Summary

Environmental Defense Fund

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Environmental Defense Fund

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I. Introduction

Inland and coastal flooding are extremely expensive categories of natural disasters in the United States costing over US\$1.5 trillion in damages since 1980 (NOAA, 2023). It is estimated that the current average annual losses from flood damages is US\$32.1 billion (Wing et al., 2022), and that amount is expected to increase by 26.4 percent in the US by 2050 because of climate change. Current losses are borne disproportionately by poorer communities with a proportionally larger white population, and the future increase in risk will disproportionately impact black communities concentrated on the Atlantic and Gulf coasts (Smiley et al., 2022). To address this growing flood risk, communities are seeking assistance from federal agencies, such as the U.S. Army Corps of Engineers (Corps) and the Federal Emergency Management Agency (FEMA) to study, fund and implement flood risk and coastal storm risk management projects through Congressional authorizations. Once authorized, the Corps will conduct the study in partnership with the local sponsor to develop alternative solutions and evaluate the benefits and impacts under the National Environmental Policy Act (NEPA). Due to historic policies of the Office of Management and Budget (OMB), the approval of solutions for funding is strongly contingent on passing Corps and FEMA designed benefit-cost analysis that maximize the net economic benefits under National Economic Development (NED).

1.1 Benefit-Cost Analysis

In general, benefit-cost analysis (BCA) is a systematic approach to estimating the strengths and weaknesses of alternatives and can aid in determining if an investment is sound (Aldy et al., 2021; Atkinson et al., 2008; Pearce et al., 2006). The origins of BCA in the United States can be traced to the New Deal era. In 1934, the Natural Resources Board issued a report and provided three reasons to adopt the use of BCA in natural resource planning. First, to achieve rational planning by achieving equitable allocations of benefits and contributions to cost in public works programs. Second, to identify and categorize benefits as tangible, measurable, intangible, and immeasurable. Third, to provide a substantial economic basis for decision making. Strict BCA requirements were written into law in the 1936 Flood Control Act and was formalized in the *Proposed practices for economic analysis of river basin projects*, also known as the Green Book, in 1950 (Baldwin, 2008).

Currently, the BCA methodology for flood mitigation studies employed by the Corps weighs construction and maintenance costs on damage losses to nationally important economic sectors and avoided property losses. The central challenge discussed here is that historically disadvantaged communities, defined as lower-income communities and communities of color, with high flood risk and increased vulnerability, may be disadvantaged due to the strict application of a BCA framework. Benefits are often summed across individuals and each dollar of benefit is treated equally. This means protecting the marginal dollar of a wealthy family to a low to middle income family has equal priority. Furthermore, summing benefits across a large project area masks the distribution of benefits and can hide inequitable outcomes. The result is disadvantaged communities who are most vulnerable to losing their wealth and livelihoods in flooding events go unprotected.

Recent evidence at the individual and community-scale has identified racial and income inequities in the allocation of flood mitigation funding to elevate homes (Frank, 2022a) buy out homes that

repeatedly flooded (Cusick, 2020), and in the provision disaster recovery assistance (Flavelle, 2021) in the Federal Emergency Management Agency (FEMA) programs. FEMA has acknowledged these disparities and has implemented plans for better outreach and grant distributions before and after disasters (Frank, 2022b; FEMA, 2023).

1.2 U.S. Army Corps of Engineers

For the Corps, there are currently several policy processes and pressures directing the Corps to address these sources of inequity. The Water Resources Development Act 2020 (WRDA 2020) requires the Corps to complete its review to update Corps' policies on environmental justice considerations and community engagement and consultation (CT&I, 2021). The Corps is also under the direction of the Biden Administration's Executive Memorandum, Modernizing Regulatory Review (MRR), and Executive Order 14008, Tackling the Climate Crisis at Home and Abroad. MRR directs the Director of OMB, in consultation with other agencies including the Corps, to develop a set of recommendations for improving and modernizing regulatory review and to provide specific suggestions on how the regulatory review process can promote public health and safety, economic growth, social welfare, racial justice, environmental stewardship, human dignity, equity, and the interests of future generations (Ehrenwerth et al., 2022). EO14008 contains the Justice40 initiative, a whole-of-government effort to ensure that Federal agencies deliver at least 40 percent of the overall benefits from Federal investments to communities that have historically been underserved by government.

In response to these directives, the Corps has identified 11 programs covered by Justice40 to advance the administration's commitment to environmental justice. The Corps has committed to furthering the administration's goals under the Justice40 Initiative to ensure that marginalized communities are supported by the Corps' work through critical infrastructure that provides healthy ecosystems and helps them to reduce their flood risks. Specifically, the Corps will seek to deliver the investment benefits of certain programs to disadvantaged communities, as well as for areas such as its studies and construction projects for flood and coastal storm risk management, and aquatic ecosystem restoration (Shannon, 2022).

The Corps is hosting workshops, seminars, and eliciting suggestions from the public and is seeking to modernize and advance the Corps Civil Works program through policy actions consistent with Administration priorities and statutory authorities. A primary focus for the modernization effort is to identify ways to better serve the needs of Tribal Nations and other disadvantaged and underserved communities. The priority policy actions include identifying ways to further advance the Corps' Civil Works commitment to environmental justice, including compliance with relevant provisions of the Water Resources Development Act (WRDA) of 2020 and WRDA 2022 (USACE, 2022).

In this report, we begin to explore **how the Corps can incorporate distributional equity considerations into its benefit-cost analysis**. This report will synthesize the observations and recommendations from an expert workshop where we gathered a diversity of input and contributions on the Corps' BCA methodology and some analysis of existing data on Corps studies.

