COMMUNITY ENGAGEMENT, ENVIRONMENTAL JUSTICE, & HEALTH

Gaps in Environmental Justice Screening and Mapping Tools and Potential New Indicators

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Executive Summary

Despite climate change being a topic of national concern and debate in elections, news cycles and scientific discourse for a long time, communities worst impacted by its effects are still underserved (Wilson & Schlesinger, 2020). Disadvantaged communities across the country are disproportionately subjected to climate burdens, with major impacts on their health and wellbeing (Mohai & Saha, 2015; Wilson et al., 2010). Through mapping health, environmental, climate, sociodemographic, and economic data, Environmental Justice Screening and Mapping (EJSM) tools reveal the inequitable distribution of environmental and climate burdens across communities. In doing so, EJSM tools have important implications for educating the public and driving equitable decision-making at the state and federal levels to build healthy, sustainable and resilient communities (Lee, 2020). Active EJSM tools in several states have effectively demonstrated not only the inequitable effects of climate change and pollution, but also the varied socioeconomic statuses that increase the susceptibility of certain communities. However, current tools still omit crucial data pertaining to social progress, vulnerability, climate equity, economic progress, environmental hazards, health disparities, and resilience—factors that can demonstrate a community's ability to withstand and respond to the threats of climate change. The objective of this paper is to review existing EJSM tools and identify gaps in the kinds of information they map. These gaps are then used to inform a new set of recommended indicators that better represent the topics of climate equity and resilience and optimize proficiency in quantifying climate disparities. We endeavor to use these findings to bolster the development of a nationwide EJSM tool in support of the White House Environmental Justice Advisory Council (WHEJAC)'s Justice 40 Recommendations. This tool will encompass a range of indicators missing from existing tools, and specifically promote more equity-focused EJ-related climate legislation and decision making. Key recommendations are also provided in this whitepaper that address

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barriers to climate justice by integrating EJSM tools into policymaking, increasing the accessibility of high-quality data, providing more funding to vulnerable communities, and developing trust between government agencies and communities.

Existing Tools and Indicators

To identify a set of indicators to map climate equity and resilience, we reviewed a number of existing environmental justice screening and mapping (EJSM) tools with varying scopes and focuses. These include California's CalEnviroScreen, Maryland (MD) EJSCREEN and the MD Park Equity Mapper, Cuyahoga County (Ohio) Planning Commission Climate Change Vulnerability Map, Florida Department of Environmental Protection Map Direct Tool, HGBEnviroscreen (which focuses on the Houston-Galveston-Brazoria region), Washington Environmental Health Disparities Map, and the Environmental Protection Agency (EPA) EJSCREEN.

These tools encompass data from broad categories of factors that impact quality of life outcomes. Environmental indicators in EJSM tools are thematically grouped into indicators of **environmental *exposures*** and **environmental *effects***. Environmental exposure indicators measure or estimate the levels of direct contact of human beings with chemicals, such as ozone and particulate matter, in their environment, as channeled from sources such as air, water, food and soil. Environmental effects indicators, on the other hand, reflect adverse environmental conditions caused by pollutants, such as impaired water bodies and proximity to hazardous waste facilities. Another category of indicators currently employed by EJSM tools are **economic and demographic** in nature; these describe the economic and sociodemographic characteristics of a given area, such as percent low-income, racial and ethnicity data, and rates of linguistic isolation. Most tools also include **health indicators,** statistics and data directly related to the health conditions and prevalence of illness in a population. Some EJSMs also employ **infrastructure indicators,** consisting of data related to facilities or services within a geographic location that would provide further evidence of the state of environmental health. **Social progress indicators** are related to infrastructure, but pertain specifically to actual and potential resources individuals receive from their participation or presence in social networks and communities, both digital and offline. Recreational areas and green spaces are included within this category. Some newer tools also include indicators of climate vulnerability and resilience, including community cohesion, sea level rise and flooding. While data included in current EJSM tools can be grouped into these thematic categories, the specific indicators in each tool vary according to the tool's area of focus. For a full list of indicators see Appendix A.

Through mapping health, environmental, climate, sociodemographic, and economic data, Environmental Justice Screening and Mapping (EJSM) tools reveal the inequitable distribution of environmental and climate burdens across communities.

The geographic scope, data granularity, and overall objective of a given tool dictate which indicators are ultimately included. Every EJSM tool must balance all these factors, which can mean tools omit data necessary to attain an accurate picture of environmental (in)justice in a given area. For example, EPA EJSCREEN, the only EJSM tool that is national in scope, utilizes publicly available data that is nationally consistent. The tool can only make use of data available

at the census block group level in every state. Because it uses only nationally consistent data, it can effectively map data related to economics, sociodemographics, and environmental exposures and effects for the entire country. It also allows users to compare their communities to national averages. However, the broad scope of the tool is also limiting—it fails to address the particular combination of issues that are specific to each state. Some indicators may be especially valuable to include, but if the data is not available for every state, then they cannot be included in the tool.

Additionally, in many cases the data that EJSCREEN does use is statistically modeled with high levels of uncertainty, resulting in potential inaccuracies (U.S. Environmental Protection Agency, 2015). Its demographic indicators, for example, are nearly all derived from the U.S. Census Bureau's American Community Survey, which relies on a small sample of the population in each census block group, and then generalizes that data for the broader block group. The effect of this methodology is that those demographic indicators are estimations with high margins of error and potential inaccuracies.

To address the shortcomings of EPA EJSCREEN, many states have designed and implemented their own EJSM tools. These are statewide in scope and include indicators that may be unavailable at the national scale, but are available in high granularity at the state level and are critical to quantifying environmental justice in the state. Statewide tools include CalEnviroScreen, Maryland (MD) EJSCREEN, the MD Park Equity Mapper, and the Washington Environmental Health Disparities Map. MD EJSCREEN, for example, includes several indicators that are specific to the state and unavailable at the national level, such as asthma emergency discharges and watershed failure (Driver et al., 2019). State-specific tools more precisely serve the needs of each state, as users can compare indicators in their community to a statewide average rather than a national average. Yet these tools are also limited by the granularity of available data and frequently employ modeled data with high levels of uncertainty. Health data is especially difficult to access at levels more granular than the state or county scope, due to privacy concerns related to the Health Insurance Portability and Accountability Act (HIPAA) (Grineski & McDonald, 2011). Some counties and municipalities—such as Cuyahoga County, Ohio and Houston, Texas—have created mapping tools even further limited in geographic scope to provide measures of environmental justice that are highly targeted to community concerns with more localized data (Bhandari et al., 2020). However, highly localized maps lack the ability to draw larger comparisons between the focus area and the broader state or other regions in the state, and are similarly limited by HIPAA so they cannot include highly accurate, highly precise health data.

EJSM tools are limited by their scopes and data granularity, and as the tools range from macro scales (e.g., national) to increasingly local (e.g., municipality) levels, there are tradeoffs in the kinds of indicators that can be included and the accuracy of those indicators. Importantly, all EJSMs are also screening tools for initial fact-finding. They cannot substitute for more direct approaches to ground-truthing the particular combination of factors that lead to each community's experiences of environmental injustice and the effects of environmental hazards.

Gaps in Existing EJSM Tools and Proposed Indicators

Current EJSM tools largely fail to account for climate-related concerns, which define the health and wellbeing of many communities on the front lines of climate change threats. For instance, vulnerability to climate-induced impacts is not comprehensively incorporated in these tools, and

disparities in climate impacts, and the varying degrees of community resiliency to withstand these impacts, are obscured in current iterations of EJSM tools. Although they do assess basic economic and sociodemographic factors, including proportions of people of color (POC) and/or low-income populations, educational attainment, and linguistic isolation, the tools lack indicators to measure socioeconomic equity and progress, such as increases in the local minimum wage, advancement of green businesses or POC-owned businesses. Understanding and mapping these climate factors is crucial for decision-making. These factors determine a community's experience in the face of a catastrophe as well as the recovery process, information that can help identify communities that are in greatest need of funding and government support. Current EJSM tools are also limited in their capacity to represent the health implications of climate change, in part due to the lack of data available at granular scales due to privacy concerns. As a result, health data currently mapped largely includes general health impacts such as rates of asthma, low birth weight infants, strokes, and other illnesses or conditions; which lack the correlation to climate change. The following section provides indicators that aim to address some of these gaps.

Through an extensive review of existing EJSM tools, health impact assessments, community needs assessments and other research, we identified six themes inadequately represented in current EJSM tools and similar resources. We then identified approximately 20 indicators within each theme to include in our literature review (see Table 1). It should be noted that this list includes some indicators for which data sets may not currently exist, which should be

Table 1: List of Themes and Indicators for each Theme

Theme	Indicators	
Social Progress	• Long Commute Times • Broadband Internet Access • Mobile Telephone Subscription • Households with Severe Housing Problems • Degree of Segregation • Investment in Public Housing • Improved Public Transit Access • Reduced Utility Costs • Government Investments in Energy Efficiency Accessibility	• Services from Human Capital • Residential Decision Making • Inclusionary Zoning Policies • Proportion of Affordable Housing • Incarcerated Population (Sensitive Subgroup) • Food Environment Index • Increase in per pupil spending • Unhoused Population • Climate Refugees
Vulnerability	• Socioclimatic Exposure • Median of Projected Change in Runoff • Climate and Ocean Risk Vulnerability Index (CORVI) • Heat Vulnerability Index • Cooling Requirements • Social Vulnerability Index (SVI) • Protection Vulnerability • Building Vulnerability • National Disaster Risk Index • Cost of Weather and Climate Disasters • Socioeconomic Status Index • Palmer Drought Severity Index • Wildfires • Extreme Heat Days • Crop moisture stress index	• Ozone (O3) Concentrations • Heat Island Effect • Number Of 100° Days • Historical Temperature and Heat Index • Area in Flood Zone • Standardized Precipitation Index • Winter Storm Occurrences • Erosion Risk • PFAS Water Surveillance • Military Bases (Proximity to Potential Hazard) • Homes in Need of Lead Water Pipe Retrofitting/lead Testing Data • Length of pollen season • Air Stagnation Index • Residential Energy Demand Temperature Index (REDTI)

