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MITRE's Response to the OSTP RFI on the Draft Environmental Justice Scorecard

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Introduction and Overarching Recommendations

On January 27, 2021, the Biden Administration issued Executive Order (EO) 14008, Tackling the Climate Crisis at Home and Abroad, which requires the federal government to publish recommendations on how to ensure 40 percent of the overall benefits flow to disadvantaged communities.[1] The focus of these recommendations is on investments in the areas of "clean energy and energy efficiency; clean transit; affordable and sustainable housing; training and workforce development; the remediation and reduction of legacy pollution; and the development of critical clean water infrastructure."[2] The EO (Sec. 223) also requires the publication on a public website of an annual Environmental Justice Scorecard (EJ Scorecard) that provides data on agency environmental justice performance.

On July 20, 2021, the Office of Management and Budget issued interim guidance, M-21-28, which included identifying "the benefits of covered programs, determining how covered programs distribute benefits, and calculating and reporting on reaching the 40-percent goal of the Justice40 Initiative."[3] While the RFI makes clear that the scorecard would eventually broadly capture the environmental justice efforts of federal agencies, an initial focus on the Justice40 initiative makes sense given the significant amount of benefits awarded under those programs.

Significance of Scorecard Design

The scorecard should be designed to baseline current efforts and identify metrics that demonstrate progress in the distribution of the benefits to underserved communities. Most

[1] Executive Order 14008: Tackling the Climate Crisis at Home and Abroad. 2021. Executive Office of the President, https://www.federalregister.gov/documents/2021/02/01/2021-02177/tackling-the-climate-crisis-at-home-and-abroad. Last accessed September 27, 2022.

[2] Ibid.

[3] Interim Implementation Guidance for the Justice40 Initiative. 2021. Executive Office of the President, https://www.whitehouse.gov/wp-content/uploads/2021/07/M-21-28.pdf.

critically, the scorecard must include measures that capture the impact of those benefits on the environmental health and well-being of the recipient communities. Ideally, these measures will contain those critical metrics that identify and assess disparities; help agencies and their programs prioritize the need for change and resources; and ultimately drive changes in program focus and delivery, legislation and policy guidance, and community engagement efforts. A scorecard with these design features is more likely to ensure that the benefits positively impact "clean energy and energy efficiency; clean transit; affordable and sustainable housing; training and workforce development; the remediation and reduction of legacy pollution; and the development of critical clean water infrastructure" for underserved communities.[4]

The assessment of the actual impact on these communities will also allow for a measurement of the collective federal government's impact if the scorecard is crafted to ensure that measures are comparable across the federal government, to the extent possible. This data-driven and evidence-based whole-of-government approach can serve as the foundation of the environmental justice and equity strategy of the federal government.

Alignment to a Comprehensive Federal Environmental Strategy

To be meaningful to the public, facilitate cross-government synergy and accountability to outcomes, and transcend any one administration, the Environmental Justice Scorecard should be aligned to a comprehensive federal strategy that fosters individual and communal welfare. Such a strategy could promote clarity, transparency, and objectivity, and facilitate long-term performance benchmarks via a small set of quantitative indicators about individuals' major life outcomes and mobility, as well as the well-being of their communities. At the same time, the strategy could be attuned to regional, cultural, and demographic diversity in needs, experiences, values, and priorities by using scores from a varying sampling of U.S. communities, where scores are from indicators selected by the communities. Scorecards, such as the Environmental Justice Scorecard, would also reveal their indicators' causal links to the benchmarks, or, where causation cannot be demonstrated, would reveal outcome and process indicators related to the benchmarks. The comprehensive strategy would therefore demonstrate how agencies' progress—or lack thereof—on environmental objectives affects the quality of life for all Americans.

The World Health Organization (WHO) presents one example of how environmental factors support broader, quality of life benchmarks that illuminate the impact of the collective effort and opportunities for action across the nation. WHO defines "quality of life" as "an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns."[5] This definition reflects the view that quality of life "refers to a subjective evaluation, which is embedded in a cultural, social and environmental context."[6] The focus on an individual's "perceived" quality of life allows for a "multi-dimensional concept incorporating the individual's perception of health status, psycho-social status and other aspects of life," and is not limited to objectively measuring "symptoms, diseases or conditions, or disability."[7] Among the many factors considered by WHO

[4] Executive Order 14008.

[5] WHOQOL: Measuring Quality of Life. 2022. World Health Organization, https://www.who.int/tools/whoqol. Last accessed September 27, 2022.

