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Functional analysis of web-based GIS tools for environmental justice assessment of transportation projects

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A B S T R A C T

Environmental justice – the concept that environmental amenities and burdens should be shared equitably among all races and socioeconomic classes – has gained diplomatic traction internationally, and political traction domestically in the United States, in recent years. In this paper, we focus on developing federal policy relevant to transportation project planning and operation in the U.S.; however, these developments reflect international issues of inequity associated with climate change and environmental burdens. First, we provide an overview of federal policy initiatives related to environmental justice, including President Biden's Justice40 initiative. Then, we examine the U.S. National Environmental Policy Act (NEPA) as a potential avenue for mandating environmental justice assessment in the transportation industry, through the lenses of both procedural and distributive justice. Finally, we review several publicly available online Geographical Information System (GIS) tools that were recently developed for purposes of expanding public and governmental understanding of environmental justice challenges, and provide decision support for users to incorporate these tools into the environmental impact assessment process for transportation projects.

1. Introduction

Transportation infrastructure complexly affects communities throughout the United States and internationally; thus, transportation analysis is an important arena for interpretation and execution of environmental justice objectives. For the purposes of providing technical guidance for governments and other organizations in promoting environmental justice, the United Nations Development Program (UNDP) establishes a three-pronged approach to environmental justice work: first, establishing legal frameworks at the national and international levels; second, strengthening people-centered and effective institutions and solutions; and third, increasing access and empowerment to individuals to play an active role in environmental and climate change matters (de Andrade Correa, 2022). While environmental justice is crucially an international issue, it is effectuated through national and local law, and its associated challenges manifest differently in every individual community.

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In this paper, we focus on the development of environmental justice (EJ) as a political movement and policy priority in the United States. The U.S. Environmental Protection Agency (EPA) EJ as the "fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies'' (U.S. Environmental Protection Agency, 2022). The EJ movement has roots in the civil rights movement, and recent years have seen some shift towards a broader definition of EJ to include equity across systems in the built environment such as transportation infrastructure.

While EJ has been prioritized via executive action with the goal of incorporating it into the decision-making of federal agencies, there is currently no statutory requirement for EJ analysis of infrastructure project proposals (Ulibarri et al., 2022). When project proposals are federally funded and have the potential for significant environmental harm, the National Environmental Policy Act (NEPA) requires federal agencies to conduct human-environmental impact analysis. There is potential for EJ to be incorporated into the NEPA process, which is a long-standing legal framework at the national level, although it is not yet required. NEPA currently provides some limited guidance on analyzing EJ and assessing cumulative impacts of transportation projects on disadvantaged communities (Buzzelle, 2016).

During the Biden administration, federal initiatives have renewed emphasis on the importance of EJ analysis for infrastructure planning and investment. At the same time, new resources, such as open-access, web-based mapping, and data visualization tools, are becoming available to transportation planners, engineers, state and local officials, and the general public. Existing work on evaluation of EJ concerns in transportation planning is predominately focused on race and income inequality (Tian et al., 2013; Antonczak et al., 2023). However, these web-based mapping tools incorporate dozens of other factors that affect distribution of EJ in communities throughout the U.S. Promoting EJ in transportation planning and engineering is complex and often subjective, as EJ assessment involves community-specific knowledge of history, economics, sociology, and technical analysis of transportation systems. The goal of this paper is to:

(1) Discuss the history of the environmental justice movement within the U.S., more recent developments in executive policy initiatives, and the potential role of EJ analysis in the NEPA review process.
(2) Evaluate online environmental justice mapping tools issued by federal agencies, and compare their data inputs, presentation, and functionality as they apply to NEPA reviews in the transportation sector.
(3) Provide decision support for selecting among various public GIS tools to best suit a diversity of users and analysis needs throughout the environmental review process, and for evaluating the effectiveness of EJ-focused transportation projects.

2. Background

EJ grounded in longstanding issues of social inequity. Height et al. (2023) defines environmental injustice as the systematic oppression of marginalized groups, including ethno-racially underrepresented as well as socioeconomically disadvantaged, rural, and other vulnerable groups, through elevated exposure to environmental hazards and inequitable access to environmental benefits. Foundational scholarly literature on EJ, such as the 1990 work *Dumping in Dixie* by Robert D. Bullard (Bullard, 1990), focused on environmental racism in hazardous waste disposal, exploring barriers to environmental and social justice experienced by majority Black communities throughout the United States. Later works such as those of Dorceta E. Taylor detailed the link between discriminatory land-use policy and public health hazards in less advantaged communities throughout the U.S. (Taylor, 2014). Over time, a more multidimensional view of EJ has developed, which reaches beyond environmental burdens into distribution of environmental benefits in a wide variety of dimensions including energy justice, distribution of green spaces, and transportation equity (Jenkins et al., 2016; Wolch et al., 2014).

In the United States, the EJ movement began as an outgrowth of the environmental and civil rights movements. In 1968, the Memphis Sanitation Strike was a major protest that mobilized a broad, national group of predominantly Black Americans in protest against racial and environmental injustice (U.S. Environmental Protection Agency, 2022). In the following years, Black low-income communities continued to organize against other examples of environmental racism. Momentum from this activism led to the 1987 publication "Toxic Wastes and Race in the United States'" from research conducted by the United Church of Christ (Chavis, 1987). This was the first study of its kind, which empirically addressed environmental racism in siting of hazardous waste disposal sites. In 1991, the First National People of Color Environmental Leadership Summit was held in Washington, D.C., where seventeen key principles of EJ were drafted (Delegates of the First National People of Color Environmental Leadership Summitt, 1991). These principles have been foundational in following policy initiatives. More research was conducted throughout the late 1980s and early 1990s, which eventually led to federal action. In 1994, President Clinton issued Executive Order 12,898 "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations."

2.1. Relevant federal law and policy

2.1.1. Executive Orders

An executive order is an order from the President that directs the operation of executive branch agencies. Executive Order 12,898 was the first major federal policy initiative to address environmental justice. It created an Interagency Working Group on environmental justice and established a framework for federal agencies to identify and address disproportionate effects of environmental burdens. E.O. 12,898 also required federal agencies to publish internal EJ strategies to establish more specific requirements in conjunction with NEPA in their areas of expertise. The connection between NEPA and E.O. 12,898 was solidified in the 1997 Council on Environmental Quality (CEQ) publication "Environmental Justice Guidance Under the National Environmental Policy Act". In this document, CEQ outlines strategies for engaging with "low-income populations, minority populations, and Indian tribes" in the NEPA public participation process. The CEQ outlines strategies for community outreach and engagement in the project scoping phase, collecting environmental and socioeconomic data to enlighten environmental impact analysis, and emphasizing input from disadvantaged community members in the decision-making phase. Since 1997, EJ implementation has varied among federal and state agencies.