Table 1 *(continued)*

Theme	Indicators	
Climate Equity	• Level of Access to Community and Emergency Services • Weatherization Investments Made (investments in clean energy, transportation, green infrastructure) • Reduction in Stormwater Flooding • Increase in Green Space/Canopy Cover • Investment in Frontline/EJ Organizations • Recovery Progress after Natural Disaster (based on exposure, vulnerability, and government support) • Demographics of People Residing in Flood Zones • Access to Clean Water at HH Level • Percent Population with Air Conditioning • Costs of Pollution • Disaster Insurance (property/home/renters) Price Index	• Relocations by Race/Ethnicity • Shelter Population by Race/Ethnicity • Formal Post Disaster Organizational Support Received • Change in Median Income Post Disaster • Food Insecurity • Neighborhoods or developments isolated by shutdowns and washouts • Building Project Management (money disbursed compared to money sustained on critical and primary infrastructure) • Buildings without working utilities • Oil/Gas availability • Relief Money Provided • Connectedness to Other Cities through transit
Economic Progress	• Underemployment rate/ labor utilization • Unemployment rate • Percent of Children on Free and Reduced Lunch • Number Of POC-Owned Businesses • Energy Burden • Green Business Development/Incentives • New Green Businesses Owned by POC • Economic Aspects of Water Security (infrastructure Financing, Water Misallocation, Water Risks) • Energy Burden • No. of Jobs in Clean Energy Sector • Percent Jobs Worked By POC	• Increase in Minimum Wage • Percent Income Spent on Food • Decrease in Gender Wage Gap • Decrease in Racial Wage Gap • Income Inequality - Gini coefficient • Income Inequality - Atkinson Index • Income Inequality - Concentration Index • BIPOC Small-business Ownership and Loans • Rate of Job Loss • Change in Prices of Basic Necessities - Water, Energy, Food • Change in No. Of Jobs in Tourism Sector • Workforce Development • Business stabilization of small businesses to prevent displacement
Health	• Self-rated Health • Mortality Due to Extreme Cold • Mental Health Support Capacity • Improvement in Health Insurance Coverage • Flooding-exposure To Mold • Deaths Related to Drowning from Flooding • Use Of E-health Interventions • Carbon Monoxide Poisoning • Respiratory and Cardiovascular Hospitalizations • West Nile Virus Index • Excessive mortality due to heat wave	• Percent Change in Mortality Associated with A 10°F Increase In Mean Daily Temperature, By Race/Ethnicity • Gastrointestinal Illnesses • Cancer Risk from Hazardous Air Pollutants (HAPs)" • Flood Fatalities Due to Indirect Causes • Heat Stroke Prevalence • Frost Bites and Hypothermia Cases • Weather-related Car Accidents • Burn Injuries Due to Forest Fires • Cases of Kidney Disorder • "Allergenicity" of pollen • Excessive mortality due to heat wave
Resilience	• Baseline Resilience Indicators for Communities (BRIC) • Rural Resilience Index (RRI) • City Resilience Index (CRI) • Hazard Resilience Index (HRI) • Coastal Community Resilience Index • Resilience Capacity Index • Up-to-date Social, Physical, Ecological Vulnerability Maps • Wild Food Harvest	• Sustained Funding to grassroot organizations for technical assistance • Ecosystem Stewardship by private landowners • Cumulative Stressors and Resiliency Index (CSRI) • Percent of Households with Air Conditioning • Homeownership • Social Cohesion • Elevated Homes • CRS (Community Rating System) Class • Resilience Hubs/Cooling Centers • Market access

created. However, most of these indicators do have an associated metric that details how the indicator may be calculated, analyzed or measured. See Appendix B for the full literature review, including individual metrics and detailed explanations.

Social Progress

Social progress refers to advancements in technology, science, and social capital that improve the wellbeing of people. These features are unrelated to economic status and can capture families' ability to escape the intergenerational cycle of poverty. On a global level, the United States is the only G7 country and one of only three countries to decrease in social progress index, according to the 2020 rankings (Deloitte and Social Progress Imperative, 2020). This demonstrates a need for monitoring and surveillance of social progress within the U.S. to identify internal deficiencies and target areas for improvement. The lack of social progress in the United States is further highlighted when stratified by disadvantaged communities, because both the history of the U.S. and current literature is rich with cases of social injustices. EJ is a social justice issue and it is therefore important to integrate EJ into the framework for social justice and progress, making this theme timely in re-cementing the U.S. as a global leader in this category (Beltran et al., 2016).

Although some measures of social progress are represented in current EJSM tools (e.g., schools, public housing indicators), social progress could be better captured with information pertaining to the 'change' or 'advancement' in social conditions. These could include the following subcategories: commute time/driving alone, broadband coverage/households

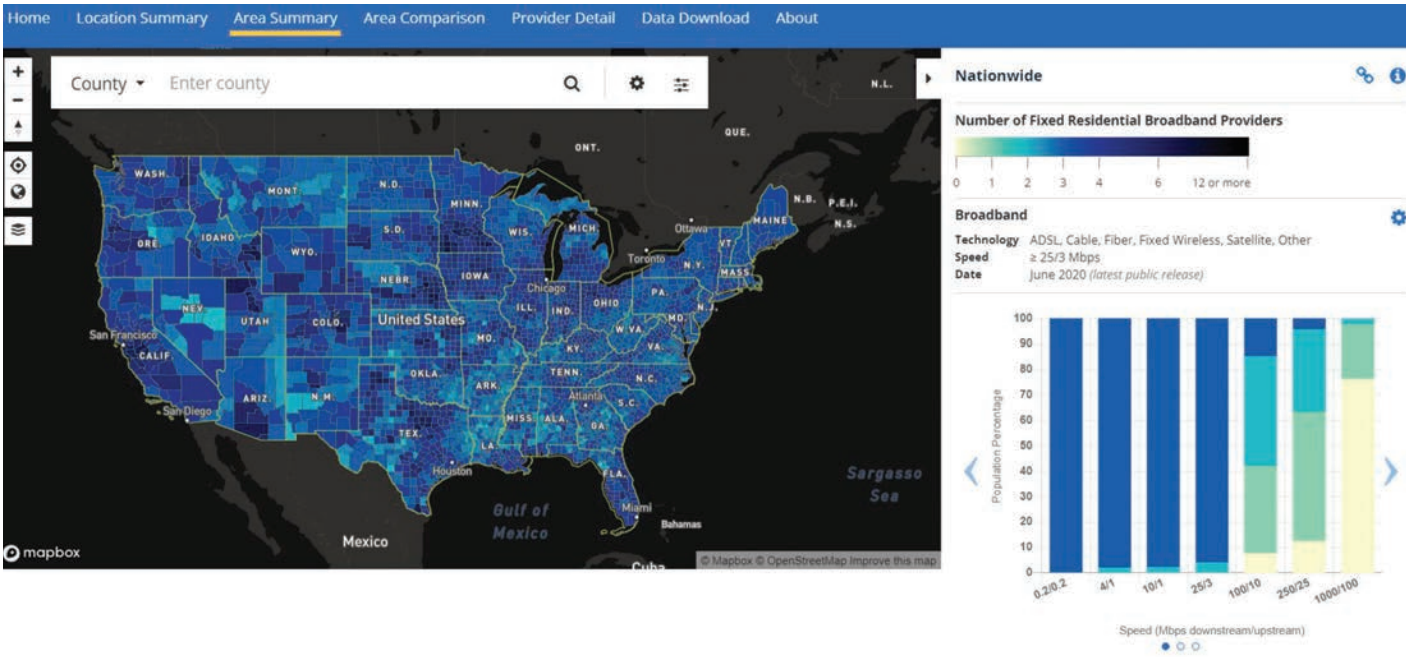

Figure 1: *The Federal Communication Commissions (FCC) has mapped counties and census-tract specific broadband coverage at various speed thresholds (as shown on the right). This allows users to not only determine their coverage speed, but also to understand the dynamics of market competition in the form of number of fixed residential broadband providers. This tactic enables researchers to employ econometrics as an assessment of health equity (e.g., spiked costs associated with a lack of market competition, cost-benefit of broadband expansion packages, quality vs. quantity of service and needs assessments based on occupational breakdown, etc.). Credit: FCC.*

with computers, mobile telephone subscriptions, reductions in severe housing problems, investment in public housing, improved public transit access, reductions in utility costs, investments in energy efficiency accessibility, and investments in human knowledge and creativity.

Vulnerability

Vulnerability is the output of sensitivity, exposure, and adaptive capacity. Assessing these dimensions across environmental, health, socioeconomic, and climate contexts can help us understand the factors contributing to community susceptibility and ability to resist environmental disturbances (Cardona et al., 2012; Weis et al., 2016; Ebi, Kovats, & Menne, 2006; Lei, Wang, Zhou, & Yin, 2014; Shonkoff, Morello-Frosch, Pastor, & Sadd, 2011). Vulnerability can take several forms. Environmental vulnerability for instance, considers the type and magnitude of environmental exposure a community might experience (Ebi et al., 2006; Weis et al., 2016) such as extreme temperatures (Karimi, Nazari, Dutova, Khanbilvardi, & Ghandehari, 2018; Dahl, Licker, Abatzoglou, & Declet-Barreto, 2019), flooding (Chakraborty, Collins, Montgomery, & Grineski, 2014), erosion (Hewett, Simpson, Wainwright, & Hudson, 2018), and drought (Stanke et al., 2013). Exposures may also include hazards in the built environment such as distressed infrastructure (Weis et al., 2016), contaminants such as per- and polyfluoroalkyl substances (PFAS) (Crone et al., 2019) and lead (Sansom et al., 2019), ozone (Nuvolone, Petri, & Voller, 2017), and the urban heat island effect (Heaviside, Macintyre, & Vardoulakis, 2017).

Social vulnerability incorporates elements of sensitivity and adaptation. It reflects individual and population characteristics that alter susceptibility to hazards, and access to resources and infrastructure that moderate the impacts of those hazards (Chakraborty, Rus, Henstra, Thistlewaite, & Scott, 2020; Conlon et al., 2020). For example, a heat vulnerability index developed by Nayak et al. (2018) considers biological factors that impact the ability to thermoregulate such as age, social factors such as poverty and employment that influence access to heat-adaptation amenities, and language barriers that could decrease accessibility to weather warnings and reports (Nayak et al., 2018). These demographic and socioeconomic data are included in a multitude of existing indices (New York State Department of Health, 2020; Centers for Disease Control and Prevention, 2018; FEMA, n.d.; Chaktraborty et al., 2019; Cutter, Boruff, & Shirley, 2003; Diffenbaugh, Giorgi, Raymond, & Bi, 2007). But tools such as the Climate and Ocean Risk Vulnerability Index (CORVI) demonstrate integrating existing metrics and adding new indicators could provide robust spatial data to further identify vulnerable populations and geographic areas. CORVI measures ecological, financial, and political risk across 96 indicators and provides critical insights into the challenges coastal cities face and "cascading risks" of exacerbating existing social,

Types of Risk	Ecological	Political	Financial
Subcategories	Geology/Water	Social/Demographics	Economics
	Climate	Governance	Major Industries
	Ecosystems	Stability	Infrastructure
	Fisheries		

Figure 2. *CORVI considers 3 types of risk using 96 indicators in 10 subcategories to assess vulnerability in coastal cities. These constructs are cumulatively weighted to provide a risk score and are categorized into risk levels.*

environmental, or economic conditions (Stuart, Yozell, & Rouleau, 2020) (Figure 2). Other indicators focus on non-health aspects such as market share and business prospects in the area. This demonstrates an additional type of vulnerability; economic vulnerability can encompass climate impacts on public and private sectors, macroeconomic impacts on gross domestic product, and stressors affecting poverty, consumption, and relief services at the individual and community levels (Cardona et al., 2012). The complex interplay of these factors necessitates better quantification of vulnerability to prioritize policy development and climate equity to build resilient cities and communities.