[6] Ibid.

[7] Ibid.

in measuring quality of life, environmental factors, such as an individual's perception of "noise, pollution, climate and general aesthetic of the environment and whether this serves to improve or adversely affect quality of life," are part of the analysis.[8] Similarly, the European Commission measures quality of life using a number of indicators, including "natural living and environmental factors."[9] These factors are indicators for self-reported exposure to air pollution, grime, and noise pollution.[10] As noted by the European Commission, "Environmental conditions not only affect human health and well-being directly, but also indirectly, as they may have adverse effects on ecosystems, biodiversity, or even more extreme consequences such as natural disasters or industrial accidents."[11]

Questions Posed in the RFI

A. Vision: The vision for the Environmental Justice Scorecard is as a robust and comprehensive assessment of the Federal Government's efforts to address current and historic environmental injustice, including the Justice40 Initiative.

1. Does this vision reflect the needs and priorities of communities that face environmental injustices?

MITRE recommends revising the vision statement to read, "The vision for the Environmental Justice Scorecard is as a robust and comprehensive assessment of the Federal Government's efforts to address current, historic, *and future* environmental injustice, including the Justice40 Initiative." The vision could benefit from the consideration of future scenarios, especially in relation to climate hazards and community-led relocation. While monitoring current and historic environmental injustices sets the stage for experienced quality of life, climate change requires planning to reduce anticipated disproportionate impacts or inequities that may be exacerbated. Therefore, MITRE recommends the EJ Scorecard incorporate projected future climate impacts in its assessment of the federal government's efforts, including Justice40 and other investments. Examples may include integration of data on forecasted employee buyouts or retirements, remediation of coal plants with community plans for relocation, and renewable energy prioritized based on future climate hazards in EJ communities. Weighting the proposed EJ Scorecard based on future climate harms, for example, may allow investments and other agency actions to be assessed based on level of harm and prioritized accordingly.

[8] Ibid.

[9] Quality of Life Indicators. 2022. Eurostat, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Quality_of_life_indicators. Last accessed September 27, 2022. Factors include "material living conditions; productive or main activity; health; education; leisure; social interactions; economic security and physical safety; governance and basic rights; natural and living environment; and overall experience of life."

[10] Quality of Life in European Cities. 2022. European Commission, https://ec.europa.eu/regional_policy/en/information/maps/quality_of_life. Last accessed September 27, 2022.

[11] Ibid.

B. Framework: In the first version of the Environmental Justice Scorecard, Federal Government activities will be organized in three reporting categories.

- Reducing Burdens and Harms in Communities: This category would measure the regulatory, enforcement, and other actions taken to reduce harms and environmental injustices.
- Benefits to Communities: This category would measure the Administration's progress on implementation of the Justice40 Initiative, among other environmental justice efforts.
- Centering Justice in Decision Making: This category would capture measures taken to reform agency decision making to incorporate the perspectives, priorities, and lived experiences of environmental justice communities.

1. Do these categories broadly reflect the needs, priorities, and impacts that communities are facing from environmental injustices?

MITRE recommends incorporating future climate harms within the categories of Reducing Burdens and Harms in Communities and Benefits to Communities. Including future scenarios as part of these categories will encourage consideration and avoidance of unintended consequences associated with evolving mitigation and adaptation efforts that may benefit or further harm EJ communities.

MITRE also recommends the addition of existing and future climate-related hazards data that is not currently included in the FEMA National Risk Index (NRI), the beta version of the Climate and Environmental Justice Screening Tool (CEJST), and the Climate Mapping for Resilience and Adaptation (CMRA) tool for consideration.[12] Common weather and climate-related hazards—that is, "events that could result in damage to assets [people, places, and services]"—are identified by the NOAA U.S. Climate Resilience Toolkit and include avalanche, coastal flooding, cold wave, drought, hail, heat wave, hurricane, ice storm, landslide, riverine flooding, strong wind, tornado, wildfire, and winter weather. These overlap with 14 of the 18 natural hazards in the NRI, which are also included in the beta CEJST created as part of the Justice40 initiative. Yet, there are opportunities to go beyond these hazards to include other climate-related hazards and future climate projections. The American Meteorological Society's annual State of the Climate in 2021 report lists 24 climate variables that are fully monitored spatially and temporally on a global scale.[13] Some of these variables, such as sea surface temperature and river discharge, could be added for consideration in the NRI along with future climate projections when available.