II. Analysis and Expert Workshop

2.1 Analysis of Existing Feasibility Studies

In preparation for the workshop, Environmental Defense Fund (EDF) compiled a database of 203 feasibility studies spanning from 2003-2022, geolocated 95% of these studies, and aggregated U.S. Census demographics data for each feasibility study.¹ EDF was able to obtain benefit-cost ratios (BCRs) for 71 of the studies. The BCRs were used to produce descriptive statistics that examined correlations present between benefit-cost ratios and poverty or share of people of color, which were in turn used to explore whether inequity based on race or income could be observed in feasibility studies. The data was used to analyze whether the benefit-cost ratios were lower for feasibility studies with a higher share of people of color.² Second, the data was used to analyze whether benefit-cost ratios were lower for studies with a higher share of households under the poverty line.³

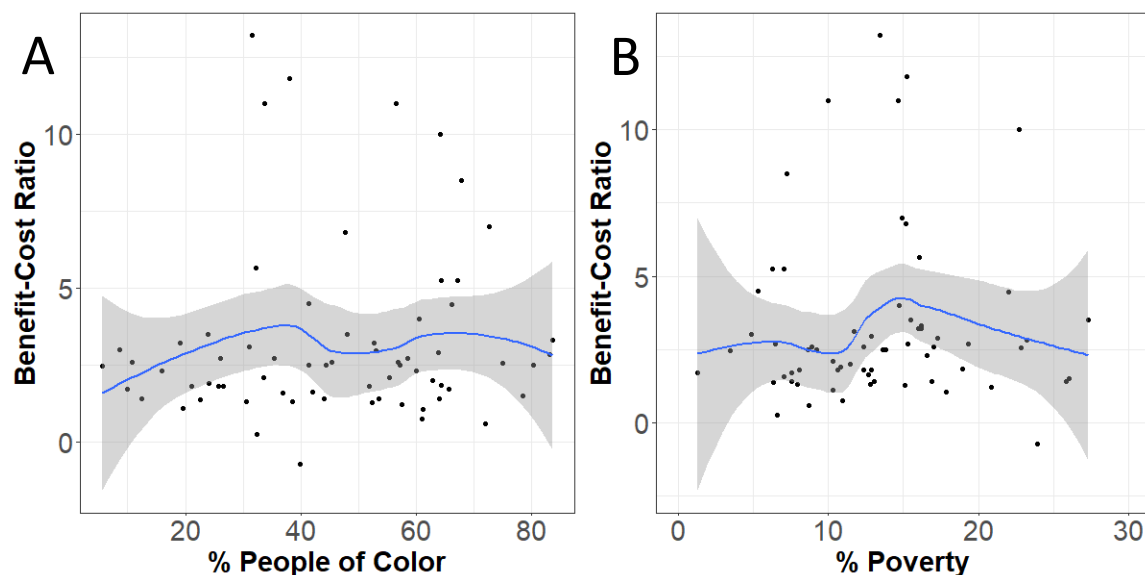


Figure 1. Analysis of Feasibility studies. Panel A is a scatterplot (points) and local linear regression (blue line) of benefit-cost ratios on percent people of color for the 71 feasibility studies in our sample. Panel B is a scatterplot (points) and local linear regression (blue line) of benefit-cost ratios on percent poverty for the 71 feasibility studies in our sample. Shaded regions represent a 95% confidence interval.

Figure 1 Panel A is a plot and a fitted line of the benefit-cost ratios on percent people of color for the 71 feasibility studies in our sample. The flat relationship between percent people of color and BCR across studies do not provide any supportive evidence of bias across studies. Similarly, **Figure 1** Panel

¹ In the geolocation performed for this analysis, we were unable to obtain benefiting regions for each feasibility study. To geolocate each feasibility study we used U.S. Census place and county name matching. Feasibility studies vary in study area size with extents ranging from neighborhoods, communities, municipalities, multiple municipalities, counties, or multiple counties.

² This analysis relied on the difference in count between total individuals (P1001) and white individuals (P1003) relative to total population at the Census place and county level in the 2020 Decennial Census conducted by the U.S. Census Bureau.

³ This analysis relied on the count of individuals with incomes below the poverty line (B16009_002) relative to total population (B16009_001) at the Census place and county level in the 2020 1-year American Community Survey conducted by the U.S. Census Bureau.

B is a plot and a fitted line of the benefit-cost ratios on share of poverty for the 71 feasibility studies in our sample. The flat relationship between poverty share and BCR across studies does not provide any supportive evidence of bias in BCR across studies. Experts considered these data and provided feedback for next steps during the expert workshop.

2.2 Expert Workshop

On September 8th, 2022, EDF hosted a three-hour virtual workshop (*EDF Emerging Issues Workshop: Integrating Equity into Benefit-cost Analysis*) and invited experts to provide guidance on how to improve the equity in Corps cost-benefit analysis methodologies. The goal of this workshop was to present preliminary analysis, elicit expert opinions, distill recommendations On how to address inequity and identify next step research priorities. More specifically, the overarching questions for this workshop were:

1. Is the benefit-cost analysis methodology used by the Corps to allocate federal investments in flood and coastal storm risk reduction inequitable?
2. What changes are necessary to ensure a benefit-cost analysis considers and incorporates equity?

During the workshop, participants were given three presentations. First, experts were shown the methods and results of EDF's preliminary analysis (described above). Second, experts were presented with several questions about equity and benefit-cost analysis to stimulate discussion, gauge positions, and elicit thoughts. Third, and finally, experts were presented with a review of recent work titled "Mainstreaming Environment and Equity in Resilient Infrastructure Assessments (MEERIA) Rubric: Development and Case Study Application." This work outlined a six-stage framework and rubric to score performance and evaluate efforts to incorporate equity into Corps decision making, demonstrating on a variety of case studies. The stages included procedural equity, scoping, planning and design, evaluation, implementation, and monitoring.

2.3 Initial Findings about Methodology

Experts agreed that the initial findings from the analysis showed no discernable correlation between benefit-cost ratios and poverty or people of color (Fig. 1). They noted that these findings do not provide evidence in support of our hypothesis that benefit-cost analysis drives inequitable outcomes, but also are also not conclusive in eliminating benefit-cost analysis as a factor. However, this study sets the stage for additional analysis and makes clear that additional data is needed to understand the relationship between the benefit-cost analysis and equity.