Climate Equity

Climate change impacts communities differentially, with frontline communities suffering first and worst from climate disasters due to decades of injustice, underinvestment, and discriminatory policies

Prioritizing Climate Justice in Urban Planning: Lessons from Maryland

The American history of urban planning and housing development is characterized by racist and classist zoning policies that have resulted in poor sanitation, food insecurity, and other neighborhood health effects for low-income communities and communities of color. To properly mitigate the health impacts of exclusionary zoning, governments must implement new approaches to urban planning that prioritize environmental and climate justice (Wilson et al., 2008). One proposed policy mechanism is the Environmental Benefit Districts (EBDs) designation for certain neighborhoods. The EPA defines EBDs as "locations where the State, EPA, and other stakeholders can focus their resources to address the environmental concerns of [...] targeted communities" (U.S. EPA, 2016). Through Economic Enterprise Zones (EEZs), a critical component of EBDs that denote targeted areas for the government to funnel monetary resources, the inclusion of disadvantaged communities prevents polluting industries from siting new facilities in those neighborhoods. Additionally, EEZs attract salutogenic (health-promoting) companies with low greenhouse gas emissions to spur economic growth in communities and lead to green economies. EEZs also expand communities' opportunities for increased funding for community resources and new infrastructure that is adapted to future or current impacts of climate change. These grants cover a wide spectrum of funding programs, tailored to the needs of designated communities (Khanjar et al., 2018). The Biden Administration has emphasized the importance of advancing equity across the country and has directed $70 million to expanding opportunities for minority-owned businesses, $3.8 billion to infrastructure modernization and rehabilitation in marginalized communities, $110 million to promote transportation equity, and many millions more to mitigating environmental injustice, racial disparities in healthcare, and other longstanding sources of climate and environmental inequity (OMB, 2021). An itemized list of White House funding opportunities for EBDs and examples of grants from other sources are listed in Appendix C.

In 2005, Maryland implemented EBDs across the state, but has not measured the success of the policy on any statewide scale. However, researchers at the University of Maryland investigated the effects of one EBD in Prince George's County, which received initial funding but little long-term support. Regardless, the designation allowed the state to infuse the county with funding, reduce local air pollution, redevelop brownfields into productive sites, and carry out other measures to improve public health and wellbeing. The Maryland team outlined a broad framework for the implementation of EBDs in Prince George's County that harnesses existing state and national programs to encourage equitable and health-focused development in disadvantaged communities (Bibb et al., 2016).

(The Greenlining Institute, 2019). As a result, these communities are left with limited accessibility and higher costs to access basic services such as housing and transportation, in addition to being subject to pollution and various environmental burdens. These factors deny low-income communities and people of color the ability to prepare for, respond to, and recover from extreme weather events. Climate equity refers to the embedding of equity into the focus of climate grant programs and policies to prioritize the needs of the most vulnerable populations and comprehensively support them in coping with climate threats to ensure they bounce back to a better status quo. Measures of climate equity describe communities' experience in responding to, preparing for, and recovering from the effects of climate change-induced disasters (e.g., stormwater and flooding, hurricanes, extreme heat, droughts). Without implementing and monitoring policies that address equity, climate change will further exacerbate the environmental injustices and health disparities associated with extreme climate events. As climate impacts increase in frequency and severity, frontline populations will experience far greater losses than whiter, more affluent communities (Shonkoff et al., 2011). Morello-Frosch et al. have referred to this widening divide as the "climate gap," where frontline communities suffer increasingly with rising threats. To adequately address this disparity, community-based organizations must be involved in guiding local and regional climate-resilience planning, policy development, and implementation to better reflect the priorities of their low-income populations. The Kresge Foundation's Climate Resilience and Urban Opportunity (CRUO) Initiative and the Greenlining Institute's Guidebook demonstrate the effectiveness of an approach to climate adaptation that adequately resources and promotes the voices of frontline communities (The Kresge Foundation, 2019; Mohnot et al., 2019).

It is worth noting that the conventional understanding of distributive risks of extreme climate events—that the most vulnerable populations experience greatest risk—fails to account for the fact that, in some cases, affluent populations are actually more likely than socially vulnerable groups to experience severe climate impacts. For example, some studies have found that socially advantaged populations experience highest pre-flood exposure to flood hazards (Chakraborty et al., 2014; Fielding and Burningham, 2005; Grineski et al., 2013; Montgomery and Chakraborty, 2013; Ueland and Warf, 2006). However, this conceptual discrepancy can be resolved when factoring in a community's social vulnerability, rather than considering human exposure to a hazard alone. An appropriate estimation of community risk—or, conversely, preparedness—must therefore include the monetary, technological, and expert resources available to that community. Returning to the example of flooding, affluent populations may voluntarily elect to live in flood-prone regions for their aesthetic and environmental benefits, knowing that they will be able to make use of state or local resources that will be provided to them in the event of a major flooding event, or else cover these costs themselves. Lower-income communities, on the other hand, will be unjustly denied these resources in the event of a major flood (Chakraborty et al., 2018). Indicators such as "Disaster Insurance Index" and "Demographics of People Residing in Flood Zones" more completely capture community preparedness for, or risk of, climate-induced severe flooding events.

Similarly, evaluations of climate equity must consider the differential capacities of communities to respond quickly and effectively to climate effects. During Hurricane Katrina, low-income Black communities were most likely to remain in New Orleans through the disaster, a product of poor communication from authorities regarding the ongoing evacuation, inadequate transportation, and widespread misunderstanding regarding the severity of the

hurricane (Elliot & Pais, 2006). Indicators such as "Level of Access to Community and Emergency Services" and "Weatherization Investments Made (including investments in transportation)" would aptly reveal the disparities in the capacity of communities to respond to natural disasters as they occur. Another method of estimating community-level response to climate effects is "Building Project Management," which refers to money disbursed compared to damage sustained on critical and primary infrastructure, and gauges how effective monetary assistance is relative to incurred climate-induced population displacement and damages.

Finally, climate equity cannot be adequately measured without indicators that highlight the disparities in communities' varied capacities to recover in the face of major climate events. In the wake of Hurricane Sandy, community recovery was dependent on exposure (water depth, prior flood experience, building heights), vulnerability (social vulnerability, seasonal occupancy), and government support (FEMA assistance, Small Business Administration loans). Low-income communities and communities of color were more likely to receive less FEMA assistance and experience greater economic insecurity in the wake of the disaster (Cutter et al., 2014). "Formal Post Disaster Support Received" and "Relocations by Race/Ethnicity" typify the climate equity indicators that capture the differential in capacities for populations to recover from a disaster.

Economic Progress

Low-income communities are much more vulnerable to climate change than affluent ones. Tol and Yohe, (2007) and Barr et al. (2010) assert that the ability to absorb climate stress depends on factors highly correlated with economic growth, such as good institutions, high levels of educational attainment, and a well-developed financial sector. Bowen et al. (2011) reveal additional factors of economic progress, including sustainable management of natural resources; transport infrastructure, communication and information assimilation systems, and municipal services and energy systems; and the absence of monopoly market power, which spurs innovation. While current economic indicators in EJSM tools contain "conventional" measures like median household income and single-parent households, they do not fully capture the various forms of economic progress and growth the scientific community has found to be strongly correlated with climate resilience, including the indicators mentioned above. Some of these additional indicators include: percent of minority-owned businesses, energy burden/injustices, green business development and adoption of renewable energy policies, energy credit imports, increase in minimum wage, percentage of income spent on food and rent, and rate of job loss. These simultaneously measure investments into communities and access to opportunities. For instance, Hongtao (2014) found that renewable energy policies, strict minimum wage legislations, and clean energy businesses all perpetuate green business development. This, combined with percent of minority-owned businesses, could be overlaid in a nationwide EJSM tool to better illustrate equitable economic progress.

Table 2: How selected indicators from above list of measures of economic progress were defined. Sources: Hernandez & Bird, 2012; Brown et al., 2020; Riccucci, 2009

Selected Indicators of Economic Progress	Definition
Energy Burden	% of people in low-income housing that experience an energy burden
# Clean Energy Jobs	# and types of jobs that result from investments in energy efficiency in homes, businesses, and industry
% Jobs by People of Color	% of jobs by POC in the federal government

People awaiting an air boat rescue after being evacuated from a flooded subdivision near Houston, Texas, in the wake of Hurricane Harvey. Measures of climate equity describe how communities respond to, prepare for, and recovery from climate impacts, like Harvey. Understanding the resources available to a community (including the monetary and technical resources) is an important part of measuring climate equity. Credit: Glenn Fawcett, U.S. CBP.

Health Disparities

Understanding health endpoints and disparities is crucial to understand the full extent of damage from climate and environmental-related hazards, and to quantify impacts to disadvantaged communities. In less than 20 years, millions of people in the U.S. could be exposed to dangerous heat conditions of 127 degrees Fahrenheit or more (Leahy, 2019). These dramatic increases in temperature help fuel and increase in wildfires, which leads to more smoke, which causes respiratory infections, inflammation, exacerbation of preexisting health conditions, and premature death. Such respiratory conditions disproportionately affect low-income communities of color at the endpoints of illness, severe morbidity, and mortality. Black Americans are 1.5 times more likely to have asthma, 5 times more likely to become hospitalized due to asthma, and 3 times more likely to die of asthma, compared to their white counterparts (Asthma and Allergy Foundation of America, 2020). Extreme heat can also cause cardiovascular disease (CVD) and cerebrovascular disease. According to a Centers for Disease Control and Prevention (CDC) report, despite the fact that CVD had decreased across all race groups over time, age-adjusted death rates for heart disease by race are still higher for Black Americans compared to white Americans (208.0 deaths per 100,000 Black Americans, versus 168.9 deaths per 100,000 white Americans) (CDC, 2019). Risk factors of CVD include: hypertension, obesity, diabetes, and high cholesterol. Of these risk factors, Black Americans were more likely to have hypertension (42.1%), be obese (47.5%), and have diabetes (19.6%), compared to White Americans (28.7%, 38.2% and 13.0%, respectively) (CDC, 2019). Hurricanes, stormwater, and flooding can lead to increased prevalence of waterborne illnesses, mold contamination, drownings, pneumonia, Respiratory Syncytial Virus (RSV), and RSV pneumonia. While many of these indicators are captured in current EJSM tools, those related to health disparities are excluded or overlooked in both databases and scientific literature. This includes indicators of health disparities that could fill in these gaps, including self-rated health, mortality due to extreme cold, West Nile virus index, burn injuries due to forest fires, mental health support capacity (poor mental health looms as a silent killer), and deaths related to drowning/mold exposure.