Based on a review of climate indicators and impact drivers as listed by the Intergovernmental Panel on Climate Change, the Environmental Protection Agency (EPA), the U.S. Global Change Research Program, and the U.S. Department of Agriculture, some additional hazards and the rationale for inclusion are found in Table 1 in the appendix. The CMRA tool developed in August 2022 through a federal interagency partnership includes both historical data and future

[12] A. Bohmholdt, F. Cochran, S. Habib, M. Rodriguez, J. Stadlan, W. Ball, M. Kim Hoa Hiu, and T. Mullen. Equity in Climate Resilience Planning and Investments (MTR220393). 2022. MITRE.

[13] J. Blunden and T. Boyer. State of the Climate in 2021. 2022. Bulletin of the American Meteorological Society, https://journals.ametsoc.org/downloadpdf/journals/bams/103/8/2022BAMSStateoftheClimate.1.pdf.

projections for extreme heat, drought, wildfire, inland flooding, and coastal flooding.[14] Since this tool was created specifically for climate resilience planning and investments, including decision making for grant funds, adding additional climate hazards to the CMRA platform instead of the NRI may be more beneficial for evaluating current and future local exposure to climate hazard risks.

2. For the first version of the Environmental Justice Scorecard, what processes and markers of progress should be reflected in each of these categories?

Recommendations for Processes

Because equity is not just an outcome but also a process, MITRE recommends community partner involvement from the planning phase through the tool building and communication phases. Publicly recognizing their contributions to the dashboard, and proactively anticipating and addressing how bad actors could misuse the dashboard to stigmatize, increases the likelihood of community adoption of a data dashboard.[15]

MITRE recommends that the process include a consistent approach to baselining the current state of program delivery from an equity lens. Applying a uniform equity framework, such as *A Framework for Assessing Equity in Federal Programs and Policies*,[16] will help to ensure a data-driven and evidence-based approach to eliminate or mitigate identified equity gaps. Based on our experience, a successful process includes critical activities to understand the current state, identify gaps and barriers, and create impactful recommendations.

MITRE conducted an equity assessment for a federal sponsor to uncover if any gaps existed in the equitable delivery of programs and services for underserved communities. The methodology included data analysis, interviews, and other qualitative data to include the voice of the community, as well as policy analysis. Through this process, MITRE uncovered the lack of complete demographic data and identified the key demographic data components required to baseline the current state to measure impact. Community engagement findings revealed misperceptions as well as opportunities to clarify processes and policies, improve legislation, and provide additional engagement. Based on the analysis and findings, concrete and actionable recommendations were provided to address gaps in the collection of relevant demographic data, gaps in program delivery, gaps/barriers in legislation and policy, and gaps in obtaining the voice of the underserved communities. As part of the first version of the scorecard, this type of programmatic baselining can provide the metrics needed to demonstrate progress holistically across a program area.

[14] Climate Mapping for Resilience and Adaptation. 2022. U.S. Global Change Research Program, https://resilience.climate.gov/. Last accessed September 27, 2022.

[15] H. Leker, J. Kirbi, J. Bernardi, and H. De los Santos. Social Justice Platform Data Guide: Integrating Equity into Data Analysis. 2022. MITRE, https://sjp.mitre.org/resources/Data_Guide_Equity_Data_Analysis_2022.08.29_PRS.pdf.

[16] A Framework for Assessing Equity in Federal Programs and Policies. 2021. MITRE, https://www.mitre.org/sites/default/files/2021-11/prs-21-1292-equity-assessment-framework-federal-programs.pdf.

Recommendations for Markers of Progress

MITRE's *Equity in Climate Resilience Planning and Investments* work proposes a quantitative accounting of social equity using metrics, indicators, and weights of inequity both within and external to economic analyses commonly used to assess cost effectiveness of climate resiliency investments proposed for government funding.[17] The purpose of this work is to identify the methods and data that contribute useful information to the formulation of plans, prioritization of funding, and tracking of impact after implementation, while recognizing limitations and potential improvements. An important step in our process is to gather feedback and vet our recommendations with subject matter experts, practitioners, and government and community representatives to reach a consensus on a path to greater understanding of how we might equitably and intentionally direct funding toward the communities that need it most.

