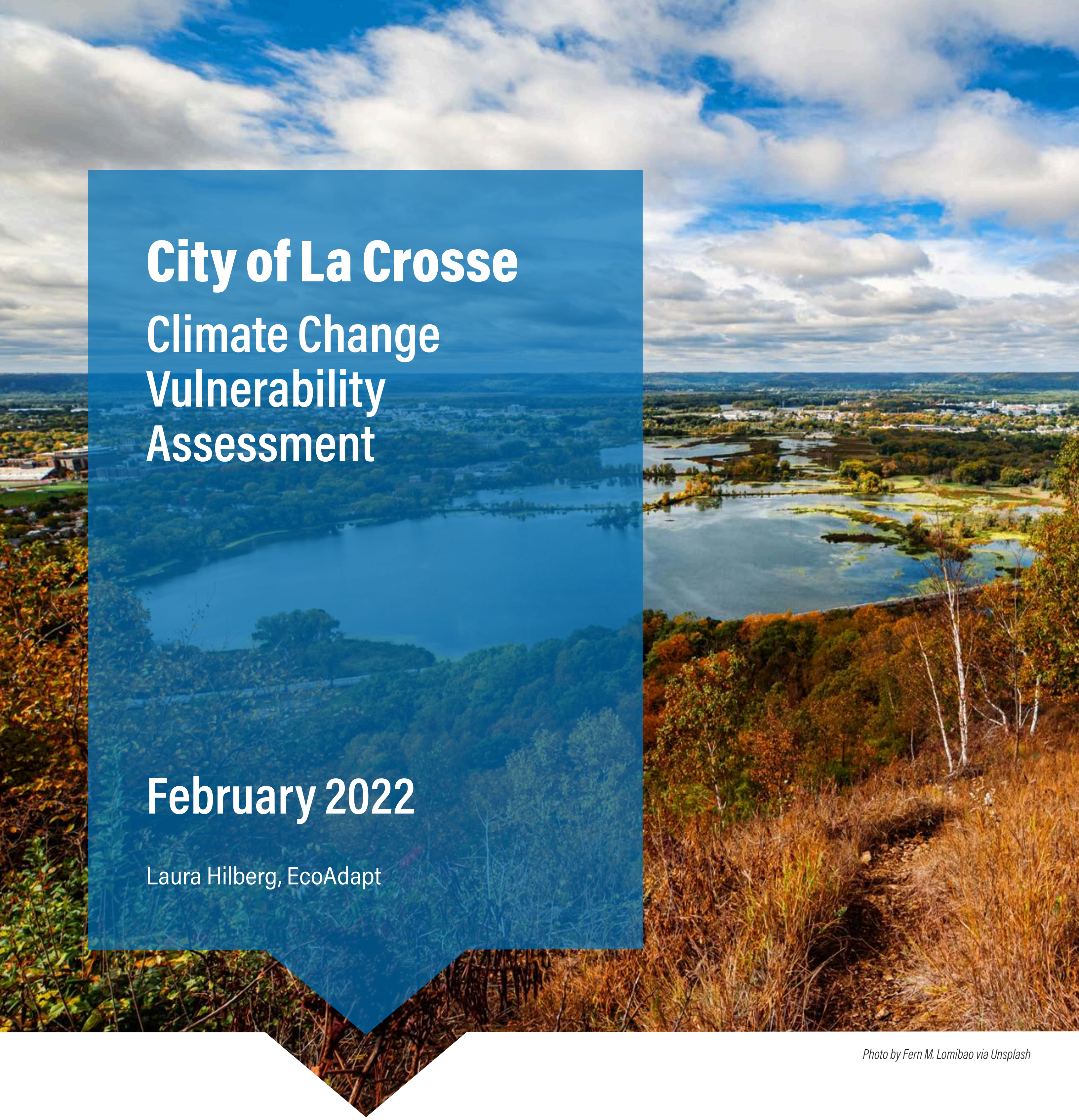


# City of La Crosse

## Climate Change Vulnerability Assessment

## February 2022

Laura Hilberg, EcoAdapt

*Photo by Fern M. Lomibao via Unsplash*

**Recommended Citation:**
Hilberg, LE. 2022. City of La Crosse Climate Change Vulnerability Assessment. EcoAdapt, Bainbridge Island, Washington.

# Table of Contents



*Photo by Fabian Keller via Unsplash*

# Introduction

Climate change is a global process, driven by emissions of greenhouse gases that impact long-term trends in temperature and precipitation as well as the likelihood and severity of extreme events such as droughts, floods, and wildfires. These changes are felt at global, national, regional, and local scales, and they are already being observed in La Crosse, where winters have become significantly warmer and wetter and localized flooding is increasingly common during heavy rain events. Over the coming century, these changes are likely to become even more significant, resulting in wide-reaching impacts across all sectors of the community.

*Photo by Erin Larson via Unsplash*

Climate change **adaptation** is focused on preparation for and response to climate changes that are already occurring, or will occur in the future. Along with climate change **mitigation**, adaptation plays a critical role in comprehensive community plans for addressing climate change. The adaptation planning process (Figure 1) is focused on systematically evaluating the likely impacts of climate change on the community and identifying strategies that can be implemented to increase resilience to those changes. The result of this process is intentional integration of climate change into plans, programs, projects, and operations across the community, ensuring a healthy, thriving city that is well-equipped to cope with the challenges of climate change but also able to take advantage of any opportunities that arise. While there are many different climate adaptation planning frameworks, they generally consist of the same steps: (1) define project scope, (2) assess vulnerability, (3) identify adaptation strategies, (4) implement strategies, and (5) monitor, evaluate, and adjust strategies, as needed (Figure 1).

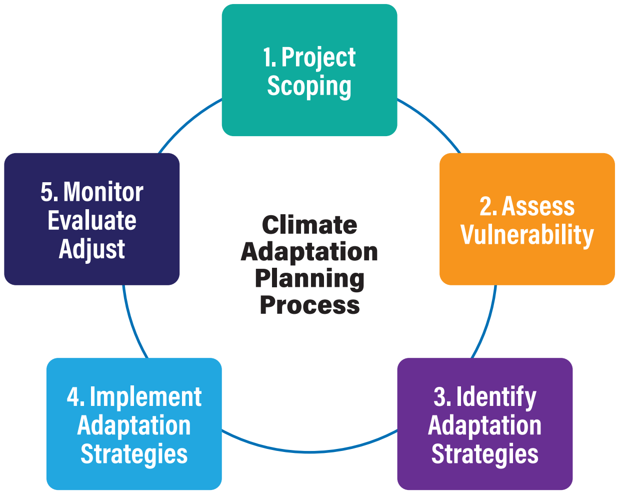



**Figure 1**. Steps in a basic climate adaptation planning process.

# Definitions of Key Terms[1]

**Adaptation** focuses on adjustments in natural or human systems in response to changing climate conditions. Adaptation is how we prepare for, respond to, and recover from changes that we are already experiencing or are anticipated to experience. These efforts can occur at individual, community, and societal scales through approaches such as home weatherization, the use of green infrastructure, changes to zoning or permitting requirements, and climate-informed emergency preparedness and hazard mitigation planning, among many others.

**Mitigation** focuses on reducing the magnitude and rate of climate change through measures that reduce greenhouse gas emissions or increase carbon sequestration and storage. Examples include reducing vehicle miles traveled, using renewable energy sources, or expanding urban tree canopies.

**Vulnerability** is the degree to which natural, built, and human systems are susceptible to harm. Vulnerability assessments include consideration of the following three components of vulnerability:

- **Likelihood** is the degree to which a community is exposed to significant changes in climate, and considers both the anticipated direction and magnitude of change.
- **Consequence** is the degree to which a community is affected by exposure to a changing climate, and considers both the anticipated impacts of climate stressors as well as the impacts of pre-existing conditions.
- **Adaptive capacity** is the ability to adjust to climate change to minimize potential damages, take advantage of opportunities, or cope with consequences.

[1] Definitions based on the IPCC Data Distribution Centre Glossary: https://www.ipcc-data.org/guidelines/pages/glossary/glossary—a.html (IPCC 2007, 2014)

Vulnerability assessments are the second step in the adaptation planning process, after establishing project goals, geographic boundaries, the time frame of interest, and other foundational planning considerations. The vulnerability assessment step of the adaptation planning process involves evaluating the impacts of climate change on a community; characterizing the community's ability to minimize or cope with impacts; assigning likelihood, consequence, and adaptive capacity rankings; and summarizing overall vulnerability based on rankings, impacts, and adaptive capacity information. Vulnerability assessments improve understanding of how climate change is likely to impact a community, and they include consideration of the likelihood of exposure to climate change, the consequence of those changes, and the community's capacity to adapt to those changes. Likelihood and consequence together give an estimation of risk which, when combined with adaptive capacity, provides an overall picture of vulnerability (Figure 2). It is important to evaluate all three components – likelihood, consequence, and adaptive capacity – in order to gain a holistic perspective on the factors that are driving vulnerability [1].

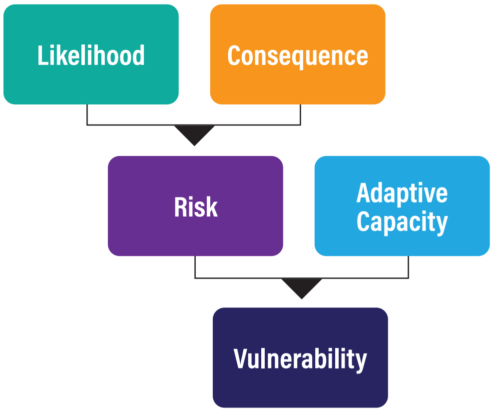



**Figure 2.** The three components of vulnerability.

This Climate Change Vulnerability Assessment has been developed as part of the broader City of La Crosse Climate Action Plan project effort, and is designed to (1) provide up-to-date information on climate changes that are expected for La Crosse; (2) describe how those changes may impact the community across nine different sectors, or topic areas, and for populations that may be most vulnerable to climate change; and (3) based on this information, identify key vulnerabilities to support the establishment of strategic goals and actions in the City's Climate Action Plan. Information from this vulnerability assessment and the resulting climate action plan can be incorporated into updates of the City's Comprehensive Plan and other community planning efforts, and can also be used more generally to increase climate-informed decision-making by the City and the broader community.

## SECTORS CONSIDERED IN THIS ASSESSMENT:

- Land Use and Housing
- Transportation and Mobility
- Buildings and Energy
- Waste Management
- Water and Wastewater
- Health and Safety
- Local Food and Agriculture
- Greenspace and Tree Canopy
- Economy

**CITY OF LA CROSSE, WI**

**Area: 21.7 square miles • Total Population (2021): 52,185 • Density (2021): 2,404.8 people per square mile**
**Households (2021): 21,239 • Median Household Income (2020): $46,438**

*Demographic based on US Census QuickFacts.*

# Climate Trends and Projections for La Crosse

*Photo by Adrian Korpal via Unsplash*

**In La Crosse:**

**Since 1950:**

+3°F increase in annual temperatures (+6°F in winter lows, +1°F in summer highs)

**By 2060:**

+6°F increase in annual temperatures (+7°F in winter lows, +5°F in summer highs)

14% decrease in frost-free nights

**By 2100:**

+11°F increase in annual temperatures (+12°F in winter lows, +10°F in summer highs)

29% decrease in frost-free nights

Prior to evaluating community vulnerability to climate change, it is important to understand the changes that have already occurred as well as those that the City of La Crosse is likely experience over the next 30–80 years. The following information summarizes historical trends and future projections in climate factors that are likely to impact the community, which include air temperature, extreme heat, precipitation (rain and snow), extreme precipitation, storms, flooding, and drought.[2]

## Air Temperature

Over the past 70 years, the average annual temperature (i.e., average daily temperature averaged over the whole year) for Wisconsin has increased by 2–3°F (Figure 3). Seasonal changes in temperature have been more extreme, with much larger changes (3–7°F) observed in winter low temperatures (i.e., minimum daily temperature averaged for the months of December, January, and February) and relatively little change (0–2°F) observed in summer high temperatures (i.e., average maximum daily temperatures for June, July, and August).

By mid-century (average of 2041–2060), average annual temperatures in Wisconsin are likely to increase by 5-6°F compared to 1981–2010, and by late-century (2081–2100) annual temperatures are likely to be 10–12°F higher than the 1981–2010 average (Figure 4). Historical trends in seasonal temperatures are likely to continue, with winter low temperatures increasing more rapidly than summer high temperatures for both mid-century (6–8°F for winter lows compared to 5–6°F for summer highs) and late-century (11–12°F compared to 9–12°F) time frames.

Frost-free nights are expected to increase significantly over the coming century as well. From 1981–2010, the majority of the state experienced 120–180 nights of frost (i.e., nights when low temperatures dip below 32°F) per year (Figure 5). However, by mid-century the number of nights per year with frost will decline to 100–160, and by the end of the century there may only be 80–120 nights of frost annually, representing an average decline of 33%.

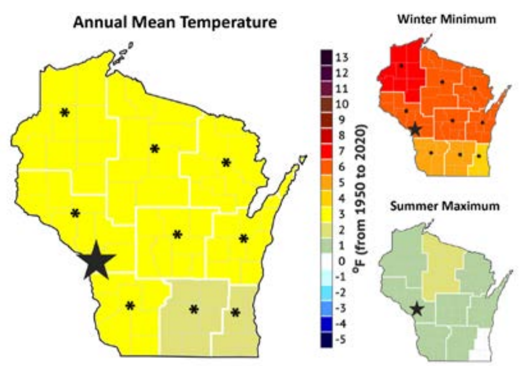



**Figure 3.** Historical change in annual mean temperature (left), winter minimum temperature (top right), and summer maximum temperature (bottom right) between 1950 and 2020. Asterisks indicate the trend for that area is statistically significant, and the larger star shows the location of La Crosse. Maps obtained from the Wisconsin Initiative on Climate Change Impacts (WICCI). *Source: Nelson Institute Center for Climatic Research. Data: NOAA NCDC nClimDiv.*

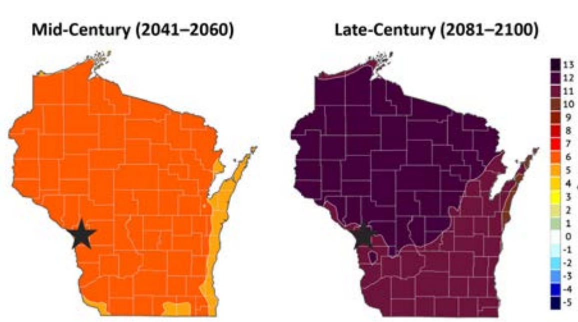



**Figure 4.** Projected change in annual mean temperature for mid-century (average of 2041–2060 conditions; left) and late-century (2081–2100; right) compared to 1981–2010 conditions. Star shows the location of La Crosse. Maps obtained from the Wisconsin Initiative on Climate Change Impacts (WICCI). *Source: Nelson Institute Center for Climatic Research. Data: Probabilitistic Downscaled Data v2.0, University of Wisconsin – Madison.*

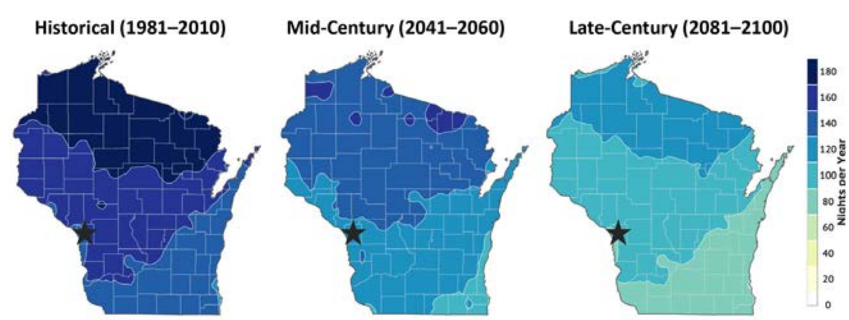



**Figure 5.** Number of nights per year with minimum temperatures below 32°F for historical (average of 1981–2010 conditions; left), mid-century (2041–2060; center), and late-century (2081–2100; right) timeframes. Star shows the location of La Crosse. Maps obtained from the Wisconsin Initiative on Climate Change Impacts (WICCI). *Source: Nelson Institute Center for Climatic Research. Data: Probabilistic Downscaled Data v2.0, University of Wisconsin – Madison.*

[2] All projections presented in this document use a high-emissions scenario (RCP 8.5), which represents the current trajectory and reduces the risk of underestimating future changes in municipal planning efforts. Maps and climate data were obtained from the Wisconsin Initiative on Climate Change Impacts (WICCI) except where otherwise specified.

# Climate Trends and Projections for La Crosse

### In La Crosse:

**By 2060:**

250% increase in days over 90°F

**By 2100:**

350% increase in days over 90°F

*Photo by Charles Edward Miller via Flickr*

### In La Crosse:

**Since 1950:**

+20% increase in annual precipitation (+20% in spring, +15% in summer, +20% in fall and winter)

**By 2060:**

+5% increase in annual precipitation (+10% in spring, 0% change in summer, +5% in fall, +15% in winter)

**By 2100:**

+10% increase in annual precipitation (+15% in spring, 0% change in summer, +10% in fall, +20% in winter)

## Extreme Heat

Extreme heat events are likely to increase significantly over the coming decades. The number of days in Wisconsin with maximum temperatures over 90°F are likely to increase from an average of 5–15 per year from 1981–2010 to 15–45 days per year by mid-century (Figure 6). By the end of the century, the vast majority of the state will experience an average of 45 days per year with high temperatures over 90°F, representing a 200–800% increase in extreme heat days annually.

