The National Business Vulnerability Index & Map

September 2024

Smart Energy Design Assistance Center (SEDAC) at the University of Illinois

Overview of the Business Vulnerability Index

The Business Vulnerability Index and Map was built by the Smart Energy Design Assistance Center (SEDAC) at the University of Illinois, the California Green Business Network (CAGBN), and the users of GreenBizTracker. GreenBizTracker is an online certification program management platform that aids in national data collection and management for 8 states and green business programs nationally. The map is a new, first of its kind, index to identify businesses in need of support across a variety of factors and data.

This index and map were developed to identify businesses that are vulnerable to climate, economic, socio-economic, or environmental impacts in their area. The index and map can be used to identify businesses in specific census tracts that are vulnerable to a variety of factors and subfactors. Our intention is that green business programs can then fill specific needs for businesses in these census tracts and that are experiencing vulnerabilities. We hope this map will continue to grow in use and support equity goals in green business programming nationally.

Overview of Map Development

The map was developed through grant funding from the U.S. Environmental Protection Agency (EPA) National Environmental Information Exchange Network (NEIEN). To begin the mapping process, SEDAC identified key questions that the map should answer around business equity and vulnerability. We wanted to identify businesses not only based on socio-economic and environmental factors, such as those under EJScreen, but understand climate and economic impacts to further identify vulnerabilities. We determined that this would help users understand both economic and climate drivers of vulnerability, along with pollution and socio-economic burdens.

Based on feedback from GreenBizTracker users, or green business programs nationally, we determined that the map would have four factors – environmental, economic, socio-economic, and climate. After finalizing the factor categories, we asked GreenBizTracker users about map attributes and environmental layers most important to their programs to help identify subfactors for each category. Based on user feedback, we identified a total of 17 datasets that would be useful to green business programs to tell a detailed story about vulnerabilities that may face a business. We then had each GreenBizTracker user and program prioritize datasets by ranking those that are most important to their program and region.

Based on this feedback, we developed a weighting for each time zone in the U.S. — Pacific, Mountain, Midwest, and East Coast. This regional weighting ensured that the national index and weightings would be even based on the number of respondents per region. Then, using the multiple-criteria decision analysis (MCDA) weighting method, we weighted each region's response for the 17 sub-categories and then normalized the weightings on a scale of 0 to 1. This ranking and weighting process developed the index of factors and subfactors for the national map. More information on the weighting methodology can be found later in this document. The weighting values and formulas can be found later in this document as well. After the weightings for each factor and subfactor was completed, we mapped the layers in ArcGIS and tested it with green business program users.

In the map, we show a color ramp that indicates the national medians of the composite score for a tract. A high vulnerability tract has a composite score of 56% or higher; a medium tract

has a composite score of 41.5%; and a score of 28% or lower means that the census tract has low composite vulnerability. A census tract can be clicked, and a menu pops up to display all factor and subfactor data, as well as the tract's composite score. There is a score for each subfactor, factor, and a composite score that takes all factors and subfactors into account.

A user can zoom into the map using the OpenStreet base layer and see current business information in a census tract. This information helps green business program staff understand what factors are impacting a business in a tract and how they might help them reduce vulnerability, or environmental impacts.

We look forward to the evolution of this map over time to help green business programs serve businesses that are vulnerable to a variety of different factors to help them thrive.

Index and Map Datasets

The map and business vulnerability index are comprised of 17 datasets from four primary sources:

- EJScreen
- U.S Census (2019 data)
- FEMA National Risk Index (NRI)
- American Communities Project

Three additional datasets used data outside of these main four sources. All data used in the map is from 2021 and 2022, as these were the most complete and current datasets available. The U.S. Census data is from 2019, as that is the most complete census period available. Additionally, asthma data and energy affordability data are from 2015, the most recent years available. Definitions of each data set are listed in Appendix A, but a complete list of data sets and sources by factor is below.