The emphasis is a community-based approach, supplemented by data-based measures. This approach can be applied in the grants process during the pre-award (application) phase, with the same data provided in the post-award, closeout, and post-closeout phases to track performance of the funded projects, with information also aggregated to evaluate the overall grant program. The markers recommended for consideration are associated with climate resilience projects and do not address capability and capacity building projects. They are listed in the next paragraph and comprehensively defined in the appendix.

The markers, ordered based on the frequency and potential order of magnitude of the impacts, are property damages avoided, population served (social capital is a subset of the population served), loss of life and injuries, mental health, agricultural damages avoided, transportation delays avoided, and nature-based solutions. MITRE suggests this order based on more than 50 economic analyses for government funding and what is common among economic analyses of investments in climate resilience.

C. Engagement

1. Please provide recommendations on how to improve engagement with, and around, the Environmental Justice Scorecard. In particular, what are ways to improve sharing information about the Environmental Justice Scorecard?

To improve engagement for the EJ Scorecard, MITRE recommends leveraging local networks working with EJ communities across Priority Equity Geographies (PEGs) in urban and rural areas.[18] This approach requires understanding where PEGs are located within the planning area, identifying appropriate representatives who can advocate for the communities and/or populations, and engaging with local networks with PEG relationships. Whether these networks exist through federal, regional, or state programs or through community-based organizations, engagement with and around the EJ Scorecard should offer equal pay for participants who provide input and feedback to the scorecard. In addition, any engagement events that are hosted locally or virtually should consider means for equitable access. For example, distribution of information online or virtually requires access to broadband/internet across both urban and rural

[17] Bohmholdt et al.

[18] Ibid.

populations. Continued broadband/internet access to view the online EJ Scorecard over time may also need to be considered, especially in communities receiving funding or being assessed. Universal broadband/internet coverage may, therefore, need to be provided as part of any EJ investment in a community.

2. For a future website, what are some usability and accessibility features that should be considered for an online platform?

Accessibility and Usability

> *"If the Internet was a country, it would be the 7th largest polluter."*
> — Sustainable Web Manifesto[19]

To optimize accessibility and usability, the website should leverage best practices:

- **Progressive enhancement**:[20, 21] This technique focuses on content and progressively layers on style and behavior, thereby ensuring access and prioritizing usability for everyone, from those with slow bandwidth and old devices to those with access to the latest technology.
- **Responsive web design**:[22] One fluid website that flexibly adapts size and functionality of the user's device increases usability and access for all devices. This minimizes resources used to deliver the site, and in turn the amount of energy and effort to maintain it.
- **Accessibility beyond compliance**: Section 508[23] and other regulations legally define minimum standards of accessibility. Regulations rely on objectively testable standards while many guidelines require subjective expertise. Governance takes time and often is well behind the current best practices and guidelines established by standards bodies like the Worldwide Web Consortium Accessibility Guidelines Working Group.[24] The most inclusive approach delivers accessibility beyond compliance—meeting the spirit and not only the letter of the law—and employs the expertise of seasoned accessibility expert.

[19] Sustainable Web Manifesto. 2019. Sustainable Web Manifesto, https://www.sustainablewebmanifesto.com/. Last accessed September 27, 2022.

[20] A. Gustafson. Understanding Progressive Enhancement. 2008. A List Apart, https://alistapart.com/article/understandingprogressiveenhancement/. Last accessed September 27, 2022.

[21] Graceful Degradation Versus Progressive Enhancement in a Nutshell. 2022. Worldwide Web Consortium, https://www.w3.org/wiki/Graceful_degradation_versus_progressive_enhancement#Graceful_degradation_and_progressive_enhancement_in_a_nutshell. Last accessed September 27, 2022.

[22] E. Marcotte. Responsive Web Design. 2010. A List Apart, https://alistapart.com/article/responsive-web-design/. Last accessed September 27, 2022.

[23] Section508.gov. 2022. General Services Administration, https://www.section508.gov. Last accessed September 27, 2022.

[24] Accessibility Guidelines Working Group. 2022. Worldwide Web Consortium, https://www.w3.org/WAI/GL/. Last accessed September 27, 2022.