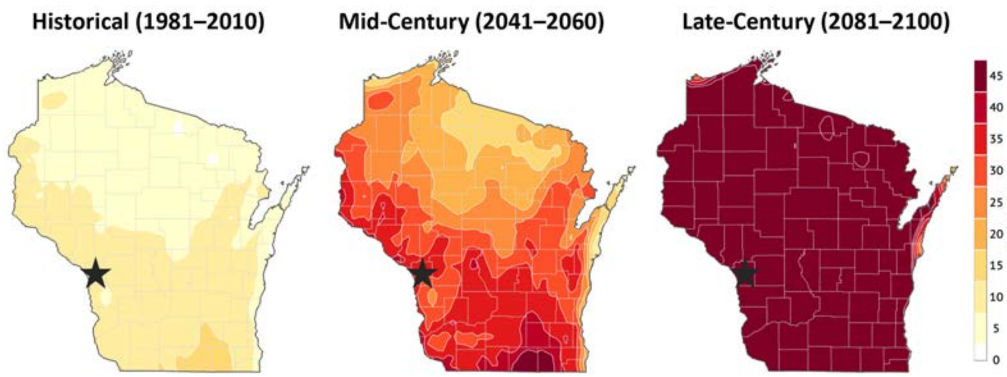



**Figure 6.** Number of days per year with maximum temperatures of at least 90°F for historical (average of 1981–2010 conditions; left), mid-century (2041–2060; center), and late-century (2081–2100; right) timeframes. Star shows the location of La Crosse. Maps obtained from the Wisconsin Initiative on Climate Change Impacts (WICCI). *Source: Nelson Institute Center for Climatic Research. Data: Probabilitistic Downscaled Data v2.0, University of Wisconsin – Madison.*

## Precipitation

Annual precipitation in Wisconsin has increased by 5–20% over the past 70 years, with more extreme increases occurring in the southern half of the state (Figure 7). Around La Crosse, precipitation has increased significantly year-round, though the changes have been slightly less in the summer (~15%) compared to other seasons (~20%).

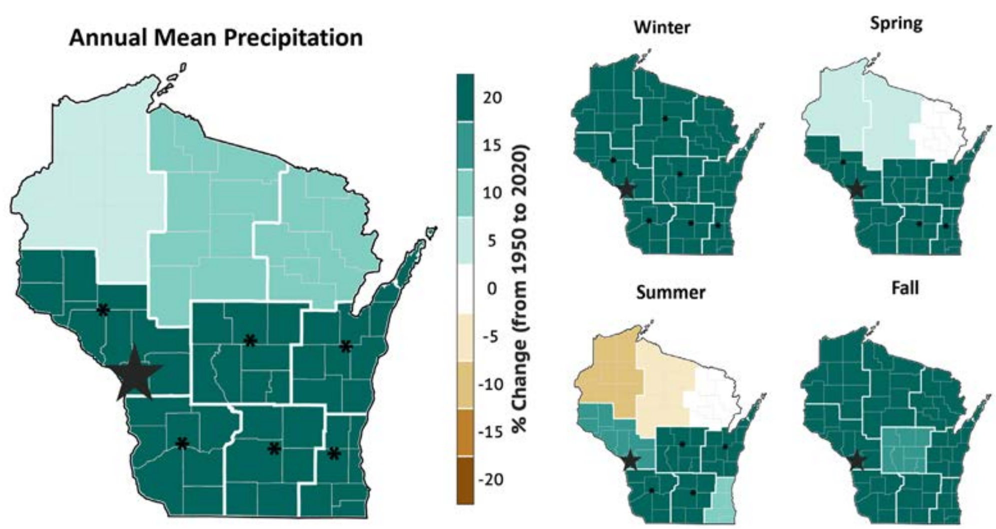



**Figure 7.** Historical change in annual (left) and seasonal (right) mean precipitation between 1950 and 2020. Asterisks indicate the trend for that area is statistically significant, and the larger star shows the location of La Crosse. Maps obtained from the Wisconsin Initiative on Climate Change Impacts (WICCI). *Source: Nelson Institute Center for Climatic Research. Data: NOAA NCDC nClimDiv.*

# Climate Trends and Projections for La Crosse

By mid-century (average of 2041–2060), annual mean precipitation in Wisconsin is likely to increase by 5–10% compared to 1981–2010, and by late-century (2081–2100) annual precipitation are likely to increase by 10–15%, with expected changes in La Crosse falling towards the lower end of that range (Figure 8).

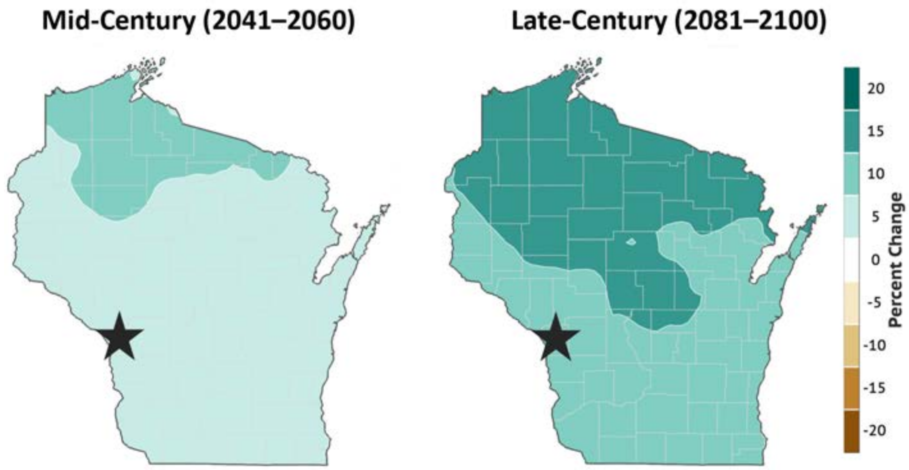



**Figure 8.** Projected change in annual mean precipitation for mid-century (average of 2041–2060 conditions; left) and late-century (2081–2100; right) compared to 1981–2010 conditions. Star shows the location of La Crosse. Maps obtained from the Wisconsin Initiative on Climate Change Impacts (WICCI). *Source: Nelson Institute Center for Climatic Research. Data: Probabilitistic Downscaled Data v2.0, University of Wisconsin – Madison.*

Seasonal precipitation changes are likely to continue to be greatest in the winter, particularly by late-century when an additional 20% increase in precipitation is expected across the state (Figure 9). In contrast to historical trends that showed greater increases in the southern half of the state, changes by the end of the century are expected to be most significant in the northern half of the state, where increases range from 5–20% depending on the season (5% in the spring, 15% in the fall, and 20% in winter and spring). The southern part of the state is expected to see the greatest increases in precipitation in the winter (20%), somewhat smaller increases in the spring (15%) and fall (10%), and little to no change in the summer. Mid-century conditions show similar but less extreme trends as expected.

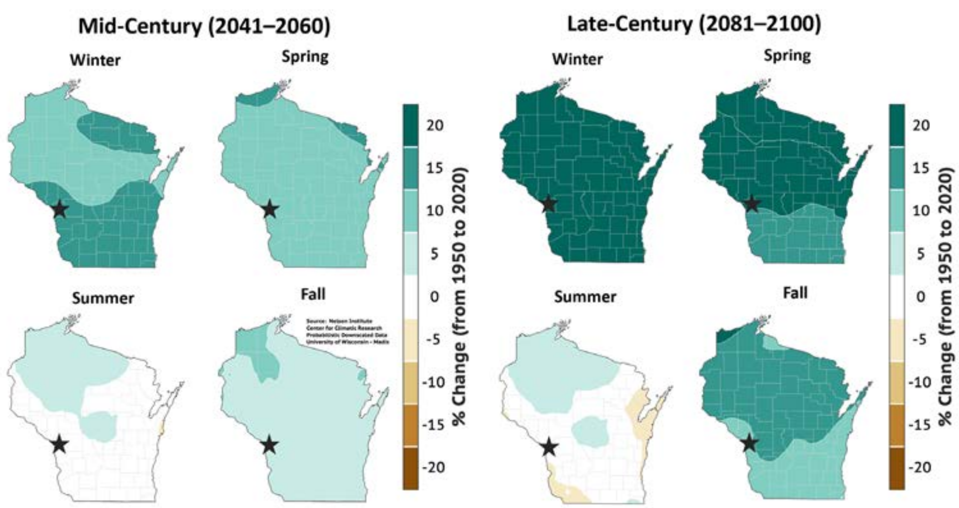



**Figure 9.** Projected change in seasonal mean precipitation totals for late-century (average of 2041–2060 conditions; left) and late-century (2081–2100) compared to 1981–2010 conditions. Star shows the location of La Crosse. Maps obtained from the Wisconsin Initiative on Climate Change Impacts (WICCI). *Source: Nelson Institute Center for Climatic Research. Data: Probabilitistic Downscaled Data v2.0, University of Wisconsin – Madison.*

The projected increases in winter precipitation are likely to occur more often as winter rain rather than snow, particularly as winter temperatures continue to rise rapidly. By the end of the century there is expected to be significant decreases in the amount of snow that falls each year, as well as in the frequency, intensity, and duration of snowstorms [2].



*Photo by Andrew Haimerl via Unsplash*

# Climate Trends and Projections for La Crosse

### In La Crosse:

**By 2060:**

25% increase in days with precipitation over 2″

100% increase in days with precipitation over 5″

**By 2100:**

50% increase in days with precipitation over 2″

400% increase in days with precipitation over 5″

### Drought

Although annual precipitation is projected to increase in Wisconsin over the coming century, summer rainfall is expected to remain relatively consistent. Because warmer temperatures increase rates of evapotranspiration (i.e., the amount of water that is lost to the atmosphere through evaporation and plant transpiration), there may be an overall net loss of water in the ecosystem during these periods of time. Additionally, a greater proportion of annual rain is expected to fall during increasingly extreme precipitation events, suggesting that the swings between wet periods and dry periods will also become more extreme. Thus, it is likely that droughts will become more common in the region, even as overall annual precipitation increases.

## Extreme Precipitation, Storms, and Flooding

Extreme precipitation, which is strongly associated with severe flooding events, has been increasing over the last several decades. For instance, rainfall totals from the wettest 1% of days increased by 42% in the Midwest between 1958 and 2016 [3]. In Wisconsin, the frequency of heavy precipitation days is also projected to increase significantly. The number of days with precipitation totals over 2 inches are expected to increase from an average of 6–14 per year from 1981–2010 to 8–18 days per year by the mid-century and late-century time periods (Figure 10). By the end of the century, the western half of the state is expected to experience an average of 18 days per year with precipitation totals over 2 inches, representing an increase of around 150%.

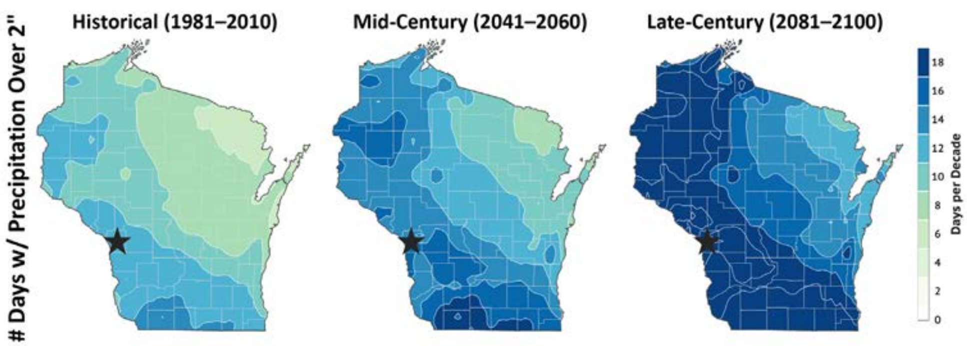



**Figure 10.** Number of days per year with 24-hour precipitation totals over 2 inches for historical (average of 1981–2010 conditions; left), mid-century (2041–2060; center), and late-century (2081–2100; right) timeframes. Star shows the location of La Crosse. Maps obtained from the Wisconsin Initiative on Climate Change Impacts (WICCI). *Source: Nelson Institute Center for Climatic Research. Data: Probabilitistic Downscaled Data v2.0, University of Wisconsin – Madison.*

Proportional increases in days with extremely high precipitation totals (over 5 inches) are expected to be even more significant (Figure 11). Historically, 24-hour precipitation totals over 5 inches occurred 1–4 times per year, on average. However, this is expected to increase to 1–7 days per year by mid-century and up to 9 days per year by the end of the century, representing increases of up to 300%.

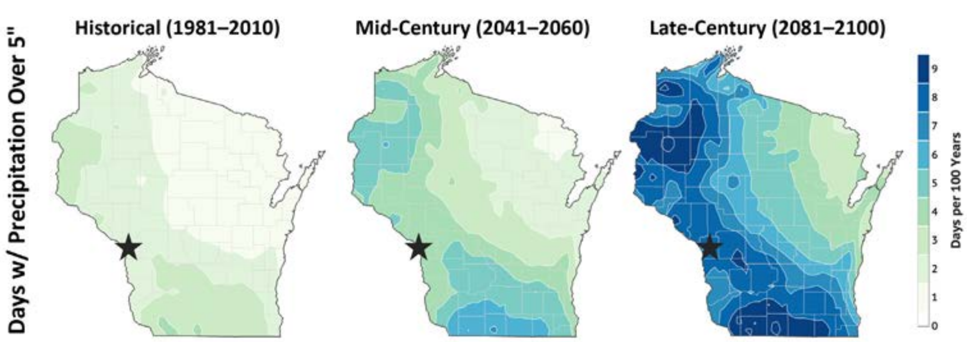



**Figure 11.** Number of days per year with 24-hour precipitation totals over 5 inches for historical (average of 1981–2010 conditions; left), mid-century (2041–2060; center), and late-century (2081–2100; right) timeframes. Star shows the location of La Crosse. Maps obtained from the Wisconsin Initiative on Climate Change Impacts (WICCI). *Source: Nelson Institute Center for Climatic Research. Data: Probabilitistic Downscaled Data v2.0, University of Wisconsin – Madison.*

There are relatively few projections for storm activity, as the drivers of these processes are complex and difficult for scientists to model. However, one study found that the amount of precipitation associated with spring storms increased by 25% per decade from 1979 to 2014, largely due to increases in the frequency, intensity, and duration of mesoscale convective systems (i.e., large complex of thunderstorms) [4]. In general, it is highly likely that spring storms will continue to increase in frequency, intensity, and duration, and that changes in temperature and humidity will generally support more extreme weather events. Continued increases in extreme precipitation will likely increase the risk of severe floods, particularly in the spring when these events are more likely to occur.

# Vulnerable Populations in La Crosse

*Photo by Rochelle Hartman via Flickr*

Within the City of La Crosse, there are an estimated 6,820 people of color comprising 9.0% of the population (Figure 12). The density of people of color is highest in census tracts in the northern and western parts of the City, making up over 15% of the population in these areas.

The impacts of the climate changes described above are likely to be significant and wide-reaching, affecting people across social, economic, and political boundaries. However, vulnerability to climate change is not evenly distributed within a community. Rather, climate risks reflect broader, pre-existing patterns of inequity, placing greater burdens on people of color, low-income residents, people with disabilities, non-English speakers, young children, and the elderly, among others [5]. Understanding the disproportionate impacts likely to be experienced by these populations is critical to ensuring that the benefits of climate adaptation and mitigation efforts are justly distributed [6–8].

The following sections summarize factors that may contribute to the disproportionate impacts of climate change likely to be felt by each group. They also provide maps to illustrate the density of these populations within City of La Crosse census tracts,[3] which can be used by City officials and the Climate Action Plan Team to aid recognition of the potential for inequities as well as the conditions that contribute to them. It is important to note that these maps reflect demographic variables that have been correlated with climate change vulnerability (e.g., race, socioeconomic status), and so they may suggest areas of the City where climate change may be more likely to have disproportionate impacts on vulnerable populations. However, they do not provide information about the specific constellation of factors that cause those disparities in each community, nor do they reflect the factors that contribute to resilience within these communities. Thus, this information should be used only as an indicator of areas where special attention should be paid to potential disparities in climate-related hazards (e.g., flooding, extreme heat, air pollution) and/or to ensuring just distribution of the benefits of actions designed to address these climate impacts.

## People of Color

Black, brown, Latinx, and Indigenous communities have faced decades of discriminatory zoning and other urban planning policies, a lack of investment in their communities, an increased risk of chronic medical conditions, and many other impacts of systemic racism, all of which may be exacerbated by climate change [9]. For instance, people of color are more likely to live in areas at higher risk of flooding, heat island effects, and air pollution or other environmental contaminants [8]. Older or poorly-maintained infrastructure within communities of color can also exacerbate climate impacts, along with limited transportation, health care access, and food insecurity, among other factors [10].

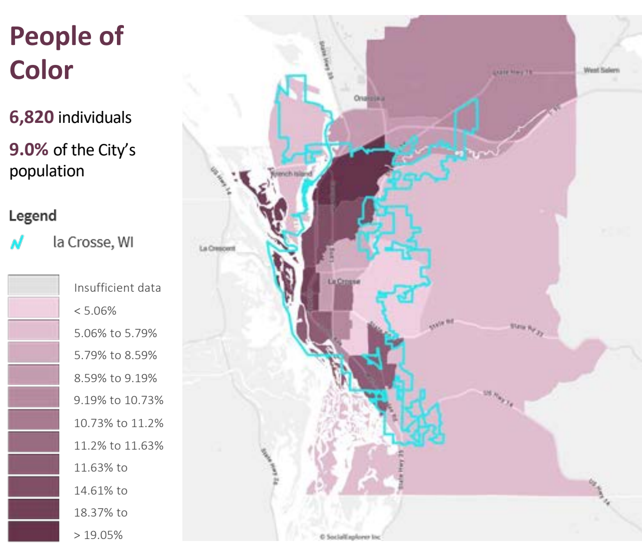



**Figure 12.** Population density of people of color within City of La Crosse census tracts, defined as all of those who did not identify their race as "white alone". Maps obtained from www.socialexplorer.com using data from the 2018 American Community Survey.

[3] All maps and population estimates for La Crosse vulnerable populations were obtained from www.socialexplorer.com, which uses data from the 2018 American Community Survey.

