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LIBERTY LAKE – 2046

Climate Vulnerability and Risk Assessment Report

Prepared for
City of Liberty Lake

The City of Liberty Lake

May 2025

Parametrix

Climate Vulnerability and Risk Assessment Report

Prepared for

City of Liberty Lake
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Acronyms and Abbreviations (continued)

Glossary

Biogeochemical cycles – Natural pathways through which essential elements of living matter are circulated. They involve the movement and transformation of chemical elements and compounds between living organisms, the atmosphere, and the Earth's crust. Consisting of the water, carbon, nitrogen, oxygen and phosphorus cycles.

Climate variability – The way aspects of climate (such as temperature and precipitation) differ from an average. Climate variability occurs due to natural and sometimes periodic changes in the circulation of the air and ocean, volcanic eruptions, and other factors.

Climate resiliency – The capacity of social systems, economic systems, and ecosystems to cope with a hazardous event, trend, or disturbance. It is a concept to describe how well people or ecosystems are prepared to bounce back from certain climate hazard events.

Compounding hazards – Occur when two or more extreme events occur simultaneously, often with different causes. These can generate multiplicative damage and losses. They are increasing in likelihood as the Earth's climate changes. These interactions between multiple hazards exacerbate the societal and ecosystem impacts of individual hazards and hinder the ability of communities to respond and cope.

Extreme precipitation – For this study, extreme precipitation is defined at the 25-year, 24-hour event, and is based on the storm that has 4% chance of occurring in any given year.

Green stormwater infrastructure – Systems that use natural processes to manage stormwater, providing benefits such as capturing and filtering runoff, creating wildlife habitats, and recharging groundwater.

Green roofs – Roofs that are partially or completely covered with plants and vegetation.

Impermeable surface – Any natural or artificial material that does not allow water or other fluids to readily penetrate or pass through it. Examples of such surfaces are concrete, oil, and gravel. Impermeable surfaces are often used to house metallic structures as a corrosion-prevention measure.

Urban heat island – Refers to the fact that cities tend to get much warmer than their surrounding rural landscapes, particularly during the summer. This temperature difference occurs when cities' unshaded roads and buildings gain heat during the day and radiate that heat into the surrounding air. As a result, highly developed urban areas can experience mid-afternoon temperatures that are 15°F to 20°F warmer than surrounding, vegetated areas.

Urban form – The physical layout and design of cities including their infrastructure, buildings, and public spaces. It plays a crucial role in influencing economic activities, social interactions, and environmental sustainability.

Wildland urban interface – Those areas where human development meets areas that are covered with more than 50% wildlands. Intermix are those areas where structures intermingle with wildlands. To be considered intermix, a development or structure must be surrounded on two or more sides by wildlands.

1. Climate Change

1.1 Introduction

The Climate Vulnerability and Risk Assessment Report for the City of Liberty Lake (City) is a comprehensive evaluation of the potential impacts of climate change on the region. This report provides a detailed understanding of the various climate risks that the City may face in the coming decades–particularly, drought, extreme heat, and increased precipitation–and the potential impacts associated with these risks. By leveraging the latest climate science and modeling, this report shows how the projected changes in Liberty Lake's climate may affect infrastructure, ecosystems, and public health.

Climate change refers to long-term shifts in temperatures and weather patterns, primarily driven by increasing concentrations of greenhouse gases in the atmosphere. These gases trap heat, leading to a rise in Earth's average surface temperature.

In the context of the City, climate change is projected to result in several changes by the 2050s and 2080s. These include increases in total annual precipitation, decreases in late summer precipitation, and increases in drought severity. Additionally, average summer maximum temperatures are expected to rise, leading to more days with extreme heat.

The cumulative effects of climate change for the City include an increased likelihood of wildfires and increases in drought. These changes will also lead to temperatures higher than historical averages and more extreme high temperatures in the future.

1.2 Geography

Liberty Lake is in the Spokane Valley in eastern Washington. The City of Liberty Lake lies within the Columbia River Basin on the western edge of the Rocky Mountains. According to the U.S. Census Bureau, the city has a total area of 6.25 square miles (15.90 km^2) with no waterbodies as of 2020.

The Spokane Valley-Rathdrum Prairie Aquifer (SVRP Aquifer) is the sole source of water for over a million people in Spokane County and Kootenai County, Idaho. The U.S. Environmental Protection Agency designated the SVRP Aquifer as a sole source aquifer in 1978. The aquifer underlies about 370 square miles in two states. It has one of the fastest flow rates in the United States, flowing as much as 60 feet per day in some areas. The volume of the entire aquifer is about 10 trillion gallons, making it one of the most productive aquifers in the country. Water from adjacent lakes, mountain streams, the Spokane River, and precipitation flow through the gravel and cobbles laid down by the ice age floods between 10,000 and 22,000 years ago.[1]

[1] Spokane County Public Works https://www.spokanecounty.org/1219/Spokane-Valley-Rathdrum-Prairie-Aquifer