Sustainability

> *"Every line of code takes energy to execute, energy to write, and likely represents a combination of communications efforts to nail down."*
> — Sustainability from the Drupal team[25]

An Environmental Justice Scorecard should be a **world-class model of best practices for sustainable web design.** Sustainability—which should be considered a third priority—pairs well with accessibility and usability as each leverage many of the same best practices and standards. Follow these practices to minimize environmental impact:[26, 27, 28, 29, 30, 31]

- Build websites and applications from scratch so that only the required code is included. Many "no-code" or frameworks-based websites include unused packaged code, emitting more carbon unnecessarily.
- Host websites on services that use renewable energy to power websites.
- Do not use video on website unless it is the only way to deliver the message.
- To reduce file size, optimize and preferably deliver all images in SVG and WebP.[32]
- Minimize all code to not only increase efficiency but improve the user experience through faster page load, thereby also improving accessibility (as it removes barriers for assistive technologies).
- As part of the progressive enhancement technique, leverage lazy loading on all website assets to reduce unnecessary resources.

[25] Sustainability. 2022. Drupal Association, https://www.drupal.org/about/sustainability. Last accessed September 27, 2022.

[26] S. Chevannes. Why Web Designers Need to Think about Sustainable Web Design. 2022, Forbes Business Council, https://www.forbes.com/sites/forbesbusinesscouncil/2022/09/01/why-web-designers-need-to-think-about-sustainable-web-design/?sh=32ec16f91c86. Last accessed September 27, 2022.

[27] D. Fork and R. Koningstein. Engineers: You Can Disrupt Climate Change. 2021. IEEE Spectrum, https://spectrum.ieee.org/engineers-you-can-disrupt-climate-change. Last accessed September 27, 2022.

[28] I. Velasco. How Many Emissions in a Gigabyte of Data? 2022. Ismael Velasco.dev, https://ismaelvelasco.dev/emissions-in-1gb?t=1661099790397. Last accessed September 27, 2022.

[29] K. Pretz. IEEE's Plan to Help Combat Climate Change. 2022. IEEE Spectrum, https://spectrum.ieee.org/ieee-plan-combat-climate-change. Last accessed September 27, 2022.

[30] Handbook of Sustainable Design of Digital Services. 2021. Institute for Sustainable IT EU, https://gr491.isit-europe.org/en/. Last accessed September 27, 2022.

[31] Digital Nations Shared Approach to Sustainable Digital Government. 2021. Digital Nations, https://www.leadingdigitalgovs.org/sustainable-government-it. Last accessed September 27, 2022.

[32] An Image Format for the Web. 2022. Google Developers, https://developers.google.com/speed/webp. Last accessed September 27, 2022.

Appendix

Question B.1: Climate and Weather Hazard Data

Table 1. Additional Natural Hazards Linked to Climate Change for Consideration

Hazard Type	Description, Rationale, and Example Data
Coastal Erosion	Long-term or episodic change in shoreline position caused by relative sea level rise, nearshore currents, waves, and storm surge is hazardous to built infrastructure, ecosystems, and livelihoods. Example data: Coastal Erosion Hazard Mapping Project – ARDC; Coastal Topobathy Lidar (noaa.gov)
Marine Heatwave	Episodic extreme ocean temperatures. "Water temperature spikes in Hawaii have also been linked to coral disease outbreaks,"[33] impacting tourism, ecosystems, and livelihoods. Example data: Marine Heatwaves: NOAA Physical Sciences Laboratory
Ocean Acidification	Profile of ocean water pH levels and accompanying concentrations of carbonate and bicarbonate ions. "Ocean acidification is currently affecting the entire ocean, including coastal estuaries and waterways. Many jobs and economies in the U.S. depend on the fish and shellfish that live in the ocean."[34] Example data: Ocean Carbon and Acidification Data Set: NCEI Accession 0219960 (noaa.gov)
Air Pollution (weather)	Atmospheric conditions that increase the likelihood of high particulate matter or ozone concentrations, or chemical processes generating air pollutants. Note: Distinct from aerosol emissions or air pollution concentrations themselves. Some examples include the increase in ground-level ozone from sunny, hot weather or the dispersal of wildfire pollutants through wind patterns and across large distances. Example data: Air Data: Air Quality Data Collected at Outdoor Monitors Across the U.S. | U.S. EPA
Low Streamflow	Trends in the amount of water carried by streams across the United States, as well as the timing of runoff associated with snowmelt. Example data: USGS Surface-Water Data for the Nation
Lake and Stream Water Quality	"Changing climate is likely to harm water quality in Lake Erie and Lake Michigan. Warmer water tends to cause more algal blooms, which can be unsightly, harm fish, and degrade water quality. During August 2014, an algal bloom in Lake Erie prompted the Monroe County Health Department to advise residents in four townships to avoid using tap water for cooking and drinking."[35] Example data: USGS Water-Quality Data for the Nation
Low Lake, River, and Sea Ice	For Alaska's native communities, "The loss of sea ice restricts the subsistence lifestyle of groups such as the Yup'ik, Iñupiat, and Inuit by limiting hunting grounds and reducing habitat for traditional food sources such as walrus."[36] Example data: Data at NSIDC | National Snow and Ice Data Center

[33] What Climate Change Means for Hawaii. 2016. Environmental Protection Agency, https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-hi.pdf.