The analysis led experts to drawing some high-level conclusions about the analysis and data available, including:

1. Inequity could be present within feasibility studies. A selected alternative could concentrate benefits in only a few communities or could spread them out more equally across a study area. The BCR hides this critical piece of information. To examine equity among alternatives would

require more detailed data from the US Army Corps on the geographic distribution of benefits for each alternative. This would facilitate research and the presentation of additional metrics to measure the equity of alternatives. It could also serve as an intermediate step in calculating an equity-weighted benefit cost analysis.

2. EDF's analysis could benefit from obtaining geographic extents for benefiting areas for feasibility studies. Currently, reliance on Census geographies may be too coarse and may introduce measurement error. This could attenuate the estimated relationship between race/income and benefit-cost ratio.
3. Experts are concerned that only 71 of the feasibility studies were located with publicly available BCR data while 132 studies were not available in the online Corps library. They identified that this could be a source of bias, as the demographic composition of the Census place and county in the studies that were easily found may differ from the composition of the population relevant to the studies that were not able to be found. A more complete sample would help mitigate this bias.
4. Similarly, experts noted that among the 71 studies located, nearly all had benefit-cost ratios that exceeded 1. This suggests that the sample could be missing studies with benefit-cost ratios below 1 and increasing the sample size to include these studies is necessary before drawing conclusions.
5. Experts decided it would be useful to examine how many feasibility studies graduated to Chiefs Reports and were recommended to Congress.

Next, EDF facilitated a discussion around three questions to prompt feedback and input from experts:

1. How might benefit calculations in benefit-cost analyses create bias against underserved communities?
2. Would making the distribution of benefits and tradeoffs clearer improve equity?
3. Are feasibility cost-share requirements a barrier to underserved communities?

Information shared with experts during the workshop, their observations, knowledge, and recommendations were transcribed, synthesized, and used as the basis for this report. The remainder of this report will discuss the observations and critiques of the current implementation of benefit-cost analysis at the Corps, provide short-term and longer-term recommendations.

III. Observations and Recommendations

3.1 Clear definition of a disadvantaged and underserved community

Attending experts agree that some populations are more vulnerable to flooding damage, and their losses have been often overlooked and underestimated. The poor, minorities, children, elderly, and the disabled are all groups that often have the fewest resources to prepare for or respond to a flood, live in the highest-risk locations, occupy substandard housing, and lack the social and political connections necessary to access resources that would speed their recovery (Tate et al., 2021). Recent research notes that numerous factors affect how challenging a flood event will be for communities

and residents and indicate vulnerability can be unevenly skewed based on race and income (Herrerros-Cantis et al., 2020).

In the Interim Implementation Guidance for the Justice40 Initiative released on July 20, 2021, agencies were directed to define community as “either a group of individuals living in geographic proximity to one another, or a geographically dispersed set of individuals (such as migrant workers or Native Americans), where either type of group experiences common conditions.” In addition, the interim guidance directed agencies to consider appropriate data, indices, and screening tools to determine whether a specific community is disadvantaged based on a combination of variables that may include, but are not limited to, the following (OMB, 2021):

1. Low income, high and/or persistent poverty;
2. High unemployment and underemployment;
3. Racial and ethnic residential segregation, particularly where the segregation stems from discrimination by government entities;
4. Linguistic isolation;
5. High housing cost burden and substandard housing;
6. Distressed neighborhoods;
7. High transportation cost burden and/or low transportation access;
8. Disproportionate environmental stressor burden and high cumulative impacts;
9. Limited water and sanitation access and affordability;
10. Disproportionate impacts from climate change;
11. High energy cost burden and low energy access;
12. Jobs lost through the energy transition;
13. Access to healthcare.

Research shows that nearly all the above factors increase vulnerability to flooding (Rufat et al., 2015). The Corps has on occasion used non-federal sponsor definitions of disadvantaged communities in the creation of Other Social Effects (OSE) account sections of feasibility studies, but this does not always occur.

For example, in the ongoing New York New Jersey Harbor and Tributaries Study (NYNJHATS), the Corps uses a non-federal definition of disadvantaged community if 23.59% or more of the population is under the federal poverty level, or greater than 51.1% of the population identify as minority. This definition was established by local legislation in New York. Similarly, New Jersey has laws defining a community as disadvantaged if 35% or more of the population is at or below twice the federal poverty level, greater than 40% identify as a minority, or greater than 40% have limited English proficiency. The NYNJHATS example demonstrates a challenge in defining a disadvantaged community consistently between jurisdictional boundaries and feasibility studies at the Corps. However, not every local sponsor jurisdiction has laws that define disadvantaged communities, and the Corps does not currently even have a working definition of disadvantaged communities.

Recommendation: The Corps needs to adopt a clear definition of what a disadvantaged community is with respect to flood risk and social factors that contribute to vulnerability to flood risk. This definition should be consistently applied across their agency. The Corps should issue guidance on how this

definition should reflect specific regional factors, such as cost of living, urban versus rural, and the needs of local populations.

Recommendation: The Corps should consult with other federal agencies that have established definitions of disadvantaged communities, such as FEMA or HUD, and evaluate the use of incorporating existing tools, such as the [Climate and Economic Justice screening tool \(CEJST\)](#).

3.2 Examine distributional equity

In short, a feasibility study calculates benefit-cost ratios⁴ for each flood risk mitigation alternative. The alternative with the highest benefit-cost ratio is then selected as a tentatively selected plan by the Corps and is presented to the non-federal partner. Most economists would agree this approach would produce the most efficient alternative and that distributional concerns would and should be dealt with using compensatory transfers. However, these compensatory transfers never explicitly occur.⁵ Several prominent economists suggested that federal agencies should not be bound by strict benefit-cost tests and should identify important distributional consequences in their analysis (Arrow et al. 1996).