In Executive Order (E.O.) 14,008 ("Tackling the Climate Crisis at Home and Abroad"), the Biden Administration focuses on prioritizing climate action in domestic and foreign affairs and securing environmental justice throughout the United States. E.O. 14,008 also established the Justice40 Initiative to promote investment in EJ related infrastructure improvements (Executive Order No. 14,008, 2021). The Justice40 Initiative seeks to deliver "40 percent of the overall benefits of relevant federal investments to disadvantaged communities," and track the performance of federal investment with the establishment of an Environmental Justice Scorecard (Young et al., 2021). Because the Justice40 initiative is characterized as a whole-of-government approach rather than an individually funded program, its opportunities for community impact will be assessed in the distribution of federal funding legislation.

President Biden's E.O. 14,091 ("Further Advancing Racial Equity and Support for Underserved Communities Through the Federal Government") also promotes EJ by establishing Equity Teams in various federal agencies to ensure that EJ efforts "are consistent and mutually reinforcing" (Executive Order No. 14,091, 2023).

Over the years, these executive actions and other federal agency guidance have attempted to strengthen the connection between EJ and the NEPA (Executive Order No. 12898; Council on Environmental Quality, 1997; Executive Order No. 14008, 2021). The 2016 CEQ publication 'Promising Practices for EJ Methodologies in NEPA Reviews," updated guidance for implementation of E.O. 12898, recommending steps for EJ evaluation throughout the NEPA process (Buzzelle, 2016). NEPA is a longstanding statute that is regularly implemented by federal agencies, and it provides an opportunity to engage with EJ communities and promote equity in the built environment.

2.1.2. The national environmental policy act

NEPA was signed into law on January 1st, 1970, establishing the first national environmental policy in the United States. NEPA is triggered when there is a proposal for a "major federal action" that could "significantly affect" the environment. 40C.F.R. 1508 et seq. A "major federal action" occurs when a federal agency constructs a project itself, provides funding for a project, issues a permit for a project, or takes certain policy actions that affect the environment. Once NEPA is triggered, it requires agencies to formally evaluate and publish its environmental impacts. Depending on the proposed environmental impacts, agencies are required to file a Categorical Exclusion (CE), Environmental Assessment (EA), or Environmental Impact Statement (EIS). If significant environmental impacts are a likely result of the proposed project, an EIS is required, and the NEPA procedure requires agencies to hold public meetings, implement public comment periods, and respond to all submitted comments. In the case of an EIS, NEPA requires agencies to conduct alternatives analysis, including the alternative of no action, and publish the respective environmental impacts for these alternatives.

NEPA provides a potential framework for incorporating EJ analysis into the review of transportation projects, as it defines protection and maintenance of the "human environment" as a multidisciplinary question to involve both social and natural science in decision-making. Further, NEPA seeks to recognize the "long-range and worldwide" nature of environmental challenges, which emphasizes cumulative impacts analysis.

Transportation projects are frequently federally funded, so transportation practitioners need to be familiar with the NEPA process. With this in mind, we will consider the potential for EJ to be incorporated into NEPA compliance, especially in the scoping, alternatives analysis, and public engagement associated with preparation of EISs. Explicitly connecting EJ and NEPA could effectively incorporate the UNDP's recommendation for establishing a legal framework at the national level for EJ consideration in the U.S.

2.2. Environmental justice and transportation

2.2.1. Transportation-specific policy initiatives

Environmental Justice is achieved differently by different federal agencies, which is reflected in agency-specific guidelines for implementation of E.O.s 12,898 and 14008. E.O. 12,898 explicitly requires federal agencies to publish internal EJ strategies to establish more specific requirements in conjunction with NEPA in their areas of expertise. In 2016, the "U.S. Department of Transportation Environmental Justice Strategy" was published (Broehm, 2016). This established an internal DOT Environmental Justice Working Group coordinated and led by the Office of the Assistant Secretary for Transportation Policy (Rowangould et al., 2016). The DOT EJ Strategy document generally expresses broad principles without providing specific guidance for individual DOT agencies and regional authorities. Since 2016, DOT has worked on various EJ-related programs for community engagement; however, annual reports as required by E.O. 12,898 have not been published publicly on the DOT website since 2015.

More recently, the Interim Implementation Guidance for the Justice 40 Initiative, issued by the Office of Management and Budget on July 20, 2021 (M−21−28), states that "President Biden is committed to securing environmental justice and spurring economic opportunity for disadvantaged communities that have been historically marginalized and overburdened by pollution and underinvestment in housing, transportation, water and wastewater infrastructure, and health care" (Young et al., 2021). This guidance raises two questions: 1.) How are disadvantaged communities defined? And 2.) How do we quantify environmental benefits and burdens, and engage in meaningful involvement of community members, in transportation infrastructure planning?

Because the Justice40 initiative explicitly mentions transportation as a key focus area, there has been significant development of DOT and FWHA (U.S. Federal Highway Administration) guidance on incorporating EJ into transportation infrastructure development

(88 Fed. Reg. 10642). Several online screening tools have been developed towards the goal of identifying and directing federal funding to communities that are overburdened by inadequate transportation infrastructure, or conversely, overburdened by exposure to transportation-related harm. To examine the inputs and outputs of these screening tools, we define environmental justice as it relates to the transportation industry.

2.2.2. Procedural and distributive justice and NEPA in the transportation sector

EJ analysis related to transportation projects in the U.S. can be broadly divided into two categories, which are directly outlined in the EPA's definition (Kuehn, 2000). The "meaningful involvement… of all people regardless of race, color, income, or national origin" refers to procedural environmental justice. NEPA emphasizes procedural EJ by outlining a public process for participation in projects that involve federal funding and potential for harm to the human environment; however, it can be difficult for federal agencies to meaningfully engage with historically marginalized communities (Ulibarri et al., 2022; Dongoske et al., 2015; Blue et al., 2021; Baptista et al., 2019). Time constraints, resource constraints, and the technical nature of NEPA guidelines need to be navigated and effectively communicated to the affected community, and especially disadvantaged groups within the affected community (Dongoske et al., 2015).