- Environmental Factor
    - Proximity to traffic (EJScreen, 2022)
    - Particulate matter (PM25) (EJScreen, 2022)
    - Hazardous waste proximity (EJScreen, 2022)
    - Air toxics (EJScreen, 2022)
    - Asthma rates reported by physicians, not hospitalizations (CDC, US Census Data, 2015)

- Economic Factor
    - Energy affordability (Department of Energy Low-Income Energy Affordability Data Tool, 2015)
    - Food desert data – Low Income (LI) and Low Access (LA) at ½ and 10 miles (USDA NIFA, 2019)
    - Expected annual loss due to natural hazards (FEMA NRI, 2021)
    - Population loss/growth rate (US Census, 2014-2019)
    - Income loss rate (US Census, 2014-2019)

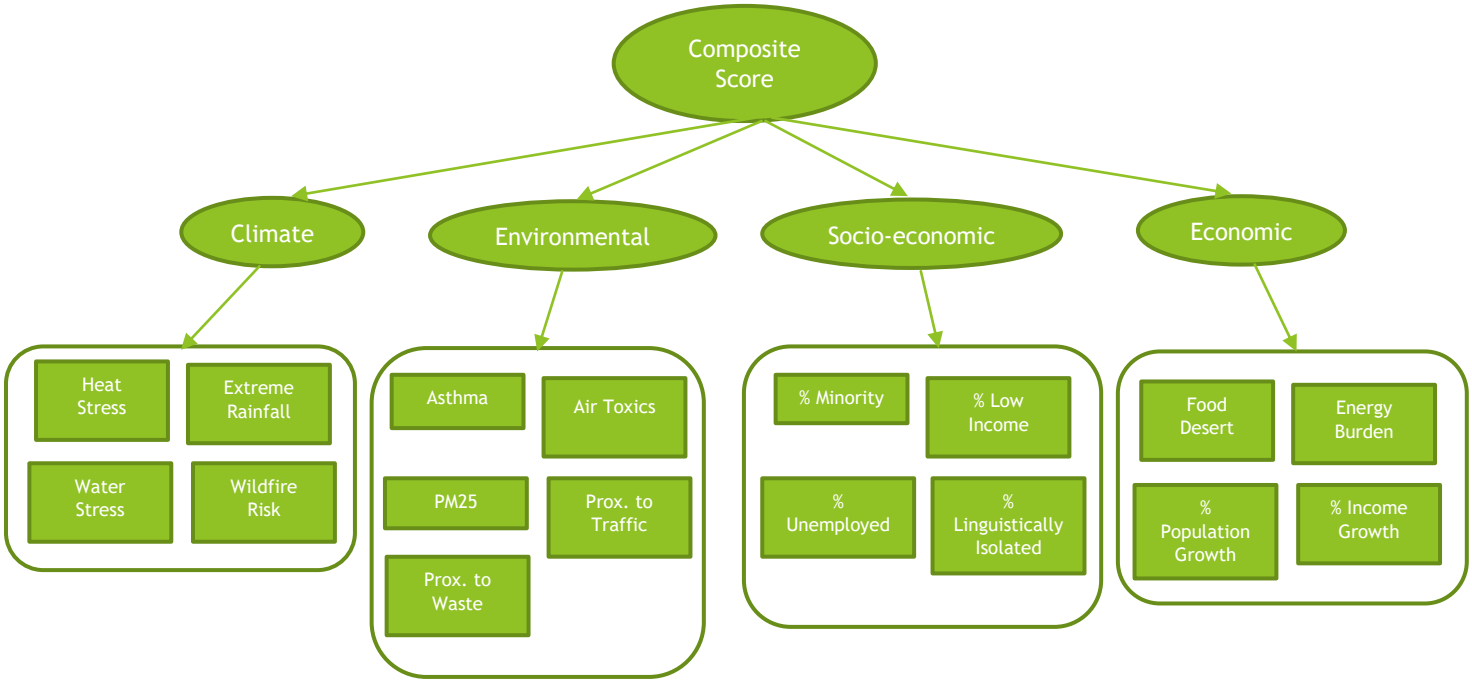
- Socio-Economic Factor
    - Percent people of color (EJScreen, 2022)
    - Percent low-income (EJScreen, 2022)

