

VULNERABILITY ASSESSMENT GUIDE

This document presents the framework, methodologies, and data tools recommended for use by municipalities in conducting a vulnerability assessment. It is informed by a comprehensive assessment developed for the City of Southfield, available for reference [here](#).

What is vulnerability?

Vulnerability, as defined by the World Health Organization, refers to “the conditions determined by physical, social, economic, and environmental factors or processes which increase the susceptibility of an individual, a community, assets, or systems to the impacts of hazards.”¹ In the context of city planning, it is shaped by historical, cultural, political, institutional, and natural resource processes, and includes conditions such as “...living in disaster-prone areas or poor housing, ill-health, political tensions, or a lack of local institutions or preparedness measures.”¹

It is based on ideals of **environmental justice**, which the state of Michigan defines as “...the equitable treatment and meaningful involvement of all people, regardless of race, color, national origin, ability, or income, and is critical to the development and application of laws, regulation, and policies that affect the environment, as well as the places people live, work, play, worship, and learn.”²

What is a vulnerability assessment?

A vulnerability assessment is a systematic process by which a municipality can take stock of the hazards present in its environment, the sensitivities of its populations, and the ability for its communities to respond and cope with change. In addition to informing municipalities about the hazards and sensitivities their communities live with, it can inform future research and planning, pinpoint gaps in data collection, inform community engagement efforts, and outline actionable next steps the city can take to improve the wellbeing of its residents.

Vulnerability assessments can vary greatly depending on the focus of the report, availability of data, scale of the project, and capacity of the reporting team. This guide will provide direction on the use of **screening tools** as primary data sources for assessing vulnerability, which are appropriate to gain a high-level, initial understanding of

vulnerability. However, the structures and methodologies used in this report are highly adaptable and could serve to inform other types of vulnerability assessments.

CONDUCTING A VULNERABILITY ASSESSMENT

Step I: Establishing a Framework

As established previously, there is no standardized way for a municipality to conduct a vulnerability assessment. However, these three components are assessed across most reports:

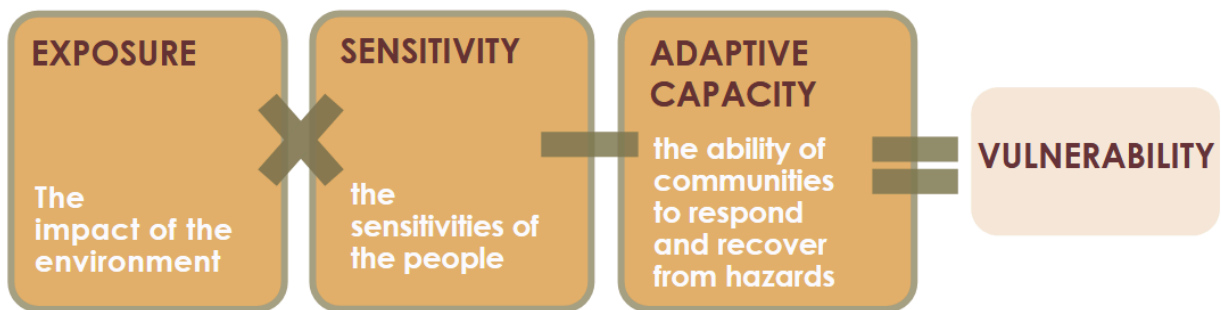
Exposure: Refers how much or little individuals, communities, and populations experience a certain hazard; this can be thought of as the impact of the environment.

Sensitivity: The physiological, socio-economic, and community design factors that increase susceptibility to hazards; this can be thought of as the sensitivities of the people.

Adaptive Capacity: A community's ability to adjust, limit and cope with potential hazards or exposures.

Formula for Vulnerability

These three components can be thought of as a “formula” for vulnerability, as shown in the figure below. Analyzing all three components will provide city officials with a holistic understanding of the hazards their communities face, the sensitivities they live with, and the ways in which they are able to respond and recover from those hazards.



The International Council for Local Environmental Initiatives, also known as the Local Governments for Sustainability is a nongovernmental, international organization that promotes sustainable development. They have created a [Climate Risk and Vulnerability Assessment Toolkit](#) that outlines a variety of resources to guide a vulnerability assessment.

This document provides guidance on the interpretation and utilization of exposure and sensitivity data. It does not cover adaptive capacity, which requires a larger capacity and time investment than what was available in the development of this guide. However, an adaptive capacity study is highly recommended to gain a full understanding of vulnerability.