When NEPA compliance is required for a project, the scoping process should include identification of low-income, minority, tribal, or otherwise disadvantaged communities (often referenced collectively as 'EJ Communities') within the proposed affected area (Rowangould et al., 2016). Methodology for identifying EJ Communities is variable but generally defines a threshold for socioeconomic disadvantage based on demographic data in a geographic area. Once affected EJ Communities are identified, the agency responsible for NEPA compliance can produce a public engagement strategy specifically tailored to community needs. In the early stages of NEPA procedures, information about the proposed project and associated public processes should be accessible, understandable, and engaging (Twaddell et al., 2019).

The "fair treatment… of all people regardless of race, color, income, or national origin," ideally realized as an even distribution of benefits and burdens of project proposals, refers to distributive environmental justice. Distributive EJ is less prevalent in the existing language and practices of NEPA (Ulibarri et al., 2022; Baptista et al., 2019). Effectively understanding the distribution of benefits and burdens of a transportation project requires advanced geospatial analysis of existing and proposed transportation systems (Giuliano & Hanson, 2017). When modeling the effects of a proposed transportation system, it is important to consider all modes of transportation, and how changes to various modes could disproportionately affect EJ Communities. Federal agencies acknowledge the importance of cumulative impacts analysis, but NEPA does not currently require agencies to make decisions based on this type of analysis (Broehm, 2016).

Existing research establishes that improvements to transportation infrastructure are highly complex in their effects on overburdened populations (Duthie et al., 2007; Amekudzi et al., 2012). Analyzing interdependent distributive and procedural justice for transportation projects require data on socioeconomic indicators of environmental justice (spatial distribution of race and income, linguistically isolated community members, and other demographic information) and existing transportation needs and patterns (spatial distribution of accessibility points of interest, trip tables, and network performance) (Giuliano & Hanson, 2017). Geographic Information Systems (GIS) are useful for this type of analysis (Twaddell et al., 2019; Rowangould et al., 2016). Along with recent federal policy initiatives, several publicly available, online GIS screening tools have been developed to assess distribution of environmental and socioeconomic indicators related to EJ. In the following section, we examine these tools' applicability for users conducting EJ analysis in the transportation industry, especially in the NEPA process.

Table 1
Selected Online GIS Tools.

Name of Tool	Federal Agency	Year Launched	Focus	URL
EJScreen 2.2	Environmental Protection Agency (EPA)	2015	Individual variables of environmental hazards, social burdens, and other GIS data are viewed in separate layers.	https://ejscreen.epa.gov/mapper/
Climate and Economic Justice Screening Tool (CEJST)	White House Council on Environmental Quality (CEQ)	2022	Disadvantaged census tracts are classified to guide funding and resource allocation.	https://screeningtool.geoplatform.gov/en/#3/33.47/-97.5
Environmental Justice Index (EJI) Explorer	Centers for Disease Control and Prevention (CDC) / Agency for Toxic Substances and Disease Registry (ASTDR)	2022	Census tracts are given an EJI ranking according to cumulative burdens in 5 categories.	https://onemap.cdc.gov/portal/apps/sites/#/eji-explorer
Equitable Transportation Community (ETC) Explorer	Department of Transportation (DOT)	2023 (Beta Version)	Focuses on transportation, expands on the transportation burden component of CEJST.	https://experience.arcgis.com/experience/0920984aa80a4362b8778d779b090723/page/Homepage/

Table 2
EJScreen Data Inputs.

Evaluated Tool	Category of Data	Sub-categories	Indicators	Data Source(s)
EPA EJScreen	Socioeconomic and social equity indicators, including human health risks and conditions	Demographic	EJ and Supplemental Demographic Indices, People of Color, Limited English Speaking, Education, Persons with Disabilities, Under Age 5, Over Age 64	U.S. Census ACS(1)
		Economic	Low Income, Unemployment Rate	U.S. Census
		Health Disparities	Low Life Expectancy, Heart Disease, Asthma, Cancer	NCHS(2), NAPHSIS(3), CDC
		Critical Service Gaps	Broadband Gaps, Food Desert, Lack of Health Insurance, Housing Burden	U.S. Census ACS, USDA(4)
	Environmental indicators, including infrastructure and the built environment	Pollution and Sources	Air Quality (PM 2.5, Ozone, Diesel PM, Air Toxics Cancer Risk & Respiratory HI, Toxic Releases to Air), Traffic Proximity, Lead Paint, Superfund Proximity, RMP Facility Proximity, Hazardous Waste Proximity, Underground Storage Tanks, Wastewater Discharge	U.S. EPA
		Climate Change Data	100 Year Floodplain, Sea Level Rise, Wildfire Risk, Flood Risk	NOAA(5), First Street Foundation
		Transportation Barriers	Transportation Access	U.S. DOT
		Housing and Communities	Housing Burden	CEJST

Notes: (1) ACS = American Community Survey; (2) NCHS = National Center for Health Statistics; (3) NAPHSIS = National Association for Public Health Statistics and Information Systems; (4) U.S. Department of Agriculture; (5) NOAA = National Oceanic and Atmospheric Administration.

3. Methods

3.1. Selection of tools for evaluation

For this study, we have selected 4 tools that are developed and maintained by federal agencies in the United States. We sought out tools that are publicly available, developed explicitly for EJ analysis, and include transportation data. Each of the tools utilizes a different methodology for quantifying and thresholding EJ parameters. Each of the tools also offers a unique online user-interface and process for downloading data. The selected online tools are outlined in Table 1.

Federal agency tools have been selected because NEPA is required only for projects that involve a "major federal action," and federal agencies are responsible for NEPA compliance. Further, the Justice40 Initiative directs funding at the federal level. However, online EJ mapping tools also have been, and continue to be, developed at the state level by state agencies, nonprofit organizations, academic institutions, and private companies (Konisky et al., 2021; Madrigano et al., 2022). To compare the selected tools' data sources, accessibility, and applicability in the transportation sector, we analyzed their online mapping infrastructure, application programming interfaces (APIs), user guides, and public commentary on the data tools, when available.

3.2. Cataloging of data inputs

To compare the data inputs utilized by federal agencies to develop the EJ screening layers, we first downloaded the publicly available user guides for each of the evaluated tools. The user guides also allowed us to identify metrics and geospatial data that could be relevant at different stages of the NEPA process for a transportation project.