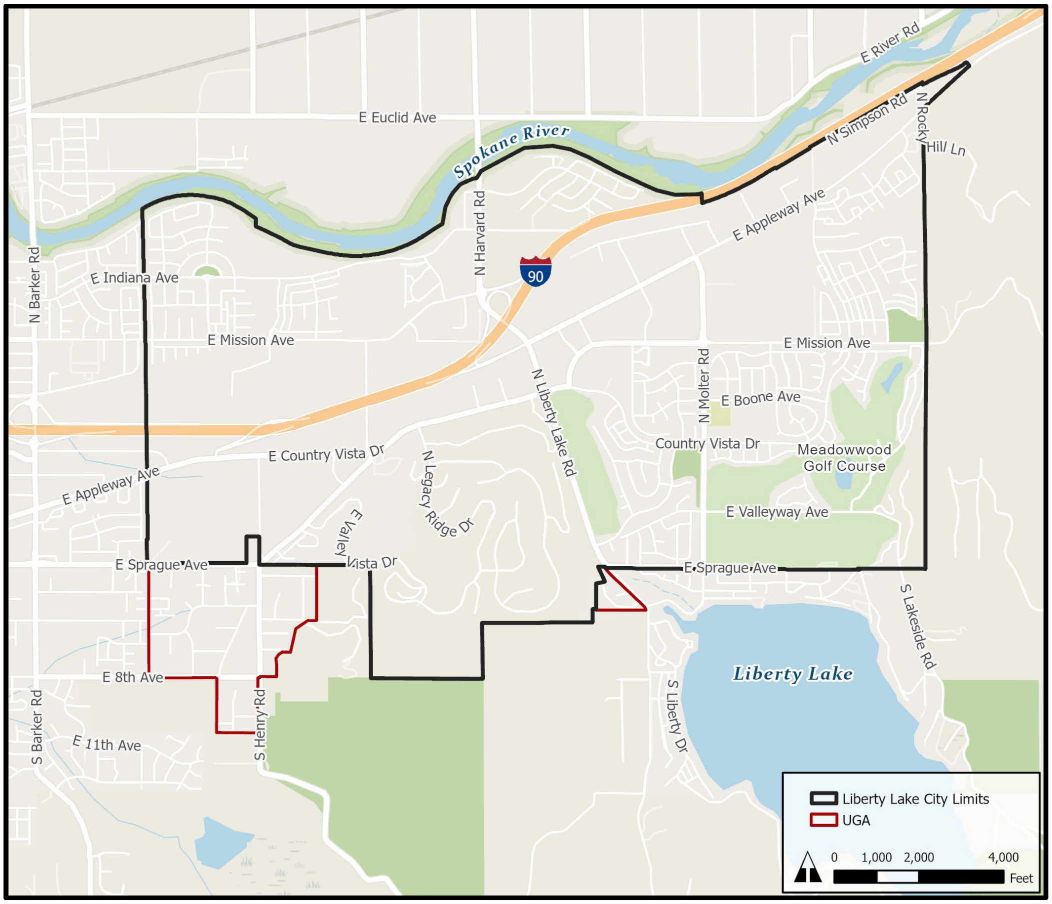

Figure 1. Topographic Map of the City of Liberty Lake

2. Risk

2.1 Risk Methodology

The Parametrix team evaluated six potential climate risks, and the impacts were categorized as high, moderate, or low. There are seven potential climate risks associated with Washington State and identified through work by the University of Washington and Washington State University.[2] Of the seven potential climate risks identified, sea-level rise does not apply to the City of Liberty Lake. Additional assumptions, quantitative data, and information are included in risk narratives in the following section.

2.2 Overall Risk Assessment

The potential climate risks were rated based on qualitative information about the impact, likelihood of the potential climate risk occurring, and the ability to mitigate each climate risk, and then classified as high, moderate, or low. The combined risk score reflects these three factors. A high

[2] Raymond, C.L, T.P. Nadreau, M. Rogers, Z. Kearl. 2022. Biophysical Climate Risks and Economic Impacts for Washington State. Report prepared for the Washington State legislature. Climate Impacts Group, University of Washington, Seattle.

impact means that the climate risk will result in disruption or danger to Liberty Lake's people or infrastructure. High probability means that the potential climate risk is likely to occur in the next 70 years based on the available science and data of projected changes in climate. Mitigation difficulty is the degree of difficulty for the City to implement new policies or actions that can effectively adapt to the climate risk. Table 1 is an assessment of the potential climate risks for the City.

Table 1. Climate Risks

Climate Risk	Impact	Probability	Mitigation Difficulty	Risk Rating
Temperature	High	High	Moderate	High
Extreme Precipitation	Moderate	High	Low	Moderate
Landslides	Low	Low	Low	Low
Decreased Snowpack (Water Resource)	High	High	High	High
Wildfires	High	High	Moderate	High
Wildfire Smoke	High	High	Low	Moderate

For planning purposes and prioritization of actions, the risks that are shown as high probability and high impact should be considered first, and to the best ability of the City, be key parts of a resiliency strategy. The high risks associated with regional temperature increases will reduce snowpack by 2070, leading to longer dry periods and minimal late spring or early summer runoff. This will reduce water availability in summer and worsen drought conditions. Dry weather will extend the fire season, increasing risks of wildfires and smoke, which will affect air quality for the entire Spokane Valley.