# Vulnerable Populations in La Crosse

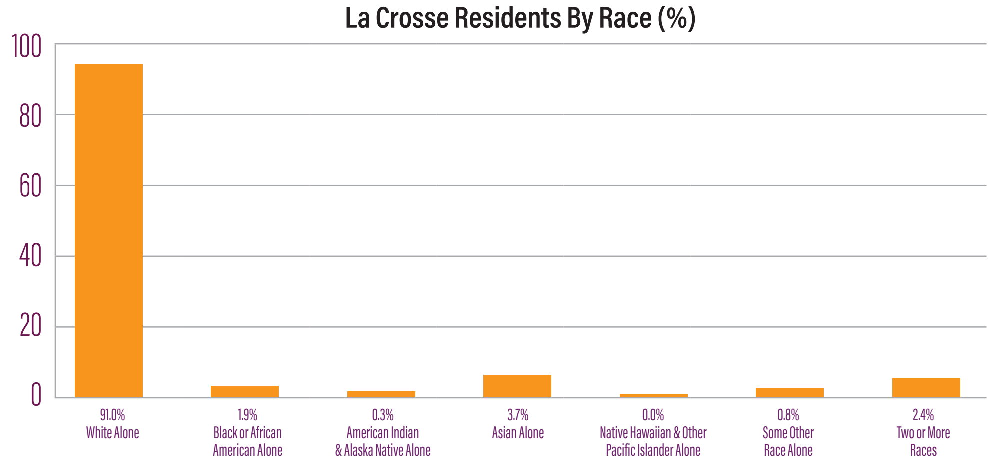



**Table 1.** Percentage of La Crosse residents by race. Information obtained from www.socialexplorer.com using data from the 2018 American Community Survey.

## Low-Income Residents

Low-income residents, defined here as individuals making up to 200% of the federal poverty level, may lack access to the resources necessary for coping with the impacts of climate change. Low-income residents are more likely to depend on public transportation, experience food insecurity, and may lack the financial resources necessary to prepare for or recover from extreme events [10, 11]. For instance, the loss of food in the refrigerator or freezer following a power outage can result in significant financial hardship. Similarly, these individuals are more likely to experience significant harm because they may not have the resources to live in an area that is less exposed to flooding or air pollution, maintain their home in good repair, or obtain preventative healthcare [12].

Within the City of La Crosse, there are an estimated 24,449 low-income residents comprising 32.4% of the population (Figure 13). The density of low-income residents is highest in census tracts in the central and western parts of the City, making up 44–80% of the population in these areas.

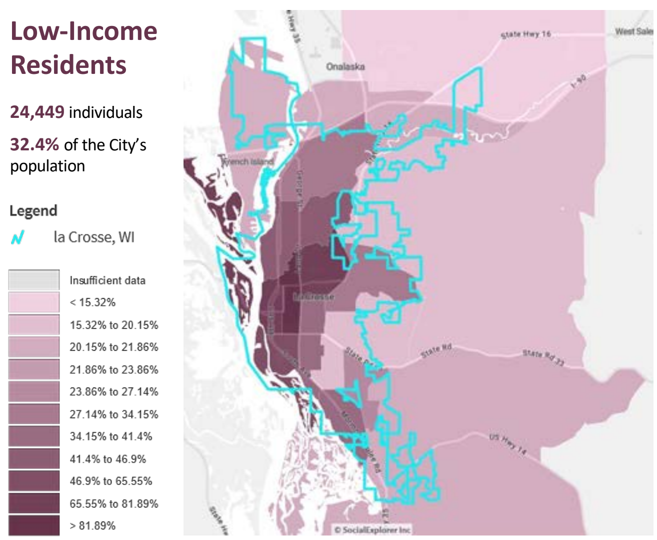



**Figure 13.** Population density of low-income residents within City of La Crosse census tracts, defined as people making up to 200% of the federal poverty level. Maps obtained from www.socialexplorer.com using data from the 2018 American Community Survey.

# Vulnerable Populations in La Crosse

## Children 5 and Under

Young children are less able to regulate their temperature and can be more vulnerable to severe illness from disease or toxins, placing them at greater risk of diseases such as asthma [9]. Young children are also less able to independently respond to stressful conditions or extreme events (i.e., by walking or driving to another location), and may be unable to verbalize discomfort or pain that can be an early indicator of illness or injury. Examples of climate-related impacts that young children are particularly sensitive to include heat stroke, asthma or other health problems as a result of air pollution, vector-borne and water-borne diseases, food insecurity, power failures, and flash floods [5, 13].

Within the City of La Crosse, there are an estimated 3,611 children 5 years of age or younger comprising 4.8% of the population (Figure 14). The density of young children is highest in census tracts in the northern and eastern parts of the City, making up 5.8–10.1% of the population in these areas.

## Seniors 65 and Over

Older adults (defined here as seniors 65 years of age and older) are particularly vulnerable to health impacts associated with climate change, including high temperatures and heat waves, air pollution, severe flooding and associated risks (e.g., waterborne illness, mold), and infectious diseases [5, 8]. Because older adults may no longer have earned income, they are also more likely to depend on public transportation, live in older or deteriorating housing, and/or experience food insecurity [10]

Within the City of La Crosse, there are an estimated 11,717 seniors 65 years of age or over comprising 15.5% of the population (Figure 15). The density of seniors is highest in census tracts in the northern and southern parts of the City, making up over 20% of the population in many of these areas.

## Individuals with Disabilities

People with disabilities may be more vulnerable to impacts from climate change and extreme events due to the direct effect of limited mobility or chronic health conditions, but they are also more likely to experience poverty and experience stressful conditions related to ongoing discrimination and lack of necessary accommodations. As a result, people with disabilities are particularly sensitive to climate-related impacts associated with extreme heat, flooding, air pollution, vector-borne and waterborne disease, food insecurity, and power outages [9, 14, 15].

Within the City of La Crosse, there are an estimated 8,557 individuals with disabilities comprising 11.3% of the population (Figure 16). The density of individuals with disabilities is highest in census tracts in the northern and western parts of the City, making up over 15% of the population in these areas.

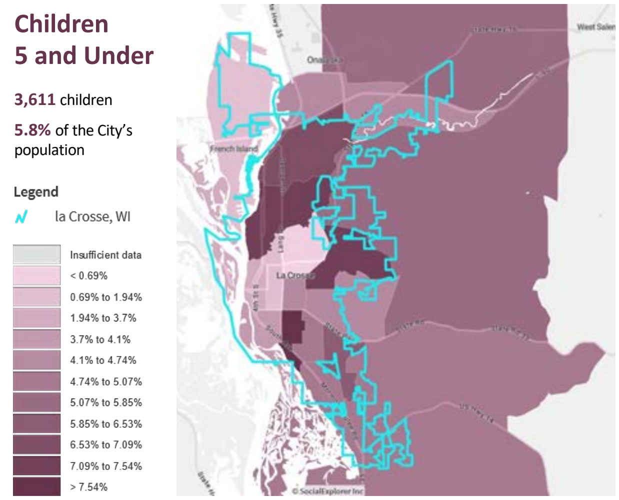



**Figure 14.** Population density of children 5 and under within City of La Crosse census tracts. Maps obtained from www.socialexplorer.com using data from the 2018 American Community Survey.

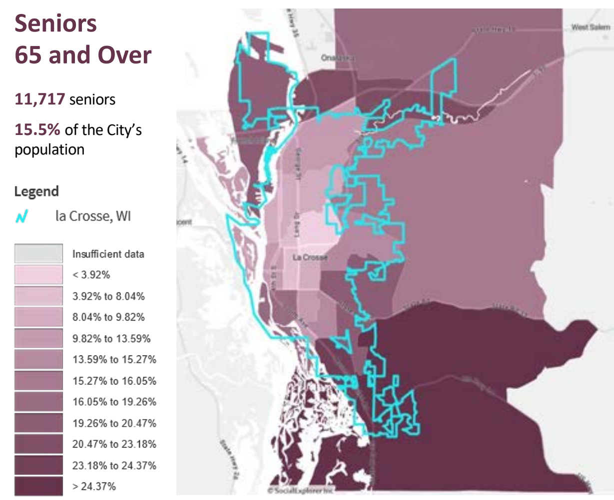



**Figure 15.** Population density of seniors 65 and over within City of La Crosse census tracts. Maps obtained from www.socialexplorer.com using data from the 2018 American Community Survey.

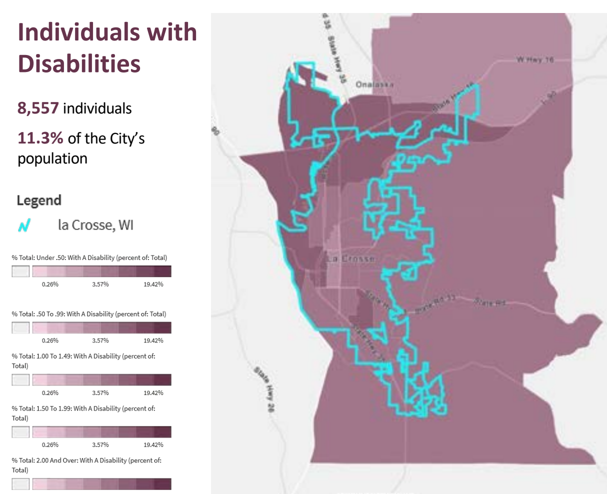



**Figure 16.** Population density of individuals with disabilities within City of La Crosse census tracts, mapped according to the ratio of income to poverty level in the past 12 months. Maps obtained from www.socialexplorer.com using data from the 2018 American Community Survey.

# Vulnerable Populations in La Crosse

## Individuals with Limited English Skills

Individuals with limited English skills are often less connected to the community, and are less able to benefit from community resources or programs that primarily provide services in English. These individuals also are at greater risk during extreme events, as they may not be able to access information related to preparation or evacuation instructions [9, 16].

Within the City of La Crosse, there are an estimated 1,245 individuals with limited English comprising 1.6% of the population (Figure 17). The density of limited English speakers is highest in census tracts in the central area of the City, making up to 6.4% of the population in the densest tract.

## At-Risk Workers

Some occupations place workers at greater risk of exposure to climate changes and extreme events that can impact their health and safety. These can include hotter temperatures and longer, more severe heat waves, low air quality, extreme flooding, waterborne and/or vector-borne diseases, and exposure to contaminants or toxins that may be exacerbated by climate change. Many occupations that place workers at greater risk of climate-related hazards are also low-wage jobs, where employers may not offer adequate safety precautions or paid time off [12, 17].

Within the City of La Crosse, there are an estimated 9,138 at-risk workers comprising 12.1% of the population (Figure 18). The density of at-risk workers is highest in census tracts in the northern and southern parts of the City, making up over 15% of the population in these areas.

## Individuals with No Vehicle Access

Individuals with no access to a personal vehicle may have limited mobility that prevents quick evacuation during extreme events, reduces their ability to reach cooling stations during heat waves, or limits access to health care and other needed services [11].

Within the City of La Crosse, there are an estimated 5,510 individuals with no vehicle access comprising 7.3% of the population (Figure 19). The density of individuals with no vehicle access is highest in census tracts in the western part of the City, making up over 20% of the population in this area.

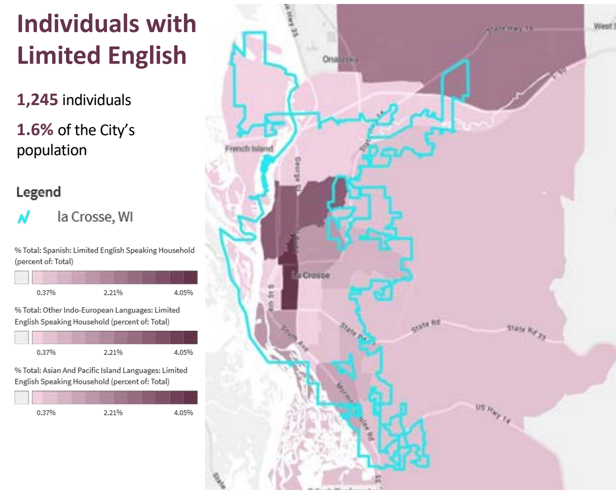



**Figure 17.** Population density of individuals with limited English skills within City of La Crosse census tracts. Maps obtained from www.socialexplorer.com using data from the 2018 American Community Survey.

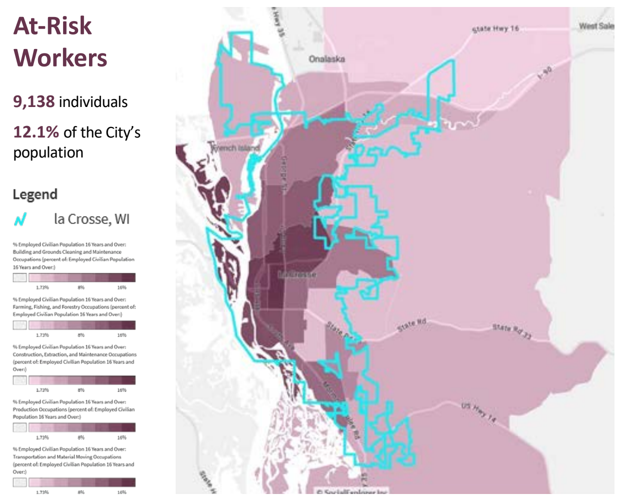



**Figure 18.** Population density of at-risk workers within City of La Crosse census tracts, including occupations related to building and grounds cleaning and maintenance; farming, fishing, and forestry; construction, extraction, and maintenance; production; and transportation and material moving. Maps obtained from www.socialexplorer.com using data from the 2018 American Community Survey.

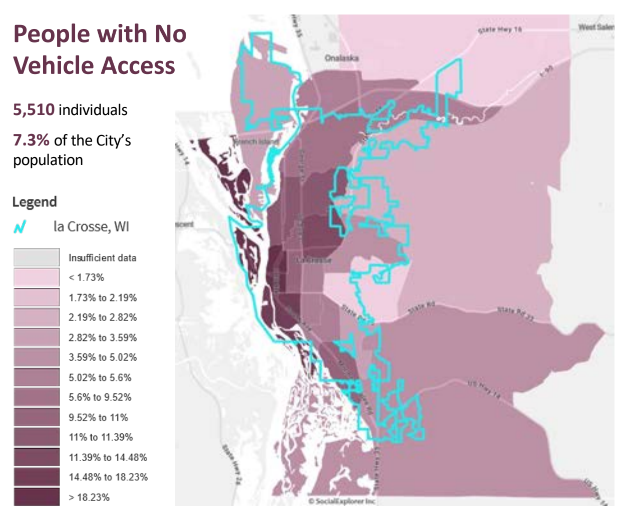



**Figure 19.** Population density of individuals with no vehicle access within City of La Crosse census tracts. Maps obtained from www.socialexplorer.com using data from the 2018 American Community Survey.

# Vulnerable Populations in La Crosse

## Summary of Vulnerable Populations

The chart below (Figure 20) summarizes the number of individuals in each vulnerable population category by census tract. Note that the "Total Instances of Vulnerability" row is the sum of this number, but does not represent the total number of potentially vulnerable individuals in each tract because people may be counted within more than one vulnerable population category. For instance, a given individual may be an adult over the age of 65 and also have an income below 200% of poverty level, which would result in them being counted within both the "Seniors Over 65" and the "Low-Income Residents" categories.

Within the chart below, "Vulnerability Coefficient" is calculated by dividing the total instances of vulnerability by the total population of the census tract, with high vulnerability coefficients representing areas where a greater proportion of residents are likely to be members of one or more vulnerable populations. "Share of Total Vulnerability" represents the census tract's share of community-wide instances of vulnerability, without consideration of the overall population within that tract. Note that a census tract with a lower Vulnerability Coefficient may still have a large share of the total instances of vulnerability, particularly in tracts with relatively high total populations. Finally, the "Composite Rank Score" is an average of the Vulnerability Coefficient and the Share of Total Vulnerability for each census tract (the tracts with composite rank scores in the highest two quartiles are highlighted in dark orange; see Figure 21 for the composite rank score represented on a map of La Crosse). In order to ensure that the City's adaptation efforts are prioritizing populations that are likely to experience disproportionate impacts of climate change, these neighborhoods should be considered critical starting places for implementation of actions that are designed to reduce climate vulnerability.