With the goal of comparing screening tool inputs related to transportation, we searched the technical guides for transportation related keywords "transportation", "transit", "mobility", "networks", "infrastructure", and "walkability." We conducted a similar search for EJ indicators in socioeconomic and social equity categories. For this step, we searched each technical guide for keywords "social", "economic", "socioeconomic", and "health." We identified datasets from sources that were consistently included in the methodology utilized by all the tools, and distinguished parameters that were uniquely utilized by individual tools. to each of the individual tools.

3.3. Functional analysis of selected tools

After reviewing the data sources and inputs utilized by the GIS tools, we analyzed the statistical and geospatial analyses applied to the datasets, and the resulting outputs in both the online and desktop user interfaces. To assess how the tools are compiling, thresholding, and displaying input geospatial data, we reviewed the methodology presented in each of the tools' technical guides. Then, after reviewing technical information available on the GIS tools, we accessed each of the tools' GIS interfaces to perform a descriptive analysis of the tools' manipulability and general user experience. Data from EJScreen, CEJST, EJI, and ETCE screening tools can be visualized in the online GIS platform or downloaded and manipulated by the user in a desktop GIS software.

Table 3
CEJST Data Inputs.

Evaluated Tool	Category of Data	Sub-categories	Indicators	Data Source(s)
CEQ CEJST	Socioeconomic and social equity indicators, including human health risks and conditions	Demographic	Limited English Speaking, Education, Lands of Federally Recognized Tribes	U.S. Census
		Economic	Low Income, Poverty, Unemployment Rate, Energy Cost	U.S. Census ACS, DOE[(1)]
		Health Disparities	Asthma, Diabetes, Heart Disease, Low Life Expectancy	CDC
	Environmental indicators, including infrastructure and the built environment	Pollution and Sources	Air Quality (PM 2.5, Ozone, Diesel PM, Air Toxics Cancer Risk & Respiratory HI), Traffic Proximity, Lead Paint, Superfund Proximity, RMP Facility Proximity, Hazardous Waste Proximity, Underground Storage Tanks, Wastewater Discharges, Abandoned Mine Land, and Formerly Used Defense Sites	EPA, DOI[(2)], USACE[(3)]
		Climate Change Data	Expected Agriculture Loss Rate, Expected Building Loss Rate, Expected Population Loss Rate, Flood Risk, Wildfire Risk	FEMA[(4)], First Street Foundation
		Transportation Barriers	Average Commute Time to Work, Walkability, Transportation Cost Burden, Pop. with No Personal Vehicle	DOT, EPA
		Housing and Communities	Historic Redlining Scores, Housing Cost, Lack of Indoor Plumbing, Lack of Greenspace	HOLC[(5)], NCRC[(6)], HUD[(7)], USGS[(8)]

Notes: [(1)] DOE = Department of Energy; [(2)] DOI = Department of the Interior; [(3)] USACE = U.S. Army Corps of Engineers; [(4)] FEMA = Federal Emergency Management Agency; [(5)] HOLC = Home Owners Loan Corporation; [(6)] NCRC = National Community Reinvestment Coalition; [(7)] HUD = Department of Housing and Urban Development; [(8)] USGS = U.S. Geological Survey.

Table 4
EJI Data Inputs.

Evaluated Tool	Category of Data	Sub-categories	Indicators	Data Source(s)
CDC EJI	Socioeconomic and social equity indicators, including human health risks and conditions	Demographic	Limited English Speaking, Disability, Under Age 17, Over Age 65, Education	U.S. Census ACS
		Economic	Unemployment, Housing Burdened Lower-income Households, Poverty	U.S. Census ACS
		Health Disparities	Prevalance of Asthma, Cancer, High Blood Pressure, Diabetes, Poor Mental Health	CDC
		Critical Service Gaps	Lack of Health Insurance, Lack of Internet Access	U.S. Census
	Environmental indicators, including infrastructure and the built environment	Pollution and Sources	Ozone, PM 2.5, Diesel PM, Air Toxics Cancer Risk, Hazardous Sites, Toxics Release Sites, Risk Management Program Sites, Treatment and Disposal Sites, Coal Mines, Lead Mines, Impaired Surface Water	EPA, DOL[(1)]
		Transportation Barriers and Transportation Safety	Walkability	EPA
		Transportation Infrastructure	High-Volume Roads, Railways, Airports	BTS
		Housing and Communities	Mobile Homes, Group Quarters, Housing Tenure, Lack of Recreational Parks	U.S. Census ACS

Notes: [(1)] DOL = Department of Labor; [(2)] BTS = Bureau of Transportation Statistics.

Table 5
ETCE Data Inputs.

Evaluated Tool	Category of Data	Sub-categories	Indicators	Data Source(s)
DOT ECTE	Socioeconomic and social equity indicators, including human health risks and conditions	Demographic	Education, Endemic Inequality (Gini Index), Under Age 17, Over Age 65, Disability, Limited English Speaking*	U.S. Census
		Economic	Unemployment, Low Income	U.S. Census
		Health Disparities	Prevalence of Asthma, Cancer, High Blood Pressure, Diabetes, Poor Mental Health, Proximity to Hospitals	CDC, DHS[(1)]
		Critical Service Gaps	Lack of Health Insurance, Lack of Internet Access	U.S. Census
	Environmental indicators, including infrastructure and the built environment	Pollution and Sources	Ozone, PM 2.5, Diesel PM, Air Toxics Cancer Risk, Hazardous Sites, Toxics Release Sites, Risk Management Program Sites, Treatment and Disposal Sites, Coal Mines, Lead Mines, Impaired Surface Water	EPA, DOL
		Climate Change Data	Annualized Disaster Losses, Increase in Excessive Heat, Increase in Excessive Rain, Drought, Coastal Inundation, Impervious Surfaces	FEMA, DOI, NOAA, USGS
		Transportation Barriers and Transportation Safety	Average Commute Time to Work, Walkability, Transportation Cost Burden, Pop. with No Personal Vehicle, Peak Transit Frequency, Jobs Within a 45-min. Drive, Transportation Related Fatalities	EPA, U.S. Census ACS, AAA[(2)], CES[(3)], NTD[(4)], NSHTA[(5)], BTS
		Transportation Infrastructure	High Volume Roads, Railways, Airports, Ports	BTS
		Housing and Communities	Pre-1980 Housing, Housing Cost Burden, House Tenure, Mobile Homes	U.S. Census ACS

Notes: [(1)] DHS = Department of Homeland Security; [(2)] AAA = American Automobile Association; [(3)] CES = Consumer Expenditure Survey; [(4)] NTD = National Transit Database; [(5)] NSHTA = National Highway Safety Administration

3.3.1. Online mapping interface: presentation and manipulability

We accessed each of the online web mapping tools to analyze their data presentation and accessibility. We then documented which data input layers can be displayed individually online, and which parameters are automatically summarized and compiled into a more abstracted format. We also noted any data that is supplied in the online environment in tabular format but not included as a layer or parameter contributing to calculated layers in the map itself.