[34] Ocean Acidification. 2020. National Oceanic and Atmospheric Administration, https://www.noaa.gov/education/resource-collections/ocean-coasts/ocean-acidification. Last accessed July 13, 2022.

[35] What Climate Change Means for Michigan. 2016. Environmental Protection Agency, https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-mi.pdf.

[36] What Climate Change Means for Alaska. 2016. Environmental Protection Agency, https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-ak.pdf.

Hazard Type	Description, Rationale, and Example Data
Thawing Permafrost	Thawing of permanently frozen deep soil layers, their ice characteristics, and the characteristics of seasonally frozen soils is hazardous to built infrastructure, ecosystems, and livelihoods. Example data: Data at NSIDC | National Snow and Ice Data Center
Growing Degree Days	Changes in growing degree days signal changes in the timing and length of growing seasons and pollen seasons in the United States, which may impact food security and human health. Example data: Explore Data | USA National Phenology Network (usanpn.org); Accumulated Growing Degree Day Products | USA National Phenology Network (usanpn.org)

Question B.2: Description of Proposed Markers

Business Interruptions Avoided

Economic recovery is the ability to return economic and business activities to the level of service provided pre-disaster. The speed and effectiveness of recovery depends on the ability to adapt to changed market conditions and reopening businesses or establishing new businesses. FEMA accounts for commercial, industrial, agricultural, religious/non-profit, government and education displacement and disruption costs based on the defined occupancy class (e.g., retail trade, wholesale trade, banks, hospital, schools/libraries) and square footage.[37] This is limited to the estimated costs of temporary quarters and the time associated with displacement. In some cases, businesses may close permanently after a disaster or lose a portion of business because customers may switch to a different establishment permanently during the business interruption. Estimating the costs associated with business interruptions is difficult to generalize since losses are specific to the business, location and market conditions. This challenge can be compounded by the challenge of obtaining data that may be considered proprietary in some cases. Further study is needed to establish metrics for avoided business interruptions.

Agricultural Damages Avoided

Climate hazards, such as flooding and drought, can have significant impacts to agricultural lands. These impacts can be widespread and vary, but often can cause reduced crop yields, adverse impacts to livestock, and damage to farming structures and equipment. Evaluating agricultural damages can be complex depending on the land use, types of crops and distribution, time of year, commodity markets, and intensity and duration of climate hazard events. Commensurate with the complexity is the uncertainty of damage estimates. As a simplification, the number of acres of pastureland and number of acres of crop land that would avoid damages from a proposed resilience project could be considered.

[37] Federal Emergency Management Agency, "BCA Reference Guide," Federal Emergency Management Agency, 2009.

Loss of Life and Injuries

Natural hazards linked to climate change can cause physical impacts during and/or after the event as a direct or indirect consequence. A suggested metric for consideration is the investment per the number of lives saved (both direct and indirect, including acute and chronic diseases) by a proposed resilience project. For injuries, we suggest investment per the number of injuries avoided by severity of injury and investment per number of avoided workdays lost due to injury. Further study is needed to recommend specific loss functions and ordinal categories for each type of disease or injury.

Penning-Rowsell et al.,[38] along with the Reclamation Consequence Estimating Methodology from the U.S. Department of the Interior Bureau of Reclamation,[39] suggest approaches that can be used for estimating direct loss of life and injuries during and in the immediate aftermath of flood events. Approaches for other climate hazards would need to be investigated further. For consistency, the grant awarding agency should specify the approved approach for estimating loss of life and injuries from climate-related events for the grant program.

When a life-threatening situation occurs, timely emergency care is a key factor that affects the chances of survival. When critical facilities such as fire departments and other emergency medical services (EMS) providers are delayed, lives may be lost. Climate hazard events may increase the response time of critical services or cause a critical facility to temporarily shut down. FEMA suggests an approach to estimate mortality and EMS response time based on critical facilities/EMS providers located within the project area, the population served by those EMS providers, and the nearest alternative provider (in miles).[40] This approach can be used to estimate the indirect lives saved by a proposed project and could be either combined with or separated from the direct lives saved metric.