Currently, the Corps aggregates benefits and costs across individuals and communities within a study area, and for each alternative. This aggregation makes the equity of an alternative harder to evaluate by obscuring the beneficiaries and the magnitude of the benefits they receive. More detailed information on the distribution of net benefits should be provided. This would allow the federal agency, non-federal sponsor, disadvantaged communities, and other stakeholders to evaluate the alternatives from an equity perspective.

The experts noted this could be addressed by providing data disaggregated at the community, Census tract, or Census block level. This would allow for an examination of how benefits vary by income, race, social vulnerability, and definitions of “disadvantaged.” The value of disaggregation can be illustrated in a two-dimensional graph (see **Figure 2**, Panel A) where net benefits for the disadvantaged community are on the x-axis and net benefits to other communities are on the y-axis. For explanatory purposes, the units can be considered dollars. The origin (point A) corresponds to the baseline condition, pre- project implementation. Now suppose there are two alternatives to choose from named B and C and they are plotted using the benefits to disadvantaged and other communities as the coordinates. Alternative B represents gains in benefits of 5 dollars to other communities and a loss of 1 dollar to disadvantaged communities, alternative C represents a gain to both disadvantaged (2 dollars) and all other communities, albeit a smaller gain to all other communities than in alternative B. Note that in aggregation both alternative B and C have total benefits of 4 dollars, but this aggregation hides that alternative B is less equitable than alternative C.

Disaggregation alone does not provide guidance on how to proceed when alternatives represent tradeoffs across groups, however decision rules based on federal guidance or non-federal sponsors preferences for equity could be implemented to accomplish desired equity goals in this framework.

⁴ The benefit-cost ratio is the sum of present discounted benefits less than the sum of present discounted costs.

⁵ Alternatively, federal spending on risk reduction could be viewed as a compensatory transfer, in which case benefit-cost ratios are irrelevant.

Figure 2, Panel B imposes a Justice40 type restriction, where only alternatives that deliver 40% of benefits to disadvantaged communities would be permitted. Note in this stylized example, alternative C would meet this criteria and alternative B would not.

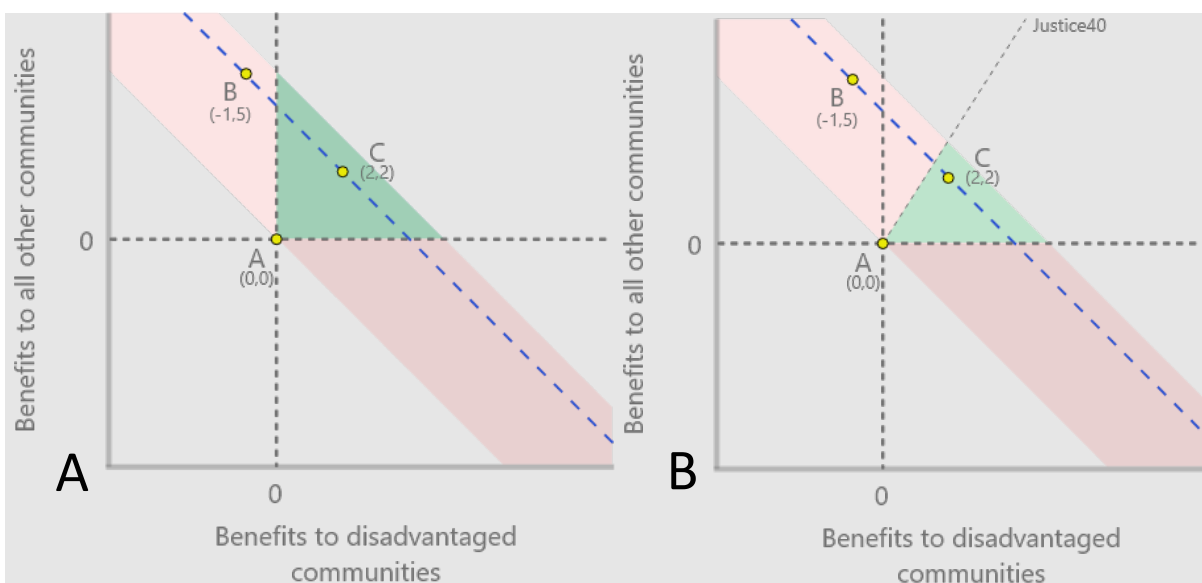


Figure 2: Conceptual graphics of the benefits of three alternatives for flood risk reduction (in dollars). In Panel A, the pink regions represent areas where total benefits are positive and represent Kaldor-Hicks improvements, or improvements that grow total benefits without regard for who gets them, relative to project alternative A, and the green shaded region represent Pareto improvements, or choices that benefit both group A and B, relative to alternative A. Panel B is an implementation of a Justice40 rule, where 40% of benefits must go to disadvantaged communities. The pink regions in Panel B represent areas that would be disallowed for either 1) not delivering sufficient benefits to disadvantaged communities, or 2) increasing damages to other communities at the expense of delivering benefits to disadvantaged communities. The green shaded region in Panel A represents Pareto improvements that comply with Justice40.

This exercise can be expanded to accommodate alternative benefit-cost analysis methodologies which incorporate various equity considerations of the non-federal sponsor.

Recommendation: Separate subtotals for benefits and costs across disadvantaged and other populations. Provide these subtotals for each project alternative so the equity and efficiency tradeoff are analyzed across alternatives. This approach is:

- a. *Easy for the Corps to compute, as it just requires subtotals for subpopulations.*
- b. *Allows for a direct visualization of efficiency and equity tradeoffs among alternatives.*
- c. *Can accommodate current Justice40 goals or future guidance or decision rules requiring desired levels of equity.*
- d. *Can inform how the non-federal share of project costs should be distributed across benefitting and non-benefitting populations, with special attention to disadvantaged communities*

3.3 Exclusion of income losses and other expenses

The foundation of benefit-cost analysis is welfare economics, and the objective is to maximize societal well-being. To do this, the best strategy is to select the choice with the largest net benefits. However, **the set of benefits and costs must be complete and comprehensive to implement this strategy.** Benefits and costs of proposed policies should be quantified and included wherever possible (Arrow et al., 1996). This echoed by guidance on BCA in the [U.S. Army's Cost Benefit Analysis Guide](#). More specifically, the Army's guide states that a "BCA must include all significant benefits (quantifiable or non-quantifiable) in the benefit analysis portion" (U.S. Army, 2018). The Corps flood damage reduction feasibility studies benefit-cost analysis should aspire to maximize social value and include all relevant benefits. The problem is that the Corps often only focuses on a subset of total benefits, often physical damage to structures and contents, when making an evaluation and selecting an alternative.