2.3 Impact Details

Temperature

There is consensus among global scientific models that within the next 5 years the average global surface temperature will increase by 2.7°F (1.5°C). The City can anticipate a shift in severe weather events including the increase of hot days defined as days over 100°F. Like other cities in eastern Washington, the City of Liberty Lake will experience warmer summers overall and an increase in 90°F humidex days. Humidex is short for *humidity index*; it defines how hot the weather feels. When the minimum humidex exceeds 65°F, it signifies nighttime heat stress, which is discussed further below.

Human Health

Heat exposure is a concern because it can aggravate cardiovascular diseases and respiratory illnesses, as well as cause heat stroke and dehydration. Small children, the elderly, people living alone, those who are pregnant, people with chronic diseases, persons of color[3], and low-income populations are particularly at risk. Temperature extremes also impact people's ability to access

[3] They are a focus in the CVI because current systems perpetuate systemic historical barriers to resources such as healthcare, education, and housing, which can exacerbate their vulnerability to climate hazards. In a CVI, they are a key focus because historical and ongoing inequities increase their exposure to risks and reduce their ability to recover from climate-related events such as floods, heatwaves, and storms.

transit, because waiting along roadsides where the heat is increased causes heat stress and discomfort for transit riders. Exposure to extreme heat will vary locally based on features that exacerbate extreme heat, such as the extent of paved surfaces, tree canopy for shade, or proximity to waterbodies. Emergency management services that serve areas of the city with more vulnerable populations and less social cohesion will be more affected by increases in the demand for services related to extreme heat emergencies. Certain populations are expected to be more affected by increases in the number of days with a minimum humidex above 65°F. The elderly, very young, people with preexisting health conditions, and people without housing or that live in substandard housing that lacks cooling systems are likely to be more affected. More frequent extreme nighttime heat events are expected to increase the demand for emergency services to plan, prepare, and respond to human health impacts.

Transportation Infrastructure

High temperatures can soften asphalt roads and cause cracking in concrete roads, leading to buckling and peeling which increases maintenance and replacement needs. Research has shown that heat waves affect bridge structures in similar ways, including stressing thermal expansion joints and prestressed concrete girders which accelerate material degradation and create or accelerate cracks in concrete and steel components.

Buildings and Homes

Heat can have negative impacts on buildings and community assets including schools, hospitals, and libraries. Heat impacts can be higher in areas where there is highly impermeable surface coverage and limited shade due to the urban heat island effect. However, there are many strategies that can mitigate these impacts that also benefit urban form and design, such as green stormwater infrastructure, street trees and other sources of shade, green roofs, and strategies to reduce or capture heat from buildings.

The heat impact to buildings is driven by building age, construction type, and insulation requirements at the time of construction. Older buildings, historic buildings, mobile homes, and public buildings may not have adequate insulation or air conditioning. As temperatures rise, these buildings may need expensive retrofits and require increased energy use for cooling. Days with low air quality, for example from wildfire smoke, can be a compounding hazard because natural ventilation is not available.

Ecosystems

Critical ecosystem services, such as shade and spring snowmelt runoff, that regulate temperature and buffer streams and wildlife habitat from heat impacts are important to conserve and protect. Increasing temperatures and repeated extreme heat events can result in ecosystem stress, reducing the ability of the system to provide these critical services. Ecosystems in more open areas, such as parks and golf courses, may be impacted by increased temperatures and extreme heat events because of the lack of shade. Wetlands, depending on the buffer area, would also see increased surface water temperatures during extreme heat.

Extreme Precipitation

As temperatures rise, more evaporation occurs over the ocean, which in turn alters the intensity, duration, and frequency of precipitation. Increased precipitation intensity contributes to increased flood risk, greater soil erosion, higher sediment transport in streams, increased runoff contributing to water quality impairment, and increased landslide vulnerability. Roads and pedestrian paths can become impassable due to flooding or downed trees, and public transit stops can become flooded or inaccessible. Extreme precipitation may impact the ability to access and utilize trails and parks. Flooding can lead to trail erosion and damage to park assets. Extreme precipitation events and the resulting impacts can also degrade local streams and wetlands through runoff and erosion, water temperature changes, and pollution. Extreme precipitation includes snowfall, and increases in the intensity of snowfall will compound urban issues such as snow removal and flooding when accumulated snow is followed by rain.

Landslides

Increased extreme precipitation causes increased land saturation, contributing to an increased likelihood of landslides. Areas with steep terrain, land previously burned in wildfires, areas impacted by deforestation, and areas along streams and rivers are particularly at risk. Landslides impact water quality by dumping sediment, debris, soil, and rocks into waterbodies. Transportation systems are vulnerable to landslides because roads and bridges can become damaged and/or impassible, and public transit stops can become inaccessible because of debris. Landslides that impact homes or other structures can have financial impacts on local property owners. The city is at low risk of landslides due to ice age floods depositing heavy material at the bottom of the valley floor.[4] The City of Liberty Lake has not experienced historical landslides according to the Washington State Department of Natural Resources geologic hazard mapping.

