

Understanding and Assessing Climate Change: Preparing for Nebraska's Future

2024 Climate Change Impact Assessment Report

Chapter 10 - Communities and the Built Environment



Chapter 10

Communities and the Built Environment

Zhenghong Tang, Tonya Haigh, Jenny B. Mason, Jahangeer Jahangeer, and Jiyoung Lee*

*Corresponding author: ztang2@unl.edu

Key messages

1. Nebraska communities have faced an increased likelihood of extreme weather and climate events, leading to longer durations, broader geographic impacts, higher costs, and deeper social consequences.
2. Nebraska's urban and rural areas are at heightened risk of extreme future weather and climate events and increased physical and social vulnerabilities.
3. To address these challenges, key strategies for reducing the potential risks of climate change include effective land-use planning, sound natural system preservation, essential infrastructure improvements, ongoing public engagement, and regional cooperation.

Introduction

Understanding the effects of climate change on Nebraska's communities and built environment is essential for developing effective strategies to mitigate and adapt to the risks of extreme weather and climate events. Climate change has significant consequences, impacting Nebraska's ecosystems, societies, and economies. These effects include important areas such as natural resources, biodiversity, public health, agriculture, infrastructure, and overall quality of life (IPCC, 2014; USGCRP, 2017).

Whether they live in urban or rural areas, Nebraskans face inevitable challenges from climate change that affect their well-being. