Climate Risk and Vulnerability Assessment Methodology

CONTENTS

This document summarizes Kansas City, Missouri's climate risks and vulnerabilities and outlines the methodology and data used to create the vulnerability assessment as part of the 2022 Climate Protection and Resiliency Plan. There are numerous acceptable methodologies for conducting climate risk and vulnerability assessments; more than 15 potential methodologies were reviewed. This climate risk and vulnerability assessment follows the standard methodology – evaluating hazards, exposure, and adaptive capacity to identify top vulnerabilities. This approach aligns with the format required of the Climate Disclosure Project (CDP) guidance reporting forms.

IDENTIFYING CLIMATE HAZARDS

The first step in completing the vulnerability analysis was to identify the climate hazards likely to be experienced by KCMO. This was done by a review of previous work in the region. The MARC regional vulnerability assessment pulled from the 2020 regional hazard plan to identify six hazards posing the greatest risk to the Kansas City region: flooding, extreme heat, drought, severe thunderstorms, severe winter weather, and tornadoes. The hazards were scored on a matrix based on probability and consequence, with flooding, drought, and extreme heat posing the greatest risk to the region (Figure 1).

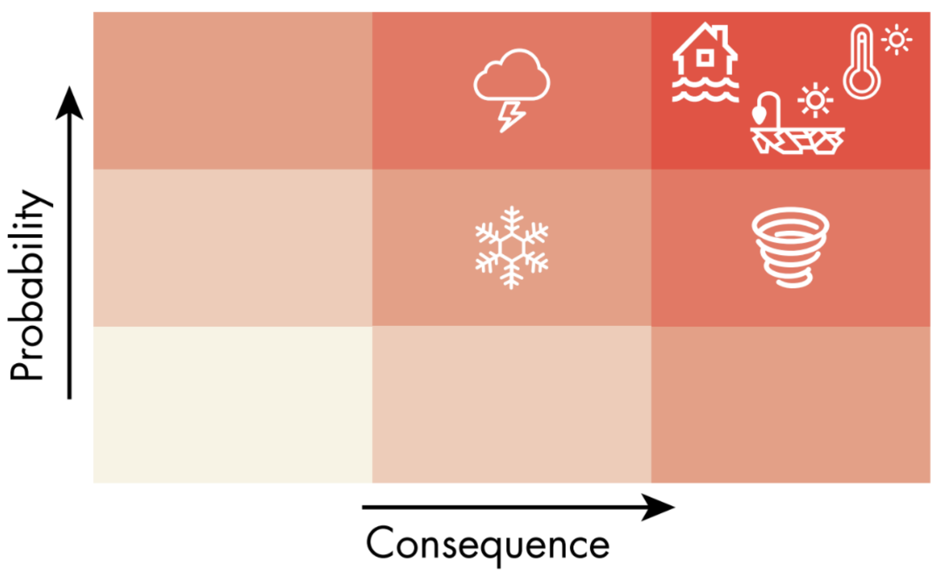

Figure 1: Climate hazards identified in the MARC regional vulnerability assessment

The Climate Look for Kansas City, MO was completed in 2016 and quantified potential climate change related trends specific to the city. The report enumerates anticipated changes in precipitation (anticipated increases in seasonal rainfall) and changes in temperatures (temperature will increase in all seasons, heat waves will become more frequent).

Kansas City's 2020 CDP questionnaire only lists flooding and extreme heat as the most significant climate hazards in the region.

CASCADING CLIMATE RISKS

Cascading climate risks are risks resulting from the primary climate hazards identified above. For instance, standing water associated with flooding can lead to mold and mildew in homes, which can cause serious health issues.

From an environmental and human health perspective, the Center for Disease Control and Prevention defines four primary climate change drivers and impacts, eight environmental impacts, and many more tertiary health impacts (CDC, 2021). Of the impacts described in Figure 2, several are relevant to Kansas City, including air pollution and respiratory health, changes in vector ecology, and forced migration.