| Tract / Block Group | Census Tract 1, La Crosse County, Wisconsin | | Census Tract 2, La Crosse County, Wisconsin | | Census Tract 3, La Crosse County, Wisconsin | | Census Tract 4, La Crosse County, Wisconsin | | Census Tract 5, La Crosse County, Wisconsin | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Est | % of tract total | | | | | | | | |
| People of Color | 909 | 19.7% | 744 | 15.9% | 423 | 18.0% | 505 | 7.8% | 317 | 6.8% |
| Low-Income Residents | 1,499 | 32.5% | 2,118 | 45.2% | 1,214 | 51.6% | 5,163 | 79.7% | 1,614 | 34.6% |
| Children 5 and Under | 327 | 7.1% | 348 | 7.4% | 87 | 3.7% | 45 | 0.7% | 5 | 0.1% |
| Seniors 65 and Over | 627 | 13.6% | 447 | 9.5% | 231 | 9.8% | 254 | 3.9% | 150 | 3.2% |
| Individuals with Disabilities | 731 | 15.8% | 668 | 14.3% | 461 | 19.6% | 561 | 8.7% | 193 | 4.1% |
| Individuals with Limited English Ski | 0 | 0.0% | 298 | 6.4% | 0 | 0.0% | 291 | 4.5% | 29 | 0.6% |
| At-Risk Workers | 793 | 17.2% | 968 | 20.7% | 210 | 8.9% | 793 | 12.2% | 259 | 5.5% |
| Individuals with No Vehicle Access | 487 | 10.6% | 623 | 13.3% | 581 | 24.7% | 594 | 9.2% | 262 | 5.6% |
| Total Instances of Vulnerability | 5,373 | 116.4% | 6,214 | 132.7% | 3,208 | 136.4% | 8,205 | 126.7% | 2,829 | 60.6% |
| Total Population in Tract | 4,615 | | 4,682 | | 2,352 | | 6,476 | | 4,669 | |
| Vulnerability Coefficient | 1.16 | | 1.33 | | 1.36 | | 1.27 | | 0.61 | |
| Percentile Rank | 72.2 | | 88.9 | | 94.4 | | 77.8 | | 11.1 | |
| Share of total Vuln | 7.6% | | 8.7% | | 4.5% | | 11.5% | | 4.0% | |
| Percentile Rank | 90.0 | | 95.0 | | 50.0 | | 100.0 | | 30.0 | |
| Composite rank score | 162.2 | | 183.9 | | 144.4 | | 177.8 | | 41.1 | |
| Blended Percentile Rank | 77.8 | | 100.0 | | 72.2 | | 94.4 | | 11.1 | |

| Tract / Block Group | Census Tract 6, La Crosse County, Wisconsin | | Census Tract 7, La Crosse County, Wisconsin | | Census Tract 8, La Crosse County, Wisconsin | | Census Tract 9, La Crosse County, Wisconsin | | Census Tract 10, La Crosse County, Wisconsin | | Census Tract 11.01, La Crosse County, Wisconsin | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| People of Color | 37 | 1.7% | 194 | 4.3% | 387 | 11.1% | 472 | 13.7% | 292 | 7.6% | 36 | 1.8% |
| Low-Income Residents | 598 | 27.1% | 892 | 19.8% | 1,412 | 40.6% | 1,515 | 44.0% | 1,437 | 37.4% | 378 | 18.9% |
| Children 5 and Under | 166 | 7.5% | 213 | 4.7% | 165 | 4.7% | 141 | 4.1% | 390 | 10.1% | 95 | 4.7% |
| Seniors 65 and Over | 324 | 14.7% | 913 | 20.2% | 280 | 8.0% | 663 | 19.3% | 489 | 12.7% | 306 | 15.3% |
| Individuals with Disabilities | 155 | 7.0% | 330 | 7.3% | 252 | 7.2% | 602 | 17.5% | 466 | 12.1% | 265 | 13.2% |
| Individuals with Limited English Ski | 19 | 0.9% | 22 | 0.5% | 0 | 0.0% | 111 | 3.2% | 0 | 0.0% | 10 | 0.5% |
| At-Risk Workers | 191 | 8.7% | 397 | 8.8% | 353 | 10.1% | 489 | 14.2% | 512 | 13.3% | 238 | 11.9% |
| Individuals with No Vehicle Access | 97 | 4.4% | 80 | 1.8% | 165 | 4.7% | 707 | 20.5% | 211 | 5.5% | 124 | 6.2% |
| Total Instances of Vulnerability | 1,588 | 72.1% | 3,041 | 67.4% | 3,013 | 86.5% | 4,701 | 136.5% | 3,797 | 98.7% | 1,451 | 72.4% |
| Total Population in Tract | 2,203 | | 4,510 | | 3,482 | | 3,443 | | 3847 | | 2004 | |
| Vulnerability Coefficient | 0.72 | | 0.67 | | 0.87 | | 1.37 | | 0.99 | | 0.72 | |
| Percentile Rank | 27.8 | | 22.2 | | 50.0 | | 100.0 | | 66.7 | | 33.3 | |
| Share of total Vuln | 2.2% | | 4.3% | | 4.2% | | 6.6% | | 5.3% | | 2.0% | |
| Percentile Rank | 20.0 | | 45.0 | | 40.0 | | 75.0 | | 65.0 | | 15.0 | |
| Composite rank score | 47.8 | | 67.2 | | 90.0 | | 175.0 | | 131.7 | | 48.3 | |
| Blended Percentile Rank | 22.2 | | 33.3 | | 38.9 | | 88.9 | | 61.1 | | 27.8 | |

| Tract / Block Group | Census Tract 11.02, La Crosse County, Wisconsin | | Census Tract 12, La Crosse County, Wisconsin | | Census Tract 103, La Crosse County, Wisconsin | | Census Tract 104.01, La Crosse County, Wisconsin | | Census Tract 105, La Crosse County, Wisconsin | | Census Tract 106, La Crosse County, Wisconsin | | Census Tract 107, La Crosse County, Wisconsin | | Totals | Percentage of City Pop |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| People of Color | 468 | 11.8% | 412 | 10.1% | 259 | 5.7% | 528 | 9.5% | 512 | 8.6% | 177 | 5.1% | 147 | 2.6% | 6,820 | 9.0% |
| Low-Income Residents | 1,309 | 33.0% | 966 | 23.7% | 992 | 21.8% | 439 | 7.9% | 1,269 | 21.3% | 529 | 15.2% | 1,105 | 19.5% | 24,449 | 32.4% |
| Children 5 and Under | 197 | 5.0% | 266 | 6.5% | 88 | 1.9% | 325 | 5.8% | 265 | 4.5% | 201 | 5.8% | 287 | 5.1% | 3,611 | 4.8% |
| Seniors 65 and Over | 967 | 24.4% | 834 | 20.5% | 919 | 20.2% | 892 | 16.1% | 1,379 | 23.2% | 550 | 15.8% | 1,492 | 26.3% | 11,717 | 15.5% |
| Individuals with Disabilities | 793 | 20.0% | 487 | 12.0% | 567 | 12.5% | 208 | 3.7% | 828 | 13.9% | 305 | 8.8% | 685 | 12.1% | 8,557 | 11.3% |
| Individuals with Limited English Ski | 153 | 3.8% | 68 | 1.7% | 0 | 0.0% | 124 | 2.2% | 0 | 0.0% | 44 | 1.3% | 78 | 1.4% | 1,245 | 1.6% |
| At-Risk Workers | 620 | 15.6% | 516 | 12.7% | 680 | 15.0% | 468 | 8.4% | 737 | 12.4% | 436 | 12.6% | 478 | 8.4% | 9,138 | 12.1% |
| Individuals with No Vehicle Access | 540 | 13.6% | 128 | 3.2% | 187 | 4.1% | 12 | 0.2% | 330 | 5.5% | 73 | 2.1% | 310 | 5.5% | 5,510 | 7.3% |
| Total Instances of Vulnerability | 5,047 | 127.2% | 3,677 | 90.2% | 3,692 | 81.3% | 2,996 | 53.9% | 5,319 | 89.4% | 2,314 | 66.6% | 4,582 | 80.9% | 71,047 | 94.1% |
| Total Population in Tract | 3968 | | 4075 | | 4543 | | 5557 | | 5950 | | 3473 | | 5663 | | 75,512 | |
| Vulnerability Coefficient | 1.27 | | 0.90 | | 0.81 | | 0.54 | | 0.89 | | 0.67 | | 0.81 | | 0.94 | |
| Percentile Rank | 83.3 | | 61.1 | | 44.4 | | 5.6 | | 55.6 | | 16.7 | | 38.9 | | | |
| Share of total Vuln | 7.1% | | 5.2% | | 5.2% | | 4.2% | | 7.5% | | 3.3% | | 6.4% | | | |
| Percentile Rank | 80.0 | | 55.0 | | 60.0 | | 35.0 | | 85.0 | | 25.0 | | 70.0 | | | |
| Composite rank score | 163.3 | | 116.1 | | 104.4 | | 40.6 | | 140.6 | | 41.7 | | 108.9 | | | |
| Blended Percentile Rank | 83.3 | | 55.6 | | 44.4 | | 5.6 | | 66.7 | | 16.7 | | 50.0 | | | |

**Figure 20.** Summary of vulnerable populations in La Crosse by census tract. Chart obtained from www.socialexplorer.com using data from the 2018 American Community Survey.

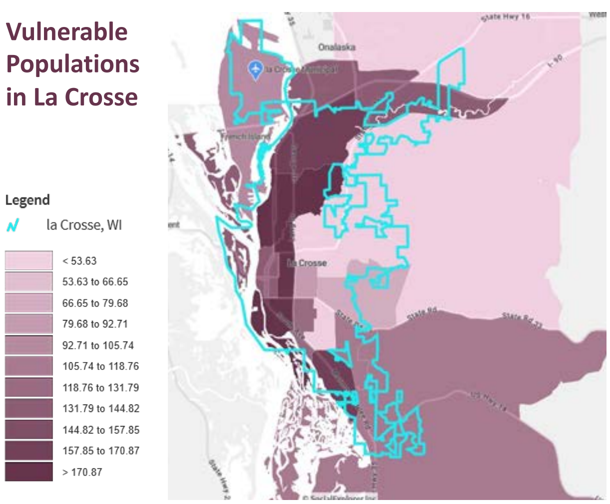



**Figure 21.** Vulnerable populations within City of La Crosse census tracts, based on census tract composite rank scores presented in Figure 20. Maps obtained from www.socialexplorer.com using data from the 2018 American Community Survey.

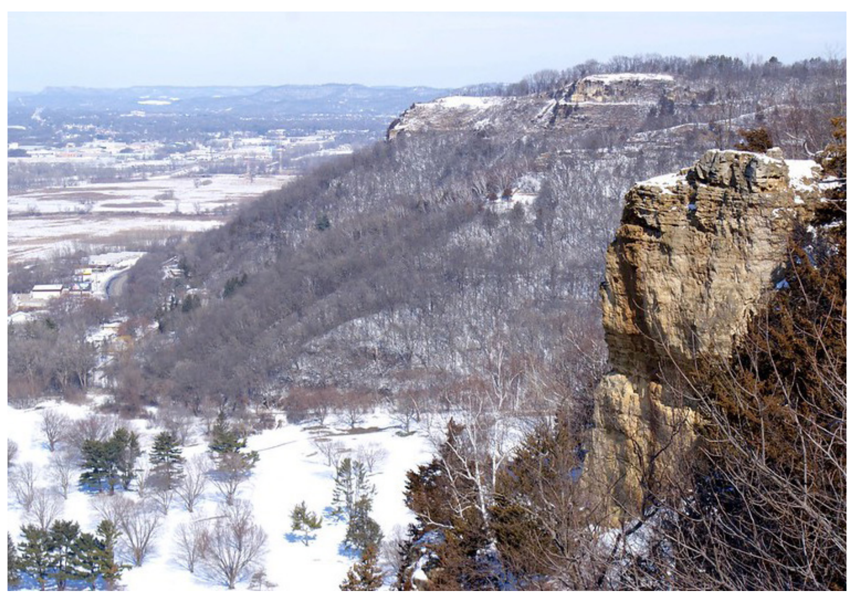
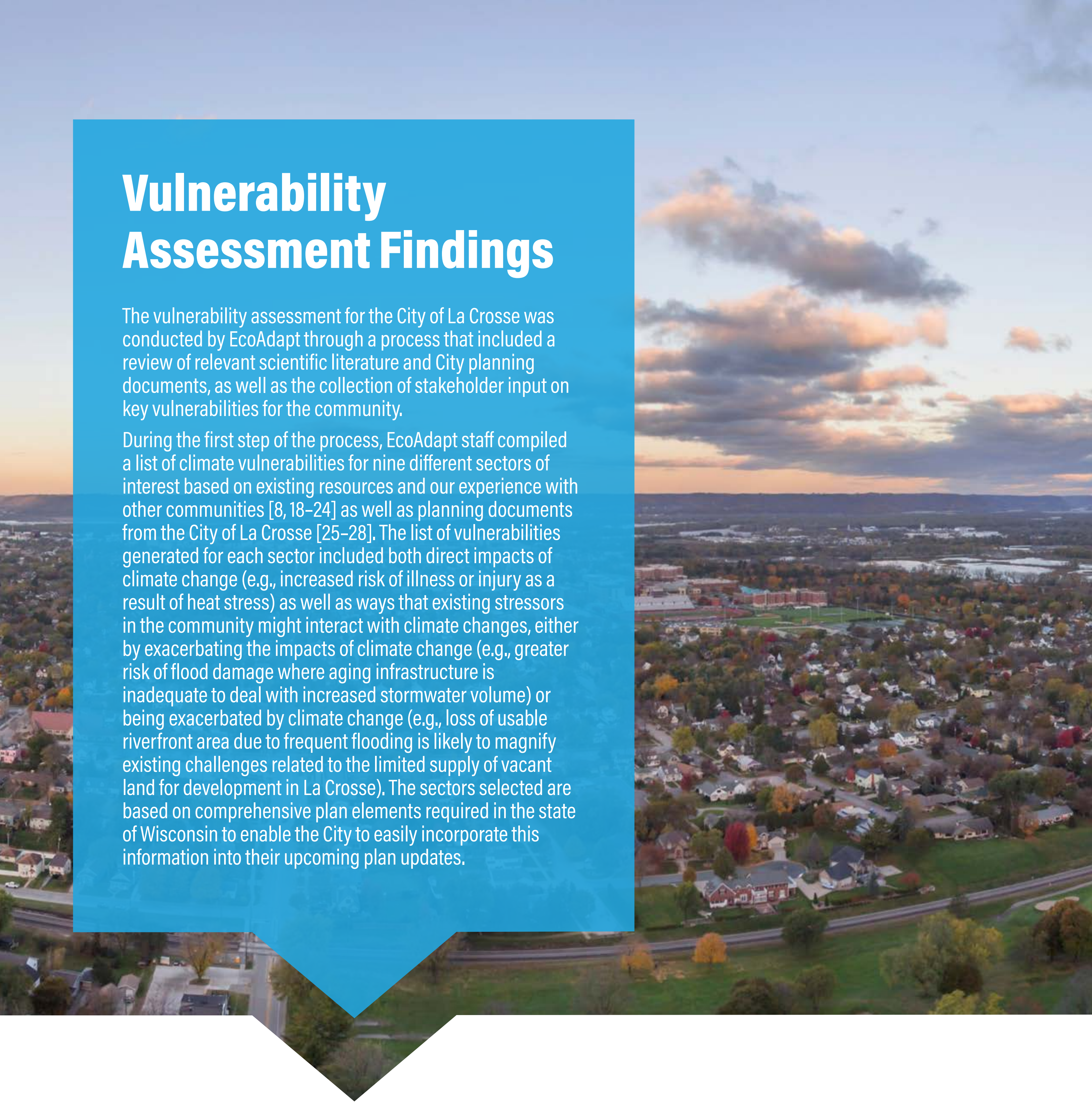


*Photo by Dan from focusonplace.com via Flickr*



# Vulnerability Assessment Findings

The vulnerability assessment for the City of La Crosse was conducted by EcoAdapt through a process that included a review of relevant scientific literature and City planning documents, as well as the collection of stakeholder input on key vulnerabilities for the community.

During the first step of the process, EcoAdapt staff compiled a list of climate vulnerabilities for nine different sectors of interest based on existing resources and our experience with other communities [8, 18–24] as well as planning documents from the City of La Crosse [25–28]. The list of vulnerabilities generated for each sector included both direct impacts of climate change (e.g., increased risk of illness or injury as a result of heat stress) as well as ways that existing stressors in the community might interact with climate changes, either by exacerbating the impacts of climate change (e.g., greater risk of flood damage where aging infrastructure is inadequate to deal with increased stormwater volume) or being exacerbated by climate change (e.g., loss of usable riverfront area due to frequent flooding is likely to magnify existing challenges related to the limited supply of vacant land for development in La Crosse). The sectors selected are based on comprehensive plan elements required in the state of Wisconsin to enable the City to easily incorporate this information into their upcoming plan updates.

**THE SECTORS EVALUATED FOR THIS ASSESSMENT INCLUDE:**

- Land Use and Housing
- Transportation and Mobility
- Buildings and Energy
- Waste Management
- Water and Wastewater
- Health and Safety
- Local Food and Agriculture
- Greenspace and Tree Canopy
- Economy

# Vulnerability Assessment Findings

Next, members of the La Crosse Climate Action Plan Team participated in a virtual vulnerability workshop (February 2022), where they reviewed the vulnerability information for each sector and then chose two to three key vulnerabilities (i.e., vulnerabilities likely to be of greatest concern for the community over the coming decades). As time allowed, workshop participants also provided additional information about key vulnerabilities, including (1) locations and/or seasons where the impact is likely to be of particular concern, as well as populations that may be impacted to a greater degree; (2) whether the impact is already occurring in the community and whether it is already being addressed; and (3) whether there are factors that would make addressing this impact more difficult and/or community strengths that will make it more possible to address.

Finally, rankings for likelihood, consequence, and adaptive capacity were assigned for each key vulnerability based on a combination of climate projection data, existing planning documents for the City of La Crosse, and stakeholder input generated during the workshop. Ranking definitions and scales were drawn from the Rapid Vulnerability and Adaptation Tool for Climate-Informed Community Planning developed by EcoAdapt [1].

- **Likelihood** is the degree to which a sector is exposed to significant changes in climate. For this ranking, likelihood was assigned based on whether effects/impacts are anticipated to occur within a 30–80-year time frame (i.e., between 2050 and 2100). The following scale was used:
  *Almost Certain:* >75% probability
  *Likely:* 25-75% probability
  *Unlikely:* <25% probability
  *Rare:* Probability zero or close to it
- **Consequence** is the degree to which a sector is affected by exposure to a changing climate. Consequence rankings were assigned based on the degree of consequence that the anticipated effect/impact would have on the functioning of that sector in the community as a whole rather than on the individuals directly experiencing the impact (e.g., the scale of flood damage or heat-related illnesses was considered at the community level rather than the severity of consequences for a given individual who might have suffered damage or illness). The following scale was used:
  *Catastrophic:* Service to community ceases to exist
  *Major:* Service significantly impacted
  *Moderate:* Service diminished
  *Negligible:* Service not visibly or functionally affected
- **Adaptive capacity** is the degree to which a sector may be able to cope with or respond to a given impact of climate change. Adaptive capacity rankings were assigned based on an assessment of factors such as existing efforts to address the anticipated effect/impact, capacity to take further action (e.g., funding, staff time), existing policies or regulations that would support climate-informed actions, partnerships and stakeholder relationships that would support robust collaborative action, ability of to be flexible or respond quickly to changing conditions, and community willingness/desire to make changes, among other considerations. A scale of Low/Moderate/High was used for this ranking.

After assigning likelihood, consequence, and adaptive capacity rankings, the following matrices (Figure 22) were used to determine rankings for risk (i.e., the interaction of likelihood and consequence) and vulnerability (i.e., the degree to which the sector is susceptible to harm from the anticipated impact of climate change).