For some background, the Corps currently has four accounts established to facilitate evaluation of alternative plans. First, is the national economic development (NED) account, and this captures any changes a project may have to the economic value of the national output of goods and services. Second, is the environmental quality (EQ) account. The EQ account catalogues the non-monetary effects of a project on significant natural and cultural resources. The third account is the regional economic development (RED) account which registers changes in the distribution of regional economic activity that result from each alternative plan. Evaluations of regional effects will be done using nationally consistent income, employment, output, and population projections. Finally, the fourth account is the other social effects (OSE) account. Social effects, in a water resources context, refer to how the constituents of life that influence personal and group definitions of satisfaction, well-being, and happiness, are affected by some water resources condition or proposed intervention (Dunning & Durden, 2009). The OSE account registers effects from these perspectives that are relevant to the planning process but are not reflected in the other three accounts.

Historically, the Corps has only been legally required to perform and consider the NED account,⁶ and the Corps often recommends the alternative plan with the greatest economic benefit as measured only by the NED account.⁷ The reasoning behind this is that contributions to NED will unambiguously increase the net value of the national output of goods and services in the planning area and the rest of the Nation benefiting from the project.

⁶ Policies, Standards and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources of 1962 (P&S) introduced the term "national economic development" (NED) and that it should be prioritized in water resource development projects (PWRC, 1962). Subsequently, in September 1973, NED was mentioned explicitly as one of the two overall purposes of water resources planning—the other being environmental quality. In 1983, the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) established that a plan recommending Federal action is to be the plan with the greatest net economic benefit, equivalent to having the highest benefit-cost ratio in the NED account, unless the Secretary of the Army or head of an independent agency grants an exception to this rule (US WRC, 1983). Concerns about an over-reliance on national economic benefits as a required decision metric with secondary consideration of other important benefit categories in part led to the development of the Principles, Requirements and Guidelines (PR&G), which were approved by the Water Resources Council in 2014 and supersede the P&G (CEQ, 2014). Agency Specific Procedures to implement the PR&G are currently under development, and the USACE are currently being directed to include a more comprehensive accounting of benefits (Department of the Army, 2021). This guidance has not been integrated with ongoing feasibility studies.

⁷ The Secretary of the Army or the head of an independent agency can grant an exception to this rule although it is rare (USACE, 2000).

The avoided damages eligible in the NED account are physical damages, income loss, and emergency costs. **Physical damages** include damages to or total loss of buildings or parts of buildings; loss of contents, including furnishings, equipment, [motor vehicles, decorations, raw materials, materials in process, and completed products; loss of roads, sewers, bridges, power lines, and other physical items. **Income loss** includes loss of wages or net profits to households or business over and above physical flood damages usually results from a disruption of normal activities. **Emergency costs** include those expenses resulting from a flood what would not otherwise be incurred, such as the costs of evacuation and reoccupation, flood fighting, cleanup including hazardous and toxic waste cleanup, and disaster relief; increased costs of normal operations during the flood; and increased costs of police, fire, or military patrol. Emergency costs should be surveyed or researched and should not be estimated by applying arbitrary percentages to the physical damage estimates (USACE, 2000).

Historically, the minimum requirement for the Corps to complete a BCA is that they must estimate physical damages using depth-damage functions for economic studies, with special emphasis on structure first floor elevation, and content and structure values for urban studies.

Income losses from flooding can be substantial for certain groups (Groen et al., 2020), but are often not incorporated into the benefit-cost analyses. The reason income losses for households, commercial, industrial, and other business firms are not included in most BCA's is because they are difficult to estimate. The complexity arises because it is hard to determine if the loss is recovered by the firm at another location or later, or by another firm. The logic is if they are recovered later, then they do not count as an NED loss. Therefore, demonstrating the burden of proof to include lost net income and lost wages requires demonstration that postponement of income or transfers do not occur.

To include lost net income or lost wages as a benefit in a BCA, an estimating procedure must be developed, included in a project study plan, and submitted to the Chief of Engineering and Construction Division, Civil Works at Corps Headquarters for approval prior to inclusion of the benefits in feasibility reports or other decision documents.

The Corps' guidance suggests that direct interviews and empirical post-flood studies are the most appropriate data sources for inventorying the loss of a real resource, such as idle capital or decaying inventories. And the Corps states that estimates of income losses must be derived from specific independent economic data on the interests and properties affected. Such income losses due to hurricanes have been documented using independent economic data and approaches. (Groen et al., 2020). However, income loss cannot be prevented by postponement or delay of an activity or transfer of the activity to other establishments, and care must be taken to avoid double-counting.

The non-postponement requirement ignores that lost income or wages could result in increased short run borrowing for unforeseen flood costs or delayed repayment of debt at high interest rates (Farrell and Greig, 2018), and these costs may never be fully compensated. Evidence for this is mixed. Studies suggest that spikes in credit card borrowing and overall delinquency rates for the most flooded residents are modest and short-lived (Gallagher and Hartley, 2014). On the other hand, incomplete information on total individual assets can hide other losses such as premature selling of property, defaults, and other borrowing.

Finally, Corps guidance states that loss of income because of idle labor must be net of income to labor employed in cleanup and repair of damage, and that unemployment compensation and other transfer payments to idle labor are not income from an NED perspective (USACE, 2000).