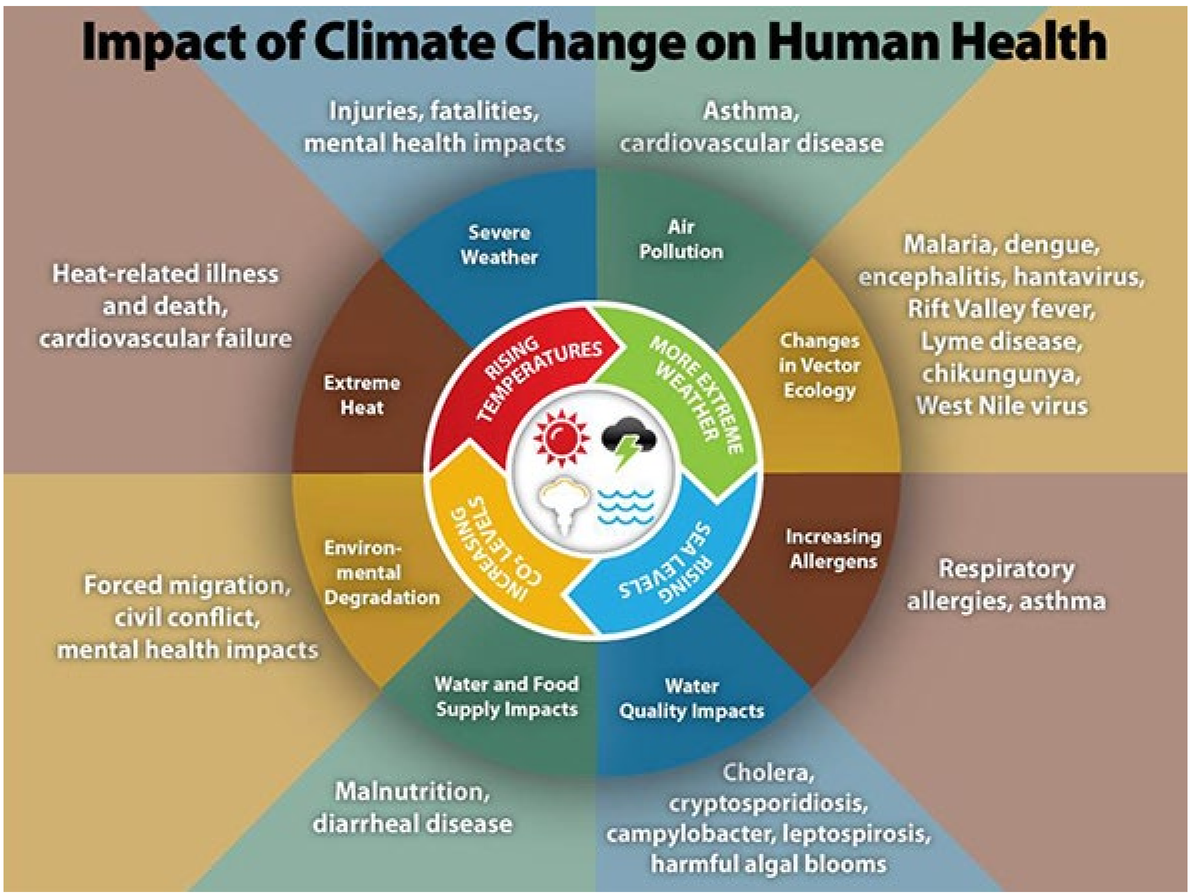

Figure 2: CDC Impacts of Climate Change on Human Health

Air Quality

Extreme heat can exacerbate air quality issues. At higher temperatures, and with greater exposure to the sun, the chemical reaction that forms ground level ozone (smog) occurs more rapidly (EPA, 2021). High levels of ground level ozone can result in respiratory health issues, especially for people with asthma (EPA, 2021).

All other variables remaining constant (e.g., precursor pollutants, wind speeds), increasing temperatures associated with climate change in Kansas City can be expected to worsen air quality issues in the City. This secondary impact may be more pronounced in areas also experiencing Urban Heat Island effects (EPA, 2021). In these urban areas, daytime temperatures are even hotter than in surrounding suburbs; and, transportation congestion may contribute additional precursor pollutants like nitrogen oxides and volatile organic compounds (VOCs).

Climate Migration

Climate stressors such as droughts, floods, rising sea levels, and wildfires are already forcing people in some parts of the world to relocate. This movement of people resulting from climate change-related impact is climate migration (Dorsey & Hight, 2020). Many regions in the United States have already experienced climate migration. For instance, when severe flooding caused by hurricane Katrina forced hundreds of thousands of New Orleans residents from their homes, Kansas City served as a refuge for hurricane victims (Environmental Management Commission, 2019). At its core, climate migration is a form of climate resilience, allowing impacted populations to adapt by relocating (Dorsey & Hight, 2020). However, maximizing the benefits of climate migration will require concerted planning, and may include identifying strategies to (Environmental Management Commission, 2019):

- Allow for sufficient concentrations of migrants to maintain a sense of community, which can help preserve and foster resilience,
- Connect climate migrants with resources to help them get established in their new communities,
- Match incoming skills with local needs and services, and
- Mitigate the perception of competition between migrants and existing community members.

In addition to serving as a potential refuge for climate migrants, Kansas City community members could, themselves, become climate migrants. The public health, environmental, and economic impacts of extreme heat, flooding, and drought could force current community members to relocate within in the city or even to seek refuge in other parts of the country. Proactive management of Kansas City's own vulnerabilities to climate migration could include (Environmental Management Commission, 2019):

- Voluntary relocation of residents and businesses located within the floodplain,
- Preventing or prohibiting future development in areas prone to flooding, and
- Researching and investing in more sustainable and drought-resistant agricultural practices.

Vector-Borne Disease

Increases in temperature, heat, and flooding may increase the incidence of diseases in Kansas City. "Vectors" – such as mosquitos and ticks - are organisms that transmit infectious diseases from one host to another. The relationship between temperature and vector survival and infection rate is complex. Generally, vectors thrive under warm temperatures, but lifespans shorten under extreme temperatures. Still, there is early evidence suggesting that an increase in temperature has increased the geographic range of certain vectors. Additionally, standing water is an ideal breeding habitat for many vectors, thus, an increase in flooding may increase the presence of vectors (Rocklöv & Rubrow, 2020).

MAPPING EXPOSURE

While exposure to some hazards is either unpredictable or not anticipated to vary spatially within the city, other hazards are likely to impact certain neighborhoods or regions more severely within the city. Figure 3 shows an example of exposure mapping. See the list below for more information on which hazards are expected to vary spatially and how this variability was analyzed:

1. **Flooding**: Mapped both waterway flood zones as well prevalence of nuisance flooding from extreme precipitation.
2. **Extreme heat**: While the whole area experiences extreme heat, the degree to which the urban heat island exacerbates this hazard was mapped.
3. **Drought**: This climate hazard has a regional impact and will affect the whole city, so is not mapped.
4. **Severe thunderstorms**: While the presence of severe thunderstorms cannot be mapped, the resulting nuisance flooding is mapped.
5. **Severe winter weather**: This hazard impacts the whole city, so is not mapped. Energy burdened households by region is mapped, which can indicate communities that may be more severely impacted by a severe winter storm.
6. **Tornadoes**: Tornados are unpredictable, so community exposure is not mapped.