3.3.2. Data download: presentation and manipulability

To further inform our descriptive analysis of the selected tools, we evaluated the data available for downloading. When available, we downloaded data directly from each of the agency websites and compared the ease of utilizing layers in a desktop GIS interface. To simplify our comparison process, we queried the downloaded data by County to only include census tracts located within St. Louis City, Missouri. Then, we compared summary statistics for EJ parameters that were consistently included in the datasets, to determine if there were any discrepancies in the screening tools' data. We referenced the methodologies outlined in the user guides to provide further insight into these discrepancies.

4. Results

4.1. Selection of evaluated tools

For our analysis, we selected 4 publicly available, online GIS tools produced at the national level by federal agencies in the U.S. These tools were all developed with different goals and provide different user experiences, but all are intended for use in EJ analysis and could contribute to the NEPA process. Table 1 lists these tools along with their affiliated agencies.

These tools are designed with different goals and GIS functionalities; therefore, they are useful in different scenarios depending on the user's needs and experience with geospatial data. Distinguishing the benefits and drawbacks associated with these functionalities is important as each of the tools has a different niche within the NEPA process. Some of the tools, such as the DOT's recently developed ETC explorer, explicitly focus on transportation infrastructure and access. Others, such as EJScreen, have a much broader scope. This variety is useful for different stages of the NEPA process, as a broader scope and simple functionality is useful for stakeholder and public engagement, whereas a transportation-focused scope is useful for more technical aspects of environmental review.

EJScreen version 2.2 was released in June 2023.

4.2. Cataloging of data inputs

When deciding which of the tools to use for EJ analysis, it is important to understand their contributing data sources. Because these tools are public and maintained by federal agencies, their data inputs are all publicly available, and mostly provided by other federal agencies. Some datasets are consistently incorporated into EJ screening methodology and utilized by all the selected tools, whereas other datasets are uniquely incorporated into an individual tool. It is important to note that social, demographic, and environmental data can change over time, and needs to be continually updated to maintain accuracy. Additionally, all these datasets are provided at a screening level, and some accuracy is lost when users are assessing EJ concerns for a small geographic area. EJ analysis with these tools should be supplemented and validated with data from local governments and other organizations. Datasets and their sources are categorized and listed for each of the selected tools in Tables 2 through 5.

Among the selected tools, there are several commonalities in data sources and input layers utilized. EJScreen was the first online mapping tool of its kind to be developed, and the EPA is a significant source for environmental data in the U.S., so EJI, CEJST, and ETCE all utilize environmental directly from EJScreen. These datasets make up most of the layers listed as "Pollution and Sources" in Tables 2 through 5. Additionally, demographic, and economic data for all the selected tools is derived from the U.S. Census Bureau's American Community Survey (ACS). EJScreen version 2.2, which was released in June 2023, includes housing and transportation data downloaded directly from CEJST and ETCE, respectively.

There are also several key differences in data sources utilized by the selected tools. Climate change and climate hazard risk data are incorporated differently by each of the tools. EJScreen has input layers of flood hazard: 100-year floodplain throughout the U.S., percentile ranked flood risk for census tracts, and projected flooding based on different levels of sea level rise. EJScreen also has a layer for wildfire risk. CEJST incorporates similar data while adding potential economic consequences of expected loss rates for agriculture, buildings, and population. Similarly, ETC builds on these data with the addition of predicted increase in excessive heat and excessive rain, as well as impervious surfaces which exacerbate these issues. EJI does not currently include climate change indicators as an input.

Incorporation of transportation data is also a key difference among the selected tools. EJScreen's data inputs focus heavily on media pollution such as air and water quality concerns that are related to transportation; however, EJScreen's recent updates have incorporated more data on transportation systems and barriers. EJScreen version 2.2 includes transportation data in its traffic proximity indicator from the EPA, and in the transportation access indicator, which is provided by the DOT's transportation disadvantaged census tracts. EJI adds onto the traffic proximity indicator more specific categories of traffic proximity that have negative health impacts on surrounding community members: high-volume roads, airports, railways, and airports. EJI also includes EPA's walkability index as a data input. CEJST again builds on this with the transportation barriers category which adds several new datasets: average commute time to work, transportation cost burden, and population with no personal vehicle. Finally, ETC provides the most comprehensive transportation data of the selected tools, as it incorporates all the previously mentioned data layers with the addition of peak transit frequency, jobs within a 45-minute drive, and transportation-related fatalities for each census tract.

It is important to acknowledge that while transportation data is clearly important for transportation projects, socioeconomic and other environmental data are also critical to holistically understanding the impact of transportation developments on a community. Especially in promotion of procedural justice, this other data plays an important role in the NEPA process. Transportation practitioners and other users should understand the available data to tailor use of these tools in a way that best suits a proposed project.

4.3. Functional analysis of tools

To varying degrees of abstraction, each of the tools utilize the data inputs to produce outputs that summarize and quantify parameters of environmental injustice. Generally, these parameters are compared to the national average by percentile ranking. Based on threshold percentiles, disadvantaged census tracts are identified. These outputs are displayed in the online mapping environment and can also be downloaded for further analysis by users. Depending on the agency's goal in developing the tool, classification based on these thresholds is variable. For each of the tools, we have included a brief description of the online data interface and download availability below.

4.3.1. Online mapping interface: presentation and manipulability

Here, we detail all layers available for users to view in the online environment for each tool, and GIS functionality available directly within the online environment. The online mapping interface is most likely to be accessed by the public. These users likely have interest in environmental justice but lack extensive knowledge of GIS technology and functionality. In this use case, a straightforward and abstracted presentation of data may be more useful.

Alternatively, more advanced GIS functionality such as buffering and statistical analysis are useful for transportation practitioners, academics, and local officials who do not have access to a desktop GIS software package. Therefore, we assess the selected GIS tools' functionality on a continuum from abstraction to manipulability, where abstraction increases utility for a general audience and manipulability increases utility for transportation industry practitioners.