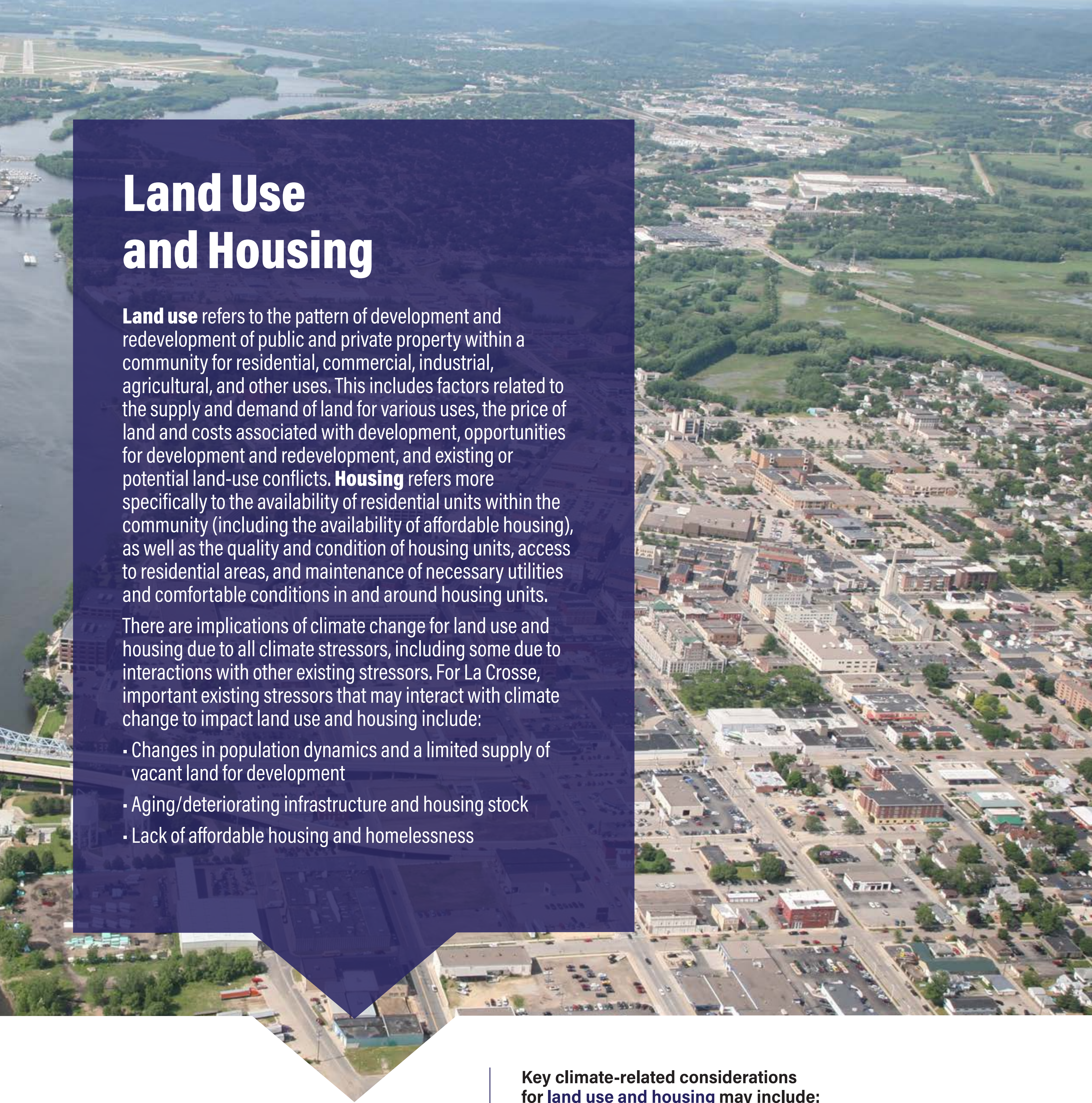
**RISK CALCULATOR MATRIX**

| | Consequence | | | |
|---|---|---|---|---|
| Likelihood | Negligible | Moderate | Major | Catastrophic |
| Rare | Low | Low | Low | Low |
| Unlikely | Low | Moderate | Moderate | High |
| Likely | Low | Moderate | High | Extreme |
| Almost Certain | Low | High | Extreme | Extreme |

**VULNERABILITY CALCULATOR MATRIX**

| | Adaptive Capacity | | |
|---|---|---|---|
| Risk | Low | Moderate | High |
| Low | Low | Low | Low |
| Moderate | Moderate | Moderate | Low |
| High | High | Moderate | Moderate |
| Extreme | High | High | Moderate |

**Figure 22.** Matrices used to assign risk and vulnerability rankings for each key vulnerability, taken from the Rapid Vulnerability and Adaptation Tool for Climate-Informed Community Planning developed by EcoAdapt [1].



# Land Use and Housing

**Land use** refers to the pattern of development and redevelopment of public and private property within a community for residential, commercial, industrial, agricultural, and other uses. This includes factors related to the supply and demand of land for various uses, the price of land and costs associated with development, opportunities for development and redevelopment, and existing or potential land-use conflicts. **Housing** refers more specifically to the availability of residential units within the community (including the availability of affordable housing), as well as the quality and condition of housing units, access to residential areas, and maintenance of necessary utilities and comfortable conditions in and around housing units.

There are implications of climate change for land use and housing due to all climate stressors, including some due to interactions with other existing stressors. For La Crosse, important existing stressors that may interact with climate change to impact land use and housing include:

- Changes in population dynamics and a limited supply of vacant land for development
- Aging/deteriorating infrastructure and housing stock
- Lack of affordable housing and homelessness

**Key climate-related considerations for land use and housing may include:**

- Identification of land uses and/or locations that might be particularly impacted by climate changes (e.g., floodplains, riverfront properties, neighborhoods with large areas of impervious surfaces that exacerbate heat island effects)
- Impacts of climate change on the availability and affordability of housing stock, costs associated with home maintenance, habitation (e.g., utility costs, ease of access) and repair
- Impacts of climate change on the functioning or maintenance requirements of infrastructure necessary for particular land uses, including residential use (e.g., utility lines, sewers and septic systems, stormwater infrastructure)
- Access to safe and affordable transportation near affordable housing units, and overall community connectedness for pedestrians, bikers, and vehicles

In the table below, both direct climate impacts and interactions between climate stressors and existing stressors are explored (Table 2; bolded bullet points represent key vulnerabilities for the land use and housing sector).

## DIRECT IMPACTS OF CLIMATE STRESSORS

### Warmer temperatures and more extreme heat

*Likely Impacts on Land Use and Housing*

- **High energy demand due to hotter summers and more extreme heat, increasing costs and the risk of power outages (with potentially significant impacts on vulnerable residents such as those who are already under financial stress)**
- Increased water demand for residential/commercial and agricultural uses (e.g., landscaping, crop irrigation) due to higher temperatures
- Increased heat stress in developed areas, particularly in areas where impervious surfaces and lack of vegetation create heat islands
- Increased wear and/or damage to houses and associated infrastructure (e.g., buckling, deterioration)
- Increased risk of heat-related health impacts and potential changes in patterns of use for businesses, public facilities, parks, and public transportation, among others (e.g., heavier use of recreation sites with water features or public spaces with air conditioning)
- Greater risk of extreme heat impacts in low-income neighborhoods and other vulnerable communities that are more likely to experience heat island effects and lack access to cooling systems

### Increased extreme precipitation, storms, & flooding

*Likely Impacts on Land Use and Housing*

- **Increased risk of flooding along waterways, floodplains and low-lying areas, and where drainage is poor (naturally or due to impermeable surfaces), with disproportionate impacts on vulnerable communities that are more likely to reside in those areas**
- Reduced suitability of some areas (e.g., high-risk riverfront properties) for residential/commercial land uses due to severe flooding along waterways, floodplains, and low-lying areas with poor drainage
- Changes in floodplain extent and distribution over time, potentially impacting existing zoning allowances
- Damage or loss of existing homes and businesses due to flooding or related impacts (e.g., mold), particularly for older, low-quality, and/or poorly-sited buildings
- Increased risk of road slides or landslides from surrounding bluffs, causing damage to roads and other infrastructure
- **Reduced access to more isolated residential areas due to road flooding (e.g., mobile home parks with only one road in and out), potentially hindering evacuation efforts or emergency response**
- Increased cost or reduced availability of flood insurance for homeowners, renters, and businesses, as well as rising costs of repair following water damage to the structures and the infrastructure that services them (e.g., roads, utilities)
- Increased risk of impact to water quality due to run-off from contaminated land, roads or sewer overflow

### Increased drought

*Likely Impacts on Land Use and Housing*

- Reduced water availability and increased water demand for agricultural and residential/commercial use
- Increased risk of impact to water quality due to concentration of contaminants through evaporation and/or harmful algal blooms

**Table 2.** Summary of likely direct impacts of climate stressors on the Land Use and Housing sector as well as potential interactions with existing stressors, with key vulnerabilities in bold type.

## INTERACTIONS WITH EXISTING STRESSORS

### Changes in population dynamics and a limited supply of vacant land for development

*Likely Interactions Between Climate Stressors and Existing Stressors*

- Increased migration of "climate refugees" from more impacted communities into La Crosse, exacerbating existing challenges related to the lack of vacant land for development
- Expansion of areas vulnerable to severe flooding (e.g., floodplains and riverfront areas) may result in additional locations that become inappropriate for development or redevelopment, or may increases costs associated with development (i.e., due to increased cost of insurance, repair, or construction in flood-prone areas)

### Aging/deteriorating infrastructure and housing stock

*Likely Interactions Between Climate Stressors and Existing Stressors*

- Increased risk of damage or structural failure in deteriorating infrastructure and homes during severe flood events
- Greater cost of retrofitting older homes and buildings with modern, energy-efficient heating and cooling systems or other measures that reduce the impacts of extreme heat and flooding (compared to incorporating those systems into new construction)
- Potential for increased issues with rodents, insects, or other wildlife seeking refuge in homes from high temperatures or extreme conditions

### Lack of affordable housing and homelessness

*Likely Interactions Between Climate Stressors and Existing Stressors*

- Increased risk of injury or death for people living in homeless communities in highly flood-prone areas (e.g., floodplains)
- Further reduction in affordable housing availability due to the loss of housing units to flooding and/or decreases in areas suitable for development as a result of increased flooding risk

**Key Vulnerability:** High energy demand due to hotter summers and more extreme heat, increasing costs and the risk of power outages (with potentially significant impacts on vulnerable residents such as those who are already under financial stress)

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Almost Certain | Moderate | High | Moderate | **Moderate** |

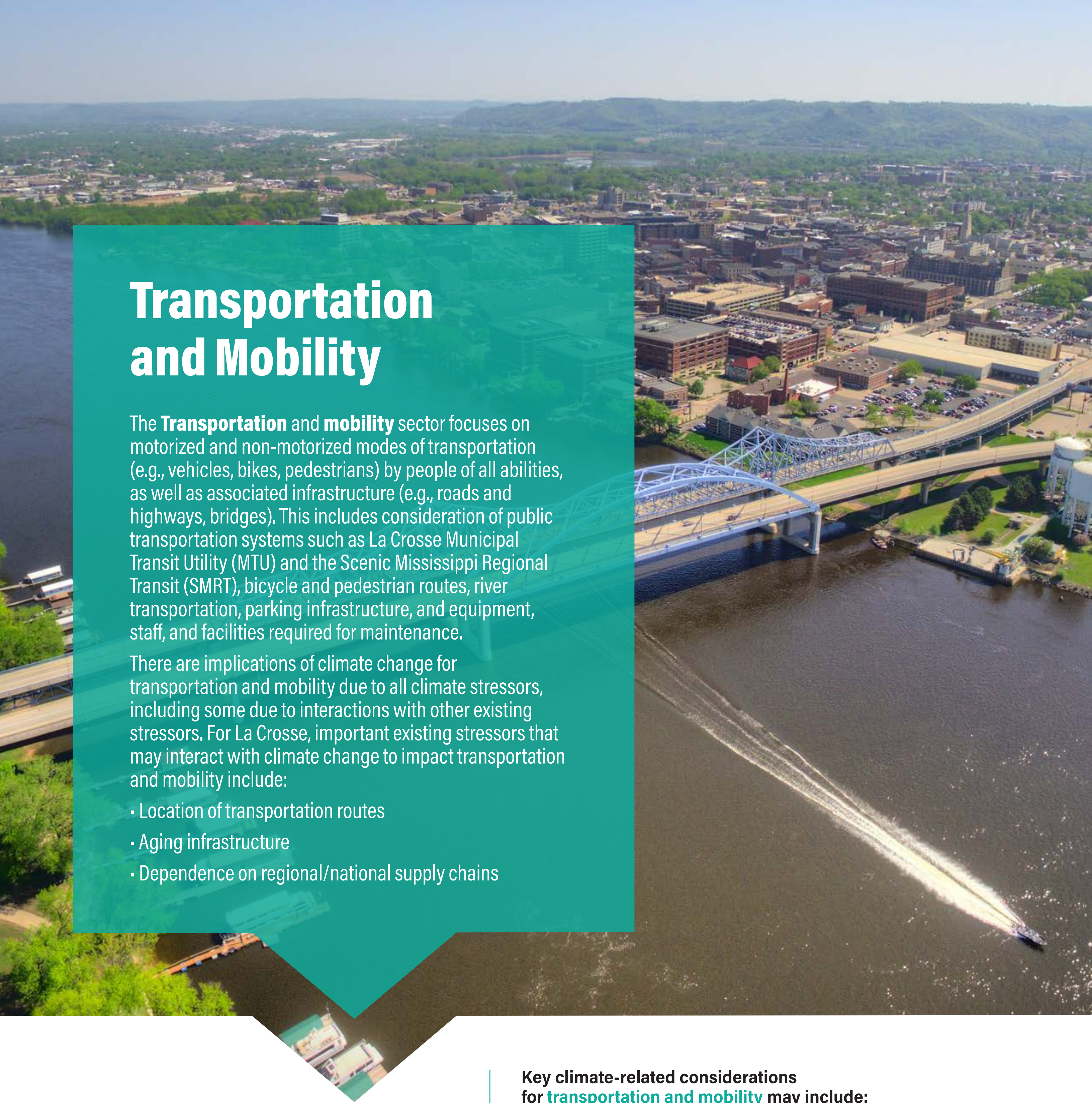
**Key Vulnerability:** Increased risk of flooding along waterways, floodplains and low-lying areas, and where drainage is poor (naturally or due to impermeable surfaces), with disproportionate impacts on vulnerable communities that are more likely to reside in those areas

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Almost Certain | Major | Extreme | Moderate | **High** |

**Key Vulnerability:** Increased risk of flooding along waterways, floodplains and low-lying areas, and where drainage is poor (naturally or due to impermeable surfaces), with disproportionate impacts on vulnerable communities that are more likely to reside in those areas

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Likely | Major | High | Low | **High** |

The likelihood, consequence, and adaptive capacity were ranked for each key vulnerability, resulting in risk and vulnerability evaluations for the impacts that were identified as being of particular concern for land use and housing.



# Transportation and Mobility

The **Transportation** and **mobility** sector focuses on motorized and non-motorized modes of transportation (e.g., vehicles, bikes, pedestrians) by people of all abilities, as well as associated infrastructure (e.g., roads and highways, bridges). This includes consideration of public transportation systems such as La Crosse Municipal Transit Utility (MTU) and the Scenic Mississippi Regional Transit (SMRT), bicycle and pedestrian routes, river transportation, parking infrastructure, and equipment, staff, and facilities required for maintenance.

There are implications of climate change for transportation and mobility due to all climate stressors, including some due to interactions with other existing stressors. For La Crosse, important existing stressors that may interact with climate change to impact transportation and mobility include:

- Location of transportation routes
- Aging infrastructure
- Dependence on regional/national supply chains

**Key climate-related considerations for transportation and mobility may include:**

- Impacts of climate change on infrastructure lifespan and need for maintenance and repair (e.g., frequency of required maintenance)
- Potential for transportation disruptions due to direct damage from extreme events (e.g., heat waves, floods)
- Impacts of climate change on ease of movement around the City and reliable access to neighborhoods, workplaces, and critical services
- Factors that could cause delays or interruptions in public transportation services, or make using public transportation more difficult and less desirable
- Impacts of climate change on the safety and comfort of pedestrians and cyclists of all abilities

In the table below, both direct climate impacts and interactions between climate stressors and existing stressors are explored (Table 3; bolded bullet points represent key vulnerabilities for the transportation and mobility sector).

## DIRECT IMPACTS OF CLIMATE STRESSORS

### Warmer temperatures and more extreme heat

*Likely Impacts on Transportation and Mobility*

- **Reduced interest in walking/biking or using public transportation on hot days, increasing dependence on cars with air conditioning**
- Increased heat stress in residents navigating lengthy public transportation routes, or those who live farther from the nearest bus stop
- Damage to surfaces (e.g., softening or buckling) of roads and sidewalks and increased potential for vehicles to overheat
- Increased stress on electrical grids, potentially resulting in power outages that can impact traffic lights and electric vehicle charging
- Changes in air density or other factors on very hot and humid days that impact airport requirements (e.g., fleet needs, runway length)
- Increased freeze/thaw cycles that damage roads and increase costs of road maintenance
- Increased potential for black ice due to melting and refreezing in the winter, increasing car accidents
- Eventual reduction in the need for winter snow removal and salting, decreasing costs and road damage and improving winter mobility for residents
- Potential for increased road rage incidents, increasing potential for traffic accidents and danger for bicyclists and pedestrians

### Increased extreme precipitation, storms, & flooding

*Likely Impacts on Land Use and Housing*

- **Increased flooding and associated damage to streets, sidewalks/trails, and parking lots during heavy rain events, particularly in low-lying areas or where stormwater infrastructure is inadequate**
- Increased cost of road maintenance, repairs, and replacement due to more frequent inundation
- Road blocks and disruption of traffic due to debris, which may also delay needed construction activities to repair damages to roads
- Damage to railroad tracks or possible derailment during extreme precipitation events
- Inundation and damage to ports, marinas, and docks due to river flooding
- Disruptions to air travel where more frequent and/or extreme storms require longer flight paths

### Increased drought

*Likely Impacts on Land Use and Housing*

- Decreased river flows, potentially impacting river transportation and commerce

**Table 3.** Summary of likely direct impacts of climate stressors on the Transportation and Mobility sector as well as potential interactions with existing stressors, with key vulnerabilities in bold type.