- Unemployment rate (EJScreen, 2022)
- Linguistically isolated rate (EJScreen 2022)

- Climate Factor
  - Water stress (American Communities Project, 2021)
  - Heat stress (American Communities Project, 2021)
  - Wildfire risk (FEMA NRI, 2021)
  - Extreme rainfall (American Communities Project, 2021)

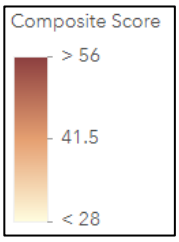
Understanding the Map Layers and Values

The Business Vulnerability Index and Map have a variety of attributes. The primary index that can be used to identify vulnerable census tracts is the composite score. The composite score comprises 4 factor scores, which in turn, comprise 4 to 5 sub-factor scores. The figure below outlines the nested structure of the factors and sub-factors.

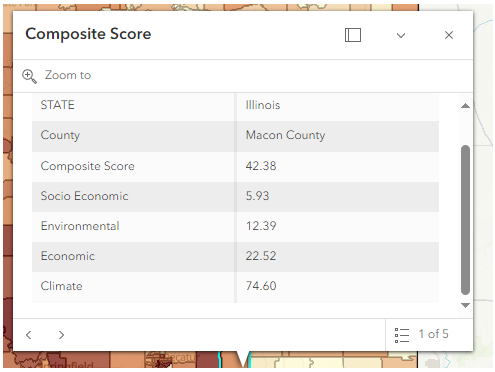


Each factor and subfactor has a score for the Census tract. All scores are standardized on a scale of 0 to 100, and higher scores indicate higher risk and vulnerability. By default, the map layers are colored as per the quantile ranges of their values. The result looks like a heat map for the country. All values are listed in percentages. census tracts with higher scores may be prioritized over those with low scores for the green business program.

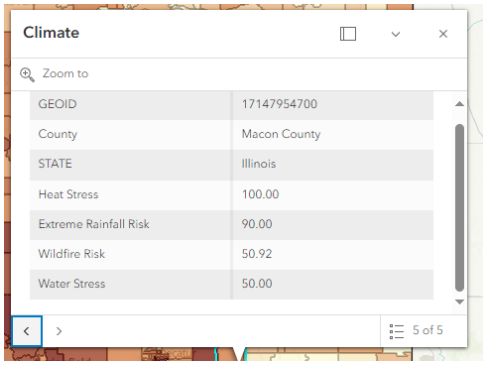
Let's review the Composite Score layer and its weightings as an example of how to interpret the map. The national median composite score is 41.5, or 41.5%. This means that the census tract is in the middle of the vulnerability index, meaning it has some vulnerabilities but is in the middle of that range.



A high composite score is 56, or 56%, or higher. This means that a census tract has high vulnerabilities in a factor or subfactor. A low composite score is less than 28, or less than 28%. This census tract has low vulnerabilities overall. The map is shown in a heat map format, meaning the darker the color on the census tract or layer, the more vulnerability that the census tract has.

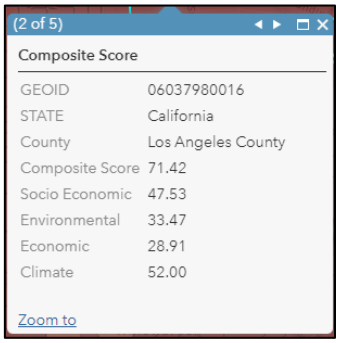


If a user is looking at an individual factor or subfactor, the higher the score, the higher rate of vulnerability of the census tract. Let's review the Composite Score table on the map, or the photo on the left. In this census tract, the composite score is 42%, but it looks like the Climate factor is high for this tract, at 74.6%, or 75%. A user can then toggle over to the Climate factor using the arrows at the bottom of the box to look deeper at the Climate factor and its subfactors.