4.3.1.1. EPA – EJScreen 2.0. In the EJScreen online interface, users can view input layers individually, aggregated at the census tract level. GIS layers of Environmental Justice Indexes, Supplemental Indexes, Pollution and Sources, Socioeconomic Indicators, Health Disparities, Climate Change Data, and Critical Service Gaps are classified and viewable by State and National percentiles. Users can also layer shapefiles with locations of other regulated facilities, places of worship, public housing, tribal lands and indigenous areas, and other environmental data.

Within the online environment, EJScreen has some built-in GIS tools. The 'threshold map' functionality allows users to manually threshold and view census tracts within a selected range of State or National percentile Environmental Index scores. The 'search Geoplatform', 'add map services', and 'add shapefile' functionalities allow users to add additional GIS data from EPA's online database, other publicly available sources, or uploaded by the user. EJScreen's 'reports' toolset allows users to select and buffer data by user-defined polygons or by politically defined boundaries such as census tract, block group, or county and export statistics as a pdf or table.

4.3.1.2. CEQ – Climate and Economic Justice Screening Tool. In the CEJST online mapping interface, users can view EJ data as aggregated and classified at the census tract level, where census tracts are highlighted if they are classified as disadvantaged. When an individual tract is selected, the user can toggle through the 8 categories of burden (Climate Change, Energy, Health, Housing, Legacy Pollution, Transportation, Water and Wastewater, and Workforce Development) which are individually highlighted for categories for which the census tract is classified as disadvantaged. Each of these 8 categories also includes a drop-down menu that allows the user to see national percentile rankings of each of the individual layers that contributed to the overall disadvantage classification for the selected tract.

CEJST's online GIS functionality is limited to selecting census tracts and viewing contributing percentile rankings utilized by the CEJST disadvantage calculation methodology. Only the binary classification of overall disadvantage by census tract can be visualized

Table 6
Summary of Online Mapping Functionality.

EPA EJScreen	CEQ Climate and Economic Justice Screening Tool (CEJST)	CDC Environmental Justice Index Explorer (EJI)	DOT Equitable Transportation Community Explorer (ETCE)
Built-in GIS Data Layers			
49 EJ screening layers **18** Other location data	**1** EJ screening layer[(1)]	**1** EJ screening layer[(1)]	**23** EJ Screening layers **16** Other location data
Symbology – EJ Screening Layers			
Classified by percentile rankings into 6 quantiles[(2)]	Binary classification	Classified by EJI index score into 4 quantiles[(3)]	Binary classification and/or percentile rankings into 10 quantiles[(4)]
Data Analysis and Functionality			
– View individual indicators – Compare data to State or National averages – dd online or uploaded data – User-defined thresholding – User-defined buffers – Generate reports directly from map	– View (tabular) parameter contributions to overall classification	– View (tabular or graph) parameter contributions to overall classification – Domain rankings (graph) compare data to current map extent, State, or National averages	– View (tabular) parameter contributions to overall classification – Add online or uploaded data

Notes: [(1)]CEJST and EJI map layers automatically compile data from dozens of environmental, socioeconomic, and other indicators, but the online map displays only the resultant classification. [(2)]EJScreen quantiles are available compared to both State and National data and are categorized as follows: 'less than 50 percentile', '50–60 percentile, '60–70 percentile', '70–80 percentile', '80–90 percentile', '90–95 percentile', and '95–100 percentile.' [(3)]EJI quantiles are evenly divided and categorized as follows: 'Low', 'Low to Moderate', 'Moderate to High', and 'High.' [(4)]ETCE quantiles are evenly divided in increments of 10% from 0 to 100%.

in the online map.

4.3.1.3. CDC – Environmental Justice Index. The EJI online interface displays census tracts, classified symbolically by overall EJI rank quartiles (Low, Low to Moderate, Moderate to High, High). When an individual tract is selected, the user can toggle to view tabular rankings for individual burden contributing percentiles. These individual percentiles are divided into 3 major categories (Environmental, Social, and Health Burdens) and 10 sub-categories which mirror the methodology. The 'Domain Rankings' tab allows the user to visualize sub-category data graphically in bar charts. The domain rankings are automatically updated to compare statistics within the map frame window, or selected State. EJI's online functionality allows users to select census tracts, view EJI indicators' percentile rankings, and compare domain ranking.

4.3.1.4. DOT – Equitable Transportation Community Explorer. The default ETCE online interface displays data aggregated at the census tract level, where census tracts are highlighted if they are classified as transportation disadvantaged by the DOT methodology. Census tribal areas and Alaska Native Villages are also highlighted. Users can customize the online map by adding and removing layers of air quality indicators, such as 1hr and 8hr ozone, lead, and carbon monoxide, classified to display 'maintenance' and 'nonattainment' zones. Users can also view percentile ranked data layers for each of the 5 contributing categories of burden (Transportation Insecurity, Environmental Burdens, Social Vulnerability, Health Vulnerability, and Climate and Disaster Risk Burden), and overall transportation disadvantage in the map viewer. Finally, the map viewer includes several layers of existing transportation networks such as routes and stops from the National Transit Map, alternative fueling stations, aviation facilities, and Intercity bus layers. Customized maps can be exported as an ArcGIS Layout in several different file formats from the online viewer.

Users can customize the online map interface by connecting with ArcGIS online, linking to other geospatial data via URL, or uploading files from their computers. When an individual census tract is selected in the map viewer, summary statistics for the EJ classification process are output for the individual tract. In the 'ETC Explorer – National Results' tab, users can view summary statistics of transportation disadvantage aggregated at the National, State, Community, or Metropolitan Planning Organization (MPO) level. In the 'ETC Explorer – State Results' tab, users can select their State, and compare indicators to State level metrics. The ETC Explorer tool also provides the user with some GIS functionality in the 'Transportation Insecurity Analysis Tool', where users can easily query data in the online environment based on a series of filters in 4 categories: urbanized area filters, cost burden filters, access burden filters, and safety filters. These filters allow the user to locate areas with specific environmental justice concerns.

The online GIS data interface for each of the tools is summarized in Table 6. We define 'Built-in' GIS data layers as those which are available in the default map view. This does not include privately or publicly available layers that can be added and customized by individual users. We define "EJ screening layers" as those which are utilized as proxies of environmental, socioeconomic, or other risk factors for community vulnerability and/or burden. "Other location data" are other GIS layers provided in the default online mapping environment to contextualize and inform EJ screening data.