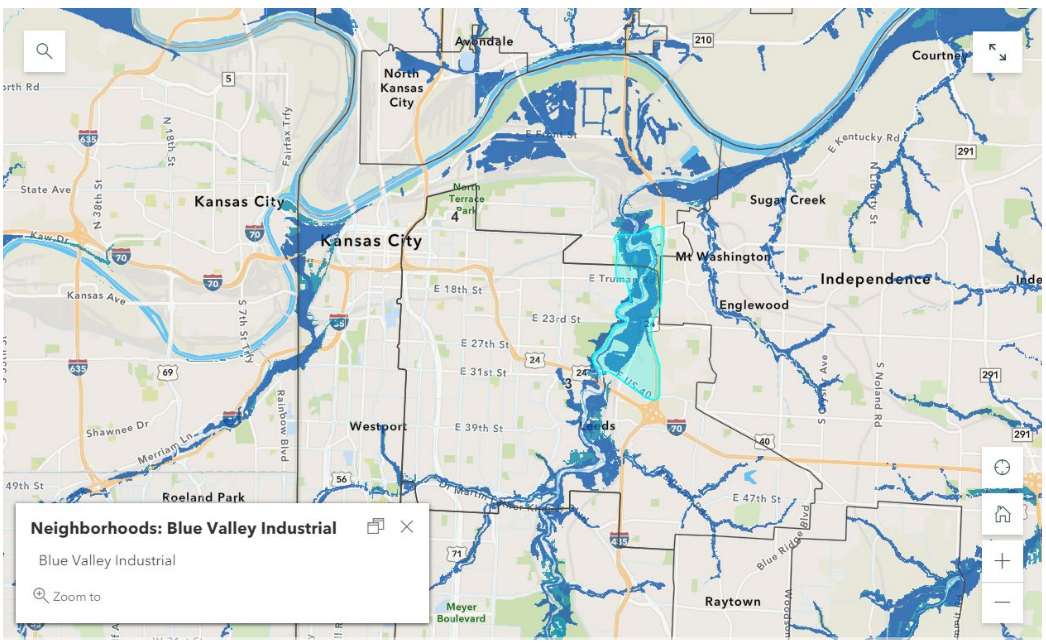

Figure 3. Example of exposure mapping - 100- and 500-year floodplain

CLIMATE HAZARD EXPOSURE DATA SOURCES

The following data were used to map exposure to spatially varied hazards (extreme heat and flooding) across Kansas City.

Table 1. Climate hazard exposure data sources and descriptions

Data	Data Source and Year	Description	Data Management and Application
100- and 500- year Floodplains	MARC Regional Climate Risk and Vulnerability Assessment Geodatabase, 2019	This layer contains information about the flood hazards within the flood risk project area. These zones are used by Federal Emergency Management Agency (FEMA) to designate the Special Flood Hazard Area (SFHA) and for insurance rating purposes. These data are the regulatory flood zones designated by FEMA.	**Management**: Data were left intact for online mapping and clipped to Kansas City municipal boundaries for static mapping. **Application**: Used to demonstrate exposure to flood-prone areas.
Urban Heat Island	MARC Regional Climate Risk and Vulnerability Assessment Geodatabase, 2019	Uses impervious surface and urban tree canopy to show areas of unmitigated Urban Heat Island exposure.	**Management**: Data were left intact, as data set only extended beyond city limits for two census tracts. **Application**: Used to demonstrate exposure to potential Urban Heat Island impact.
Nuisance Flooding Data	KC Water, 1900-2018	Historical point data describing 311 calls related to localized flooding collected between 1900-2018	**Management:** Data were left intact and visualized using the "Heat Map" function available through ArcGIS online to demonstrate clusters of localized flooding reports. **Application:** Used to demonstrate non-floodplain related flooding, primarily associated with combined sewer and stormwater overflows.

MARC (Mid-America Regional Council) Methodology for Creating Urban Heat Island Index

This index identifies census tracts that have 35% or more impervious landcover. Census tracts with less than 35% impervious landcover are not displayed. The resulting map presents an Urban Heat Island Index, showing which census tracts are most likely to experience Urban Heat Island and would benefit most from additional tree canopy. Census tracts colored in darkest orange are those most likely to experience Urban Heat Island effects and would benefit most from additional tree canopy (Figure 4).