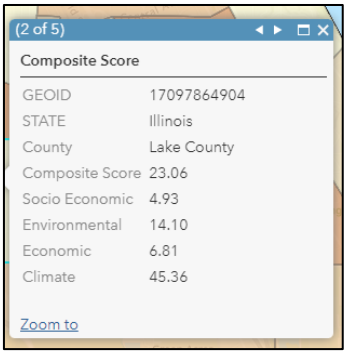


The photo to the right shows the Climate factor and its subfactors. After reviewing this table, we can see that the score for the subfactors under the Climate factor are high for heat stress (100%) and extreme rainfall risk (90%). The other two factors, wildfire and water stress are also at 50%. An interpretation of these scores could be that businesses in this tract should focus on heating and cooling efficiency, especially since heat stress is high. Also, extreme rainfall could damage the business' livelihood and space, so it may be in the business' best interest to ensure they are prepared for high rainfall events.

Here are a couple more examples:



Census tract 06037980016 in LA county, CA has a composite score of 71.42% (high, red). The pop-up shows the tract's score for the 4 factors — while the scores are moderately low in Environment and Economic, they are on the higher side for Climate and Socio Economic. This way, we can detect what component is causing the composite score to be high or low.



Looking at another example, census tract 17097864904 in Lake County, IL has a low composite score of 23.06%. The pop-up shows that except for Climate, the tract scores low on all other sub-factors.

Appendix A. Dataset Glossary

Socio-Economic Factor:

- **Percent People of Color**
  - The percent of individuals in a block group who list their racial status as a race other than white alone and/or list their ethnicity as Hispanic or Latino. That is, all people other than non-Hispanic white-alone individuals. The word "alone" in this case indicates that the person is of a single race, not multiracial.
  - Source: EJScreen

- **Percent Low-Income**
  - Percent of individuals whose ratio of household income to poverty level in the past 12 months was less than 2 (as a fraction of individuals for whom ratio was determined).
  - Source: EJScreen

- **Unemployment Rate**
  - All those who did not have a job at all during the reporting period, made at least one specific active effort to find a job during the prior 4 weeks, and were available for work (unless temporarily ill).
  - Source: EJScreen

- **Linguistically Isolated** – percent in limited English speaking
  - Percent of households in which no one age 14 and over speaks English "very well" or speaks English only (as a fraction of households).
  - Source: EJScreen

Environmental Factor:

- **Proximity to Traffic**
  - Count of vehicles per day (average annual daily traffic) at major roads within 500 meters (or nearest one beyond 500 m), divided by distance in meters. Calculated from U.S. Department of Transportation National Transportation Atlas Database, Highway Performance Monitoring System.
  - Source: EJScreen

- **Particulate Matter**
  - Particulate matter (PM2.5) levels in air, micrograms per cubic meter (µg/m3) annual average. Source: EPA Office of Air and Radiation
  - Source: EJScreen

- **Hazardous Waste Proximity**
  - Count of hazardous waste management facilities (TSDFs and LQGs) within 5 km (or nearest one beyond 5 km), each divided by distance in km. Calculated from EPA RCRAInfo database.
  - Source: EJScreen

- **Air Toxics**
  - Air toxics respiratory hazard index (the sum of hazard indices for those air toxics with reference concentrations based on respiratory endpoints, where each hazard index is the ratio of exposure concentration in the air to the health-based reference concentration set by EPA).
  - The EPA Air Toxics Screening Assessment (AirToxScreen) is EPA's ongoing review of air toxics in the United States. EPA developed AirToxScreen as a screening tool for state, local, and tribal air agencies. AirToxScreen's results help these agencies identify which pollutants, emission sources and places they may wish to study further to better understand any possible risks to public health from air toxics.
  - Source: EJScreen

- **Asthma Data** – data source - Centers for Disease Control and Prevention, 2022 release by PLACES
  - This dataset contains model-based census tract level estimates for the PLACES 2022 release in GIS-friendly format. PLACES covers the entire United States — 50 states and the District of Columbia (DC) — at county, place, census tract, and ZIP Code Tabulation Area levels. It provides information uniformly on this large scale for local areas at 4 geographic levels. Estimates were provided by the Centers for Disease Control and Prevention (CDC), Division of Population Health, Epidemiology and Surveillance Branch.
  - The health outcomes include arthritis, current asthma, high blood pressure, cancer (excluding skin cancer), high cholesterol, chronic kidney disease, chronic obstructive pulmonary disease (COPD), coronary heart disease, diagnosed diabetes, depression, obesity, all teeth lost, and stroke.
  - Model-based estimate for crude prevalence of current asthma among adults aged >=18 years, 2020
  - Sources: PLACES: Census Tract Data