Resilience

While vulnerability considers exposures and susceptibility, resilience focuses on the capacity and functionality of assets to respond, withstand, and recover after a climate event has occurred (C2ES, 2018; Lei et al., 2014; Burwell-Naney, Wilson, Whitlock, & Puett, 2019). Communities need to be climate resilient to cope with the acute shocks (heavy downpours, hurricanes, wildfires) that will become more frequent or intense with climate change, and to cope with the chronic stressors (disenfranchised and marginalized neighborhoods) that pose systemic challenges (Burwell-Naney et al., 2019). The Kresge Foundation expands this definition of climate resilience to encompass mitigation, adaptation, and social cohesion which underscores the need for "not only bouncing back but 'bouncing forward' from the effects of adverse climate impacts" (The Kresge Foundation, 2019). The Foundation centers climate equity in its approach to resilience to focus low-income communities and communities of color within investments, benefits, and planning. This presents a multitude of opportunities to build climate resilience, including through funding

Number of check marks	Percentage of infrastructure and facilities functioning after a disaster	Resilience Index
0	0%	LOW
1	25%	LOW
2	50%	MEDIUM
3	75%	MEDIUM
4	100%	HIGH

Your critical infrastructure Resilience Index is _____

Number of check marks	Percentage of critical facilities functioning after a disaster	Resilience Index
1	13%	LOW
2	25%	LOW
3	38%	LOW
4	50%	MEDIUM
5	63%	MEDIUM
6	75%	MEDIUM
7	88%	HIGH
8	100%	HIGH

Your critical facilities Resilience Index is _____

Sections 2-6	Number of Yes answers	Translate number of Yes answers to Resilience Index	Resilience Index	Comments
(Example) Section 2: Transportation issues	*1*	*2 or fewer (LOW)* *3 to 4 (MEDIUM)* *5 or more (HIGH)*	*LOW*	*A road construction project will create an additional evacuation route within a year. Also, we are in talks with the local public transportation provider about a program to assist evacuation.*
Section 2: Transportation Issues		2 or fewer (LOW) 3 to 5 (MEDIUM) 6 or more (HIGH)		
Section 3: Community Plans and Agreements		4 or fewer (LOW) 5 to 8 (MEDIUM) 9 or more (HIGH)		
Section 4: Mitigation Measures		4 or fewer (LOW) 5 to 8 (MEDIUM) 9 or more		
Section 5: Business Plans		1 or fewer (LOW) 2 to 3 (MEDIUM) 4 or more (HIGH)		
Section 6: Social Systems		1 or fewer (LOW) 2 to 3 (MEDIUM) 4 or more (HIGH)		

Figure 3: *Example of components from datasheet used by research team to capture coastal community resilience. Credit: Sempier et al., 2010.*

and technical assistance for clean energy initiatives; community planning; social connectivity; and policy change dialogues about climate action, land-use, infrastructure, transportation, community development, environmental justice, and emergency preparedness (The Kresge Foundation, 2019).

A suite of resilience indices has been developed that can be integrated into EJSM tools such as the Rural Resilience Index (Cox & Hamlen, 2015), Coastal Resilience Index (Reid & Schneider, 2010) and City Resilience Index (The Rockefeller Foundation and ARUP, 2014). These indicators measure the level of resilience of a system, community, or individual for areas prone to natural disasters and climate events and can demonstrate the unique challenges within the urban and rural divide. For example, the City Resilience Index uses 52 indicators across 4 dimensions (health and well-being, economy and society, infrastructure and environment, leadership and strategy) to assess the ability of cities to resist shocks or stressors, which could "bridge the gap between disaster risk reduction and climate change adaptation" (The Rockefeller Foundation and ARUP, 2014). The Rural Resilience Index demonstrates a community-engaged approach to incorporate relevant indicators and empower communities in the participatory process. The Index has 3 domains (social fabric, community resources, disaster management) and the development process provides a path to elevate elevating local knowledge and includes rural communities in regional planning, a current gap in disaster and emergency preparedness

Communities need to be resilient to cope with acute shocks that will become more frequent or intense with climate change, and to cope with chronic stressors that pose systemic challenges.

(Cox & Harlem, 2015). The Coastal Resilience Index further exemplifies place-based resilience factors that need to be incorporated, such as critical infrastructure and facilities (wastewater treatment, power grid, evacuation shelters, critical record storage), transportation issues (primary bridges, flood-prone areas, public transportation), community plans (early warning systems, leadership), mitigation measures (flood-proofing, education), business plans (generators, basic needs), and social systems (cultural identity, neighborhood associations) (Reid & Schneider, 2010). Figure 3 shows how this self-scoring assessment can be used to assess resilience and inform planning (Reid & Schneider, 2010). Regional variation in resilience challenges reinforces the need for integrated resilience measures within a new EJSM tool. Within the resilience dimension of the proposed nationwide EJSM tool are measures of non-human species quality. White these measures are outside the scope of this paper, such ecological indicators (e.g., wildlife abundance) are extremely important when contextualizing human health, alluding to the "one health" public health initiative (Buttke et al., 2015).

Application in Policy and Decision making

The gaps identified in existing EJSM tools can help policymakers create, finetune, amend, and more effectively vote on regulations that protect vulnerable communities. The proposed indicators can be integrated into various EJ-related and decision frameworks (e.g., EPA Collaborative Problem-Solving Model, Political Economy Framework) to work with communities, stakeholders, and politicians to identify problems and generate recommendations (Angelsen & McNeill, 2015) (EPA, 2021b). See Figure 5 for more detail. In terms of decision-making, it is imperative that coupled indicators be used to identify areas in greatest need of intervention. Overlaying multiple indicator types can demonstrate cumulative exposures. This

can then inform more targeted allocation of grant funding and siting of salutogenic (health-promoting) infrastructure. It could also define disadvantaged communities with critical service gaps in need of targeted agency funding under the Justice40 initiative. It is important to note EJ approaches necessitate communicating with and brainstorming indicators to community members. Indicators are most helpful when they reflect the community's values and priorities, and are designed with input from community members themselves. This adheres to the pillars of EJ, which seeks to ensure EJ communities are both engaged in and benefit from research. Similarly, ideal intervention strategies are ones that are evaluated, monitored and adapted for the community's interests. Decision-makers must develop a way to define target communities by ranking them based on region-specific vulnerabilities and risks. Although this will be a national screening tool, it is important to note there are indicators specific to only certain regions of the United States.

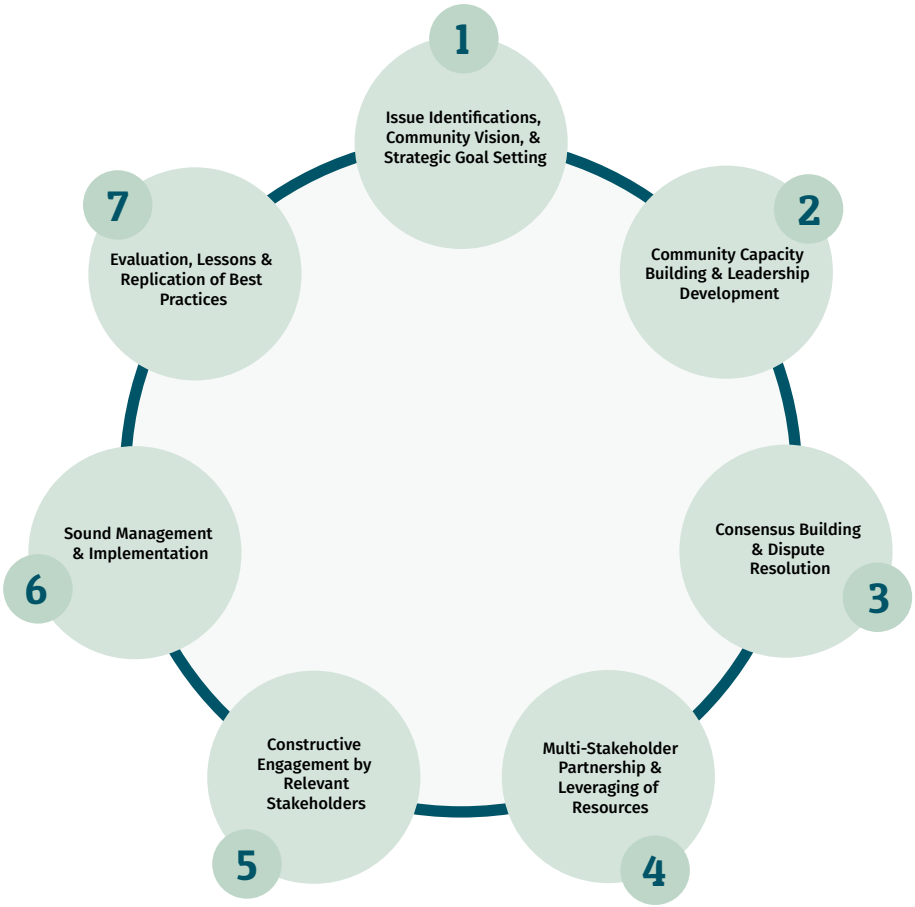

Figure 4: *EPA's Collaborative Problem Solving (CPS) Model allows seamless integration of the indicators presented in this paper into the elements outlined, namely the issue identification and evaluation phases. The Environmental Justice CPS Cooperative Agreement Program provides financial assistance to eligible organizations (i.e., community-based and grassroots organizations, environmental justice networks, faith-based organizations, and those affiliated with religious institutions, tribal governments) who use the model to address environmental concerns in underserved communities in collaboration with other stakeholders (EPA, 2021b). Through the seven steps outlined, the EPA CPS Model facilitates the development of meaningful solutions that address environmental and/or public health issues at the local level. For more information on the Political Economy framework, see Brockhaus & Angelsen, 2012. Credit: Wilson et al., 2014.*

Rural-specific indicators, including rural-specific health disparity data, will be especially important. Gathering region-specific vulnerabilities and risks will also assist in creating EJ regional hotspot crisis teams, as recommended by the White House Environmental Justice Advisory Council.