Loss of Social Capital

Social capital refers to the goods of individuals' social connection—"social networks and the norms of reciprocity and trustworthiness that arise from them"—through both personal relationships and more formal associations.[41] The concept of social capital helps pinpoint the social harms of climate-related disaster and displacement experienced disproportionately by EJ communities. It also provides a factor for community resilience to climate disaster and an additional benefit to some community resilience interventions. For quantifying social capital related to climate-driven hazards and displacement, we recommend community-centered research on the most important services provided from social capital that climate displacement would disrupt (or ameliorate). We also recommend quantifying the costs (including barriers to access) of temporary replacement of those socially furnished services by paid services.

[38] E. Penning-Rowsell, P. Floyd, D. Ramsbottom, and S. Surendran. Estimating Injury and Loss of Life in Floods: A Deterministic Framework. 2004. Natural Hazards, 1-22.

[39] Guidelines for Estimating Life Loss for Dam Safety Risk Analysis. 2015. U.S. Department of the Interior Bureau of Reclamation.

[40] Benefit-Cost Analysis Re-Engineering. 2011. Federal Emergency Management Agency.

[41] R. Putnam. Bowling Alone: The Collapse and Revival of American Community. 2000. Simon and Schuster.

Mental Health

Mental health impacts associated with exposure to a disaster can include stress associated with evacuations, losing a home and possessions, physical injuries, and illness of family and friends. Mental stress can also be a secondary response to other direct impacts, such as being displaced from home and community, loss of electricity and heat in the home for extended periods of time, inability to receive regular counseling or treatment as the result of closure or lack of transportation, or inability to obtain needed medication. Mental health issues can lead to sleep disorders, drug/alcohol use, and inability to work, and can last for months or years following a disaster. Productivity losses can occur from lost labor and production for those affected by mental health issues and those who provide care for affected people.

FEMA provides guidance on the prevalence and course (rate of reduction of symptoms over time) of mental health impacts following a disaster.[42] FEMA categorizes mental health impacts as mild/moderate and severe and provides suggested prevalence rates by the time after disaster, as shown in Table 2. By associating these impacts with the costs of treatment and lost productivity, it effectively weights the mental health impacts. As an alternative to monetizing the mental health impacts, the number of people by duration and category can be used to understand the avoided mental health impacts of a proposed climate resilience project.

[42] Final Sustainability Benefits Methodology Report. 2012. Federal Emergency Management Agency.

Table 2. Mental Health Prevalence Percentages with Effect and Course

Time after Disaster	Mild/Moderate	Severe
7-12 months	26%	6%
13-18 months	19%	7%
19-24 months	14%	7%
25-30 months	9%	6%

FEMA used 2009 and 2010 studies as the basis for the monetized value of lost productivity from people suffering from a severe mental illness. Further study is needed to leverage more recent data (within the past five years) to understand how to estimate the number of productive days that would be lost from mental health impacts.

Nature-Based Solutions

Nature-based solutions, as defined by The Nature Conservancy, are "project solutions that are motivated and supported by nature and that may also offer environmental, economic, and social benefits, while increasing resilience. Nature-based solutions include both green and natural infrastructure."[43] FEMA defines nature-based solutions as "sustainable planning, design, environmental management, and engineering practices that weave natural features or processes into the built environment to build more resilient communities." The benefits of nature-based solutions can include ecosystem services such as recreation benefits, reduced urban heat island effects, appreciating property values, reduced energy use and improved human health.[44] The value of these benefits is highly context specific and related to the location and type of habitat created (or restored).

Ecosystem services can be categorized as provisioning, regulating, supporting, and cultural services.[45] Provisioning services may include food, raw materials, and medicinal resources. Regulating services are services provided by ecosystems that act as regulators, such as regulating air quality or water quality, moderating extreme events, erosion prevention, and biological control. Supporting services can be described as the habitats that provide for flora and fauna to survive, such as food, water, and shelter. Supporting services may also include the maintenance of genetic and species diversity. Cultural services can include the recreational value of the ecosystem, aesthetics, tourism, and the spiritual experience provided by the ecosystem.