The advent of large microeconomic datasets makes it possible to demonstrate the small and transitory impacts Hurricane Katrina had on income (Deryugina et al., 2018). Some studies find real effects of flooding and hurricane damages after Hurricanes Katrina and Rita on individual income based on the sector of employment (e.g., hospitality, tourism, and health care are most affected) is uneven, and larger for individuals who moved or separated from employment due to the flood (Groen et al., 2020). Households following Hurricane Katrina who did not return were more likely to be black, less-educated, lower-income, and less likely to be homeowners (Groen and Polivka, 2010). Additionally, recent data shows that disabled individuals are also more likely to be permanently relocated after a disaster (Frank, 2023). Welfare losses after floods disproportionately harm low-income households and increase inequality (Reaños, 2020). Taken together, the evidence imply that considerable income losses are acutely felt in disadvantaged communities and by the disabled, evidence that is largely unaccounted for in the Corps' BCA.

Additional categories that represent real losses should be considered when estimating in an economic study and included in the BCA. These include direct costs, such as increased childcare costs, increased health care costs, school closures and lost learning and other disruption costs. These estimates often could also include the compounding and interdependent economic impacts on: economic drivers (ports, tourism, fisheries); ecosystem services; real estate values; wastewater treatment and subsequent water quality and public health impacts from increased leakages, saltwater intrusion impacts on groundwater supplies for drinking water and agriculture, replacement/relocation costs for all community infrastructure (housing including affordable housing, roads, utilities, critical and public infrastructure), loss of property taxes and jobs, and the mental and physical health to coastal residents.

In summary, benefits in the Corps BCA are inadequate and incomplete. Many other losses occur due to catastrophic flooding and are omitted or unaccounted for by a Corps BCA. The current focus on physical damage ignores other costs of disasters and increases inequity by favoring higher property values over other incurred costs. For some disadvantaged groups who may lack significant assets, most damages to their wealth, well-being, and income are typically unaccounted for in their benefit-cost analysis.

Recommendation: The Corps should include estimates of lost income, lost wages, emergency costs, excess household expenditures, excess borrowing costs, and other relevant costs in the BCA, with careful attention to those that accrue to disadvantaged communities. These costs must be included in a benefit-cost analysis to ensure equity in decision-making.

3.4 Maximizing social value

At its simplest, benefit-cost analysis (BCA) is an economic method used in decision making to provide insight into which decisions maximize social value. BCA estimates the returns from each alternative, and the choice with the largest returns is recommended. However, maximizing returns from a decision

does not maximize societal well-being. Society has preferences for equity, or how returns from a decision should be distributed among individuals. Society's preferences must be used to determine how to redistribute benefits to distinct groups to maximize social value, however this often does not happen in practice.

Currently, the Corps BCA utilizes an approach where each dollar of net benefit is summed across individuals and communities. This assumes that each dollar is equal in its value and assumes that society is indifferent to who receives benefits. This approach likely does not reflect society's preferences for equity. If society values marginal dollars more in the hands of low-income individuals relative to high-income individuals, this is known as *diminishing marginal utility of income* (**Figure 3**). Recent empirical studies have corroborated the existence of the diminishing marginal utility of income (Layard et al., 2008).

To address equity concerns and integrate the diminishing marginal utility of income into BCA distributions of net benefits could be reweighted and then aggregated. A method for incorporating diminishing marginal utility of income into benefit-cost analysis involves using *equity-weighted annual damages* (Kind et al., 2017).

The equity-weighted annual damages methodology requires a five-step procedure.

1. Develop and find the low and high values for income cohorts in a study area. This could be done by decile.
2. Choose an estimate of the utility function and estimates of the elasticity of utility with respect to income, both obtained from causal economic research.
3. Take the first derivative of the utility function.
4. Using midpoint values from the income cohorts to estimate cohort specific marginal utilities.
5. Normalize all cohort specific marginal utilities by the average or median marginal utility. The remaining values are equity weights which can weigh benefits before aggregation.

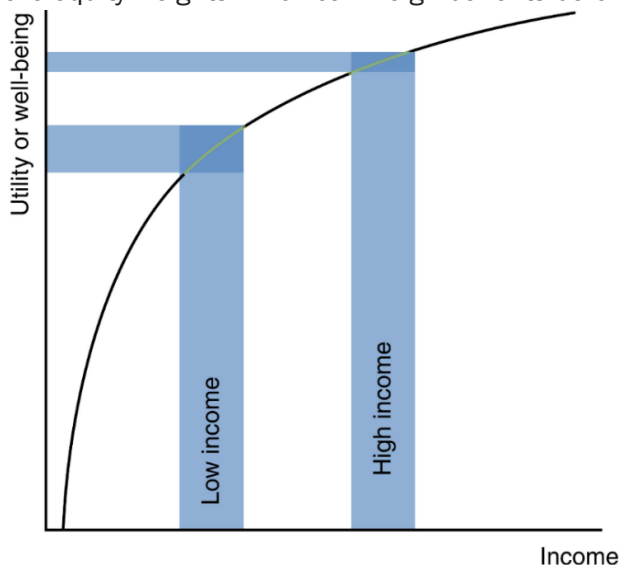


Figure 3. Illustration of the diminishing marginal utility of income. Note that the utility from a marginal dollar of income for low-income individuals results in a larger increase in well-being than the same marginal dollar

of income for high-income individuals. This figure was used from Kind et al., 2017 and modified by the authors.

To address both diminishing marginal utility, the Corps could use a calculation equity-weighted annual damages which involves estimating expected damages and applies equity weights in flood risk reduction studies (Adler, 2016; Kind et al., 2017; Kind, 2019). This would differ from standard damage calculations by weighting benefits by equity weights prior to aggregation and construction of a benefit-cost ratio.

This approach to incorporate equity is more appropriate when damage compensation is insufficient, damages are high relative to income, the income distribution is unfair, and when redistribution is insufficient that to maximize well-being (Kind et al., 2017).