These are the key components of the report:

Introduction:

- Includes a definition of vulnerability, the purpose of the report, and outlines the methodology

Context:

- Familiarizes the reader with your municipality, including demographic and spatial information.

Exposure

- Analysis and discussion of exposure data; highlights key indicators of hazards in the community.

Sensitivity

- Analysis and discussion of sensitivity data; highlights key indicators of sensitivities in the community.

Areas of Especially High Vulnerability

- Highlights census tracts displaying especially high levels of vulnerability.

Recommendations

- Outlines actionable next steps the municipality can take to address vulnerability.

Step II: Understanding Data Tools

Screening Tools

This guide will focus on the use of **environmental justice screening tools**, which are geographic information system (GIS) tools that use data to identify communities that may be disproportionately impacted by environmental hazards. Examples of tools include **MiEJScreen**, developed and maintained by the Department of Environment, Great Lakes, and Energy (EGLE), and the **U.S. Climate Vulnerability Index (CVI)**, developed and maintained by the Environmental Defense Fund, Texas A&M University, and Darkhorse Analytics.

Screening tools provide high-level proxies for actual risk or exposure to hazards. They are a useful first step in identifying communities that may be impacted by environmental hazards, but cannot determine the presence or absence of environmental justice concerns. Data from these tools can be used to inform future research and planning, target resources (such as distribution of funding or services), and foster discussion.

They provide high-level understandings of vulnerability and are appropriate for projects with shorter timelines or areas that lack data collection or access to data.

Recommended Screening Tools

[Climate and Economic Justice Screening Tool \(CEJST\)](#)

CEJST is a screening tool developed in support of the Justice40 Initiative. The Justice40 Initiative was a Biden-era directive that aimed to redistribute 40% of benefits from certain federal programs to disadvantaged communities. If census tracts were above the 90th percentile for one socioeconomic indicator **and** one environmental hazard indicator, they were considered disadvantaged. CEJST maps these disadvantaged census tracts while providing nation percentile rankings for a variety of vulnerability data. While this methodology effectively pinpoints concentration of vulnerability, it does not provide a holistic understanding of vulnerability. CEJST provides a starting point to understand vulnerability, but we recommend the examination of vulnerability beyond the designated “disadvantaged” census tracts identified by the tool.

[MiEJScreen](#)

MiEJScreen is an environmental justice screening tool designed by EGLE to “...examine and map environmental, health, and socioeconomic indicators to identify communities in Michigan that may be disproportionately affected by environmental hazards.”

The tool allows for comparison of exposure and sensitivity data across census tracts, counties, and regions in Michigan. Each vulnerability indicator identified within the exposure and sensitivity categories is assigned a percentile based on a ranking of raw values or percentages from every census tract in the state compared to one another. This results in a standardized ranking of exposure or sensitivity across the state.

[Climate Vulnerability Index \(CVI\)](#)

The Climate Vulnerability Index is a climate vulnerability screening tool, which focuses on "...visual[izing] how drivers of cumulative vulnerability disadvantage communities across the United States." It seeks to provide a better understanding "...of the intersections between growing climate risks and pre-existing, long-term health, social, environmental, and economic conditions."

The CVI functions similarly to MiEJScreen by providing percentile rankings of vulnerability for specific indicators of sensitivity and exposure. It also measures various risks related to climate change, such as flood risk.

Demographic Data

Can be sourced from the Census, however the **[Southeast Michigan Council of Governments \(SEMCOG\)](#)**, a nonprofit organization of governments that supports regional planning through its technical, data, and intergovernmental resources provides demographic data in ways relevant to a vulnerability assessment.

[Demographic Emphasis Areas](#)

The Demographic Emphasis Areas is an interactive tool that provides demographic information across seven counties in Southeast Michigan. The tool compiles important demographic indicators of vulnerability such as disability, minority population, and poverty level. It is a data source from which communities, government actors, and other stakeholders can easily access important socioeconomic information to assist in effective planning.

[Community Profiles](#)

The SEMCOG Community Profiles are detailed reports of demographic data and analysis spanning across Southeast Michigan. They cover a range of topics, including

basic demographic information, economy and jobs, housing, transportation, environmental and land use.

Step III: Data Interpretation and Visualization

Vulnerability Indicators

Vulnerability is composed of exposure and sensitivity data, as explained in Step II. The exposure and sensitivity data collected from screening tools are composed of individual indicators, which measure or estimate the impact of specific environmental hazards or population characteristics.