Loss of Snowpack

The SVRP Aquifer beneath Liberty Lake is fed by lakes that rely on snowmelt from the Rocky Mountain and Selkirk Ranges. These mountain ranges will experience changes in snowpack throughout the twenty-first century, with more rain-dominated basins along the western front range. By 2070, no snow is expected after April 1 in this region. During the twentieth century, snowpack was typical through July.

The SVRP Aquifer is supplied from lakes in the Rocky Mountain Western Slope including Hayden, Pend-Orielle and Priest Lake. These lakes are fed by precipitation (rain and snow). Long-term water supply is dependent on snowpack through early summer. A reduction in late-season snowpack will mean more severe and long-term drought for the SVRP Aquifer.

The consequences of drought are extensive, affecting water quality, water quantity, public health, the economy, the natural environment, and public infrastructure. Economic impacts of drought refer to the financial costs incurred by individuals or businesses. The economic costs are associated with increased costs for water and energy as well as loss of vegetation.

Social impacts of drought encompass the ways in which drought affects people's health and safety, including public safety, health issues, conflicts arising from insufficient water supply, and changes in lifestyle. Losses range from local impacts such as loss of vegetation and aesthetics to the larger context of crop and wildlife losses.

Moreover, drought significantly affects the environment. Plants and animals rely on water. During a drought, their food supply may diminish and their habitats can be damaged. While some damage may be temporary, allowing habitats and food supplies to return to normal post drought, other environmental impacts may be long-lasting or even permanent.

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[4] Washington Geologic Information Portal Washington State Department of Natural Resources and U.S. Geological Survey. https://geologyportal.dnr.wa.gov/2d-view#natural_hazards?-13988207,-12951110,5758377,6289767?Surface_Geology,500k_Surface_Geology,Map_Units

Wildfire

Wildfires are already common in Eastern Washington and damage forests, grasslands, and structures. Changing weather patterns increase the wildfire risk in two ways: (1) over time, winter precipitation is increasing at the same time summer precipitation is decreasing, resulting in drier summers, (2) warmer weather during the increasingly dry summers further exacerbates drought and decreases moisture content in the atmosphere and soil. Increased wildfires throughout the region contribute to increased greenhouse gas emissions. The burning material releases greenhouse gases made up mostly of CO_2 and methane. This deteriorates air quality (particulate pollution) as well. Local wildfire events may result in increased stormwater runoff due to the destruction of vegetation and reduction of soil absorption post wildfire. Vegetation destruction can also increase the risk of landslides although there is a low risk of landslides in Liberty Lake, more exposed soils and loss of vegetation can cause more sedimentation in runoff.

The most immediate risk of wildfire is the threat to human life in areas where fuel (e.g., trees, grasslands) is close to structures (e.g., homes). Wildfires can spread quickly through residential areas, and severe, fast-moving fires in other regions have devastated suburban developments and commercial areas.[5] Increasing risks throughout the western United States have resulted in increasing insurance costs for property owners in areas considered to be higher risk. There are some mitigation strategies, (e.g., selecting less flammable building materials, reducing vulnerability to embers, storing flammable materials safely, managing vegetation) that can reduce risks to structures, and some insurance carriers may require such measures to obtain insurance.

Wildfires do not typically burn roads, but they can lead to cracks, deformations, and potholes that come later. Wildfires can create conditions where roads and bridges are unsafe or impassable, similar to flooding. Wildfires can burn or destroy bridge structures, especially older bridges with wooden supports. According to the National Interagency Fire Center, landslides and flash flooding are common after wildfires and may lead to road washouts, buckling, and other road impacts.

Fire can reduce safe access to parks and trails, which are at higher risk of being destroyed or seriously damaged by wildfires. Wildfires can threaten drinking water quality through contamination of surface and groundwater during the first rain after a fire. Wildfires can leach chemicals into groundwater and leave many toxic chemicals on soil from burning structures which can also degrade water quality.

The city includes areas that are considered high risk for wildfires. The city also includes both intermix and wildland urban interface areas that are at increased risk of wildfire. Seasonally, there will always be more risk in the summer than in the wetter seasons throughout the city.

The city is also impacted by smoke from regional, national, and international wildfires. Wildfire smoke reduces air quality and can be a significant risk to vulnerable populations including seniors, children, people with underlying health conditions including pregnancy, outdoor workers, and people who are living unsheltered. People who live in non-air-conditioned homes may also be vulnerable to summer wildfire smoke that coincides with higher temperatures or extreme heat events.