The Corps guidance on BCA does allow for the use of different utility functions in conjunction with assessments of uncertainty to explore design adaptations reflecting specific preferences (USACE, 2000). Benefit-cost analysis is premised on the notion that the values to be assigned to program effects should be based on the preferences of the affected individuals, not those held by economists, moral philosophers, environmentalists, or others (Arrow et al. 1996). Furthermore, Corps guidance states that if public preferences are known, they may be used to show decision makers what the best design would be without uncertainty (USACE, 2000). And in the cases where public preferences are not well known, justification could be given for the selection of various utility functions, or preferences of individuals, which can be used only to illustrate the effects on design of various preferences (USACE, 2000). The Corps can consider a variety of welfare functions where public preferences are known.

Recent developments in the economic literature using equity weighting, weighting by social vulnerability indices, Gini indices, Generalized Lorenz (GL) curves or equally distributed equivalents (EDE) (Mansur & Sheriff, 2021) to determine the most desirable alternative for a given demographic group, as well as which groups benefit most from a given policy.

Recommendation: The Corps should use and present alternative valuations of the benefits of flood risk reduction that incorporate the diminishing marginal utility of income. These should be presented alongside current benefit-cost ratios to offer more information to non-federal sponsors.

3.5 Cost-share requirement barriers to disadvantaged communities.

Benefit-cost analyses are costly, and Corps requires that the non-federal sponsor pay 50% of the feasibility study costs up to a maximum of \$1.5 million. Experts believe this may be a barrier to smaller disadvantaged communities to initiate and maintain funding for duration of a three-year feasibility study. FEMA has smaller cost-share requirements for communities designated as small and impoverished.

Recommendation: Provide capacity-building resources to enable more communities to engage in feasibility studies. Also, the Corps should conduct a study to determine if cost-sharing requirements are a barrier to pursuing feasibility studies. The Corps could reduce feasibility study cost-sharing requirements for projects in which many disadvantaged communities are expected to be affected by flooding.

IV. Conclusion

In summary, the *EDF Emerging Issues Workshop: Integrating Equity into Benefit-cost Analysis* was unique in that it yielded valuable feedback, observations, and recommendations to the Corps for incorporating equity concerns into their Benefit-Cost Analysis methodologies. The six major recommendations are to:

- 1.) Clearly identify disadvantaged populations;
- 2.) Transparently disaggregate net benefits by disadvantaged and other populations;
- 3.) Account for income losses and other relevant benefits identified by non-federal sponsors and community stakeholders;
- 4.) Use aggregation methods that account for the diminishing marginal utility of income;
- 5.) Require a framework and rubric for incorporating equity concerns throughout the feasibility study process, including developing explicit procedural equity protocols;
- 6.) Consider reducing cost-share requirements for feasibility studies in disadvantaged communities.

EDF believes these modifications to the benefit-cost analysis process at the Corps will greatly improve the transparency and equity of the flood risk management studies and infrastructure.

V. References

- Adler, M. D. (2016). Benefit–cost analysis and distributional weights: an overview. *Review of Environmental Economics and Policy*.
- Aldy, J. E., Atkinson, G., & Kotchen, M. J. (2021). Environmental benefit-cost analysis: A comparative analysis between the United States and the United Kingdom. *Annual Review of Resource Economics*, 13, 267-288.
- Arrow, Kenneth J., Maureen L. Cropper, George C. Eads, Robert W. Hahn, Lester B. Lave, Roger G. Noll, Paul R. Portney et al. "Is there a role for benefit-cost analysis in environmental, health, and safety regulation?." *Science* 272, no. 5259 (1996): 221-222.
- Atkinson, G., & Mourato, S. (2008). Environmental cost-benefit analysis. *Annual review of environment and resources*, 33(1), 317-344.
- Baldwin, W. (2008). The US Army Corps of Engineers: A History (Vol. 870, No. 1-68). Department of Defense.
- Committee on Transportation & Infrastructure (CT&I). (2021). The Water Resources Development Act of 2020: Division AA of H.R. 133, Consolidated Appropriations Act, 2021 Fact Sheet. <https://transportation.house.gov/imo/media/doc/2020-12-21%20WRDA%202020%20Conference%20Agreement%20Omnibus%20Fact%20Sheet%20FINAL.pdf>
- Council on Environmental Quality (CEQ). (2014). Principles, Requirements and Guidelines (PR&G) [https://planning.erdc.dren.mil/toolbox/library/Guidance/PRG Interagency Guidelines December2014.pdf](https://planning.erdc.dren.mil/toolbox/library/Guidance/PRG%20Interagency%20Guidelines%20December2014.pdf)
- Cusick, D. (2020). Racial Inequalities in Housing Extend to Flood Buyout Programs: Whiter, wealthier communities disproportionately benefit from government programs to purchase flood-damaged homes. E&E News. <https://www.scientificamerican.com/article/racial-inequalities-in-housing-extend-to-flood-buyout-programs/>
- Department of the Army. (2021). POLICY DIRECTIVE – Comprehensive Documentation of Benefits in Decision Document https://planning.erdc.dren.mil/toolbox/library/MemosandLetters/ComprehensiveDocumentationofBenefitsinDecisionDocument_5January2021.pdf#:~:text=Purpose.%20This%20memorandum%20issues%20policy%20direction%20on%20the.policy%20directive%20is%20implemented%20as%20soon%20as%20practicable.
- Deryugina, T., Kawano, L., & Levitt, S. (2018). The economic impact of Hurricane Katrina on its victims: Evidence from individual tax returns. *American Economic Journal: Applied Economics*, 10(2), 202-233.
- Dunning, M., & Durden, S. E. (2009). Handbook on applying “other social effects” factors in Corps of Engineers water resources planning. St. Davis, CA: Institute for Water Resources.
- Ehrenwerth, J. R., Jones, S. B., Windhoffer, E., Fischbach, J. R., Hughes, S., Hughes, Pippin, S., Shudtz, M., and Jones, S. (2022). Enhancing benefits evaluation for water resources projects: towards a more comprehensive approach for nature-based solutions.