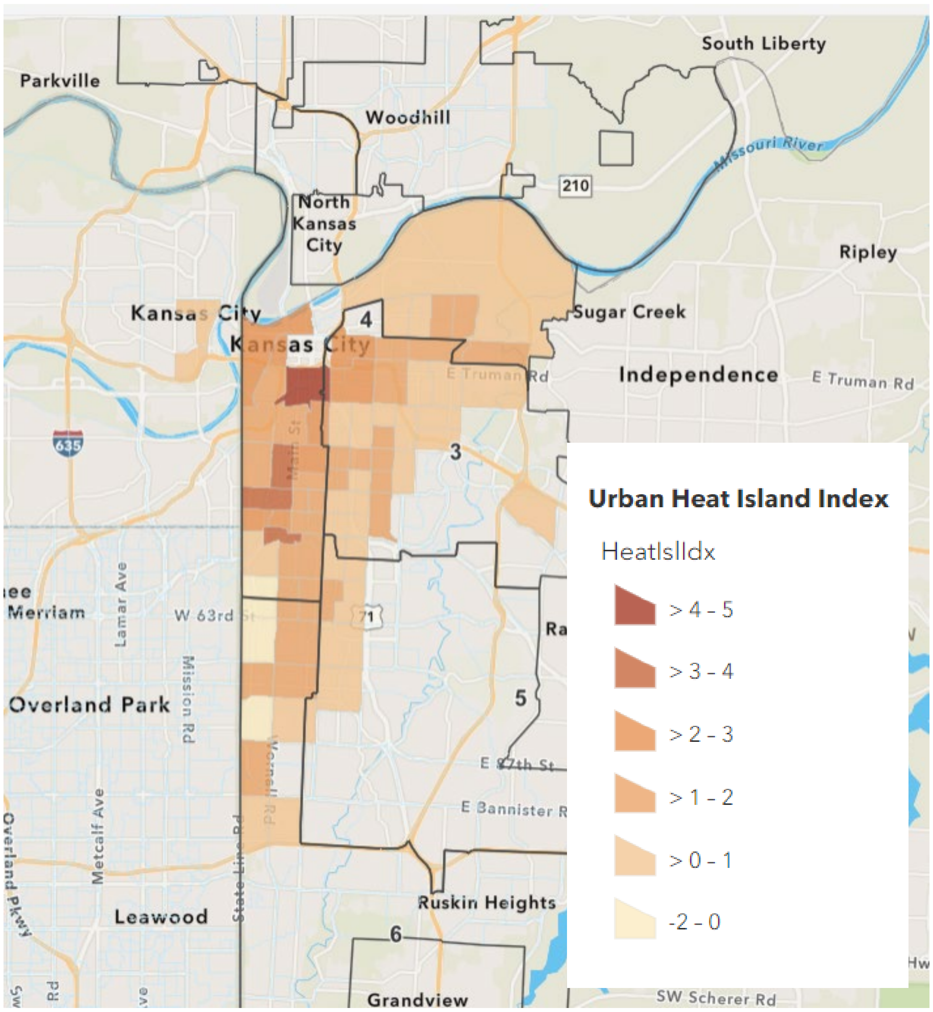

Figure 4. KCMO Urban Heat Island Index

EVALUATING ADAPTIVE CAPACITY

Next, adaptive capacity was evaluated in relation to mapped hazards (extreme heat and flooding). Adaptive capacity is the ability to respond to or cope with the impacts of a given climate hazard. Many factors influence adaptive capacity, including socioeconomic characteristics and access to goods and services. This section explains how adaptive capacity was evaluated through mapping and an inventory of programs and policies.

MAPPING ADAPTIVE CAPACITY

Like exposure, adaptive capacity varies spatially across Kansas City. Socioeconomic characteristics, such as race, age, disability status, income, access to a vehicle, English proficiency, home age, and housing type can all inform an individual's or household's capacity to respond to or cope with the impacts of climate-related exposure. These characteristics vary across the city, with some neighborhoods at greater risk to climate-related impacts than others (Figure 5). Additionally, proximity to infrastructure, goods, and services varies across Kansas City. For instance, not all neighborhoods have equitable access to cooling centers. The data sources used to map this variation are detailed in the following section.

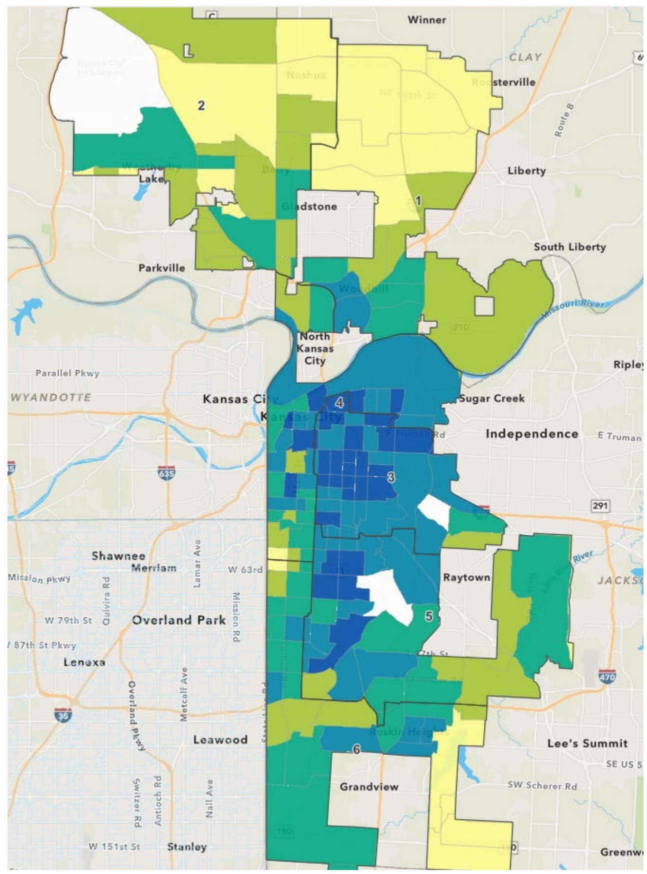

Figure 5: Mapping adaptive capacity example -Heat-related socioeconomic index

ADAPTIVE CAPACITY DATA SOURCES

The following data (Table 2) were used to map adaptive capacity to extreme heat and flooding across Kansas City. The methodology used to develop the indices listed below is detailed on the page following the indices.

Table 2. Adaptive capacity data sources and descriptions

Data	Data Source and Year	Description	Data Management and Application
General socioeconomic index	MARC Regional Climate Risk and Vulnerability Assessment Geodatabase, 2019 Census tract-level 5-year American Community Survey (ACS) data (2014-2018)	Variables include: • Non-white Population • Population Below 200% of Poverty Level • Population Under Age 5 • Population Over Age 65 • Renter Occupied Housing Units	**Management**: Data were clipped to municipal boundaries and a text field was added to indicate the severity of the index (lowest, low, medium, high, highest) using the same data breaks as the MARC regional climate risk and vulnerability assessment. **Application**: Used to demonstrate generalized disproportionate impacts related to climate change.
Tornado socioeconomic index	MARC Regional Climate Risk and Vulnerability Assessment, 2019 Geodatabase Census tract-level 5-year ACS data (2014-2018)	Variables include: • Disabled Population • Zero Vehicle Households • Population Speaking English Less than Very Well • Population Below 200% of Poverty Level • Housing with 10+ Units • Mobile Homes • Population Over Age 65 and Living Alone	**Management**: Data were clipped to municipal boundaries and a text field was added to indicate the severity of the index (lowest, low, medium, high, highest) using the same data breaks as the MARC regional climate risk and vulnerability assessment. **Application**: Used to demonstrate disproportionate impacts related to flooding. The MARC regional climate risk and vulnerability assessment data did not include a "flood-related socioeconomic index"; however, all of the variables used to develop the tornado socioeconomic index are relevant to flooding.