## INTERACTIONS WITH EXISTING STRESSORS

### Location of transportation routes

*Likely Interactions Between Climate Stressors and Existing Stressors*

- Existing transportation routes leave some areas of the city isolated, increasing the risk of traffic disruptions and loss of access during extreme events (e.g., if there is an issue with the railroad, traffic disruptions/loss of access would occur in many areas)
- **Historical investment in car-focused transportation has resulted in greater interest in suburban areas and reduced City walkability, complicating future changes to increase the ease and desirability of public and non-motorized transportation**

### Aging infrastructure

*Likely Interactions Between Climate Stressors and Existing Stressors*

- Increased need to retrofit and/or replace transportation infrastructure that is unable to cope with future stormwater volume (and costs associated with those upgrades)

### Dependence on regional/national supply chains

*Likely Interactions Between Climate Stressors and Existing Stressors*

- Increased fuel costs due to disruptions in fuel production or transport following extreme events, either locally or in other areas (e.g., as occurred in many places following the 2021 winter storms in Texas)

**Key Vulnerability:** Reduced interest in walking/biking or using public transportation on hot days, increasing dependence on cars with air conditioning

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Almost Certain | Moderate | High | High | **Moderate** |

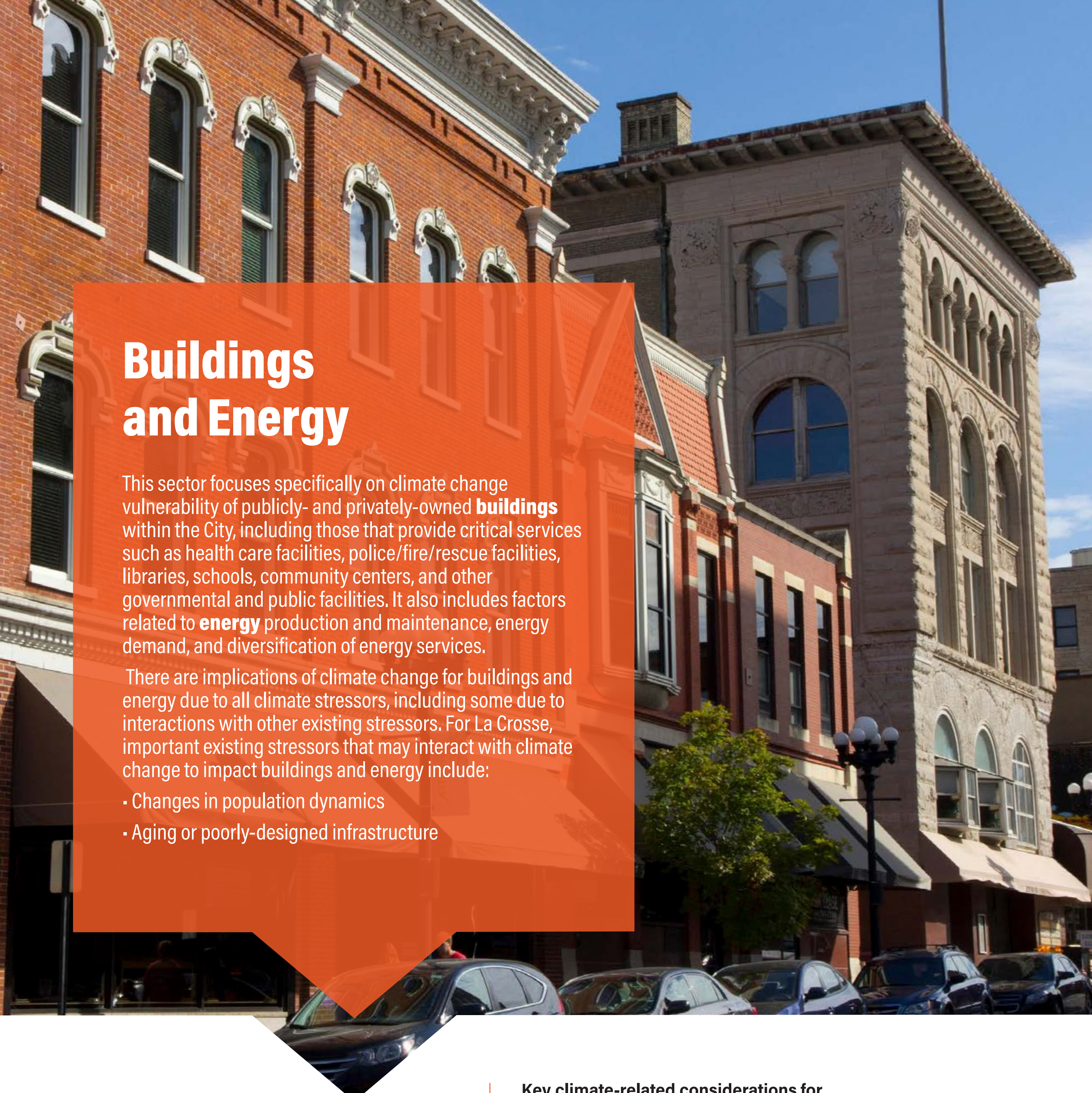
**Key Vulnerability:** Increased flooding and associated damage to streets, sidewalks/trails, and parking lots during heavy rain events, particularly in low-lying areas or where stormwater infrastructure is inadequate

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Almost Certain | Major | Extreme | Moderate | **High** |

**Key Vulnerability:** Historical investment in car-focused transportation has resulted in greater interest in suburban areas and reduced City walkability, complicating future changes to increase the ease and desirability of public and non-motorized transportation

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Likely | Moderate | Moderate | Moderate | **Moderate** |

The likelihood, consequence, and adaptive capacity were ranked for each key vulnerability, resulting in risk and vulnerability evaluations for the impacts that were identified as being of particular concern for transportation and mobility.



# Buildings and Energy

This sector focuses specifically on climate change vulnerability of publicly- and privately-owned **buildings** within the City, including those that provide critical services such as health care facilities, police/fire/rescue facilities, libraries, schools, community centers, and other governmental and public facilities. It also includes factors related to **energy** production and maintenance, energy demand, and diversification of energy services.

There are implications of climate change for buildings and energy due to all climate stressors, including some due to interactions with other existing stressors. For La Crosse, important existing stressors that may interact with climate change to impact buildings and energy include:

- Changes in population dynamics
- Aging or poorly-designed infrastructure

**Key climate-related considerations for buildings and energy may include:**

- Whether buildings are in areas that are particularly vulnerable to climate-related hazards such as flooding, and if so the degree to which the building itself is likely to be impacted based on factors such as age and condition
- Climate change impacts that might affect infrastructure necessary for buildings to remain functional, including stormwater and utilities infrastructure
- Impacts of extreme heat and other climate changes on energy supply and demand, as well as potential impacts of power outages and damage to powerlines or other infrastructure in the event of an extreme event

In the table below, both direct climate impacts and interactions between climate stressors and existing stressors are explored (Table 4; bolded bullet points represent key vulnerabilities for the buildings and energy sector).

## DIRECT IMPACTS OF CLIMATE STRESSORS

**Warmer temperatures and more extreme heat**

*Likely Impacts on Buildings and Energy*

- **High energy demand due to hotter summers and more extreme heat, increasing costs and the risk of power outages (with potentially significant impacts on vulnerable residents such as those who are already under financial stress)**
- Increased degradation of buildings and associated infrastructure (e.g., buckling, deterioration), requiring more frequent and/or more expensive repairs, replacements, or retrofits

**Increased extreme precipitation, storms, & flooding**

*Likely Impacts on Buildings and Energy*

- Increased damage or loss of buildings due to flooding or related impacts (e.g., mold)
- Increased risk of power outages and/or damage to energy infrastructure following extreme storm events

**Increased drought**

*Likely Impacts on Buildings and Energy*

- Reduced generation of hydroelectric power, increasing demand on natural gas/coal-fired power plants (given current grid configuration) and causing associated increases on electrical costs as well as greenhouse gas emissions

## INTERACTIONS WITH EXISTING STRESSORS

**Changes in population dynamics**

*Likely Interactions Between Climate Stressors and Existing Stressors*

- Changes in energy demands due to warmer temperatures and altered precipitation patterns, which may be strained further by increasing energy use associated with changing population dynamics

**Aging or poorly-designed infrastructure**

*Likely Interactions Between Climate Stressors and Existing Stressors*

- **Increased risk of damage or structural failure as a result of extreme events (e.g., heat, flood, wind) in buildings that are older and/or newer but poorly-designed**
- Greater cost of retrofitting older buildings with modern, energy-efficient heating and cooling systems or other measures that reduce the impacts of extreme heat and flooding (compared to incorporating those systems into new construction)

**Table 4.** Summary of likely direct impacts of climate stressors on the Buildings and Energy sector as well as potential interactions with existing stressors, with key vulnerabilities in bold type.

The likelihood, consequence, and adaptive capacity were ranked for each key vulnerability, resulting in risk and vulnerability evaluations for the impacts that were identified as being of particular concern for buildings and energy.

**Key Vulnerability:** High energy demand due to hotter summers and more extreme heat, increasing costs and the risk of power outages (with potentially significant impacts on vulnerable residents such as those who are already under financial stress)

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Almost Certain | Moderate | High | Moderate | **Moderate** |

**Key Vulnerability:** Increased damage or loss of buildings due to flooding or related impacts (e.g., mold)

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Almost Certain | Major | Extreme | Moderate | **High** |

- Stormwater flooding is already occurring across the City. It is particularly severe within the floodplains, but these areas seem to be expanding.
- Flooding has historically been exacerbated by inadequate stormwater and sewer infrastructure, and more rain falling during extreme events overwhelms the capacity of marshes and other natural systems.
- Some infill projects and efforts to remove houses from the floodplain are already occurring. The City has also added two new pumping stations to divert water out of the La Crosse River and is continuing to work on sewer/stormwater upgrades (though these are extremely expensive and can only be done when roads are already being replaced)
- The City adopted a Complete Streets ordinance in 2012, which requires better ,landscaping, increased use of permeable pavement, and other improvements that address stormwater management whenever streets are replaced.

**Key Vulnerability:** Increased risk of damage or structural failure as a result of extreme events (e.g., heat, flood, wind) in buildings that are older and/or newer but poorly-designed

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Almost Certain | Major | Extreme | Moderate | **High** |

- Newer buildings often struggle during windstorms because they are not sturdy enough. However building codes were recently updated to require 16 inch corner supports that ensure greater stability.

# Waste Management

**Waste management** refers to both municipal solid waste and recycling, and includes consideration of volume, demand and service capacity, and infrastructure associated with collection and disposal.

There are implications of climate change for waste management due to all climate stressors, including some due to interactions with other existing stressors. For La Crosse, important existing stressors that may interact with climate change to impact waste management include:

- Water pollution/water quality

*Photo by Rajvinder Singh via Unsplash*

**Key climate-related considerations for waste management may include:**

- Existing waste management infrastructure that may be particularly impacted by climate change, including facilities located in high-risk areas (e.g., close to the river)
- Potential climate change impacts on waste collection frequency and route length, as well as ways that climate impacts might be exacerbated by the current waste collection routines (e.g., less frequent collection could increase change of debris being spread and contamination into waterways)
- Cost of collection and transport of waste to transfer, recycling and dumpsite facilities as fossil fuel prices rise and climate impacts complicate existing processes

In the table below, both direct climate impacts and interactions between climate stressors and existing stressors are explored (Table 5; bolded bullet points represent key vulnerabilities for the waste management sector).

## DIRECT IMPACTS OF CLIMATE STRESSORS

### Warmer temperatures and more extreme heat

*Likely Impacts on Waste Management*

- Increased maintenance needs and costs
- Increased need for odor abatement
- Increased issues with air quality (beyond odor) and associated health impacts
- Increased pest activity and altered waste decomposition rates
- Increased potential for overheating of sorting equipment and collection vehicles
- Potential for shifts to earlier pick-up, and possible staffing challenges if this cannot be achieved

### Altered precipitation patterns

*Likely Impacts on Waste Management*

- Increased need for enclosed or protected facilities (e.g., processing sites, multi-family waste facilities, college move in/out, curbside trash)
- **Increased leakage and run-off, potentially impacting local water quality**

### Increased extreme precipitation, storms, & flooding

*Likely Impacts on Waste Management*

- Flooding and destruction of dumpsites, collection systems, drainage systems and management facilities, leading to decrease in capacity and management options
- Impact to delivery of waste and transport infrastructure (including inability to pick up) and increased potential for closure of facilities
- **Increased waste generation due to debris and other damage (including organic debris from vegetation damage), which is likely to be exacerbated by illegal dumping**
- Increased wind-driven dispersal (i.e., dumpster tipping, curbside cans)

### Increased drought

*Likely Impacts on Waste Management*

- Concentration of waste-related pollutants due to reduced river levels
- Increased risk of fire at disposal sites (usually if coupled with extreme heat)

**Table 5.** Summary of likely direct impacts of climate stressors on the Waste Management sector as well as potential interactions with existing stressors, with key vulnerabilities in bold type.

## INTERACTIONS WITH EXISTING STRESSORS

### Water pollution/ water quality

*Likely Interactions Between Climate Stressors and Existing Stressors*

- Existing concerns with the pollution and quality of city water may be exacerbated by the impacts that increased precipitation and extreme heat will have on the occurrence and mobility of waterborne diseases, debris and waste from dumpsites, and nutrient run-off

**Key Vulnerability:** Increased leakage and run-off, potentially impacting local water quality

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Almost Certain | Moderate | High | High | **Moderate** |

- These impacts are already occurring (e.g., dumpsters downtown release grease into rivers, and it is being addressed by replacing drain systems in older parts of town and educating renters on proper waste disposal.
- This is likely to be a year-round concern across the entire region (e.g., leaking into marshes and rivers as well as ground infiltration), but may be particularly impactful as winter rains increase; may be exacerbated in areas with high population density, especially around rentals.
- Infrastructure solutions are likely doable, but changing habitats through community education is more difficult.
- A communications director is being contracted to increase community engagement, and there is a similar position in water utilities. However, it can be challenging to reach a large proportion of the community because there are so many communication paths available to City residents.

**Key Vulnerability:** Increased waste generation due to debris and other damage (including organic debris from vegetation damage), which is likely to be exacerbated by illegal dumping

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Almost Certain | Major | Extreme | Moderate | **High** |

- This is likely to be a year-round problem across the City.
- The City Recycling and Street Departments currently have a yard waste drop-off site that is open from March to Nov. (with additional openings after large storms) and is free to residents; the site takes organic yard waste (less than 8 inches diameter) and waste cooking oil. The Parks Department takes on tree damage clean-up for the Street Department, although this is somewhat variable. Wood waste currently goes to Excel Energy Incinerator via the county landfill. Other materials are recycled (e.g., roof shingles, road material) or go to the county landfill.
- In order to address this issue, there would need to be increased capacity to deal with tree damage (would need to assess ability of the landfill to take on additional material).

The likelihood, consequence, and adaptive capacity were ranked for each key vulnerability, resulting in risk and vulnerability evaluations for the impacts that were identified as being of particular concern for buildings and energy.

# Water and Wastewater

This topic area includes drinking water, in terms of water quality and quantity and timing of supply, and wastewater, including stormwater runoff as well as municipal wastewater. Both drinking water and wastewater/stormwater require infrastructure for processing and distribution, which includes source water, underground water and sewer lines, culverts and stormwater management systems, and treatment facilities. Critically, this topic area must also include consideration of natural water resources that supply drinking water for the City (e.g., aquifers and reservoirs) and wetlands that provide water filtration and floodwater storage.

There are implications of climate change for water and wastewater due to all climate stressors, including some due to interactions with other existing stressors. For La Crosse, important existing stressors that may interact with climate change to impact water and wastewater include:

- Water quality
- Limited freshwater supplies
- Aging or inadequate infrastructure

*Photo by Enoch Leung via Flickr*

**Key climate-related considerations for water and wastewater may include:**

- Impacts of current and projected future precipitation patterns on water resources, including processes that are critical for maintaining drinking water supplies (e.g., groundwater recharge and surface water runoff)
- Impacts of extreme events (e.g., heat waves, flooding, drought) on water quality and stormwater management systems
- Water resource conservation measures that are already being implemented in the City, as well as existing and potential areas that could be used for natural floodwater storage

In the table below, both direct climate impacts and interactions between climate stressors and existing stressors are explored (Table 6; bolded bullet points represent key vulnerabilities for the water and wastewater sector).

## DIRECT IMPACTS OF CLIMATE STRESSORS

### More extreme heat

*Likely Impacts on Water and Wastewater*

- Increased water demand for municipal and agricultural use
- Reduced water quality due to high water temperatures and increased risk of harmful algal blooms

### Increased extreme precipitation, storms, & flooding

*Likely Impacts on Water and Wastewater*

- **Increased flooding during periods of heavy rain, particularly where the City's stormwater infrastructure is inadequate for increased volumes or impermeable surfaces prevent infiltration**
- Impacts on stormwater retention and effects on stormwater discharge compliance
- **Elevated groundwater tables due to frequent large storms, infiltrating the sanitary sewer system and increasing the cost of treatment**
- Increased soil erosion and nutrient runoff into rivers
- Reduced water quality due to stormwater inundation, localized flooding, and non-infiltrated runoff, potentially disrupting drinking water supplies where contamination occurs
- Increased occurrence and mobility of waterborne disease
- Increased community energy demand and costs to pump water out of flooded spaces

### Increased drought

*Likely Impacts on Water and Wastewater*

- Depletion of aquifer and reservoirs, potentially impacting drinking water supplies under extreme conditions (even as demand for water increases)
- Increased risk of harmful algal blooms in warm, slow-moving water bodies
- Potential for concentration of contaminants due to evaporation, impacting water quality
- Effects on function of septic and sewage systems, and increased odor complaints around the marsh when the water is low

## INTERACTIONS WITH EXISTING STRESSORS

### Water quality

*Likely Interactions Between Climate Stressors and Existing Stressors*

- Existing concerns with the pollution and quality of city water may be exacerbated by the impacts of increased precipitation and extreme heat, which will increase the occurrence and mobility of waterborne diseases, debris and waste from dumpsites, and nutrient run-off
- Impacts to local economy, as fishing tourism relies on water quality and access

### Limited freshwater supplies

*Likely Interactions Between Climate Stressors and Existing Stressors*

- Severe drought and high temperatures may deplete local aquifers and reservoirs, potentially impacting drinking water supplies
- Fluctuations in population can increase water demand and extraction

### Aging or inadequate infrastructure

*Likely Interactions Between Climate Stressors and Existing Stressors*

- Increased potential for localized to widespread flooding as increased precipitation and more frequent/severe extreme precipitation events overwhelm the City's existing stormwater infrastructure, which is already inadequate for brief, intense rainstorms that are common in the summer
- Increasing issues with the City's existing sewer lines as precipitation increases, as these already fail frequently and need to be replaced
- Increasing issues with failing septic systems that were not designed for changing environmental conditions
- Infiltration and sink-holes (esp. with spring thaw) lead to sand in pipes and sewers, damage to property, cost of repair, and disruption of other services (waste pick up, transportation)

**Table 6.** Summary of likely direct impacts of climate stressors on the Water and Wastewater sector as well as potential interactions with existing stressors, with key vulnerabilities in bold type.