Legislators should codify the use of federal EJSM tools into all levels of governance, planning, and development. Formal guidance on proper use and acceptability of the data will increase application and impact for translation into policy development. To facilitate this, legislators, urban planners, and communities must be trained on how to use the tool. In addition to policy development, this tool can empower communities and other stakeholders through increased environmental health literacy and awareness of surrounding risks and hazards. This can augment community wisdom so communities can better advocate for themselves and participate in promoting health equity. Once the tool is integrated into legislation, its indicators must be disseminated and published for community members, to help ensure widespread and effective use of the tool, particularly by the EJ communities it aims to serve. If this is achieved in tandem with providing information and requirements for grant funding opportunities, communities can better take advantage of opportunities and apply for funding. This is in line with the Justice40 recommendation to include "program criteria to maximize federal investment benefits and avoid harm in EJ communities."

Recommendations

This section provides a list of specific recommendations to operationalize climate equity and social progress into programs and policies. Research suggests that protecting the most vulnerable populations can serve to make the larger population resilient. Thus, our recommendations include identification of target communities, establishing a national metric for assessing vulnerability, greater community involvement in data collection and decision making, creating a climate justice fund/academy, and applying EJSM tools to prioritize funding from grants, stimulus bills, and other federal investments.

1. Microtarget areas in greatest need of intervention

Microtargeting to identify communities of greatest need has been proposed in the past, but met with backlash from Democrats and Republicans alike. For example, during the Obama Administration, Rep. Jim Clyburn (D-SC) introduced the "10-20-30 plan" to branch off the Recovery Act of 2009. This plan directed 10% of total investments (about $1.7 billion at the time) to counties where greater than 20% of the population lived under the federal poverty line for at least 30 years (Kneebone, 2016). Critics, including 2016 Democratic Presidential Nominee Hillary Clinton, asserted that counties were not granular enough and disadvantaged communities at the zip code and census block levels were being overlooked (Kneebone, 2016). To counter this, the nationwide EJSM tool's score should not only assess cumulative impacts that pertain to climate change, but also be granular enough to capture "hotspots" from decades of neglect and longstanding poverty. The tool can also identify communities that warrant pre-disaster hazard mitigation strategies. In the FY 2022 White House Discretionary Budget Request, $815 million will be provided towards climate resilience and disaster planning (Office of Management and Budget, 2021). While this is $540 million above 2021 figures, coupling of EJSM indicators will encourage efficient usage of these funds towards better preparedness. President Biden recently announced $1 billion for the Building Resilient Infrastructure and Communities (BRIC) program, which seeks to invest in community resilience to better prepare communities for future extreme climate events (The White House, 2021). EJSM tools can help pinpoint disadvantaged communities that lack resilience infrastructure (See Literature Review Table for examples of indicators that capture this construct) and target funds to them.

2. Communicate and brainstorm indicators with community members to reflect lived expertise

The tool will be most effective in tackling disparities when it reflects a community's values and priorities. Therefore, indicators should be inclusive of inputs from community members. This includes their involvement on the established climate task forces within various federal government agencies (i.e., Department of Interior Climate Task Force), as well as the state and local level. They should also be given an opportunity to convene with involved non-profit organizations (i.e., Center for American Progress, Sierra Club chapters) to provide their insights to and aid the White House Environmental Justice Advisory Council and the National Environmental Justice Advisory Council in their recommendations regarding federal legislation and presidential executive orders akin to Executive Order 14008. The inclusion of such community members adds first-hand credibility, builds trust with disadvantaged communities, and promotes cultural competence.

3. Ensure adequate funding, maintenance, and oversight of the tool

Once the EJSM tool is developed, it should be properly funded and maintained on a regular basis – including by annually updating datasets and by soliciting feedback from EJ communities and organizations on a regular basis. This can ensure effective implementation of the tool for policy development, and that changing climate, social, and policy landscapes are accounted for. A system should be put in place for periodic funding, evaluation, and assessment of the tool.

4. Focus on equitable organizational and procurement capacity building

The development of locally relevant indicators should be a reciprocal process to ensure the data reflects challenges and barriers faced by community-based organizations while guiding restorative policies and financial assistance for dismantling systemic inequities. The tools should be adequately maintained and funded for continuous development and upkeep. The need for annually updated datasets presents an opportunity for "authentic participation" (Freudenberg, Pastor, & Israel, 2011) by soliciting feedback from environmental justice communities and organizations on a regular basis. Centering communities can also help build local capacity and increase community resistance to external hazards (Williamson et al., 2020). Capacity building practices include green workforce development and the creation of more local supply chains.

5. Screen for cumulative impacts

EPA EJSCREEN is not intended to be a risk assessment tool for environmental justice concerns (U.S. Environmental Protection Agency, 2020b), so there is no nationally available tool to identify and prevent cumulative impacts in already overburdened communities. Cumulative impacts comprise the totality of chemical and non-chemical stressors individuals experience as well as factors such as the built environment and socioeconomic status that can mitigate or exacerbate these effects (Burwell-Naney et al., 2019; Payne-Sturges et al., 2018). The White House Environmental Justice Advisory Council has recommended the new tool feature an index of cumulative impacts (White House Environmental Justice Advisory Council, 2021). This could be used for screening for communities that are cumulatively most exposed to climate risks and environmental justice issues. The tool could assist in tracking mitigation policy progress, monitoring and evaluating impacts of planning

There is currently no nationally available tool to identify and prevent cumulative impacts in already overburdened communities.

decisions on overburdened communities, and informing decision making for equitable growth and development. The tool should also use an encompassing EJ score to microtarget areas in greatest need of intervention. Combining multiple indicator types, with thoughtful integration of statistical tests to account for indicator multicollinearity/redundancy, can calculate an encompassing score analogous to what is presented in EPA EJSCREEN and the Maryland Park Equity Mapper tool, to better assess regional cumulative impacts. The overarching nationwide EJSM equity score should include indicator types such as economic progress, climate resilience, and equity. These can demonstrate cumulative exposure to environmental risks and social vulnerability. Determining which indicators to combine could depend on factors such as: the nature of the climate-fueled disaster events in a community, whether the community is urban or rural, income or racial data, , or other similar, more local considerations. This data can then be used to calculate EJ indices, effectively allocate grant funding and site salutogenic infrastructure (also known as environmental elements that support human health, rather than focusing on mitigating those that harm health) (Mittelmark & Bauer, 2016). This could also be used to define disadvantaged communities with critical service gaps in need of targeted agency funding under Justice40, and close economic disparities as well as the climate gap. It is important to note that combining multiple indicator types into a comprehensive equity score requires thoughtful integration of statistical tests to account for indicator redundancy and multicollinearity (when multiple indicators are related to each other).

6. Develop a way to define target communities by ranking them based on region-specific vulnerabilities and risks

Although this will be a national screening tool, it is important to note there are indicators specific to only certain regions of the U.S. Rural-specific indicators, including rural-specific health disparity data, will be especially important to achieve this recommendation. Gathering region-specific vulnerabilities and risks will also assist in creating EJ regional hotspot crisis teams familiar with specific regions, as recommended by Justice40. These task-force-like teams could monitor and address service gaps, reflecting individualized needs of regional climates. It is also necessary to prioritize by EJ percentile rankings to microtarget community subgroups of EJ communities that warrant immediate attention and resources. Specific to Maryland, MD EJSCREEN currently generates an EJ Score to communities but has generated a cutoff at the 75th percentile for Environmental Benefit Designation (EBD). This unlocks priority grant opportunities for programs that include air quality improvements through smart school buses, fostering participation in the “Green Schools” initiative, stricter facility monitoring, and brownfields assessment and revitalization efforts (Morrison, 2005).

This is a good start, but researchers should utilize a second threshold (over the 90th percentile) to identify “higher needs” communities. Once these communities are determined, similar components of EBDs can be applied to them. These include further designation of Economic Enterprise Zones (EEZs) and Health Enterprise Zones (HEZs) for these higher-percentile EJ communities. Examples of grants related to climate change and community revitalization include the Brownfield Assessment Grant offered by the EPA, and the USDA’s Rural Development grants. Eligible applicants include businesses, governmental agencies, individuals, and non-profit organizations. See Appendix C for a comprehensive list of available grants.

7. Codify the use of federal environmental justice mapping tools into legislation at all levels of governance, planning, and development

Formal guidance on proper use and acceptability of EJSM tools, their data, and their analysis will increase application and impact for translation into policy

Solar company employees install solar panels in upstate New York. Measures of economic progress, including green business development and new green businesses owned by people of color, are important indicators to include in a comprehensive EJSM tool. Credit: Stephen Yang, The Solutions Project.

development. Ensuring the new nationwide EJSM tool can calculate cumulative impacts and a comprehensive equity score will also help policymakers more effectively integrate the tool into decision making. At the federal level, legislative pieces pertaining to EJSM applications and microtargeting of communities have been sponsored by members of the House of Representatives. For example, the Environmental Justice Mapping and Data Collection Act of 2021 (H.R. 516/S. 101) requires the EPA to establish an EJ repository with EJSM-generated data, via a new interagency EJ Mapping committee, that identifies EJ communities. The bill defines EJ communities as those "with significant representation of communities of color, low-income communities, or tribal and indigenous communities that experience, or are at risk of experiencing, higher or more adverse human health or environmental effects, as compared to other communities." EJSM tools should also reflect delegation from the $2.2 trillion Coronavirus Aid, Relief, and Economic Security Act (CARES). Specifically, the identification of POC-owned businesses and communities would aid in proper allocation of resources from the FEMA Disaster Plan and Small Business Administration (SBA) loans. This would spur economic recovery in disadvantaged areas and encourage resilience during the COVID-19 pandemic, which has disproportionately impacted communities of color and hurt POC-owned business throughout the U.S.

8. Train legislators, urban planners, and communities how to use the tool

In addition to policy development, this tool can empower communities and other stakeholders through increased environmental health literacy and awareness of surrounding risks and hazards. This can especially augment community wisdom so they can better advocate for themselves and participate in promoting EJ, and climate and health equity.

9. Pursue further high-resolution datasets to fill spatial data gaps

A major challenge for effectively building and utilizing this tool is the lack of quality data on indicators related to environmental risks and community needs as well as economic progress, climate risk, and resilience—especially at granular scales which are required for conducting a just analysis. Systems should be developed to gather this information to better understand and map climate inequities.