Cumulative Impact on Well-Being

While most risks can be directly tied to specific impacts, it is also important to recognize the areas where there may be cumulative impacts to well-being from the combination of multiple impacts. The

[5] Geotechnical Extreme Events Reconnaissance Association, The 2021 Marshall Fire, Boulder County, Colorado, May 2022. https://geerassociation.org/?view=geerreports&id=103&layout=default.

impact of wildfire smoke is one example—the effect on well-being for vulnerable populations will likely be exacerbated if the wildfire smoke impact occurs during hot weather or an extreme heat event where opening windows and fresh air ventilation are the strategy to reduce temperatures. According to the National Institute for Health Care Management), multiple climate impacts can result in stress and anxiety that can reduce well-being and threaten mental health.[6] Many different people may experience some form of climate anxiety, but the impact on mental health may be particularly acute for members of local tribes, who sometimes experience climate impacts as a cultural loss.

3. Climate Modeling

Globally, greenhouse gas concentrations have risen substantially because of human activities and are a primary driver of warming. To project future climate, scientists use "what if" scenarios of plausible future greenhouse gas emissions to drive computer simulations of Earth's climate. There are multiple greenhouse gas scenarios, numerous global climate models (each constructed slightly differently), and multiple techniques for "downscaling" coarse global model projections to local scales. The many possible combinations of scenarios, models, and downscaling techniques are used to estimate a range of possible future climates. The range reflects some of the important unknowns regarding our understanding of the climate system and the potential impact of different approaches over the next decade.

3.1 Updates to Climate Modeling

Climate models are constantly being updated, as different modeling groups around the world incorporate higher spatial resolution, additional physical processes, and biogeochemical cycles. These modeling groups coordinate their updates around the schedule of the Intergovernmental Panel on Climate Change (IPCC) assessment reports, releasing a set of model results in the lead-up to each new report. These coordinated efforts are part of the Coupled Model Intercomparison Projects (CMIP). The 2013 IPCC fifth assessment report (AR5) featured climate models from CMIP5, while the 2021 IPCC sixth assessment report (AR6) features new CMIP6 models. The information presented in this report is from CMIP5 modeling as part of AR5 and is the recommend source of data from the Washington State Department of Commerce.

Parametrix reviewed CMIP6 data when assessing the vulnerability and risk to the city from future climate impacts and assessed whether the risks were greater with CMIP6 information than CMIP5. The results were mostly similar between the two models, but the risks discussed between 2050 and 2080 may occur sooner according to CMIP6 modeling than CMIP5. This information is an important factor in planning, as risks identified to occur in 2050 are based on projections from 2040 to 2060, meaning these impacts would come within the next two decades versus three decades.

Because of the time and expense of providing local data from global models, most of the data used in this report is from CMIP5 with temperature and precipitation information coming from CMIP6 when possible. Based on the current trends from CMIP5 and CMIP6 modeling, this report references the "business as usual" scenario; along with the uncertainty ranges to reflect the most plausible future projections.

[6] https://nihcm.org/publications/climate-change-is-affecting-our-mental-health.

3.2 Uncertainty

Because there are many variables involved in climate, it is not possible to project exactly how climate change will play out into the future. As a result, modeling future climate change must account for uncertainty. Sources of uncertainty in climate forecasting include the following:

1. Different economic and social approaches over the next decade.
2. Uncertainty due to natural variability, which encompasses climate variability and externally driven (e.g., solar, volcanic) natural climate change.
3. Uncertainty in the climate system's response to external forcing due to incomplete knowledge of feedback and time scales in the system.

Acknowledging uncertainty allows the City to be prepared for a range of climate futures. Ultimately, uncertainties in climate projections are unknowable because they can only be verified in the future.

3.3 Future Updates to this Work

The following evaluation and methodology are based on the best climate science available at a local scale or regional scale. As climate science advances, new information will be available, and projections may need to be refined. In particular, the Washington State Department of Natural Resources will release updated Washington State Wildfire Risk mapping which will be updated in summer 2026.

Demographic data provided as part of the evaluation is updated by the U.S. Census Bureau and is updated after each census, usually within the first 5 years. Data provided in this report from the American Community Survey (ACS) are updated after the census is taken.

4. Climate Vulnerability Index

4.1 Purpose

The purpose of a Climate Vulnerability Index (CVI) is to quantify climate vulnerability across key climate, environmental, and community data. The final index can be visualized in maps and tables to help identify and prioritize projects that facilitate climate resiliency across the city. The CVI provides quantitative data to assess the impacts or vulnerability of a community. This in turn can help assess risk along with an understanding of probability and the ability to mitigate the risk (climate impact), as has been done in Section 2.

The CVI is available online via the City of Liberty Lake Climate Element Explorer.

4.2 Methodology and Data

Parametrix grouped indicators which are listed below (from geographic information system [GIS] data layers) into three individual indexes: adaptive capacity, sensitivity, and exposure (Figure 2). Each individual index is composed of 8 to 15 indicators that score each census block group based on their percentile rank compared to other block groups in the city. The indicators are mapped in GIS at the census block group level and exported to a custom Microsoft Excel tool developed by the consulting team to automate the scoring of the indexes for future updates as new source data becomes available. The final map product, a CVI webmap application, allows the user to visualize the block group scores of either the cumulative index or the CVI or any of the individual indexes (adaptive capacity, sensitivity, and exposure).