When ecosystem services benefits are monetized, there is a high degree of uncertainty. The suggested metrics below reduce uncertainty by focusing on the quantity and quality of the habitat created (or restored). Further study is needed to define ordinal ranking for the quality of the habitat by type of habitat (e.g., maturity of tree at time of planting and whether it is native to the

[43] Promoting Nature-Based Hazard Mitigation through FEMA Mitigation Grants. 2021. The Nature Conservancy, https://www.nature.org/content/dam/tnc/nature/en/documents/Promoting-Nature-Based-Hazard-Mitigation-Through-FEMA-Mitigation-Grants-05-10-2021-LR.pdf.

[44] F. Cochran, L. Jackson, A. Neale, J. Lovette, and L. Tran. A Community EcoHealth Index from EnviroAtlas Ecosystem Services Metrics. 2019. International Journal of Environmental Research and Public Health, https://pubmed.ncbi.nlm.nih.gov/31382383/.

[45] Texas Coastal Resiliency Master Plan. 2019. Texas General Land Office, https://coastalstudy.texas.gov/resources/files/crmp-technical-report-05-21-2019.pdf.

habitat); therefore, this was not included in the suggested metrics. Suggested metrics for consideration are listed below and are not intended to be exhaustive:

- Investment per acre of urban/rural green space created or restored given ecoregion or ecozone
- Investment per acre of riparian created or restored
- Investment per acre of shellfish/coral reefs created or restored
- Investment per acre of coastal/inland wetlands created or restored
- Investment per acre of coastal forests created or restored
- Investment per acre of mangroves created or restored
- Investment per acre of prairies created or restored
- Investment per acre of seagrass created or restored
- Investment per acre of beaches and dunes created or restored
- Investment per number of trees planted given ecoregion or ecozone

Population Served

Because information about property owners and occupants is not likely to be available by structure, the population served should be evaluated separately from property damages avoided. The total investment for the project could be distributed by the equity indicators that have been established by the grant program and the community served by the proposed project. The population served may expand beyond the project area, considering public resources and critical and public facilities within the project area may serve populations outside of the project area. Multiple metrics could be established, depending on whether different outcomes have different associated populations. Some of the damages avoided are a function of the population impacted, such as costs associated with loss of services (e.g., utilities, public services), evacuation and subsistence, disruption, displacement, and reoccupation. Additionally, the total investment for the project per capita could be another metric used for comparison.

Property Damages Avoided

In general, a large share of benefits for climate resilience projects are derived from damages avoided to structures (residential and non-residential) and contents. To avoid biasing results toward communities with the highest property values, we recommend using the number of properties by category instead of the depreciated replacement value of properties. The categories could align with the applicable depth-damage function, such as those used by the U.S. Army Corps of Engineers, approved for use by the federal awarding agency. For example, residential structures may be classified as house with basement, house without basement, bi-level and split-level homes, apartment on slab, or apartment with first floor 4 feet below grade.

Various ordinal categories could be developed based on national depth-damage functions to sort structures by category and by the percentage of structure and content damage. For example, low

structure damage for a residential structure without a basement may be greater than 0 and up to 20 percent damage, low-medium structure damage may be 21 percent to 40 percent, medium structure damage may be 41 percent to 60 percent, medium-high structure damage may be 61 percent to 80 percent, and high structure damage may be 81 percent to total loss. Further study is needed to recommend specific ordinal categories for each structure type. A similar approach could be used for other damages that have an established depth-damage function, such as automobiles.

Transportation Disruptions Avoided

A climate hazard event can have potentially significant impacts on a transportation network. The impacts may include impediment of traffic flow between origin and destination, increased travel times, road closures, and corresponding detours. The U.S. Department of Transportation has well established guidance for estimating costs associated with transportation delays.[46] Instead of monetizing the costs, the methods can be used to identify the delay time, number of vehicles impacted, number of miles, number of people impacted (based on occupancy rate for vehicles or ridership for other modes), and associated fatalities and injuries. Any of these impacts become a benefit when a proposed project would avoid them from occurring. Suggested metrics for consideration could include investment per travel time savings (in hours), which can be used to capture all modes of travel. When considering the safety benefits, it is important that these are not captured elsewhere to avoid double counting. If these are not accounted for already, additional metrics could include investment per fatality avoided and investment per injury avoided.

[46] Benefit-Cost Analysis Guidance for Discretionary Grant Programs. 2022. U.S. Department of Transportation, https://www.transportation.gov/sites/dot.gov/files/2022-03/Benefit%20Cost%20Analysis%20Guidance%202022%20%28Revised%29.pdf.