Economic Factor

- **DOE Low-Income Energy Affordability Data**

        - The Low-Income Energy Affordability Data (LEAD) Tool was created to help stakeholders understand housing and energy characteristics for low- and moderate-income households. Using data, maps, and graphs from the LEAD Tool, stakeholders can make data-driven decisions when planning for their energy goals.
        - Source: LEAD Tool (Department of Energy)

- **Food Desert Data: Layer: ½ and 10 miles – Orange**
    - The Food Access Research Atlas:
        - Presents an overview of food access indicators for low-income and other census tracts using different measures of supermarket accessibility;
        - Provides food access data for populations within census tracts; and
        - Offers census-tract-level data on food access that can be downloaded for community planning or research purposes.
        - Low-income census tracts where a significant number or share of residents is more than ½ mile (urban) or 10 miles (rural) from the nearest supermarket.
    - Source: U.S. Department of Agriculture https://www.ers.usda.gov/data-products/food-access-research-atlas/go-to-the-atlas/

- **Expected Annual Loss**
    - Expected Annual Loss (EAL) represents the average economic loss in dollars resulting from natural hazards each year. It is calculated for each hazard type and quantifies loss for relevant consequence types: buildings, people, and agriculture.
    - As the natural hazards of component of the National Risk Index, an Expected Annual Loss score and rating represent a community's relative level of expected losses each year when compared to all other communities at the same level. An Expected Annual Loss score is positively associated to a community's risk; thus, a higher Expected Annual Loss score results in a higher Risk Index score.
    - NRI Index – FEMA
        - The National Risk Index is a dataset and online tool to help illustrate the United States communities most at risk for 18 natural hazards. It was designed and built by FEMA in close collaboration with various stakeholders and partners in academia; local, state and federal government; and private industry.

- **Population Loss/Growth Rate**
    - 2014 - 2019 US Census data

- **Income Loss Rate**
    - 2014- 2019 US Census data
    - Source: FEMA

Climate Factor

- **Water Stress**

    - With the Biden administration elevating climate change concerns to the national agenda, the American Communities Project leveraged data from Four Twenty Seven, a physical climate risk data firm and affiliate of Moody's, to understand how the risks manifest by ACP type — and where populations and infrastructure may be especially vulnerable.
    - Four Twenty Seven analyzes several physical risks to the U.S. landscape, including sea level rise; hurricanes; extreme rainfall; water stress; and heat stress, characterized by higher temperatures. Many of Four Twenty Seven's projections through 2040 show the risks are regional, as illustrated in maps.
    - https://www.americancommunities.org/mapping-climate-risks-by-county-and-community/

- **Heat Stress**
    - Increasing temperatures have the potential to gravely impact public health. Affected communities are home to many lower-income families that often cannot afford air conditioning, work outdoors for a living, and/or live in difficult housing conditions. Four Twenty Seven's white paper "Heat and Social Inequity in the United States" examines heat vulnerability in detail.
    - Heat waves can also take a toll on physical infrastructure, particularly in cities, and the EPA recommends protecting roads and bridges with materials that can withstand heat as well as bolstering energy efficiency to avoid power problems. Arizona, for its part, maintains a detailed extreme heat response plan.
    - https://www.americancommunities.org/mapping-climate-risks-by-county-and-community/

- **Wildfire Risk**
    - A Wildfire is an unplanned fire burning in natural or wildland areas such as forests, shrub lands, grasslands, or prairies.
    - In the National Risk Index, a Wildfire Risk Index score and rating represent a community's relative risk for Wildfires when compared to the rest of the United States. A Wildfire Expected Annual Loss score and rating represent a community's relative level of expected building and population loss each year due to wildfires when compared to the rest of the United States.
    - Source: https://hazards.fema.gov/nri/map