Farrell, D., & Greig, F. (2018). Weathering the storm: The financial impacts of Hurricanes Harvey and Irma on one million households. Available at SSRN 3135266.

FEMA. (2023). NFIP (National Flood Insurance Program) Modifies Benefit-Cost Ratio for Community Grant Programs. <https://www.fema.gov/case-study/nfip-modifies-benefit-cost-ratio-community-grant-programs>

Flavelle, C. (2021). FEMA Says It's Still Working to Fix Racial Disparities in Disaster Aid. The New York Times. <https://www.nytimes.com/2021/10/27/climate/fema-aid-racial-disparities.html>

Frank, T. (2022a). How FEMA helps white and rich Americans escape floods. Politico. <https://www.politico.com/news/2022/05/27/unfair-fema-climate-program-floods-00032080>

Frank, T. (2022b). 'We know we have work to do' on equity, FEMA tells lawmakers. E&E News. <https://www.eenews.net/articles/we-know-we-have-work-to-do-on-equity-fema-tells-lawmakers/>

Frank, T. (2023). Majority of disabled people never go home after disasters. E&E News. <https://www.eenews.net/articles/majority-of-disabled-people-never-go-home-after-disasters/>

Gallagher, J., & Hartley, D. (2017). Household finance after a natural disaster: The case of Hurricane Katrina. *American Economic Journal: Economic Policy*, 9(3), 199-228.

Groen, J. A., & Polivka, A. E. (2010). Going home after Hurricane Katrina: Determinants of return migration and changes in affected areas. *Demography*, 47(4), 821-844.

Groen, J. A., Kutzbach, M. J., & Polivka, A. E. (2020). Storms and jobs: The effect of hurricanes on individuals' employment and earnings over the long term. *Journal of Labor Economics*, 38(3), 653-685.

Herreros-Cantis, P., Olivotto, V., Grabowski, Z. J., & McPhearson, T. (2020). Shifting landscapes of coastal flood risk: environmental (in) justice of urban change, sea level rise, and differential vulnerability in New York City. *Urban transformations*, 2(1), 1-28.

Kind, J., Wouter, Botzen, W. J., & Aerts, J. C. (2017). Accounting for risk aversion, income distribution and social welfare in cost-benefit analysis for flood risk management. *Wiley Interdisciplinary Reviews: Climate Change*, 8(2), e446.

Kind, Jarl. (2019). Drowning by Numbers - Social Welfare, Cost-Benefit Analysis and Flood Risk Management. 10.13140/RG.2.2.35717.01769.

Layard, R., Mayraz, G., & Nickell, S. (2008). The marginal utility of income. *Journal of Public Economics*, 92(8-9), 1846-1857.

Mansur, E. T., & Sheriff, G. (2021). On the measurement of environmental inequality: ranking emissions distributions generated by different policy instruments. *Journal of the Association of Environmental and Resource Economists*, 8(4), 721-758.

NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2023). <https://www.ncei.noaa.gov/access/billions/>, DOI: 10.25921/stkw-7w73

Office of Management and Budget (OMB). (2021). Interim Implementation Guidance for the Justice40 Initiative. Memorandum for the Heads of Departments and Agencies. <https://www.whitehouse.gov/wp-content/uploads/2021/07/M-21-28.pdf>

Pearce, D., Atkinson, G., & Mourato, S. (2006). *Cost-benefit analysis and the environment: recent developments*. Organization for Economic Co-operation and development.

President's Water Resource Council (PWRC). (1962). Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for use and Development of Water and Related Land Resources (P&S).

https://planning.erdc.dren.mil/toolbox/library/Guidance/PoliciesStandardsProceduresWResources1962wSupp1_1964.pdf

Reaños, M. A. T. (2021). Floods, flood policies and changes in welfare and inequality: Evidence from Germany. *Ecological Economics*, 180, 106879.

Rufat, S., Tate, E., Burton, C. G., & Maroof, A. S. (2015). Social vulnerability to floods: Review of case studies and implications for measurement. *International journal of disaster risk reduction*, 14, 470-486.

Shannon, J. (2022). Army Civil Works announces programs covered under the Biden-Harris Administration's Justice40 Initiative. *U.S. Army website*. [URL](#)

[Smiley, K. T., Noy, I., Wehner, M. F., Frame, D., Sampson, C. C., & Wing, O. E. \(2022\). Social inequalities in climate change-attributed impacts of Hurricane Harvey. *Nature communications*, 13\(1\), 3418.](#)

Tate, E., Rahman, M. A., Emrich, C. T., & Sampson, C. C. (2021). Flood exposure and social vulnerability in the United States. *Natural Hazards*, 106(1), 435-457.

[U.S. Army, 2018. Benefit-cost Analysis Guide. 3rd Edition.](#)

U.S. Army Corps of Engineers (USACE), 2000. Planning Guidance Notebook. Engineer Regulation 1105-2-100

U.S. Army Corps of Engineers (USACE), 2022. Notice of Virtual Public and Tribal Meetings Regarding the Modernization of Army Civil Works Policy Priorities; Establishment of a Public Docket; Request for Input. <https://www.federalregister.gov/documents/2022/06/03/2022-11881/notice-of-virtual-public-and-tribal-meetings-regarding-the-modernization-of-army-civil-works-policy>

United States Water Resources Council (US WRC). (1983). Economic and Environmental Guidelines for Water and Related Land Resources Implementation Studies
https://planning.erdc.dren.mil/toolbox/library/Guidance/Principles_Guidelines.pdf

Wing, O.E.J., Lehman, W., Bates, P.D. et al. [Inequitable patterns of US flood risk in the Anthropocene](#). *Nat. Clim. Chang.* **12**, 156–162 (2022). <https://doi.org/10.1038/s41558-021-01265-6>