Heat socioeconomic index	MARC Regional Climate Risk and Vulnerability Assessment Geodatabase, 2019 Census tract-level 5-year ACS data (2014-2018)	Variables include: • Disabled Population • Zero Vehicle Households • Population Below 200% of Poverty Level • Population Over Age 65 and Living Alone • More than 1 Occupant per Room • Housing Units built prior to 1960	**Management**: Data were clipped to municipal boundaries and a text field was added to indicate the severity of the index (lowest, low, medium, high, highest) using the same data breaks as the MARC regional climate risk and vulnerability assessment. **Application**: Used to demonstrate disproportionate impacts related to extreme heat.
Cooling Centers	MARC Regional Climate Risk and Vulnerability Assessment Geodatabase, 2019	Air-conditioned buildings open and accessible to the public (e.g., libraries, community centers). Note, this data set was developed prior to the COVID-19 pandemic.	**Management**: Data were limited to cooling centers within one mile of municipal boundaries, since cooling centers outside of municipal boundaries may still benefit residents who live near municipal boundaries. **Application**: Used to demonstrate localized adaptive capacity related to extreme heat.
Above Average Energy Burden	Greenlink Equity Map 1-yr ACS Data (2018)	Energy Burden is the percent of median yearly income that households pay for electricity and gas bills. Nationally, the average household spends about 3% of their income on energy bills.	**Management**: Data were clipped to municipal boundaries and were visualized using natural data breaks to create data bins. **Application**: Used to identify census tracts with more households experiencing above-average energy burden.
Asthma Rates	Greenlink Equity Map CDC 500 Cities (2017)	Median percentage of adults (populations age 18 or older) with asthma.	**Management**: Data were clipped to municipal boundaries and were visualized using natural data breaks to create data bins. **Application**: Used to identify census tracts with higher rates of asthma.

MARC Methodology for Creating Vulnerability Indices

This methodology applies to the following indices listed in the table above:

- General socioeconomic index
- Tornado socioeconomic index
- Heat socioeconomic index

Each index was created by summarizing z-scores for relevant indicators; z-scores were generated based on regional averages (the "region" included the 9-county MARC region plus Douglas County, KS). The z-score for each indicator describe the position of a raw score in terms of its distance from the mean when measured in standard deviation units as shown in Figure 6. The z-score is positive if the value lies above the mean and negative if the value lies below the mean. The z-scores relevant to each vulnerability layer were added together to generate the index score. The shade of the census tract is based on the index, as indicated in the legend. The darker the color, the higher the stress index.

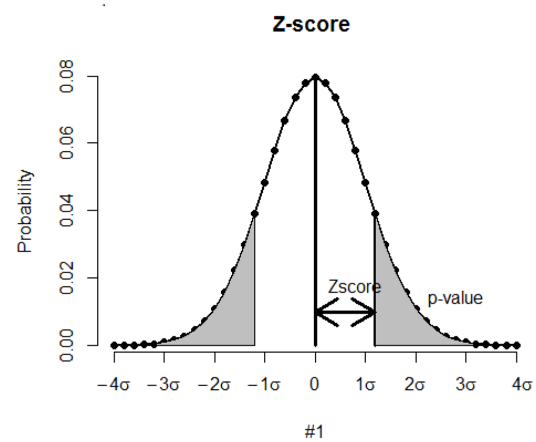

Figure 6: Example of z-score calculation (Sys, Klinec, & Svenda, 2017)

Greenlink Equity Mapping (GEM) Tool

Data collected from the GEM tool were collected and collated for the following counties: Platt, Clay, Jackson, and Cass. Data were joined to census tracts (clipped to Kansas City's municipal boundary) in ArcGIS.

IDENTIFYING ADAPTIVE CAPACITY ACTIVITIES

The City of Kansas City and its community partners are already taking action to build adaptive capacity against both primary climate hazards and cascading climate risks. This includes plans, policies, programs, and infrastructure improvements to help community members mitigate and adapt to climate related impacts like extreme heat and flooding. Some of these efforts are top down, such as **Kansas City's Digital Equity Strategic Plan**, an effort spearheaded by the City Manager's Office to improve equitable access to the digital economy. Other efforts are bottom up, such as grassroots organizations like **Deep Roots KC** and the **Giving Grove**, that serve as community partners in improving resiliency.

General Resiliency and Capacity Building Activities

While some actions are intended to directly address specific impacts (see the flooding and heat sections), many City-led activities increase resiliency against a wide range of climate impacts. For instance, **Services and Funding for Unhoused Persons** helps prevent homelessness and increase affordable housing, which can help reduce exposure to a wide range of climate impacts, including extreme heat, severe winter weather, or even tornadoes. Similarly, the **Targeted Minor Home Repair Program** helps fund repairs to water lines, water heaters, sewer mains, roofs, furnaces, and more. These repairs can help increase adaptive capacity to cope with every identified climate impact. The **Healthy Homes Ordinance** establishes the minimum health and safety standards for rental properties, providing an avenue for tenants to advocate for safer living conditions.

The City seeks to lead by example, by using the **ENVISION Infrastructure Rating System** to ensure infrastructure, such as roadways, bridges, or stormwater projects, are sustainable and resilient. The City's Parks department leads by example by implementing the **Parks Sustainability Plan.** One focus of this plan is transitioning to landscapes that are more resilient to extreme heat and drought.