10. Measure the success of adaptation strategies

Indicators of socio-economic progress as well as climate equity can be used to determine the effectiveness or failure of policies and programs such as infrastructure protection or surveillance of infectious diseases in mitigating the impacts of climate change and reducing disparities.

11. Develop inclusive mitigation strategies

Investments in climate mitigation should strive to do no harm to environmental justice communities and minimize any climate transition-related economic, social, and health disparities. These strategies should work to proactively advance economic opportunity and health equity for historically marginalized groups.

Policies for infrastructure upgrades, clean energy, and revitalization must consider localized impacts on disadvantaged communities. This presents an opportunity for restorative policies such as green workforce development, air and water improvements, and community grant programs (Senate Democrats' Special Committee on the Climate Crisis, 2020; Morello-Frosch et al., 2011; The White House, 2021a). The Senate Democrats' Special Committee on the Climate Crisis report provides one framework for Congress to build the clean energy future that incorporates public health benefits (such as reduced respiratory disease) and creates green jobs through the COVID-19 recovery while decarbonizing our economy. This requires targeted investments to create well-paying, quality jobs that prioritize the health of workers and environmental justice communities (Senate Democrats' Special Committee on the Climate Crisis, 2020).

12. Measure and analyze equity

The tool can be used to operationalize equity. In other words, it can be used to establish a system to measure and analyze equity across the country, which can help ensure that equity-focused measures, goals and policies are achieved successfully. This may involve redefining how climate equity and resilience are defined, as well as integrating equity into decisions about climate adaptation funding—from resilience planning and implementation to response and recovery. Addressing equity may also include channeling funding into addressing root causes of racism such as by supporting frontline communities and organizations to improve basic infrastructure and services and reduce their overall vulnerability to climate change. This would align with the Presidential order for budgetary discretion, which clearly establishes America's commitment to "advancing equity across the Nation—creating an inclusive economy, expanding housing and reducing the racial wealth gap...redressing long standing injustice" (White House, 2021).

13. Deliver targeted and assured benefits

This tool can be used as an accountability mechanism for tracking investments (both direct and indirect) to disadvantaged communities and assuring that programs are locally relevant, accessible, and effective. Co-benefits from climate mitigation and adaptation strategies can fall into four categories: social, environmental, economic, and health. These can be assessed using our proposed indicators such as energy burden, changes in the price of necessities, number of clean jobs in clean energy sector, green businesses owned by people of color, and self-rated health (Markkanen & Anger-Kraavi, 2019). Progress across these categories can inform equitable adaptive management strategies and demonstrate the long-term return on investment within communities. This can also help ensure benefits are locally retained. If microtargeted benefits are not enough for disadvantaged communities to overcome climate-related impacts—and if the tool does not show positive progress in the indicators, particularly in EJ or climate-vulnerable communities—then the federal government should work with FEMA to distribute appropriate resources via the Stafford Act. The nationwide EJSM tool will allow the government and FEMA to properly apply emergency declaration tags by gauging hyperlocalized situations to avoid overlooking neighborhood-level hotspots and assuring climate health-related benefits (FEMA, 2021).

14. Utilize EJSM tools to inform federal funding distribution

EJSM tools are useful in increasing public environmental health literacy, validating community experiences, and informing federal and local plans to build healthy, resilient and just communities. Numerous proposed policies could benefit from using EJSM tools to gather appropriate and clear background information on the communities they aim to target (or they communities

Brainstorming indicators with community members is key to building out a comprehensive EJSM tool. That engagement can help identify community-specific climate risks and aspects of climate resilience, such as food access. Here, community members maintain an urban farm in Phoenix, Arizona. Credit: Peter Haden/Flickr.

they should target). Specifically, as it relates to lawmaking surrounding environmental issues, accurate information and community feedback are important decision-making factors. The utilization of social and environmental indicators along with geospatial mapping tools will effectively highlight resource gaps, and direct federal attention where appropriate. By using EJSM tools to target underserved and in-need communities, federal funding can be distributed to drive positive change most effectively. This extends to using the aforementioned equity score to help prioritize federal grant applications. For example, the Department of Transportation's Rebuilding American Infrastructure with Sustainability and Equity (RAISE) grants provide up to $30 million to planning, with at least $10 million going towards areas of persistent poverty (U.S. Department of Transportation, 2021). These grants are highly competitive (about a7% historical acceptance rate); EJSM tools would help present the case for improved transportation and transit equity, which could reduce the burden of climate change and provide inclusive mitigation strategies. Usage of aforementioned EJ score percentiles would further promote the prioritization of applications and should be considered by grant proposal reviewers.

15. Develop regional hot-spot crisis teams to adequately respond to environmental health hazards, specifically as they relate to vulnerable communities

The White House Council on Environmental Quality (CEQ) should implement task-force-like teams to monitor and address service gaps, and to improve public health. This initiative would reflect the individualized needs of regional climates, such as areas of high wildfire risk. Various environmental exposures—like wildfire—cause adverse impacts to both ecological systems and community members, which could be identified and monitored with a nationwide EJSM tool. Important indicators of these hazardous exposures include the length of the pollen season, the air stagnation index, impact of wildfires, and the crop moisture stress index. By developing hotspot crisis teams within the CEQ, resources could be better spent as human error would likely decrease with the implementation of specialized teams. Furthermore, adverse effects of these climate justice issues could be minimized through direct oversight.

Appendix A: Indicators in Existing EJSM Tools

Name of Tool	Indicators included
EPA EJSCREEN	**Environmental:** PM 2.5, Ozone, NATA Diesel PM, NATA Cancer Risk, NATA respiratory HI, Traffic proximity, Lead paint indicator, Superfund proximity, RMP proximity, Hazardous waste proximity, Wastewater discharge indicator **Demographic:** Demographic index, People of color population, Low income population, Linguistically isolated, Less than HS education, Under age 5, Over age 64
CALENVIROSCREEN	**Exposures:** Ozone, PM2.5, Diesel Particulate matter, Toxic releases, Traffic, Pesticides, Drinking water, Lead from housing **Environmental effects:** Cleanup sites, Groundwater threats, Hazardous waste, Impaired waters, Solid waste **Sensitive populations:** Asthma, Low birth weight, Cardiovascular disease **Socioeconomic factors:** Education, Linguistic isolation, Poverty, Unemployment, Housing burden, race/ethnicity profiles, Age profiles
Cuyahoga County Planning Commission Climate Change Vulnerability Assessment Map	**Social factors:** Population under age 5, Population aged 65 and over, Population below poverty, POC population, Households without a vehicle, Rental housing, Population lacking high school diploma, Persons with disability **Physical factors:** Heat island effect, Flood plain, Older residential buildings, Impervious cover, Lack of tree canopy
MD EJSCREEN	**Exposure:** NATA air toxics cancer risks, NATA respiratory hazard index, NATA diesel particulate matter, PM2.5, Ozone, Traffic proximity and volume **Environmental effects:** Lead paint indicator, Proximity to risk management plan sites, Proximity to treatment and disposal facilities, Proximity to national proximity list sites, Proximity to major direct water discharges, Watershed failure **Sensitive populations:** Asthma emergency room discharges, Myocardial infarction discharges, Low birth weights infants **Socioeconomic factors:** Percent low-income, Percent non-white, Less than high school education, Linguistic isolation, Individuals under 5yo, Individuals over 64yo, Unemployment **Context layers:** COVID-19 cases, Segregation, GINI index, Percent non-White, Food access, Supermarkets, Small grocery & corner stores, Education, Public schools, Green space availability, Parks, Urban heat island, Transit infrastructure, Public transit stops, Railroads, Industrial pollution sources, Combined sewer outfalls, Wastewater treatment plants, Solid waste landfill facilities, TRI facilities, Powerplants, EPA superfund sites, Meat packing plants, Concentrated animal feeding operations, Healthcare infrastructure, Health professional shortage areas **Socioeconomics:** 200% federal poverty level, USDA low income and low access, Percent Hispanic and Black, Income inequality

Appendix A: Indicators in Existing EJSM Tools *(continued)*

Name of Tool	Indicators included
MD PARK EQUITY MAPPER	**Park Equity Factors:** Population density, Concentration of households below 185% of the Federal Poverty Line, Concentration of children under the age of 18, Concentration of adults over the age of 64, Concentration of non-white population, Distance to Public Park Space, Distance to Public transportation, Walkability index, Linguistic isolation, Segregation, GINI Index, % non-white, MD COVID-19 cases, Food access, Supermarkets, Small grocery and corner stores, Education, Public schools, Green space availability, Parks, Urban heat island, Transit infrastructure, Public transit stops, Railroads, Industrial pollution sources, Combined sewer outfalls, Wastewater treatment plants, Solid waste landfill facilities, TRI facilities, Powerplants, EPA Superfund sites, Meat packing plants, CAFOs, Healthcare infrastructure, Health professional shortage areas (HPSA) **Socioeconomics:** 200% federal poverty level, USDA low income and low access, Percent Hispanic and Black, Income inequality
MD CLIMATE AND HEALTH EQUITY MAPPER	**FEMA Natural Disaster Risk Score, Natural Disaster Risk Score:** Health Outcomes, Asthma Emergency Room Discharges, Low Birthweight Infants, Myocardial Infarctions, COVID-19 Cases **Health Infrastructure Score:** Health Infrastructure, Proximity to Nursing Locations, Medically Underserved Areas, Health Provider Shortage Areas, No Health Insurance, Medicare/Medicaid **Community Resilience Score, Vulnerability score**
USDN SOCIOECONOMIC MAPPING TOOL	**People:** Households with no car, Housing units that are rentals, People of Color and Hispanics, Families in poverty, Children under 5 years, People who don't speak English well, People with disabilities, People without health insurance, People over 65 **Climate exposure:** Area in hurricane flood zone, Area lacking tree canopy, Area of impervious surface, Area in 500-yr floodplain
ACIS CLIMATE MAPS	Precipitation (absolute, departure from normal, percent of normal), Standardized precipitation index, Temperature (absolute, departure from normal, maxim and minimum), Cooling degree days (absolute, departure from normal), Heating degree days (absolute, departure from normal)
CAL-ADAPT CLIMATE TOOLS	Local climate change snapshot, Annual averages, Maps of projected change, Extreme precipitation events, Extreme heat, Sea level rise, Snowpack, Wildfire, Cooling degree days, heating degree days, Stream flow, Extended drought, Hourly projections of sea level
WASHINGTON TRACKING NETWORKS	**Environmental exposures:** NOx-Diesel emissions, Ozone, PM2.5, Populations near heavy traffic roadways, Toxic releases from facilities, Environmental effects, Lead risk from housing, Proximity to hazardous waste treatment storage and disposal facilities, Proximity to national priorities list facilities (superfund sites), Proximity to risk management plan facilities, Waste water discharge **Socioeconomic factors:** Limited English, no high school diploma, People of Color (race/ethnicity), Population living in poverty (<185% federal poverty level), Transportation expense, Unaffordable housing (>30% of income), Unemployed, Sensitive populations, Death from cardiovascular disease, Low birth weight