- **Extreme Rainfall**
    - For extreme rainfall, the risk picture looks markedly different, covering more of America's interior. The Midwest's Ohio, Appalachia's West Virginia and Kentucky, and Washington State's coastline are dubbed red flag. But high-risk fans out across the Midwest as well as the South, Northeast, and Pacific Northwest. In March 2020, severe weather in the Midwest and Ohio Valley, including Missouri, Ohio, Kentucky, Tennessee, West Virginia, and Pennsylvania, caused $2.6 billion in damage, according to NOAA estimates. (Scroll over the map to see a county's risk level and community type designation.)

- Extreme Rainfall is measured by the number of historical floods, the frequency of future heavy rainfall events, and the intensity of prolonged periods of heavy rainfall. More intense patterns of extreme rainfall are expected to hit the Middle Suburbs particularly hard, as 62% of these 77 average-income, mostly white counties face red flag or high risk. Meanwhile, 58% of the 337 counties of Working Class Country, known for mostly white populations without much higher education, are red flag or high risk. The African American South is not far behind, with 56% of counties deemed red flag or high risk.
- Source: https://www.americancommunities.org/mapping-climate-risks-by-county-and-community/

Appendix B. Weighting Calculation

The weights used to calculate composite score and factor scores based on the sub-factor scores come from a national survey of GreenBizTracker users and program managers. Below are the formulae:

Composite Score = 0.32*Socio-economic + 0.23*Environmental + 0.25*Economic + 0.21*Climate

Socio-economic score = 0.27*%Minority + 0.28*%Ling.Isolated + 0.25*%LowIncome + 0.2*%Unemp

Environmental score = 0.2*Prox.Traf + 0.28*PM25 + 0.24*Prox.Waste + 0.28*AirToxics

Economic Score = 0.26*EnergyBurden + 0.14*FoodDesert + 0.18*EnvironmentLoss + 0.2*PopulationGrowth + 0.22*IncomeGrowth

Climate Score = 0.29*WaterStress + 0.34*HeatStress + 0.23*WildFireRisk + 0.14*ExtremeRainfall

Appendix C. Weighting Methodology and Approach

- Total Survey Response: 20
- 1 being highest rank and 4 or 5 being lowest rank
- Factors: Socio-economic Factors, Environmental Factors, Economic Factors, Climate Factor
- Following is the table showing sub factor in each factor.

Socio-economic Factors	Environmental Factors	Economic Factors	Climate Factor
Percent people of color	Proximity to traffic	DOE Low-Income Energy Affordability Data map	Water stress
Linguistically isolated	Particulate matter	Food desert data	Heat stress
Low income	Hazardous waste proximity	Building loss/growth rate	Flooding
Unemployment	Air toxics: asthma	Population loss/growth rate	Extreme rainfall
		Income loss rate	

- For the ‘Not a Priority’ option given in the survey, the value assign is 0 to not consider the parameter in the weigh calculation

Following are the steps for the weighing the factors and subfactors ranking data from survey. This method is based on **Multiple-criteria decision analysis (MCDA) method**.

1. **Calculate the average ranking for each parameter:** Add up the numerical values of all the items for each parameter and divide by the number of responses to get the average ranking for that parameter. For example, for taste, if there were 10 responses to the survey, add up the numerical values of all the items for taste and divide by 10 to get the average ranking.

2. **Calculate the weight for each parameter:** Subtract the average ranking for each parameter from the minimum possible ranking value and divide by the maximum possible ranking value. This will give you the weight for each parameter. For example, if the average ranking for X is 2, the weight for X would be (1-2)/(5) = -0.2. (minimum ranking-average)/(maximum ranking) would give us weightage. We subtracted it from 1 to remove the negative sign.

3. **Normalize the weights:** If you want the weights to add up to 1, you can normalize the weights by dividing each weight by the sum of all the weights.
   These normalized weights can then be used to weigh the ranking data and calculate the overall score for each item.