Other capacity building efforts include those focused on improving health and wellness. Kansas City developed a **Community Health Improvement Plan** and accompanying **State of Health interactive dashboard** to help shed light on and chart a course for improving health discrepancies across the community. Access to parks and nature is a key component of mental, physical, and environmental health. KC Parks prioritizes investments in **Quality of Life Investment Districts** where life expectancy is lower than average.

Access to healthy foods is another major barrier to health in Kansas City. Many community partners, like the **Kansas City Community Gardens** and **Cultivate KC,** are helping connect community members with nutritious foods, especially in lower-income neighborhoods. The **Environmental Health Program at Children's Mercy** is another example of a community partnership seeking to improve the health, and therefore adaptive capacity, of Kansas City community members.

Finally, skill-building programs can help improve community resilience in the face of climate hazards. For instance, the **Community Emergency Response Team (CERT) Program** is a police and fire program designed to educate the community about disaster preparedness and response, training neighborhood and community leaders in fire safety, light search and rescue, and even disaster medical operations.

Building Adaptive Capacity to Cope with Extreme Heat

To combat the impacts of extreme heat, the City maintains a list of **designated cooling centers**, including libraries, community centers, swimming pools, and spray grounds. These locations can be critical to the health and safety of Kansas Citians, especially those without access to air conditioning. Some cooling centers – like libraries and community centers - can also provide protection against extreme winter weather. Similarly, **RideKC offers a cooling and heating bus** service when temperatures exceed 100 degrees Fahrenheit or drop below 10 degrees Fahrenheit. The Neighborhoods and Housing Services department recently funded the **Emergency Rental and Utilities Assistance** program, which set aside $4.5 million to help tenants pay rent and utility bills. This program can help tenants keep their heat on during extreme winter weather and their air conditioning on during extreme heat.

Communication is a key component to keeping community members safe on extremely hot days. Kansas City partnered with the Weather Service to create **customized heat briefings** to help community members more easily spread the word and take the necessary precautions.

In addition to providing resources to help residents cope with the realized impacts of extreme heat, the City is also working toward reducing city-wide exposure to extreme heat. The **Kansas City Urban Forest Master Plan** establishes a roadmap for the long-term management and improvement of the city's tree canopy. One study conducted by the **Heartland Conservation Alliance** identified 40,000 acres eligible for reforestation throughout Kansas City. This would provide tremendous cooling benefits and could help sequester up to two megatons of carbon per year.

Building Adaptive Capacity to Cope with Flooding

As with general resilience and heat-related resilience, Kansas City takes a multi-pronged approach to mitigate and adapt to increasingly frequent and severe flooding. The City's **Floodplain Management Ordinance** and **Floodplain Development Permitting** process seek to minimize flood-related losses, and the City's **Floodplains and Flood Recovery** webpage connects community members with essential information about flood zones, flood insurance, and flood recovery resources.

One of Kansas City's most innovative responses to flooding is the **Smart Sewer Plan and Program,** which prioritizes data-driven solutions and innovative overflow control technologies to address flooding in the portions of Kansas City served by a combined sewer and stormwater system. The primary principles of this program include strategic investment, applying technology-driven solutions, and prioritizing green infrastructure. The plan is implemented through a series of **Smart Sewer Projects** and a variety of supporting programs. For instance, **Keep Out the Rain** helps residents find and fix prohibited stormwater connections to the sewer system at no cost. The **KC Green Infrastructure program** connects community members with essential information about the costs and benefits of green infrastructure. The **Green Infrastructure Manual** guides the design and implementation of green infrastructure across the city. Maintenance is a critical component to the success of green infrastructure; the **Green Stewards Program** provides workforce development, in partnership with **Bridge the Gap**, to support the day-to-day maintenance and monitoring of 230 green infrastructure installations. Finally, programs like the City's **Sub-to-Prime Initiative** helps ensure minority- and women-owned businesses are at the center of delivering Kansas City's Smart Sewer Program.

Additional capacity building activities include the **Water Equity Roadmap**, which outlines pathways toward equitable access to clean, affordable drinking water and healthy watersheds. Specific initiatives, such as the **Blue River Valley Opportunity Zone,** demonstrate the role of economic development and flood-prevention infrastructure in neighborhood revitalization.

COUNCIL DISTRICT-LEVEL VULNERABILITY ASSESSMENT

In addition to cataloging (in the sections above) community-wide climate hazard exposure and adaptive capacity, a more granular vulnerability assessment was completed at the council-district level. To determine climate vulnerability, exposure to climate hazards must be compared against adaptive capacity to those hazards. As shown in Figure 7 below, where exposure is high and adaptive capacity is low, vulnerability is highest. Where exposure is low and adaptive capacity is high, vulnerability is lowest. Thus, to reduce vulnerability, action can be taken to reduce exposure, bolster adaptive capacity, or both.

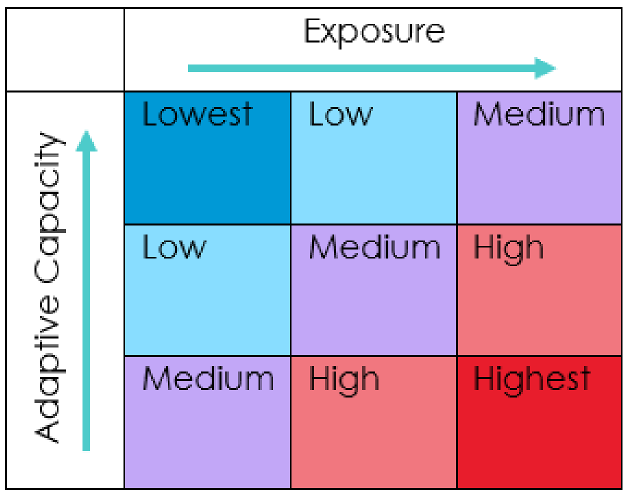

Figure 7. Climate vulnerability matrix legend

To compare exposure against adaptive capacity, online interactive maps were developed and embedded within a Story Map. For instance, exposure to the Urban Heat Island effect is overlaid on socioeconomic adaptive capacity to extreme heat, to identify the City's most vulnerable populations. Cooling centers are overlaid on socioeconomic adaptive capacity to extreme heat, to identify opportunities to decrease vulnerability to extreme heat. Similarly, exposure to flooding is layered on top of socioeconomic adaptive capacity to flooding. Importantly, these interactive maps allow users to search for addresses, neighborhoods, or landmarks within Kansas City, and to explore how exposure and adaptive capacity data varies between neighborhoods.