**Key Vulnerability:** Increased flooding during periods of heavy rain, particularly where the City's stormwater infrastructure is inadequate for increased volumes or impermeable surfaces prevent infiltration

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Almost Certain | Major | Extreme | High | **Moderate** |

- Increased flooding is already being observed in La Crosse, and efforts to address it are led by the Water and Sewer Department.
- Stormwater modeling has been completed for the City, and has led to identification of key areas where improvements are needed; these include the north side of town where groundwater tables are already highest and intersection flooding occurs.
- The City implemented a Stormwater Utility to fund needed infrastructure improvements, and is working towards grants and matchings.
- There is also a Stormwater Coordinator that works with the community to encourage behaviors that reduce flooding vulnerability (e.g., don't blow grass clippings into the street, clean storm grates, remove ice from catch basins).

**Key Vulnerability:** Elevated groundwater tables due to frequent large storms, infiltrating the sanitary sewer system and increasing the cost of treatment

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Almost Certain | Moderate | High | High | **Moderate** |

- The most significant impacts are likely to be on the north side of the City, but all of the old clay tile pies are vulnerable to infiltration. The roots of street trees infiltrate sewers, and there are trees on top of most sanitary laterals; sump pumps also discharge into the sewer system.
- Existing issues with infiltration are being addressed by relining sewers that are in otherwise acceptable condition, and replacing those that are in bad shape; these efforts are being led by the Water and Sewer Department, along with the Engineering Department and the Street Department (as sewer work is often paired with road repairs). The Water and Sewer Dept. is also working with the Park Dept. to avoid issues with street trees by planting in better locations and potentially selecting different species.
- Year-by-year access to funding for needed improvements is an ongoing effort, but collaboration between City departments (e.g., Water/Sewer, Streets, Parks) reduces costs. The City is also trying to educate the community about ways to ensure that this problem is not being exacerbated.

The likelihood, consequence, and adaptive capacity were ranked for each key vulnerability, resulting in risk and vulnerability evaluations for the impacts that were identified as being of particular concern for water and wastewater.

# Health and Safety

**Health** and **safety** include potential hazards that directly or indirectly impact public health by exacerbating chronic health conditions, causing illness or disease, and increasing the risk of injury or death. This topic also considers emergency services (e.g., fire, rescue), social services, and public health programming.

There are implications of climate change for health and safety due to all climate stressors, including some due to interactions with other existing stressors. For La Crosse, important existing stressors that may interact with climate change to impact health and safety include:

- Aging infrastructure
- Lack of adequate community healthcare services

*Photo by Peg Lemkuil via Unsplash*

**Key climate-related considerations for health and safety may include:**

- Emergency, health, and safety resources or services that may be affected by changing conditions, particularly those in high-risk areas that are more likely to be impacted by flooding or other extreme events
- Potential changes in patterns of demand for emergency and health care services as a result of climate change, including changes in the type, frequency, or location of emergency calls and health care services required
- Impacts of extreme events on ambulance access or other factors that would prevent emergency personnel from quickly and safely reaching those in need, or would otherwise limit operation/functioning of emergency systems (e.g., impacts to dispatch, vehicles or equipment, etc.)
- Potential ways that climate change could impact the type of public health programming or outreach/education that is required to meet the needs of the community

In the table below, both direct climate impacts and interactions between climate stressors and existing stressors are explored (Table 7; bolded bullet points represent key vulnerabilities for the health and safety sector).

## DIRECT IMPACTS OF CLIMATE STRESSORS

### Warmer temperatures and more extreme heat

*Likely Impacts on Health and Safety*

- Increased air pollution (e.g., fine particulate matter, ground-level ozone) that impacts respiratory and cardiovascular health, particularly for at-risk individuals (e.g., children, seniors, people with chronic health conditions)
- **Increase in heat- or cold-related illness and death, which may be exacerbated by pre-existing medical conditions, age, occupation, and/or socioeconomic variables (e.g., access to a vehicle or regular health care)**
- Increased demand for public shelter, emergency, and medical services
- Reduced ability for individuals to leave their home, participate in the community, and access critical services
- Increased loss of cooling systems to prevent heat-related illness, risk of food spoilage, and loss of refrigeration for critical medications due to power outages
- Increased potential for mental health impacts or violence/unrest associated with heat waves

### Altered precipitation patterns

*Likely Impacts on Health and Safety*

- Increased incidence of mold in homes that may lead to health conditions
- Increased issues with disease vectors (e.g., ticks, mosquitos) as moisture levels increase

### Increased extreme precipitation, storms, & flooding

*Likely Impacts on Health and Safety*

- Increased risk of injuries and increased demand on medical and emergency services due to damage and debris associated with extreme storms/flooding
- **Increased demand for public shelter, emergency, and medical services**
- Disruption to medical and emergency services (supply, access, and dissemination)
- Decreased access to critical services, disruption to communication systems, and delayed emergency response due to impacts to road accessibility
- Displacement of individuals whose homes are damaged, exacerbating inequities for lower-income individuals due to the cost of replacing or repairing their homes and belongings
- Reduced water quality and increased risk of waterborne disease outbreaks
- Scarcity of basic goods (e.g., food) due to supply chain disruptions

### Increased drought

*Likely Impacts on Health and Safety*

- Water scarcity
- Increased concentrations of pollutants due to reduced river levels and flows
- Impact to subsistence (pea patches, fishing) and commercial (farmers market, fisheries) food sources

**Table 7.** Summary of likely direct impacts of climate stressors on the Health and Safety sector as well as potential interactions with existing stressors, with key vulnerabilities in bold type.

## INTERACTIONS WITH EXISTING STRESSORS

### Aging infrastructure

*Likely Interactions Between Climate Stressors and Existing Stressors*

- Water, energy, and transportation systems may not be able to handle increased demand during periods of extreme heat

### Lack of adequate community healthcare services

*Likely Interactions Between Climate Stressors and Existing Stressors*

- Emergency centers and critical services may not have the capacity to address increases in the community's needs as climate change exacerbate existing shortages
- Extreme events can cause a disruption in usual daily responsibilities and priorities in order to address emergencies, placing additional strain on healthcare staff

**Key Vulnerability:** Increase in heat- or cold-related illness and death, which may be exacerbated by pre-existing medical conditions, age, occupation, and/or socioeconomic variables (e.g., access to a vehicle or regular health care)

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Almost Certain | Moderate | High | High | **Moderate** |

- Increased illness and death is mostly likely to occur during the hottest months of the summer, as well as during the most extreme cold events (particularly when more winter rain and ice and less snow cover decreases insulation for infrastructure such as pipes, increasing the likelihood of damage); unsheltered community members are at particularly high risk.
- Extreme heat events have not yet caused spikes in illness or death, though older homes may not be comfortable.
- Weatherization programs for existing homes will be critical as extreme temperatures (both heat and cold) become more dangerous for human health and safety.

**Key Vulnerability:** Increased demand for public shelter, emergency, and medical services

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Almost Certain | Moderate | High | High | **Moderate** |

- Demand is likely to increase for all extreme events, including storms/flooding and extreme temperatures (heat and cold), particularly among unsheltered community members and where there is less access to transportation.
- It will be important to ensure that 24-hour availability of these services exists, and that emergency personnel preparedness efforts are coordinated.
- Modification of public buildings to serve as shelters may also play a role in preparedness for extreme events.

The likelihood, consequence, and adaptive capacity were ranked for each key vulnerability, resulting in risk and vulnerability evaluations for the impacts that were identified as being of particular concern for health and safety.

# Local Food and Agriculture

This topic area considers **local food** and **agriculture** systems, including farms and associated infrastructure, food processing and distribution systems, and community food security.

There are implications of climate change for local food and agriculture due to all climate stressors, including some due to interactions with other existing stressors. For La Crosse, important existing stressors that may interact with climate change to impact local food and agriculture include:

- Changes in population dynamics and limited supply of undeveloped land

*Photo by Bob Nichols USDA via Flickr*

**Key climate-related considerations for local food and agriculture may include:**

- Current impacts of climate conditions on existing agricultural/food systems, and how that may be altered by changes in temperature and precipitation in coming decades
- Extreme events that could lead to crop failure and associated impacts (e.g., economic losses, supply chain issues)
- Potential impacts of climate change on patterns of supply and demand of food, as well as impacts on factors related to food distribution (e.g., supply chain) and storage (e.g., increased spoilage)
- Climate-related impacts that may influence food prices and community food security, particularly for vulnerable populations (e.g., low-income and mobility-limited residents)

In the table below, both direct climate impacts and interactions between climate stressors and existing stressors are explored (Table 8; bolded bullet points represent key vulnerabilities for the local food and agriculture sector).

## DIRECT IMPACTS OF CLIMATE STRESSORS

### Warmer temperatures and more extreme heat

*Likely Impacts on Local Food and Agriculture*

- Increased length of the growing season and potential increases in heat stress, disease, and insect pests, impacting growth and productivity of agricultural crops
- Increased presence of weeds and fungi that compete with crops for light, water, and nutrients
- Expansion of non-native invasive plants and insect pests as temperatures increase (particularly winter temperatures)
- Changes in pollinator populations due to warmer temperatures and associated phenological changes (potential for positive and negative impacts on local food and agriculture)
- **Current crops may not be suited for new conditions, requiring changes in crops and equipment needed for new crop cultivation and processing**
- Possibility for more than one cropping per season due to warming temperatures, potentially increasing local food production
- Increased water temperatures, adversely impacting local trout fisheries
- Reduced plant growth and increased mortality during periods of extreme heat, decreasing crop production and sustainability
- Increased need for supplemental watering during periods of extreme heat
- Increased erosion and topsoil loss where extreme heat leads to loss of existing plant cover
- Potential for changes in nutritional value of crops
- Increased cost of refrigeration for food transport and preservation due to warming temperatures and energy/climate costs (e.g., chemicals)
- Increased health risks for agricultural workers exposed to extreme temperatures, vector-borne diseases, and other outdoor hazards exacerbated by climate change

### Altered precipitation patterns and increased extreme precipitation, storms, & flooding

*Likely Impacts on Local Food and Agriculture*

- **Current crops may not be suited for new conditions, requiring changes in crops and equipment needed for new crop cultivation and processing**
- Changes in the timing of planting and harvest (e.g., farmers may not be able to plant crops early in the season and may have to wait in the fall to harvest corn) due to muddy fields, difficulty in accessing farms
- **Shifts in the size and location of floodplains, which may influence areas of land that are suitable for agriculture and/or the crops that can be grown there**
- **Increased flooding and erosion of agricultural lands located near rivers and floodplains, resulting in crop failures and/or damage or destruction of infrastructure**
- Loss of crops such as corn where extreme precipitation or storms/wind events (e.g., derechos) occur mid-season
- Greater need for expansion of underground infrastructure that drains farmed wetlands
- Impaired water quality due to flooding

### Increased drought

*Likely Impacts on Local Food and Agriculture*

- Reduced groundwater discharge and overall water availability as well as diminished water quality
- Increased water demand due to greater need for irrigation (and associated increases in cost)
- Degradation of soil health, threatening crop production and contributing to food price instability
- Increased flooding and erosion when heavy rains occur following periods of drought due to reduced ability of dry soil to absorb water
- Increased risk of wildfires during periods of severe drought, destroying and impacting crops and food accessibility, and threatening open spaces

## INTERACTIONS WITH EXISTING STRESSORS

### Changes in population dynamics and limited supply of undeveloped land

*Likely Interactions Between Climate Stressors and Existing Stressors*

- Increased demand on agricultural systems and local food supplies and food transportation systems due to increasing populations and changes in patterns of demand (e.g., increases in animal consumption require more agricultural space to be used to feed those animals), which will be stressed further by climate change and more frequent extreme events that also impact patterns of supply and demand
- Because there are already very few areas of undeveloped land in the City, the loss of additional agricultural land as a result of expanding floodplains, contamination, or other climate-related hazards would be an enormous challenge
- Increasing development pressure is likely to place additional stress on agricultural areas, and may put some of them at risk of conversion (i.e., to housing)

**Table 8.** Summary of likely direct impacts of climate stressors on the Local Food and Agriculture sector as well as potential interactions with existing stressors, with key vulnerabilities in bold type.

**Key Vulnerability:** Current crops may not be suited for new conditions, requiring changes in crops and equipment needed for new crop cultivation and processing

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Likely | Moderate | Moderate | High | **Low** |

- Hmong, Amish, and indigenous farmers and communities are likely to experience the greatest impacts.
- Diversity is known to be a key driver for resilience, and the region is an epicenter for small, diversified farms. Small farmers may be better able to adapt, and farmers in the area may be able to learn from indigenous and Amish practices.
- It will be difficult to address this impact without further education for the community about where their food comes from, as well as willingness to adjust their eating habits.

**Key Vulnerability:** Shifts in the size and location of floodplains, which may influence areas of land that are suitable for agriculture and/or the crops that can be grown there

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Almost Certain | Major | Extreme | Low | **High** |

**Key Vulnerability:** Increased flooding and erosion of agricultural lands located near rivers and floodplains, resulting in crop failures and/or damage or destruction of infrastructure

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Almost Certain | Major | Extreme | Moderate | **High** |

The likelihood, consequence, and adaptive capacity were ranked for each key vulnerability, resulting in risk and vulnerability evaluations for the impacts that were identified as being of particular concern for local food and agriculture.

# Greenspace and Tree Canopy

This topic area includes community **greenspace**, including parks, conservation lands, and other open space resources, as well as the urban **tree canopy**. Important aspects include the condition and management needs of these natural systems, which are associated with groundwater and surface water resources, recreation, native plants and wildlife (including threatened and endangered species), and other natural resources. The City of La Crosse already has over 40 parks and open spaces, many of which have been established since the early 1900s, and which occupy over 1,300 acres within the City boundary.

There are implications of climate change for greenspace and tree canopy due to all climate stressors, including some due to interactions with other existing stressors. For La Crosse, important existing stressors that may interact with climate change to impact greenspace and tree canopy include:

- Availability of open space
- Insufficient capacity to maintain existing facilities

*Photo by Andrew Haimerl via Unsplash*

**Key climate-related considerations for local food and agriculture may include:**

- Current impacts of climate conditions on existing agricultural/food systems, and how that may be altered by changes in temperature and precipitation in coming decades
- Extreme events that could lead to crop failure and associated impacts (e.g., economic losses, supply chain issues)
- Potential impacts of climate change on patterns of supply and demand of food, as well as impacts on factors related to food distribution (e.g., supply chain) and storage (e.g., increased spoilage)
- Climate-related impacts that may influence food prices and community food security, particularly for vulnerable populations (e.g., low-income and mobility-limited residents)

In the table below, both direct climate impacts and interactions between climate stressors and existing stressors are explored (Table 9; bolded bullet points represent key vulnerabilities for the greenspace and tree canopy sector).

## DIRECT IMPACTS OF CLIMATE STRESSORS

### Warmer temperatures and more extreme heat

*Likely Impacts on Greenspace and Tree Canopy*

- Increased length of the growing season and potential increases in heat stress, disease, and insect pests, impacting growth and productivity of trees and native vegetation
- **Expansion of non-native invasive plants and insect pests as temperatures increase (particularly winter temperatures), likely resulting in the introduction of new invasive species into the area**
- Shifts in the composition and distribution of native plant communities due to warmer temperatures and associated impacts (e.g., loss of ash trees as emerald ash borer continues to expand)
- Changes in use of parks and recreational areas with more warm days (e.g., increased demand for areas with more shade and water features, reduced demand for areas like soccer fields when it is too hot for people to want to play)
- Reduced plant growth and increased mortality during periods of extreme heat, impacting street trees and native plant communities

### Altered precipitation patterns and increased extreme precipitation, storms, & flooding

*Likely Impacts on Greenspace and Tree Canopy*

- Shifts in the composition and distribution of native plant communities due to wetter conditions and shifts in seasonal precipitation patterns
- Changes in the size and location of floodplains and wetlands
- Increased runoff of nutrients and contaminants from urban and agricultural areas, impacting water quality
- Changes in the size and location of floodplains and wetlands
- **Increased flooding and erosion, impacting native plant communities (e.g., can result in loss of species such as ash) as well as access to and condition of parks and conservation areas (e.g., trail flooding in and around the La Crosse River Marsh)**
- Loss of trees and other native vegetation during windstorms (greenspace areas are very vulnerable to derechos), which are being observed more frequently in the winter months
- Increases in costs for repairs and cleanup due to damage (e.g., washouts)
- Increased use of de-icing chemicals, which may impact native vegetation

### Increased drought

*Likely Impacts on Greenspace and Tree Canopy*

- Increased water demand for irrigation and other uses, as well as increases in associated costs
- Increased risk of wildfire during severe droughts, impacting native plants and animals and potential damaging or destroying infrastructure
- Increased risk of harmful algal blooms, impacting aquatic systems (e.g., rivers, lakes/ponds) and people (e.g., respiratory distress)

**Table 9.** Summary of likely direct impacts of climate stressors on the Greenspace and Tree Canopy sector as well as potential interactions with existing stressors, with key vulnerabilities in bold type.