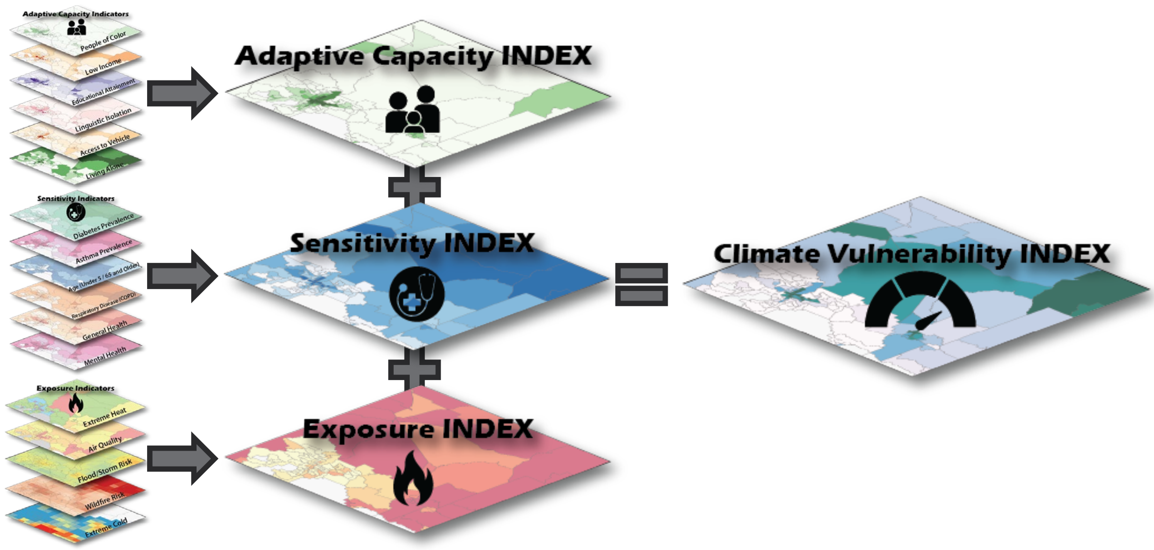

Figure 2. Climate Vulnerability Index Methodology

Adaptive Capacity

Adaptive capacity indicators include features of people or places that can affect their ability to cope with change. These indicators are primarily gathered from the ACS tables mapped at the block group level. There are other indicators such as tree canopy and impervious surface that are used to identify the potential for heat islands. Overall job density and the job density of outdoor professions are determined using longitudinal employer-household dynamics data that are a product of the U.S. Census Bureau.

The Adaptive Capacity Index is made up of the following inputs:

- People of color.[7]
- Low-income households.[8]
- Educational attainment – less than high school degree.

[7] They are a focus in the CVI because current systems perpetuate systemic historical barriers to resources such as healthcare, education, and housing, which can exacerbate their vulnerability to climate hazards. In a CVI, they are a key focus because historical and ongoing inequities increase their exposure to risks and reduce their ability to recover from climate-related events such as floods, heatwaves, and storms.

[8] Following the Office of Management and Budget's Statistical Policy Directive 14, the U.S. Census Bureau uses a set of money income thresholds that vary by family size and composition to determine who is in poverty. If a family's total income is less than the family's threshold, then that family and every individual in it is considered in poverty. The official poverty thresholds do not vary geographically, but they are updated for inflation using the Consumer Price Index. The official poverty definition uses money income before taxes and does not include capital gains or noncash benefits (such as public housing, Medicaid, and food stamps).

- Linguistic isolation.[9]
- Living alone.
- Housing cost burden – less than 30% income to housing ratio.
- Access to a vehicle.
- Housing condition (built before 1980) – homes built before 1980 potentially have dangers such as faulty wiring, cracked foundations, and hazardous building materials.
- Population density.
- Job density.
- Impervious surface.
- Unemployment.
- Outdoor professions – resource and construction jobs likely to be performed outside.
- Population between the ages of 18 and 64 without health insurance.
- Tree canopy coverage.

Sensitivity

Sensitivity indicators include age and health conditions that affect the degree to which the population may be affected by hazards. The Sensitivity Index is composed of GIS inputs from the Centers for Disease Control's "Places: Local Data for Better Health[10]" dataset and data from the ACS.

The Sensitivity Index is made up of the following inputs:

- Less than 5 years old.
- More than 64 years old.
- Diabetes – diagnosed diabetes among adults aged 18 years and older.[11]
- Asthma – current asthma prevalence among adults aged 18 years and older.
- Respiratory disease – chronic obstructive pulmonary disease.
- Heart disease – coronary heart disease.
- Physical health not good for 14 days or more among adults aged 18 years and older.
- Mental health not good for 14 days or more among adults aged 18 years and older.

[9] An entire household's inability to communicate in English can be even more of a barrier than an individual's inability. For example, in the case of a national or local emergency, such households could not receive an emergency communication in English. The concept of "linguistic isolation" was developed in preparation to provide estimates of the numbers and characteristics of households that might need assistance to communicate with government and social services—for example, to follow instructions from the Federal Emergency Management Agency in the event of a disaster.