These interactive maps are available on the project Story Map site. During this project, the Story Map will serve as an internally facing tool to support vulnerability analysis and engagement strategy. Future enhancements to this vulnerability assessment could include a map of green infrastructure across Kansas City. Such a map could be layered on top of nuisance flooding to identify opportunities to decrease vulnerability to flooding.

DISTRICT-LEVEL SUMMARIES

The data embedded in the interactive maps (Figure 8) were summarized and used to develop district summary cards. District summary cards can be accessed for each district through the "Council District Summaries" section. District summaries succinctly describe, by council district:

1) The severity of exposure to mapped climate risks, and
2) The adaptive capacity of community members to respond to mapped climate risks for each district.

The tables on the following pages describe the methodology for calculating the data displayed on the district summaries.

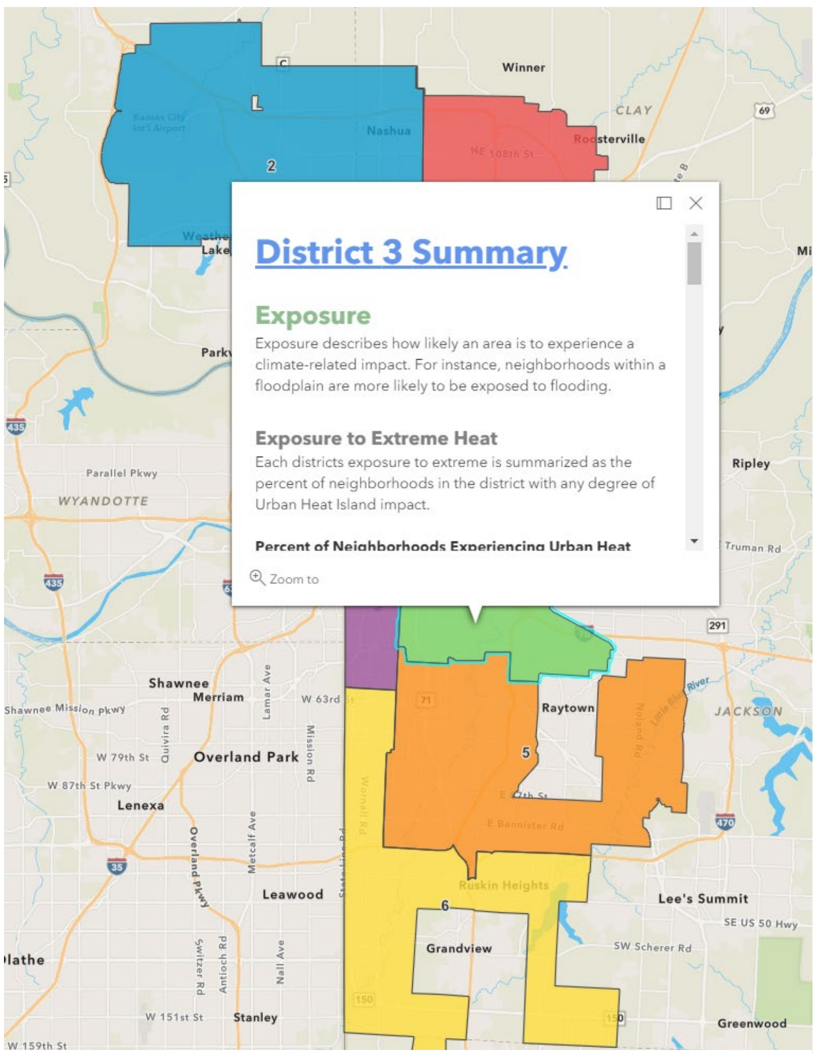

Figure 8: Example of the district summary for District 3

District-Level Summary Data Sources

Table 3 describes the methodology for calculating exposure metrics, by council district. Table 4 describes the methodology for calculating adaptive capacity metrics, by Council District.

Table 3. District summary exposure data sources and descriptions

Measure	Description	Methodology
Urban Heat Island Exposure	Percent of neighborhoods experiencing some degree of Urban Heat Island impacts	To evaluate exposure to Urban Heat Island effects, the total number of neighborhoods in a district with any amount of unmitigated Urban Heat Island were divided by the total number of neighborhoods in that district. Exposure to Urban Heat Island effects is presented as the percent of total neighborhoods in a district experiencing some amount of unmitigated Urban Heat Island effects. Total neighborhoods were calculated using the "select by location" tool to select any neighborhood that intersected each district. This results in a double counting of neighborhoods that are split between multiple districts.
Floodplain Exposure	Percent of the council district covered by the floodplain	To evaluate exposure to the floodplain, the area (square feet) of the floodplain shapefile was calculated and summarized by council district. Note, area was calculated for all datapoints available, and was not sorted or filtered by the 'fld zone' or 'zone subty' field. The area (square feet) for each district was calculated. Floodplain exposure is represented as the total percent of the council district area covered by the floodplain (floodplain area / council district area * 100).
Nuisance Flooding/ Sq. Mi.	Number of nuisance flooding complaints per square mile	Total reports of historic nuisance flooding (collected between 1900 and 2018) were summarized by district, then divided by the size (in square miles) of the district. Nuisance flooding exposure is represented as number of historic nuisance reports per square mile.