Appendix A: Indicators in Existing EJSM Tools *(continued)*

Name of Tool	Indicators included
SEATTLE CLIMATE CRISIS ATLAS	**Equity index:** Four characteristics: People of Color, at or below 200% of the federal poverty level, born in another country, households with limited English proficiency Extreme heat/urban heat islands, Air quality, Pollen, Particulates, Wildfire, Urban flooding areas, Stormwater, Combined sewer overflow, Vulnerable transits, Landslides, flooding, black outs, Urban canopy coverage, Neighborhood assets, Natural assets, community assets, social connections **Food:** Household food-security, Price of cereal grains (likely to rise globally under climate change), Percent of income spent on food, Access to traditional foods (i.e., fish, shellfish, native plants)
NEW JERSEY EJ MAPPING TOOL	Low Income, POC, and Limited English
Houston–Galveston–Brazoria (HGB) ENVIROSCREEN	**Social Vulnerability:** Socioeconomic Theme, Household composition theme, POC status/ language, Modified Retail Food Environment Index (mRFEI), % low food security, sum of two food low access flags **Health:** Stroke, Asthma, COPD, CHD, Life expectancy, Hospital within 5km buffer **Exposures and Risks:** Risk-screening environmental indicators, NATA average cancer risk, NATA respiratory non-cancer risk, Average 3 years PM 2.5, Average 3-year satellite 2.5 **Flooding:** 100-year flood based on fraction of area, 500-year flood based on fraction of area, FEMA affected (# residents impacted), FEMA minimum (# residents impacted), FEMA maximum (# residents impacted), FEMA destroyed (# residents impacted), CANService density need **Pollution sources:** Petrochemical and Oil refineries total count within 1km buffer, Cement batch plant within 1km buffer, Concrete crushers combined within 1km buffer, Metal recyclers count within 1km buffer, Leaking petroleum storage tank count, Powerplant within 1km buffer, Superfund sites count, Major road count within 1km buffer, RMP facilities count, RMP # accidents, # evacuation and shelter-in-place
Florida Department of Environmental Protection Map Direct Tool	Includes the option to include over 365 layers. Some of these include -- solid waste facilities, general disposal area, waste processing area, Florida Water Resource Caution Areas (WRCA), Stream Site Selections, Department of Health (DOH) Dental Facilities, Florida Total Maximum Daily Load (TMDL), Florida State Funded Cleanup Sites, Dry Cleaning Solvent Program Cleanup Sites, Used Oil Transfer Facilities, Wastewater Facility Regulation (WAFR) - Wastewater Sites, Wastewater Facilities Potentially Accepting Septage, Florida Superfund Waste Cleanup Sites, Unconfined Aquifer Wells - Well List Frame

Appendix B: Literature Review

Appendix C: Funding

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References

Angelsen, A., & McNeill, D. (2015). The evolution of REDD+: a political economy framework.

Asthma and Allergy Foundation of America, (2020). [Asthma Disparities in America: A Roadmap to Reducing Burden on Racial and Ethnic Minorities]. aafa.org/asthmadisparities.

American Heart Association. Bridging the gap: CVD health disparities. www.heart.org/idc/groups/heart-public/@wcm/@hcm/@ml/documents/downloadable/ucm_429240.pdf.

Barr R., Fankhauser, S., & Hamilton K. (2010). Adaptation investments: a resource allocation framework. *Mitigation and adaptation strategies for global change,* 15, 843-858. 10.1007/s11027-010-9242-1.

Beltrán, R., Hacker, A., & Begun, S. (2016). Environmental justice is a social justice issue: Incorporating environmental justice into social work practice curricula. *Journal of Social Work Education, 52*(4), 493-502.

Bhandari, S., Lewis, P. G. T., Craft, E., Marvel, S. W., Reif, D. M., & Chiu, W. A. (2020). HGBEnviroscreen: Enabling community action through data integration in the Houston–Galveston–Brazoria region. *International Journal of Environmental Research and Public Health,* 17(4), 1130. doi.org/10.3390/ijerph17041130.

Bibb, K., Bradshaw, R., Bueno de Mesquita, J., Craddock, H., DeSantiago, M., & Mutunga, W. (2016). An Investigation of the Scope and Utility of a New Environmental Benefits District Framework for Prince George's County, Maryland.

Bowen, A., Cochrane, S., & Fankhauser, S. (2012). Climate change, adaptation and economic growth. *Climatic change*, 113(2), 95-106.

Brown, M. A., Soni, A., & Li, Y. (2020). Estimating employment from energy-efficiency investments. *MethodsX*, *7*, 100955. doi.org/10.1016/j.mex.2020.100955.

Burwell-Naney, K., Wilson, S. M., Whitlock, S. T., & Puett, R. (2019). Hybrid resiliency-stressor conceptual framework for informing decision support tools and addressing environmental injustice and health inequities. *International Journal of Environmental Research and Public Health, 16*(8), 1466. doi.org/10.3390/ijerph16081466.

Buttke, D. E., Decker, D. J., & Wild, M. A. (2015). The role of one health in wildlife conservation: a challenge and opportunity. *Journal of wildlife diseases*, *51*(1), 1-8.

Cardona, O.D., M.K. van Aalst, J. Birkmann, M. Fordham, G. McGregor, R. Perez, R.S. Pulwarty, E.L.F. Schipper, and B.T. Sinh. (2012). Determinants of risk: exposure and vulnerability. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 65-108.

C2ES. (2018, October 26). *Climate Resilience Portal.* Center for Climate and Energy Solutions. www.c2es.org/content/climate-resilience-overview/.

Climate Central. Surging seas: Sea level rise analysis. https://sealevel.climatecentral.org/.

CDC. (2019, April). Racial and Ethnic Disparities in Heart Disease. CDC. www.cdc.gov/nchs/hus/spotlight/HeartDiseaseSpotlight_2019_0404.pdf.

Centers for Disease Control and Prevention/ Agency for Toxic Substances and Disease Registry/Geospatial Research, Analysis, and Services Program. CDC/ATSDR Social Vulnerability Index [2018] Database. www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html.

Chakraborty, J., Collins, T. W., Montgomery, M. C., & Grineski, S. E. (2014). Social and spatial inequities in exposure to flood risk in Miami, Florida. *Natural Hazards Review, 15*(3), 04014006. doi.org/10.1061/(ASCE)NH.1527-6996.0000140.

Chakraborty, L., Rus, H., Henstra, D., Thistlehwaite, J., & Scott, D. (2020). A place-based socioeconomic status index: Measuring social vulnerability to flood hazards in the context of environmental justice. *International Journal of Disaster Risk Reduction, 43*. doi.org/10.1016/j.ijdrr.2019.101394.

Conlon, K. C., Mallen, E., Gronlund, C. J., Berrocal, V. J., Larsen, L., & O'Neill, M. S. (2020). Mapping human vulnerability to extreme heat: A critical assessment of heat vulnerability indices created using principal components analysis. *Environmental Health Perspectives, 128*(9), 097001. doi.org/10.1289/EHP4030.

Cox, R. S., & Hamlen, M. (2015). Community disaster resilience and the rural resilience index. *American Behavioral Scientist, 59*(2), 220-237.

Crone BC, Speth TF, Wahman DG, et al. (2019). Occurrence of Per- and Polyfluoroalkyl Substances (PFAS) in Source Water and Their Treatment in Drinking Water. *Crit Rev Environ Sci Technol.,49*(24):2359-2396. doi:10.1080/10643389.2019.1614848.

Cutter, S. L., Boruff, B. J., & Shirley, W. L. (2003). Social vulnerability to environmental hazards. *Social Science Quarterly, 84*(2), 242–261. doi.org/https://doi.org/10.1111/1540-6237.8402002.

Cutter, S. L., Schumann, R. L., & Emrich, C. T. (2014). Exposure, social vulnerability and recovery disparities in new jersey after hurricane sandy. *Journal of Extreme Events,* 01(01), 1450002. https://doi.org/10.1142/S234573761450002X.

Dahl, K., Licker, R., Abatzoglou, J. T., & Declet-Barreto, J. (2019). Increased frequency of and population exposure to extreme heat index days in the United States during the 21st century. *Environmental Research Communications, 1*(7), 075002. doi.org/10.1088/2515-7620/ab27cf.

Diffenbaugh, N. S., Giorgi, F., Raymond, L., & Bi, X. (2007). Indicators of 21st century socioclimatic exposure. *Proceedings of the National Academy of Sciences, 104*(51), 20195-20198.

Deloitte and Social Progress Imperative. (2020). 2020 Social Progress Index results. www2.deloitte.com/global/en/pages/about-deloitte/articles/social-progress-index-results.html.

Driver, A., Mehdizadeh, C., Bara-Garcia, S., Bodenreider, C., Lewis, J., & Wilson, S. (2019). Utilization of the Maryland Environmental Justice Screening Tool: A Bladensburg, Maryland case study. *International Journal of Environmental Research and Public Health, 16*(3), 348. https://doi.org/10.3390/ijerph16030348.

EPA (2021a). Climate Change Indicators: Heat-Related Deaths. www.epa.gov/climate-indicators/climate-change-indicators-heat-related-deaths#ref1.

EPA. (2021b). *The Environmental Justice Collaborative Problem-Solving Cooperative Agreement Program.* EPA. www.epa.gov/environmental-justice/environmental-justice-collaborative-problem-solving-cooperative-agreement-0.

Ebi, K. L., Kovats, R. S., & Menne, B. (2006). An approach for assessing human health vulnerability and public health interventions to adapt to climate change. *Environmental Health Perspectives, 114*(12), 1930–1934. doi.org/10.1289/ehp.8430.

Elliott, J. R., & Pais, J. (2006). Race, class, and Hurricane Katrina: Social differences in human responses to disaster. *Social science research, 35*(2), 295-321.

FCC. (2020). *Fixed Broadband Deployment.* Federal Communications Commission. https://broadbandmap.fcc.gov/#/.

FEMA. (n.d.). The National Risk Index. FEMA. https://hazards.geoplatform.gov/portal/apps/MapSeries/index.html?appid=ddf915a24fb24dc8863eed96bc3345f8.

FEMA. (2021, July 6). *Stafford Act.* FEMA. https://www.fema.gov/disaster/stafford-act.