## INTERACTIONS WITH EXISTING STRESSORS

### Availability of open space

*Likely Interactions Between Climate Stressors and Existing Stressors*

- Because there is already a limited amount of undeveloped land in the city, it is challenging to add new parks and open space
- Development pressure on existing open space is likely to increase over time, particularly if climate change impacts the suitability of other areas for development (e.g., limiting development within expanding floodplains)
- Loss of open space and tree cover exacerbates heat islands)

### Insufficient capacity to maintain existing facilities

*Likely Interactions Between Climate Stressors and Existing Stressors*

- Increased need to maintain and clean up after storms will increase stress for the City, particularly in areas where there are many trails (e.g., Hixon Forest where trails are maintained by non-profit organizations with City oversight)
- Increased cost and maintenance needs for public pools as demand increases during hotter summers
- Overall, the city needs increased capacity to maintain its existing park and open space facilities, and future demand for land, increasing use of parks and open space, and the impacts from climate change will increase these stressors

**Key Vulnerability:** Expansion of non-native invasive plants and insect pests as temperatures increase (particularly winter temperatures), likely resulting in the introduction of new invasive species into the area

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Almost Certain | Moderate | High | Moderate | **Moderate** |

**Key Vulnerability:** Increased flooding and erosion, impacting native plant communities (e.g., can result in loss of species such as ash) as well as access to and condition of parks and conservation areas (e.g., trail flooding in and around the La Crosse River Marsh)

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Almost Certain | Major | Extreme | Moderate | **High** |

The likelihood, consequence, and adaptive capacity were ranked for each key vulnerability, resulting in risk and vulnerability evaluations for the impacts that were identified as being of particular concern for greenspace and tree canopy.


# Economy

This topic area includes various indicators of **economic activity and opportunities** within the community, including employment, ability to attract and retain businesses and local industries, and community support for the local economy.

There are implications of climate change for the economy due to all climate stressors, including some due to interactions with other existing stressors. For La Crosse, important existing stressors that may interact with climate change to impact the economy include:

- Costs and funding allocation
- Aging infrastructure

**Key climate-related considerations for the economy may include:**

- Impacts of current climate conditions (precipitation and temperature) that affect the City's economy and resources that drive it, and consideration of how local business and industry might be affected if these patterns change (e.g., hotter or colder days, less snow, etc.)
- Potential for climate-driven changes in either the supply or demand for products or services that are crucial to the local economy (e.g., tourism, agricultural or forest products)
- Impacts of action to address climate change – or inaction – on various aspects of the local economy, including direct costs or savings, job creation/ employment rates, and vitality of the downtown areas and local businesses

In the table below, both direct climate impacts and interactions between climate stressors and existing stressors are explored (Table 10; bolded bullet points represent key vulnerabilities for the economy sector).

## DIRECT IMPACTS OF CLIMATE STRESSORS

### Warmer temperatures and more extreme heat

*Likely Impacts on Economy*

- Altered consumer patterns due to changing temperatures (e.g., fewer winter shoppers and street traffic in downtown areas where windows reflect the sun and there is little shade)
- **Increased demand on electrical grids, which increase costs associated with heating/cooling and could result in more frequent power outages that impact business and industry (e.g., manufacturing)**
- Increased costs associated with maintenance (e.g., of parking lots and roofs), insurance, and continuity of services (e.g., air conditioning of stores and businesses)
- Longer growing seasons and shifts in the suitability of climate conditions for plant growth and productivity could impact commercial agriculture and forestry, with potential implications on the supply chain
- **Increased risks for outdoor workers who are more exposed to heat, potentially reducing labor productivity**
- Increased costs of heat-related injuries or illness (i.e., increased use of medical services)
- Changes in recreation and tourism that impact the economy due to reduced potential for winter sports (e.g., skiing, ice fishing, ice hockey) as well as temperature-driven losses of native fish (e.g., trout) valued for recreational fishing

### Altered precipitation patterns and increased extreme precipitation, storms, & flooding

*Likely Impacts on Economy*

- Greater risk of flood/storm damage, causing economic stress due to lost revenue and increasing costs of repair/rebuilding, insurance, and continuity of service
- Disruption of commercial and consumer activity during and after extreme events, depleting financial resources and reserves
- Increased costs due to the agricultural economy due to greater energy use for drying wet corn

### Increased drought

*Likely Impacts on Greenspace and Tree Canopy*

- Drops in Mississippi River water levels that create places for barges to run aground, which can lead to problems for travel and transport of goods locally and the supply chain regionally
- Reduced ability to supply businesses and residents (e.g., the City, the brewery) with clean water or very high expenses associated with providing bottled water, which is likely to be exacerbated by contamination

**Table 10.** Summary of likely direct impacts of climate stressors on the Economy sector as well as potential interactions with existing stressors, with key vulnerabilities in bold type.

## INTERACTIONS WITH EXISTING STRESSORS

### Costs and funding allocation

*Likely Interactions Between Climate Stressors and Existing Stressors*

- Increases in cost of development due to higher insurance costs
- Increased funding needed for retrofits and repairs/upgrades, straining local businesses that may already be struggling
- Funds being used to address repairs following extreme events, rather than proactively retrofitting or replacing aging infrastructure that may be unlikely to cope with future conditions (e.g., retrofitting or replacing stormwater infrastructure that is unable to adequately handle future precipitation amounts); may result in need to increase local taxes to cover increasing expense

### Aging infrastructure

*Likely Interactions Between Climate Stressors and Existing Stressors*

- Increased risk of damage and disruption to transportation and businesses due to infrastructure failure, and more extended time and cost needed for post-disaster recovery

**Key Vulnerability:** Increased demand on electrical grids, which increase costs associated with heating/cooling and could result in more frequent power outages that impact business and industry (e.g., manufacturing)

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Almost Certain | Moderate | High | High | **Moderate** |

**Key Vulnerability:** Increased risks for outdoor workers who are more exposed to heat, potentially reducing labor productivity

| Likelihood | Consequence | Risk | Adaptive Capacity | **Vulnerability** |
|---|---|---|---|---|
| Almost Certain | Moderate | High | Moderate | **Moderate** |

The likelihood, consequence, and adaptive capacity were ranked for each key vulnerability, resulting in risk and vulnerability evaluations for the impacts that were identified as being of particular concern for greenspace and tree canopy.

# Conclusions

In the table below, both direct climate impacts and interactions between climate stressors and existing stressors are explored (Table 10; bolded bullet points represent key vulnerabilities for the economy sector).

| SECTOR | KEY VULNERABILITIES | |
|---|---|---|
|  | • High energy demand due to hotter summers and more extreme heat, increasing costs and the risk of power outages (with potentially significant impacts on vulnerable residents such as those who are already under financial stress) | ▶ MODERATE VULNERABILITY (temperature, extreme heat) |
| | • Increased risk of flooding along waterways, floodplains and low-lying areas, and where drainage is poor (naturally or due to impermeable surfaces), with disproportionate impacts on vulnerable communities that are more likely to reside in those areas | ▶ HIGH VULNERABILITY (storms/flooding) |
| | • Reduced access to more isolated residential areas due to road flooding (e.g., mobile home parks with only one road in and out), potentially hindering evacuation efforts or emergency response | ▶ HIGH VULNERABILITY (storms/flooding) |
|  | • Reduced interest in walking/biking or using public transportation on hot days, increasing dependence on cars with air conditioning | ▶ MODERATE VULNERABILITY (temperature, extreme heat) |
| | • Increased flooding and associated damage to streets, sidewalks/trails, and parking lots during heavy rain events, particularly in low-lying areas or where stormwater infrastructure is inadequate | ▶ MODERATE VULNERABILITY (storms/flooding) |
| | • Historical investment in car-focused transportation has resulted in greater interest in suburban areas and reduced City walkability, complicating future changes to increase the ease and desirability of public and non-motorized transportation | ▶ MODERATE VULNERABILITY (ALL) |
|  | • High energy demand due to hotter summers and more extreme heat, increasing costs and the risk of power outages (with potentially significant impacts on vulnerable residents such as those who are already under financial stress) | ▶ MODERATE VULNERABILITY (temperature, extreme heat) |
| | • Increased damage or loss of buildings due to flooding or related impacts (e.g., mold) | ▶ HIGH VULNERABILITY (storms/flooding) |
| | • Increased risk of damage or structural failure as a result of extreme events (e.g., heat, flood, wind) in buildings that are older and/or newer but poorly-designed | ▶ HIGH VULNERABILITY (extreme heat, storms/flooding) |
|  | • Increased leakage and run-off, potentially impacting local water quality | ▶ MODERATE VULNERABILITY (precipitation, storms/flooding) |
| | • Increased waste generation due to debris and other damage (including organic debris from vegetation damage), which is likely to be exacerbated by illegal dumping | ▶ HIGH VULNERABILITY (storms/flooding) |
|  | • Increased flooding during periods of heavy rain, particularly where the City's stormwater infrastructure is inadequate for increased volumes or impermeable surfaces prevent infiltration | ▶ MODERATE VULNERABILITY (storms/flooding) |
| | • Elevated groundwater tables due to frequent large storms, infiltrating the sanitary sewer system and increasing the cost of treatment | ▶ MODERATE VULNERABILITY (storms/flooding) |
|  | • Increase in heat- or cold-related illness and death, which may be exacerbated by pre-existing medical conditions, age, occupation, and/or socioeconomic variables (e.g., access to a vehicle or regular health care) | ▶ MODERATE VULNERABILITY (extreme heat) |
| | • Increased demand for public shelter, emergency, and medical services | ▶ MODERATE VULNERABILITY (extreme heat, storms/flooding) |
|  | • Current crops may not be suited for new conditions, requiring changes in crops and equipment needed for new crop cultivation and processing | ▶ LOW VULNERABILITY (temperature, precipitation) |
| | • Shifts in the size and location of floodplains, which may influence areas of land that are suitable for agriculture and/or the crops that can be grown there | ▶ HIGH VULNERABILITY (precipitation, storms/flooding) |
| | • Increased flooding and erosion of agricultural lands located near rivers and floodplains, resulting in crop failures and/or damage or destruction of infrastructure | ▶ HIGH VULNERABILITY (storms/flooding) |
|  | • Expansion of non-native invasive plants and insect pests as temperatures increase (particularly winter temperatures), likely resulting in the introduction of new invasive species into the area | ▶ MODERATE VULNERABILITY (temperature) |
| | • Increased flooding and erosion, impacting native plant communities (e.g., can result in loss of species such as ash) as well as access to and condition of parks and conservation areas (e.g., trail flooding in and around the La Crosse River Marsh) | ▶ HIGH VULNERABILITY (storms/flooding) |
|  | • Increased demand on electrical grids, which increase costs associated with heating/cooling and could result in more frequent power outages that impact business and industry (e.g., manufacturing) | ▶ MODERATE VULNERABILITY (temperature, extreme heat) |
| | • Increased risks for outdoor workers who are more exposed to heat, potentially reducing labor productivity | ▶ MODERATE VULNERABILITY (extreme heat) |

# Conclusions

Across all sectors, storms/flooding and extreme heat emerged as the climate stressors of greatest concern. Key vulnerabilities that were very similar across multiple sectors included:

- Increased risk of damage or losses to infrastructure (e.g., roads, buildings) due to flooding, particularly along waterways, floodplains, and other low-lying areas or where stormwater infrastructure is adequate
- Shifts in the size and location of floodplains, resulting in the loss of areas suitable for certain uses (e.g., development, agriculture)
- Impacts to crops and native plant communities as a result of increased flooding and erosion
- High energy demand due to hotter summers and more extreme heat, increasing costs and the risk of power outages

*Photo by Dave Hoefler via Unsplash.jpg*

Key vulnerabilities identified in this report may be used as a starting point for discussion of strategic goals and actions that should be prioritized for implementation in the City of La Crosse, with particular attention paid to vulnerable populations that may be disproportionately impacted by these changes. Because climate adaptation is an iterative process and new research and modeling on projected climate change and its impacts are regularly released, it is important to revisit and/or revise the vulnerability assessments and adaptation strategies on a regular basis (e.g., every 5-10 years), as well as when additional topics of concern become priorities.

Adaptation efforts that effectively address these key vulnerabilities will not only reduce the negative impacts of climate change on La Crosse, but also have the potential to address underlying stressors and inequities that have long been an issue in the community (e.g., pollution, aging infrastructure). With careful attention and community willingness to invest time and resources into adaptation as well as mitigation efforts, the City of La Crosse can become more resilient and continue to grow and thrive over the coming decades.

# Literature Cited


[1] L. J. Hansen, J. M. Kershner, and E. E. Mielbrecht, "Rapid Vulnerability & Adaptation Tool for Climate-Informed Community Planning," EcoAdapt, Bainbridge Island, WA, 2021.

[2] M. Notaro, D. Lorenz, C. Hoving, and M. Schummer, "Twenty-first-century projections of snowfall and winter severity across central-eastern North America," *Journal of Climate*, vol. 27, no. 17, pp. 6526–6550, Sep. 2014, doi: 10.1175/JCLI-D-13-00520.1.

[3] D. R. Easterling et al., "Precipitation change in the United States," in *Climate Science Special Report: Fourth National Climate Assessment*, Volume I, D. J. Wuebbles, D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, and T. K. Maycock, Eds. Washington, DC: U.S. Global Change Research Program, 2017, pp. 207–230. doi: 10.7930/J0N29V45.

[4] Z. Feng, L. R. Leung, S. Hagos, R. A. Houze, C. D. Burleyson, and K. Balaguru, "More frequent intense and long-lived storms dominate the springtime trend in central US rainfall," *Nature Communications*, vol. 7, no. 1, Art. no. 1, Nov. 2016, doi: 10.1038/ncomms13429.

[5] K. L. Ebi et al., "Human Health," in Impacts, *Risks, and Adaptation in the United States: Fourth National Climate Assessment*, Volume II, D. R. Reidmiller, C. W. Avery, D. R. Easterling, K. E. Kunkel, K. L. M. Lewis, T. K. Maycock, and B. C. Stewart, Eds. Washington, DC: U.S. Global Change Research Program, 2018, pp. 539–571. [Online]. Available: https://nca2018.globalchange.gov/chapter/14/

[6] J. Balbus et al., "Ch. 1: Introduction: Climate Change and Human Health," in *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*, Washington, DC: U.S. Global Change Research Program, 2016, pp. 25–42. doi: 10.7930/J0VX0DFW.

[7] City of Cleveland, "Cleveland Climate Action Plan—Appendix A: Racial Equity Tool," Sustainable Cleveland, Cleveland, OH, 2018. [Online]. Available: https://www.sustainablecleveland.org/racial-equity

[8] EPA, "Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts," U.S. Environmental Protection Agency, Washington, DC, EPA 430-R-21-003, 2021. [Online]. Available: www.epa.gov/cira/social-vulnerability-report

[9] J. L. Gamble et al., "Ch. 9: Populations of Concern," in *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*, Washington, DC: U.S. Global Change Research Program, 2016, pp. 247–286. doi: 10.7930/J0Q81B0T.

[10] J. M. Jacobs et al., "Transportation," in Impacts, Risks, and Adaptation in the United States: *Fourth National Climate Assessment, Volume II*, D. R. Reidmiller, C. W. Avery, D. R. Easterling, K. E. Kunkel, K. L. M. Lewis, T. K. Maycock, and B. C. Stewart, Eds. Washington, DC: U.S. Global Change Research Program, 2018, pp. 479–511. [Online]. Available: https://nca2018.globalchange.gov/chapter/12/

[11] K. Thomas et al., "Explaining differential vulnerability to climate change: A social science review," *WIREs Climate Change*, vol. 10, no. 2, p. e565, 2019, doi: 10.1002/wcc.565.

[12] B. S. Levy and J. A. Patz, "Climate change, human rights, and social justice," *Annals of Global Health*, vol. 81, no. 3, pp. 310–322, 2015, doi: 10.1016/j.aogh.2015.08.008.

[13] Council on Environmental Health et al., "Global climate change and children's health," *Pediatrics*, vol. 136, no. 5, pp. 992–997, 2015, doi: 10.1542/peds.2015-3232.

[14] M. M. King and M. A. Gregg, "Disability and climate change: A critical realist model of climate justice," *Sociology Compass*, vol. 16, no. 1, p. e12954, 2022, doi: 10.1111/soc4.12954.

[15] T. Dietz, R. L. Shwom, and C. T. Whitley, "Climate change and society," *Annual Review of Sociology*, vol. 46, no. 1, pp. 135–158, 2020, doi: 10.1146/annurev-soc-121919-054614.

[16] E. Fussell, L. Delp, K. Riley, S. Chávez, and A. Valenzuela, "Implications of social and legal status on immigrants' health in disaster zones," *Am J Public Health*, vol. 108, no. 12, pp. 1617–1620, Dec. 2018, doi: 10.2105/AJPH.2018.304554.

[17] M. Nilsson and T. Kjellstrom, "Climate change impacts on working people: how to develop prevention policies," *Global Health Action*, vol. 3, no. s3, p. 5774, 2010, doi: 10.3402/gha.v3i0.5774.

[18] L. J. Hansen, S. J. Nordgren, and E. E. Mielbrecht, "Bainbridge Island Climate Impact Assessment," EcoAdapt, Bainbridge Island, WA, 2016.

[19] EcoAdapt, "Climate Vulnerability and Adaptation Report for Santa Rosa, California," EcoAdapt, Bainbridge Island, WA, 2021.

[20] EcoAdapt, "Climate Vulnerability and Adaptation Report for Johnson County, Iowa," EcoAdapt, Bainbridge Island, WA, 2021.

[21] EcoAdapt, "Climate Vulnerability and Adaptation Report for Indian River County," EcoAdapt, Bainbridge Island, WA, 2022.

[22] USGCRP, *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II*. Washington, DC: U.S. Global Change Research Program, 2018. [Online]. Available: https://nca2018.globalchange.gov/

[23] K. Gordon, M. Lewis, J. Rogers, and F. Kinniburgh, "Heat in the Heartland: Climate Change and Economic Risk in the Midwest," Risky Business Project, 2015. [Online]. Available: https://riskybusiness.org/report/heat-in-the-heartland-climate-change-and-economic-risk-in-the-midwest/

[24] USGCRP, *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*. Washington, DC: U.S. Global Change Research Program, 2016. doi: 10.7930/J0Q81B0T.

[25] City of La Crosse, "Confluence: The La Crosse Comprehensive Plan," City of La Crosse, La Crosse, WI, 2002.

[26] P. E. Lockwood and K. Ray, "La Crosse Transportation Vision Charrette," Toole Design Group, Boston, MA, 2015.

[27] J. Eastwood, "Grand River Transit Service Enhancement & Policy Plan 2015–2025," Prepared for the City of La Crosse Municipal Transit Utility by Jackie Eastwood, Transportation Planner, La Crosse Area Planning Committee, La Crosse, WI, 2015.

[28] City of La Crosse Planning and Development Department, "City of La Crosse Neighborhood Revitalization Strategy Area Plan," City of La Crosse Planning and Development Department, La Crosse, WI, 2015.