Table 4. District summary adaptive capacity data sources and descriptions

Measure	Description	Methodology
General Socioeconomic Stress Index	Average socioeconomic stress index for each district.	"Select by location" was used to select all census tracts, from the **General Socioeconomic Stress Index shapefile,** within each council-district boundary. The statistics feature was used to identify the average for the selected census tracts. The minimum and maximum values were also identified.
Average Median Household Income	Average median household income for each district.	"Select by location" was used to select all census tracts, from the **Energy Burden shapefile,** within each council-district boundary. The statistics feature was used to identify the average for the selected census tracts. The minimum and maximum values were also identified.
Heat-related Socioeconomic Stress Index	Average flood-related socioeconomic stress index for each district.	"Select by location" was used to select all census tracts, from the **Heat-related Socioeconomic Stress Index shapefile,** within each council-district boundary. The statistics feature was used to identify the average for the selected census tracts. The minimum and maximum values were also identified.
Average Asthma Rate	Average asthma rate for each district.	"Select by location" was used to select all census tracts, from the **Asthma Rate shapefile,** that are within each council-district boundary. The statistics feature was used to identify the average asthma rate for the selected census tracts. The minimum and maximum values were also identified.
Average % of households with Energy Burden	Average % of households with above-average energy burden for each district.	"Select by location" was used to select all census tracts, from the **Energy Burden shapefile,** that are within each council-district boundary. The statistics feature was used to identify the average for the selected census tracts. The minimum and maximum values were also identified.
Number of Cooling Centers	Total number of cooling centers within each district.	"Select by location" was used to select all **cooling centers,** with their centroid, within each council-district boundary. The statistics feature was used to identify the "count".
Flood-related Socioeconomic Stress Index	Average heat-related socioeconomic stress index for each district.	"Select by location" was used to select all census tracts, from the **Flood-related Socioeconomic Stress Index shapefile,** that are within each council-district boundary. The statistics feature was used to identify the average for the selected census tracts. The minimum and maximum values were also identified.

DISTRICT-LEVEL VULNERABILITY ASSESSMENT RESULTS

To summarize district-level exposure and adaptive capacity, a heat map was created to show, by district, relative exposure to mapped climate risks and relative adaptive capacity to respond to those risks (Table 5). Districts were evaluated across three exposure indicators and seven adaptive capacity indicators. Cells marked in red indicate relatively high exposure or low adaptive capacity, compared to the other districts, for that indicator. Cells marked in blue indicate relatively low exposure or high adaptive capacity, compared to the other districts, for that indicator.

Table 5. Heat Map of Climate Risk and Vulnerability by Council District

		Exposure			Adaptive Capacity						
		Heat	Flooding		General		Heat				Flooding
Region	District	Urban Heat Island Exposure	Floodplain Exposure	Nuisance Flooding/Sq.Mi.	General Socioeconomic Stress	Average Median Household Income	Heat-related Socioeconomic Stress	Average Asthma Rate	Average % of households with energy burden	Number of Cooling Centers	Flood-related Socioeconomic Stress
North	1	3%	4%	9.6	Low	$ 76,558	Low	7%	58%	4	Low
	2	14%	6%	15.0	Low	$ 76,172	Low	8%	52%	4	Low
Central	3	73%	5%	15.4	High	$ 27,151	Highest	11%	91%	8	High
	4	71%	4%	7.5	Medium	$ 55,869	High	9%	75%	13	High
South	5	15%	7%	16.7	Medium	$ 41,960	Medium	10%	81%	5	Medium
	6	25%	5%	32.4	Low	$ 66,050	Medium	8%	65%	5	Low

Exposure Legend
- Highest exposure
- Above average exposure
- Average exposure
- Below average exposure
- Lowest exposure

Adaptive Capacity Legend
- Lowest adaptive capacity
- Below average adaptive capacity
- Average exposure
- Above average adaptive capacity
- Highest adaptive capacity

The heat map above shows that across all metrics of exposure, Council District 3 has the highest exposure to heat and moderate exposure to flooding. Council District 4 also has very high exposure to heat, but the lowest exposure to flooding. Concurrently, Council districts 3 and 4 have low adaptive capacity across all metrics except for cooling centers. Though access to cooling centers is a critical resilience strategy in response to extreme heat, other strategies – such as improving energy efficiency of buildings, increasing access to air conditioning in homes, increasing the health of community members, decreasing impervious surface, and increasing tree canopy – remain important priorities to reduce exposure and increase adaptive capacity in these districts. Council Districts 5 and 6 have the highest exposure to flooding, though these districts are moderately- to well-equipped to adapt to flood-related challenges.

This heat map, in conjunction with the more detailed interactive maps presented throughout the Story Map, should be used as tools to identify and communicate climate vulnerability and to prioritize actions to reduce exposure or increase adaptive capacity.

RECOMMENDATIONS FOR UPDATING THIS VULNERABILITY ASSESSMENT

Per CDP guidelines, it is recommended that this vulnerability assessment is reviewed at least every 4 years and updated as needed to remain current.

Whenever possible, use updated data to conduct future vulnerability assessments. For instance, future updates to Urban Heat Island data may be developed by using updated impervious surface and tree canopy data and applying MARC's methodology to calculate a new Urban Heat Island Index. The most recently available 100- and 500-year floodplain data should be used to map floodplain exposure; updated nuisance flooding data should be used to map nuisance flooding exposure. Socioeconomic stress indices may be updated by using the most recently available ACS data to recalculate z-scores.

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