[10] https://www.cdc.gov/places/index.html

[11] People with diabetes are at greater risk of experiencing dehydration and cardiovascular events during periods of extreme heat.

Exposure

The Exposure Index are the indicators identified by the University of Washington Climate Impacts Group (UW CIG) for the State of Washington from changes in the climate and climate-related natural hazards. The Parametrix team identified climate impacts and projections for Liberty Lake from the UW CIG Climate Mapping for Resilient Washington[12] as recommended by the Washington State Department of Commerce. Table 2 summarizes the changes expected by mid-century (2050s) and end of the century (2080s). For community planning, the business-as-usual scenario is used for climate projections based on social and economic reductions of greenhouse gases that do not dramatically change over time, including uncertainty ranges in parentheses. This approach helps assess risk and populations impacted by these risks within the city. Section 2.3 provides details on the impacts the City is likely to face over the coming decades

Table 2. Climate Impacts and Projections for 2050 and 2080 for RCP8.5 for the City of Liberty Lake

Climate Projection (Key indicators from CMRW Tool)	By 2050s	By 2080s
Total annual precipitation (percentage change)	8% increase *(5% to 14%)*	15% increase *(7% to 24%)*
Late summer precipitation	10% decrease *(-25% to +8%)*	8% decrease *(-31% to +30%)*
Change in extreme precipitation (change in 24-hour 25-year precipitation)	9% increase (0% to 24%)	18% increase (11% to 46%)
Change in hot days (<100 °F), historical is 1 day	6 days *(2 to 10)*	24 days *(12 to 40)*
90° max. humidex (change in days), historical 2 days	23 *(11 to 34)*	55 *(34 to 77)*
65° min. humidex (change in days), historical is 5 days	13 *(7 to 21)*	37 *(17 to 59)*
Wildfire, change in high fire days – historical is 48 days (1971–2000)	10 additional days *(3 to 17 days)*	

Source: Raymond, C., M. Rogers, 2022. Climate Mapping for a Resilient Washington. Prepared by the Climate Impacts Group, University of Washington, Seattle and Research Data & Computing Services, University of Idaho, Moscow.

CMRW = Climate Mapping for Resilient Washington; RCP = Relative Concentration Pathway

Winds are a concern during and cause significant damage and exacerbate wildfires. As of the time of this study, there is no statistically significant change in the frequency of severe surface winds associated with climate change based on available scientific literature

4.3 Summary of the Climate Vulnerability Index

The CVI quantifies climate vulnerability using indicators in three categories: adaptive capacity, sensitivity, and exposure. It identifies and prioritizes a pathway to climate resiliency in Liberty Lake. While the risk assessment is citywide, more specific information is available for different areas of the

[12] https://cig.uw.edu/resources/analysis-tools/climate-mapping-for-a-resilient-washington/

city. While small in land area, the city has some demographic differences from west to east. CVI is used to map and score census block groups, aiding in future updates and community planning to ensure the resilience of Liberty Lake against these climate threats.

This information is useful in planning for resiliency but should not be taken alone. Open dialogue between planning for resiliency and the communities impacted is important to successful work to increase resiliency over time. These are observations from the CVI:

- Adaptive Capacity: Factors such as tree canopy, job density, and housing conditions contribute to the community's ability to adapt to climate changes. The adaptive capacity is lower on the west side of Liberty Lake than the east side driven by symptoms of low-income communities such as high housing cost burden, outdoor jobs, and lack of health insurance.
- Sensitivity: This category includes age and health conditions that affect vulnerability. For instance, elderly populations or those with preexisting health conditions may be more susceptible to the impacts of climate change. The west side of the city is also higher sensitivity due to elderly population and the health issues associated with the elderly such as chronic obstructive pulmonary disease, cancer, and heart disease.
- Exposure: Focuses on the climate impacts from natural hazards. Since the city is a small area, it is not useful to differentiate the exposures geographically; the community as whole will face the same risks, but the ability to prepare and respond to those risks will differ geographically.

5. Conclusion

This assessment details the projected impacts of climate change on the city of Liberty Lake, including increased precipitation, higher summer temperatures, and resulting risks such as flooding and wildfires. It evaluates climate risks through six categories, emphasizing drought, wildfire, and temperature increases as threats to prioritize. The CVI quantifies vulnerability using indicators grouped into sensitivity, adaptive capacity, and exposure to prioritize climate resiliency projects.

Based on this assessment, the following goals are recommended as part of the Climate Element of the City of Liberty Lake Comprehensive Plan. These goals and policies are under review and are subject to change.

Land use – Establish land use patterns that increase the resilience of the built environment, ecosystems, and communities to climate change.

Water quality – Protect and preserve water quality.

Cultural resources and practices – Ensure that cultural resources and practices, including outdoor recreation and natural resources, are resilient to the impacts of extreme weather and other natural hazards worsened by climate change.

Local transportation system – Ensure that the local transportation system—including infrastructure, routes, and travel modes—can withstand and recover quickly.