Example: MiEJScreen Indicators

For example, MiEJScreen organizes exposure data into two categories: environmental exposure and environmental effects. Environmental exposure refers to indicators that measure air quality (e.g. exposure to PM 2.5) while environmental effects refers to indicators that measure proximity to hazardous sites (e.g. proximity to hazardous waste facilities).

Similarly, MiEJScreen divides sensitivity data into two categories: sensitive populations and socioeconomic factors. Sensitive populations primarily refers to health data (e.g. percentage of populations with asthma) while socioeconomic factors refer to the demographic or socioeconomic characteristics that might make a community more vulnerable (e.g. percentage of households in poverty).

Organizing Data

Depending on the scale at which data is collected and the size of your municipality, you may be collecting many indicators, each with their own percentile ranking of exposure or sensitivity. For example, if data is collected at the census tract level and your municipality has twenty tracts, you will be comparing twenty scores per indicator. You might be comparing forty or so indicators in total - that's a lot of data.

In order to make sense of this data, some organization is required. One way to do this is to create “levels” of vulnerability based on percentile score ranking. For example, indicator scores that fall into the 80-99th percentile range might qualify as “High-Level Vulnerability”; this captures the top 20% of indicator scores. Scores that fall into the 75-80th percentile range might qualify as “Mid-Level Vulnerability,” capturing scores that are higher than the majority (75%) of the population. Scores that fall below the 75th percentile range might qualify as “Low-Level Vulnerability.” Indicator scores can then be grouped and referred to as falling into high, mid, or low-level vulnerability. For example, you might be able to say that “20% of census tracts in the municipality fall into high vulnerability for exposure to diesel particulate matter,” without needing to name the individual indicator scores for each tract. This will improve the legibility of your assessment and allow readers to gain a quick understanding of the degree to which a community is experiencing vulnerability.

High-Level Vulnerability: within the 80-99 th percentile
Mid-Level Vulnerability: within the 75-80 th percentile
Low-Level Vulnerability: under the 75 th percentile

Data Visualization

Data visualization is another valuable method to improve the readability of a vulnerability assessment. Particularly, mapping can support data analysis and text by presenting large volumes of data in a digestible format that facilitates reading comprehension. Maps also provide a spatial understanding of vulnerability, allowing readers to understand where vulnerability is most present or concentrated.

Step IV: Data Analysis

Data Collection and Cleaning

Once you have developed a system to organize your data, analysis can begin. To optimize this process, it is recommended to use some kind of data analysis program. Excel or similar spreadsheet programs are easily available and user-friendly. Your indicator scores should be in a table, organized by census tract (or whatever scale you

are using). Most data sources will allow you to download CSV or Excel files; see below for an example of what these tables should look like. In some cases, you may need to manually create your tables.

CensusTract	Sensitive Populations Composite Score	Asthma	Cardiovascular Disease	Low Birth Weight Infants	Life Expectancy	Diabetes (CVI)	Stroke (CVI)	High Blood Pressure (CVI)
1603	90	85	98	94	83	76	80	80
1604	86	81	93	73	73	91	92	92
1605	52	72	64	65	34	67	68	71
1606	70	73	46	71	35	72	68	75
1607	55	78	63	87	14	81	73	89
1608	72	82	85	17	61	82	80	91
1609	78	80	84	75	63	40	35	50
1610	75	84	88	96	59	88	87	93
1611	75	86	91	74	74	86	90	94
1612	71	81	62	83	40	71	58	82
1613	62	74	62	39	46	58	51	70
1614	74	79	77	68	58	96	97	95
1615	55	76	71	33	63	76	64	84
1616	61	80	64	68	49	63	61	68
1617	65	83	69	85	43	82	73	85
1618	71	86	77	68	74	82	76	84
1619	76	79	68	78	31	74	68	75
1620	74	81	76	80	45	91	87	92
1621	83	85	66	80	86	83	78	87
1622	64	88	78	99	10	86	83	91
1623	68	89	81	97	24	89	83	94
1624	67	88	75	68	55	79	73	78
1625	75	86	71	82	86	79	76	85

Table of Sensitivity Indicators. The values represent indicator percentile scores. Data Source: MIEJScreen and CVI.

Analysis and Determining Significance

The goal of analyzing indicator scores

These tables will allow you to quickly determine the levels of vulnerability each indicator presents for your municipality. If you are using Excel, the IFCOUNT function will allow you to determine what percentage of your municipality falls into high, medium, and low vulnerability for any given indicator. From here you can determine which indicators present a significant concern for your municipality.