The most manipulable of the selected tools are EJScreen and ETCE. While EJScreen does not incorporate as many transportation-related data inputs as ETCE, it is the most manipulable of the tools. EJScreen is highly customizable and offers some advanced functionality that allows users to tailor the mapping tool for a wide variety of applications. One feature of EJScreen's online tool that is beneficial for transportation analysis is 'buffer by path'. For example, for a highway project, one could buffer and generate statistics for any EJ indicators within a certain radius of the affected highway stretch. Understanding socioeconomic dynamics in the affected area would help planners and engineers design the project to maximize benefits to the surrounding community and reduce its associated burdens. This could also be useful in communicating with the public about expected changes to traffic patterns, construction timing, and economic stimulation in the neighborhood. Earlier in the NEPA process, EJScreen layers 'limited broadband access' and 'limited English speaking' would be useful to tailor outreach efforts and coordinate public meetings to increase accessibility and match

Table 7
Summary of Data Download Formats.

EPA EJSCREEN	CEQ Climate and Economic Justice Screening Tool (CEJST)	CDC Environmental Justice Index Explorer (EJI)	DOT Equitable Transportation Community Explorer (ETCE)
Pre-download Query Capability			
From API: Can query data by point, line, polygon, rectangle, census block group, census tract, city, or county. ***From website:*** Census tract or census block group	Only entire USA	Individual or multiple census tracts	Only entire USA
Geographical Data Available for Zonal Statistics			
State, county, census tract, census block group	State, county, census tract	State, county, census tract	State, county, census tract, metropolitan planning organization (MPO)
Available Export Formats			
JSON, CSV, geodatabase	Shapefile, CSV	JSON, GeoJSON, CSV	Shapefile, JSON, CSV
Total Number of Parameters in Output Table			
156	123	121	177
Currently Available Data Dates			
2015 - present	2022	2022	2022

community needs. EJScreen version 2.2 includes a more detailed and graphically improved EJScreen Community Report feature, which can help bridge the gap between transportation practitioners and stakeholders in the public engagement process of NEPA.

Compared to EJScreen, ETC provides much less GIS functionality; however, it provides significantly more data on transportation indicators. ETC is the only tool that includes existing transportation systems data (i.e., public transit stops and routes, bus stops, etc.), which can be insightful for community members and transportation planners alike in the scoping stages of the NEPA process. Both EJScreen and ETC would also be useful in alternatives analysis, responding to public comments, and other later stages of the NEPA process.

The most abstracted of the selected tools are CEJST and EJI. CEJST's online user interface is highly simplified, and there is only one available layer. This is beneficial for users who are conducting a high-level EJ assessment or just need a quick answer of whether a specific census tract is classified as disadvantaged, for purposes of distributing funding or other resources. CEJST may be referenced earlier in the NEPA process for a broad overview of community dynamics before conducting more advanced impact assessment. Because CEJST is the most abstracted of the selected tools, it could be useful for a general audience with little to no experience with online mapping or GIS software. EJI is similarly abstracted and useful for a general audience. EJI's uniqueness comes from its methodology, which prioritizes cumulative impacts from environmental burdens experienced by communities. Unlike CEJST, EJI does not explicitly classify census tracts as disadvantaged; rather, it displays census tracts by EJI ranking. This allows for the EJI online tool to provide more nuanced information while still maintaining a simplified user interface that can be accessed by a general audience.

4.3.2. Data download: presentation and manipulability

Downloading EJ data from these online mapping tools enhances the manipulability of the data and expands functionality available to users. This is particularly of interest when the data is being applied in a more technical context, and the user is interested in more advanced statistical analysis tailored to the needs of a specific community or project.

4.3.2.1. EPA – EJScreen 2.0. To download, EJScreen's API is an interactive tool that helps users narrow the geographic scope of data to download. Through the API, users can query data by point, line, polygon, rectangle, census block group, census tract, city, or county. To query by census block group, tract, city or county, the user can select its location on the API map or input its FIPS code. The data can be exported as a JSON which can be exported and visualized in a desktop or online GIS software or online with some programming. Additionally, the data can be exported as an EJScreen printable standard report, which displays state and national percentiles for EJ indexes, environmental indicators (pollution and sources), and socioeconomic indicators.

Alternatively, EJScreen data can be downloaded directly from the EPA's EJScreen website, in csv or geodatabase (gdb) format. Historical EJScreen data for every year from 2015 to present can be downloaded, which is unique among the tools analyzed. EJScreen data can also be downloaded at the census tract or census block group resolution.

4.3.2.2. CEQ – Climate and Economic Justice Screening Tool. To download CEQ's CEJST, data is available for the entire United States in shapefile and csv formats (see Figure). In a desktop GIS software, census tract data can be queried by individual indicators, allowing the user to visualize different contributions to a census tract's disadvantaged classification. The exported shapefile attribute table has 119 different data attributes, which includes some demographic statistics that are not included in the CEJST disadvantaged census tract calculation methodology, such as racial and ethnic demographic information.

4.3.2.3. CDC – Environmental Justice Index. To download with the CDC's EJI Accessibility Tool viewer, a user can search for data by State and County, then view all census tracts in the selected county. Each Census tract has a dropdown menu to display raw data for all EJI parameters (air pollution, potentially hazardous & toxic sites, built environment, transportation infrastructure, water pollution, minority status, socioeconomic status, household characteristics, housing type, and high pre-existing chronic disease prevalence). The data from this page can be exported as a JSON file, GeoJSON file, or csv for individual or multiple census tracts. We exported data for all 106 census tracts in St. Louis City as csv and JSON files.

4.3.2.4. DOT – Equitable Transportation Community Explorer. To download DOT's ECTE, data is available for the entire United States in shapefile, geodatabase, and comma-separated value (csv) formats. The exported shapefile is aggregated by census tracts, and each census tract has attributes for each of the indicators referenced in Table 6 (167 total attributes, excluding general location attributes 'County', 'State', 'County ID', 'Metropolitan Planning Organization', etc.). The 'Alias Lookup Table' is paired with the data exports to allow the user to decode field names in attribute tables (for example, attribute field 'wlkblt' is the census tract's ranked EPA Walkability Index).

A summary of data download presentation and manipulability is detailed in Table 7. When data is exported and examined in a desktop GIs interface, the downloaded data is very similar among the selected tools. Generally, the downloaded data is presented in shapefile format, where shapefiles for each individual census tract (or optionally in the case of EJScreen, census block group). Each tract has over 100 different fields in its attribute table, with each indicator from Tables 2-5, and some more general geographic information, input as an individual field.