Emergency preparedness – Increase community emergency preparedness.

Resilient and sustainable buildings – Ensure that buildings are designed and built sustainably to reduce environmental impacts and remain resilient to extreme weather and other hazards worsened by climate change.

Community health – Protect community health and well-being.

Public education – Increase climate literacy among the general population. Provide information to the public to increase the level of knowledge across the city for people to be more engaged.

Appendix A - Liberty Lake Climate Vulnerability Index – Correlation Analysis

LIBERTY LAKE CLIMATE VULNERABILITY INDEX – CORRELATION ANALYSIS

Pearson Correlation Coefficient Explained

This appendix summarizes the results of correlation analysis performed to understand relationships among the metrics and indexes that make up the Climate Vulnerability Index (CVI). Correlations were calculated using the **Pearson Correlation Coefficient**, which measures the strength and direction of the linear relationship between two variables and ranges from –1 to 1:

- **1** = perfect positive linear relationship (both increase together)
- **–1** = perfect negative linear relationship (as one increases, the other decreases)
- **0** = no linear relationship

When interpreting correlation values, remember that **correlation does not imply causation**: a strong correlation means two variables move together, but it does not prove one causes the other.

Correlation Values and Their Significance

For practical interpretation:

Coefficient (r)	Strength	Interpretation
0.90–1.00 or –0.90–(–1.00)	Very strong	Strong linear alignment
0.70–0.89 or –0.70–(–0.89)	Strong	Likely a major contributor
0.40–0.69 or –0.40–(–0.69)	Moderate	Meaningful but not dominant
0.20–0.39 or –0.20–(–0.39)	Weak	Limited influence
0.00–0.19 or –0.00–(–0.19)	Very weak or none	Essentially no linear relationship

Positive values mean variables increase together; negative values mean one increases as the other decreases.

Summary of Correlation Results Across Index Components

To evaluate the CVI's internal consistency and explore how its components interact, Pearson correlations were calculated among the three parent indexes—**Exposure**, **Sensitivity**, and **Adaptive Capacity Burden**—and between each parent index and the overall CVI.

CVI correlations with parent indexes

- The **Adaptive Capacity Burden Index** shows the strongest correlation with the CVI (**r = 0.71**). This highlights that areas facing structural and socioeconomic challenges—such as low income, high housing cost burden, and lower educational attainment—are most strongly associated with higher climate vulnerability.
- The **Sensitivity Index** also has a positive, but weaker, correlation with the CVI (**r = 0.25**), suggesting that demographic factors (like age, disability, or language isolation) play a meaningful but secondary role.
- The **Exposure Index** shows only a very weak correlation with the CVI (**r = 0.11**), indicating that, within Liberty Lake, the geographic pattern of climate-related hazards (e.g., heat, wildfire, drought) doesn't overlap closely with the areas most vulnerable due to social and economic conditions.

This pattern aligns with broader climate equity research: **vulnerability depends not only on exposure but on the capacity of communities to prepare for, cope with, and recover from climate hazards.**

Correlations among the parent indexes

- **Exposure vs. Adaptive Capacity Burden: r = –0.24** — areas with higher exposure tend to have slightly lower adaptive capacity burdens, suggesting spatial separation between hazard intensity and social vulnerability.
- **Exposure vs. Sensitivity: r = 0.25** — a weak positive relationship, indicating limited overlap between hazard exposure and sensitive populations.
- **Adaptive Capacity Burden vs. Sensitivity: r = –0.48** — a moderate negative correlation implies that socially and economically burdened areas may not always be the same areas that have the highest demographic sensitivities.

Internal consistency of each index

Adaptive Capacity Burden Index

- Strongly correlated with:
  - **Low Income Populations** (r = 0.89)
  - **Cost-Burdened Renters** (r = 0.82)
  - **Unemployment Rate** (r = 0.78)
- These correlations confirm that economic hardship is the main driver of adaptive capacity burden in Liberty Lake.

Sensitivity Index

- Strongest correlation with **Percent Disabled** (r = 0.89).
- Moderate correlations with other metrics like **Limited English Proficiency** and **Older Adults**, showing the index captures multiple dimensions of social sensitivity.

Exposure Index

- Strong positive correlations with composite metrics:
  - **Heat Score** (r = 0.76)
  - **Precipitation Score** (r = 0.75)
  - **High Fire Danger Days** (r = 0.60)
- Strong negative correlations with:
  - **Drought Score** (r = –0.77)
  - **Late Summer Precipitation** (r = –0.75)
- These patterns validate the index is sensitive to both extreme heat and precipitation conditions. Some redundancy was identified (e.g., **Ozone and Air Quality**: r = 1.00; **Wildfire Score and WUI Score**: r = 0.99), but these were retained for transparency and consistency.

Conclusion

The correlation analysis demonstrates that the CVI is most influenced by adaptive capacity burdens, moderately by social sensitivity, and only weakly by direct exposure to climate hazards. Internally, each index is consistent with its intended design and shows logical alignment between its composite score and key underlying metrics.