One important aspect of your analysis will be to determine what percentage of high or mid level vulnerability is significant. For example, is it significant if 20% of census tracts in your municipality are in high vulnerability for exposure to particulate matter (PM) 2.5? How about 15%? While there are many approaches one can take to determining significance in this way, we recommend around 20-25% as a significant representation of vulnerability.

A Note About Significance

Indicators that do not display significant levels of vulnerability should still be featured in your report, especially if they are a part of a particular dataset. For example, out of the six indicators that make up Environmental Exposure under MiEJScreen, only five may show significance for your municipality. The sixth indicator should still be mentioned in your analysis and its data featured in the appendices of your report, to show that you have considered the full dataset.

Step V: Writing Your Report

Once the technical analysis has been completed, the report writing can begin. The report should follow the format outlined at the beginning of this document:

- 1. Introduction**
- 2. Context**
- 3. Exposure**
- 4. Sensitivity**
- 5. Highest Vulnerability**
- 6. Recommendations**

Introduction

The introduction should include:

- Who the author of the report is, what the report is about, and why it is important. What will it provide your municipality with?
- A definition and framework for vulnerability
- A review of the data sources and methodology used in the report.

Context

The context section of the report serves to familiarize the reader with your municipality. This section should “set the stage” for the rest of the report by providing general facts, demographic information, and highlighting influential components of your municipality, such as highways, rivers, industrial sites, etc. Providing a map of the municipality also provides a spatial understanding for the reader.

Exposure and Sensitivity

This section will house your data analysis, and should make up the bulk of your report.

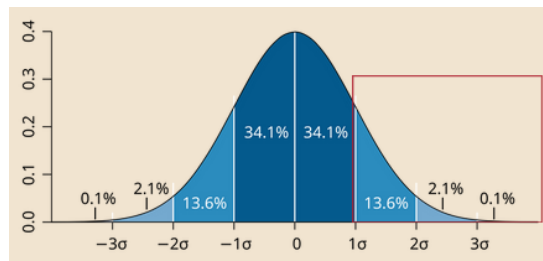
Effective communication of your data is just as important as its interpretation and analysis. We recommend writing about exposure and sensitivity data separately, in order to provide a clear picture of both conditions in your report. When discussing relevant indicators, be sure to address their importance. What potential impacts might they have?

We highly recommend the use of maps in these sections. They provide a spatial understanding of vulnerability, in which the reader can see where vulnerability is located or concentrated in your municipality.

Areas of Especially High Vulnerability

Identifying areas of especially high vulnerability provides a concise understanding of where vulnerability is concentrated and highlights communities that are in most need of service.

A variety of methodologies can be employed to highlight these areas. We recommend utilizing statistical analysis to highlight areas with indicator scores that are one standard deviation above the mean. Values that fall one standard deviation above the mean represent the top 16% of data, and are relatively high compared to the average.



The red box represents the data captured by the statistical analysis used for this report.

Utilizing the tables created previously, the average should be calculated for each individual indicator, in addition to the standard deviation. Then, the average and standard deviation should be added together to calculate a “threshold” score. This should be done separately for exposure and sensitivity data. Indicator scores that fall above the threshold score display either *heightened exposure* or *heightened sensitivity*.

Especially High Vulnerability

Utilizing the data collected for census tracts displaying heightened exposure and/or heightened sensitivity, you must now determine which census tracts are displaying especially high vulnerability. To do so, we recommend establishing a threshold number of indicators that each census tract must display in **both** exposure and sensitivity. This number may vary depending on your data, but around two or three indicators should suffice.

For example, this might mean that a census tract must display heightened exposure for three indicators **and** heightened sensitivity for three indicators in order to qualify as especially vulnerable.

Recommendations

The recommendations that come out of your report should outline next steps for your municipality to carry out. They should be informed by your report findings, be clear in their objectives, and provide practical actions that your municipality can execute.

Some suggestions for crafting recommendations:

- Highlighting gaps in data collection or knowledge. Can you recommend an action to address this?
- Pursuing further investigation. This is especially relevant if you are using screening tools as your data source. Additional risk assessments can confirm the presence of vulnerability in your municipality
- Reinforcing actions currently taking place. Is your municipality pursuing any plan or initiative that might incorporate vulnerability data? It might be impactful to reinforce the importance of those initiatives, or highlight how vulnerability data can be incorporated.

That's it! You are now prepared to conduct your own vulnerability assessment.

References

¹ Kruse, Katie, et al. "MiEJScreen1.0 Michigan Environmental Justice Mapping and Screening Tool Technical Report." Michigan Department of Environment, Great Lakes, and Energy, July 2024.

² World Health Organization. "Vulnerability and Vulnerable Populations."

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