Fielding J, Burningham K (2005) Environmental inequality and flood hazard. *Local Environ,* 10:379–395. doi:10.1080/13549830500160875.

Grineski S, Collins T, Chakraborty J, Montgomery M (2015) Hazardous air pollutants & flooding: a comparative interurban study of environmental injustice. *GeoJournal,* 80:145–158. doi:10.1007/s10708-014-9542-1.

Grineski, S., & McDonald, Y. (2011). Mapping the uninsured using secondary data: An environmental justice application in Dallas. *Population and Environment, 32*(4), 376-387. www.jstor.org/stable/41487557.

Heaviside, C., Macintyre, H., & Vardoulakis, S. (2017). The urban heat island: Implications for health in a changing environment. *Current Environmental Health Reports,* 4(3), 296–305. https://doi.org/10.1007/s40572-017-0150-3.

Hernandez, D., Bird, S. (2012). Energy Burden and the Need for Integrated Low-Income Housing and Energy Policy. *Poverty & Public Policy. 2*(4), 5-25. doi.org/10.2202/1944-2858.1095.

Hewett, CJM, Simpson, C, Wainwright, J, Hudson, S. (2018). Communicating risks to infrastructure due to soil erosion: A bottom-up approach. *Land Degrad Dev., 29*, 1282– 1294. doi.org/10.1002/ldr.2900.

Hongtao, Y. (2014). Green businesses in a clean energy economy: Analyzing drivers of green business growth in U.S. states. *Energy*, 68, 922-929.

Karimi, M., Nazari, R., Dutova, D., Khanbilvardi, R., & Ghandehari, M. (2018). A conceptual framework for environmental risk and social vulnerability assessment in complex urban settings. *Urban climate, 26*, 161-173.

Khanjar, N., Deng, A., Homsi, R., & Khan, S. (2020, October 6). *Combating environmental injustice: Environmental benefit districts (EBDs) as a solution to create just, equitable, and sustainable communities.* Community Engagement, Environmental Justice & Health. www.ceejh.center/blog/combating-environmental-injustice-environmental-benefit-districts-ebds-as-a-solution-to-create-just-equitable-and-sustainable-communities-9h4rg-pdeye-nb6ay.

Leahy, S. (2019, July 16). *'Off-the-charts' heat to affect millions in U.S. in coming decades.* National Geographic. www.nationalgeographic.com/environment/article/extreme-heat-to-affect-millions-of-americans.

Lee, C. (2020). A Game Changer in the Making? Lessons From States Advancing Environmental Justice Through Mapping and Cumulative Impact Strategies. *The Environmental Law Reporter, 50*(3). https://www.eli.org/sites/default/files/docs/50.10203.pdf.

Lei, Y., Wang, J., Yue, Y., Zhou, H., & Yin, W. (2014). Rethinking the relationships of vulnerability, resilience, and adaptation from a disaster risk perspective. *Natural Hazards, 70*(1), 609–627. doi.org/10.1007/s11069-013-0831-7.

Mohnot, S., Jordyn, B., & Alvaro, S. (2019). *Making Equity Real in Climate Adaptation and Community Resilience Policies and Programs: A Guidebook.* The Greenlining Institute. greenlining.org/wp-content/uploads/2019/08/Making-Equity-Real-in-Climate-Adaption-and-Community-Resilience-Policies-and-Programs-A-Guidebook-1.pdf.

Mohai, P., & Saha, R. (2015). Which came first, people or pollution? Assessing the disparate siting and post-siting demographic change hypotheses of environmental injustice. *Environmental Research Letters, 10*(11), 115008. doi.org/10.1088/1748-9326/10/11/115008.

Montgomery M, Chakraborty J (2013) Social vulnerability to coastal and inland flood hazards: a comparison of GIS-based spatial interpolation methods. *Int J Appl Geospatial Res,* 4:58–79. doi:10.4018/jagr.2013070104.

Nayak, S. G., Shrestha, S., Kinney, P. L., Ross, Z., Sheridan, S. C., Pantea, C. I., Hsu, W. H., Muscatiello, N., & Hwang, S. A. (2018). Development of a heat vulnerability index for New York State. *Public Health, 161*, 127–137. doi.org/10.1016/j.puhe.2017.09.006.

Newman, G., Shi, T., Yao, Z., Li, D., Sansom, G., Kirsch, K., Casillas, G., & Horney, J. (2020). Citizen science-informed community master planning: Land use and built environment changes to increase flood resilience and decrease contaminant exposure. *International Journal of Environmental Research and Public Health, 17*(2), 486. doi.org/10.3390/ijerph17020486.

New York State Department of Health. (2020). Heat Vulnerability Index. www.health.ny.gov/environmental/weather/vulnerability_index/.

Nuvolone, D., Petri, D., & Voller, F. (2017). The effects of ozone on human health. *Environmental Science and Pollution Research, 25*(9), 8074–8088. doi.org/10.1007/s11356-017-9239-3.

Office of Air and Radiation, U.S. Environmental Protection Agency. (2015). EJ Screening Report for the Clean Power Plan; U.S. Environmental Protection Agency: Washington, DC, USA.

Reid, D. & Schneider, M. (2010). Coastal Resilience Index: A Community Self-Assessment. Mississippi-Alabama Sea Grant Consortium. masgc.org/assets/uploads/publications/662/coastal_community_resilience_index.pdf.

Residential energy demand temperature index (REDTI) | National Centers for Environmental Information (NCEI). (2021). www.ncdc.noaa.gov/societal-impacts/redti/.

Riccucci, N.M. (2009). The Pursuit of Social Equity in the Federal Government: A Road Less Traveled? *Public Administration Review, 69:* 373-382. doi.org/10.1111/j.1540-6210.2009.01984.x.

Saegert, S., & Evans, G. W. (2003). Poverty, housing niches, and health in the United States. *Journal of Social Issues, 59*(3), 569-589.

Sansom G, Cizmas L, Aarvig K, et al. (2019). Vulnerable Populations Exposed to Lead-Contaminated Drinking Water within Houston Ship Channel Communities. *Int J Environ Res Public Health,16*(15), 2745. doi:10.3390/ijerph16152745.

Sempier, T.T., Swann, D.L., Emmer, R., Sempier, S.H., and Schneider, M. (2010). *Coastal Community Resilience Index: A Community Self-Assessment.* MASGP-08-014. masgc.org/assets/uploads/publications/662/coastal_community_resilience_index.pdf

Shonkoff, S. B., Morello-Frosch, R., Pastor, M., & Sadd, J. (2011). The climate gap: Environmental health and equity implications of climate change and mitigation policies in California—a review of the literature. *Climatic Change, 109*(S1), 485–503. doi.org/10.1007/s10584-011-0310-7.

Social Progress Imperative. www.socialprogress.org/index/global/results.

Stanke C, Kerac M, Prudhomme C, et al. (2013). Health Effects of Drought: A Systematic Review of the Evidence. *PLOS Currents Disasters, 1.*

Stuart, J., Yozell, S., & Rouleau, T. (2020, June 1). The Climate and Ocean Risk Vulnerability Index. Stimson Center. www.stimson.org/2020/corvi-report-climate-and-ocean-risk-vulnerability-index/.

The Kresge Foundation. (2019, December). *The Kresge Foundation Climate Resilience and Urban Opportunity Initiative: Evaluation Report.* kresge.org/sites/default/files/library/cruo_evaluation_final_121319.pdf.

The Rockefeller Foundation and ARUP. (2014). City Resilience Index. www.arup.com/perspectives/publications/research/section/city-resilience-index.

The White House. (2021, April 9). *FY2022 Discretionary Request.* The White House. www.whitehouse.gov/wp-content/uploads/2021/04/FY2022-Discretionary-Request.pdf.

The White House. (2021, May 24). *FACT SHEET: Biden Administration Invests $1 Billion To Protect Communities, Families, and Businesses Before Disaster Strikes.* The White House. www.whitehouse.gov/briefing-room/statements-releases/2021/05/24/fact-sheet-biden-administration-invests-1-billion-to-protect-communities-families-and-businesses-before-disaster-strikes/.

Tol, RSJ, Yohe, GW. (2007). The weakest link hypothesis for adaptive capacity: an empirical test. *Glob Environ Chang 17*, 218–227.

Ueland J, Warf B (2006) Racialized topographies: altitude and race in southern cities. *Geogr Rev* 96:50–78. doi:10.1111/j.1931-0846.2006.tb00387.x.

U.S. Department of the Interior. (2021, April 16). *Secretary Haaland Establishes Climate Task Force, Strengthens Scientific Integrity.* U.S. Department of the Interior. www.doi.gov/news/secretary-haaland-establishes-climate-task-force-strengthens-scientific-integrity.

U.S. Department of Transportation. (2021, April 13). *RAISE Discretionary Grants*. U.S. Department of Transportation. www.transportation.gov/RAISEgrants.

Wagmiller, R. L., & Adelman, R. M. (2009). Childhood and intergenerational poverty: The long-term consequences of growing up poor. doi.org/10.7916/D8MP5C0Z.

Weis, S. W. M., Agostini, V. N., Roth, L. M., Gilmer, B., Schill, S. R., Knowles, J. E., & Blyther, R. (2016). Assessing vulnerability: An integrated approach for mapping adaptive capacity, sensitivity, and exposure. *Climatic Change, 136*(3–4), 615–629. doi.org/10.1007/s10584-016-1642-0.

Wilson, S., Hutson, M., & Mujahid, M. (2008). How planning and zoning contribute to inequitable development, neighborhood health, and environmental injustice. *Environmental Justice*, 1(4), 211–216. doi.org/10.1089/env.2008.0506.

Wilson, S. M., Richard, R., Joseph, L., & Williams, E. (2010). Climate change, environmental justice, and vulnerability: An exploratory spatial analysis. *Environmental Justice, 3*(1), 13–19. https://doi.org/10.1089/env.2009.0035.

Wilson, S., & Schleshinger, S. (2020, October 23). *Environmental Justice Mapping Tools: Use and Potential in Policy Making to Address Climate Change.* The National Wildlife Federation Blog. blog.nwf.org/2020/10/environmental-justice-mapping-tools-use-and-potential-in-policy-making-to-address-climate-change/.

Wilson, S., Campbell, D., Dalemarre, L., Fraser-Rahim, H., Williams, E. (2014). A Critical Review of an Authentic and Transformative Environmental Justice and Health Community—University Partnership. *International journal of environmental research and public health,* 11. 12817-12834. 10.3390/ijerph111212817.

Young, S. D. (2021). The President's FY 2022 Discretionary Request. Office of Management and Budget. www.whitehouse.gov/omb/fy-2022-discretionary-request/.

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