The user experience of manually downloading the data is more variable among the tools. CEJST and ETCE only provide the option to download data for the entire U.S., which simplifies the download process, but provides the user with excessive information in some cases. The query feature of EJI's online interface increases complexity of the download process but does allow the user to narrow the scope of exported data before downloading. EJScreen provides both options, and exporting directly from the EJScreen website is a simplified interface, whereas the EJScreen API allows the user to access a much more tailored dataset.

5. Discussion

All the selected GIS tools we analyzed for this study have applicability in the NEPA process, and each of the tools has features that make it unique. For transportation practitioners, academics, and engineers interested in advanced analysis of transportation-related EJ indicators, we recommend the DOT's ETC Explorer. Use of the ETC Explorer should be supplemented with the other tools, especially EJScreen, which has a well-refined user interface, broad range of environmental and socioeconomic indicators, and significantly more datasets available for viewing in the online environment. On the other side of the spectrum, for users with less familiarity with GIS software or seeking a simplified user interface, we recommend CEJST and EJI. Like ETC and EJScreen, these tools incorporate dozens of EJ indicators; however, the online tools automatically summarize this data to provide a simplified output and user experience.

In the environmental review process, a combination of these tools and other methods for EJ analysis would be beneficial to ensure distributive and procedural justice is achieved in transportation systems. As transportation initiatives focused on reducing environmental injustice are implemented, detecting change in geospatial data can be beneficial to evaluating the effectiveness of these initiatives. EJScreen, for example, has been updated annually since 2015; thus, some basic change detection analysis can be performed in a desktop GIS software to identify evolution in benchmark EJScreen parameters associated with a specific intervention's goals. This type of analysis only provides a coarse-resolution tool for monitoring and must be paired with ground-truthing to isolate whether observed changes are actually caused by the original intervention. However, as GIS data increases in quality, and screening tools are updated over time, this could be a useful quantitative supplement to community engagement in evaluation of EJ-oriented interventions. Internationally, optical and radar remote sensing data can be useful for observing changes in environmental risk parameters (i.e., air quality, water quality, flood inundation) as well as environmental benefits (green spaces, transportation infrastructure, etc.) as an evaluation tool.

National level screening tools are made available as a proxy for actual environmental risk and burdens, so users should take caution when drawing conclusions based on information presented by these tools. A binary classification of census tracts is based on distinct thresholds for EJ indicators, which produces a boundary at which very slight changes in a community can produce a completely different result. Some of the GIS tools have incorporated built-in corrections to account for potential misclassifications; for example, CEJST automatically classifies a census tract as disadvantaged when it is surrounded by disadvantaged tracts. When examining results and drawing conclusions from the more abstracted tools, one should keep in mind that despite the simplicity of their outputs on a map, they're representing environmental justice, which is a complex and ever-evolving concept.

When using the more manipulable tools, it is also important for users to exercise caution. Even though GIS functionality makes it mathematically possible for users to isolate and draw conclusions on smaller communities and even neighborhoods within census tracts, analysis of these smaller areas needs to be limited by the resolution of input data. These tools are not intended for use on very small scales; rather, they represent proxies of environmental risk that need to be verified on the ground.

Over time, these tools have evolved as higher quality data and web mapping technologies have become available. Also, these tools reflect an evolution of U.S. federal policy initiatives and priorities that indicate an expanding definition of environmental justice. Since the 1990s, Executive Orders addressing EJ have become a way for the executive branch to direct the national discourse. These Executive Orders, in some ways, have contributed to this broadening definition of EJ. Distributive EJ in relation to transportation and transportation infrastructure, for example, likely would not have been considered in the EJ movement when initiated in the 1960s. Now, our definition of EJ is increasingly multidisciplinary, which is beneficial as we learn more about cumulative burdens of socioeconomic, environmental, and health hazards. However, this new, expansive definition of EJ can also be harmful as it leaves significant room for interpretation and the regulatory framework for EJ assessment currently lacks clarity. Moving forward, incorporating EJ assessment requirements into NEPA could ensure that these executive actions are more durable.

While GIS tools useful in broadly screening for general demographic, socioeconomic, and other indicators of inequity in communities, it is important that these tools are always accessed in conjunction with engagement and consistent communication with affected community members. There is no way to evaluate the effectiveness of EJ-focused transportation projects and other initiatives without direct input from the full diversity of affected community members. Empowering individuals to participate in the public process is applicable in the U.S. and beyond, as GIS tools are increasingly available online, and there are more opportunities for individuals to contribute to these tools.

Our foregoing analysis has focused on GIS-based tools for EJ assessment that have been produced by the U.S. federal government. Directly relevant to U.S. practitioners, this evaluation of the strengths and weaknesses of various approaches can also be useful to transportation professionals in other countries that are prioritizing EJ at the national or subnational level, and to international development experts. For instance, the Canadian National Collaborating Centre for Environmental Health hosts a GIS-based website "HealthyPlan.City" (https://healthyplan.city/en) that depicts priorities for improving equity, health and well-being of vulnerable Canadians, including mapping access to public transit. The EJAtlas Collective, a collaboration of academic institutions and international nonprofits, maintains the EJAtlas Global Atlas of Environmental Justice (https://ejatlas.org/), presenting case studies of environmental injustice around the world, including infrastructure and the built environment.

6. Conclusions

Environmental Justice is also growing as a federal policy priority in the U.S., and it is likely to receive increased attention in the environmental impact assessment review process in the coming years, particularly if President Biden is retained for a second term. On the international stage, Environmental Justice is gaining traction, particularly relating to climate justice, water access, and the international waste / e-waste trade. GIS methods are beneficial for identifying inequity and promoting environmental justice in our communities, and as online GIS sources are updated with annual changes in demographic and socioeconomic data, they can be useful for evaluating changes within a community over time in response to EJ-focused initiatives. Publicly available, online resources for GIS assessment are useful for transportation practitioners conducting environmental reviews. Utilizing data from these tools promotes procedural justice to enhance community engagement throughout the NEPA process. Data from these can also be utilized to promote distributive justice, as transportation practitioners design, analyze alternatives, and assess community impacts for transportation projects. However, it is important to prioritize communication with community members in evaluating the effectiveness of EJ-focused transportation policy initiatives and infrastructure design.

CRediT authorship contribution statement

Amber Spriggs: Conceptualization, Data curation, Investigation, Methodology, Formal analysis, Software, Writing – original draft. **Robin Rotman:** Conceptualization, Methodology, Supervision, Writing – review & editing. **Kathleen Trauth:** Funding acquisition, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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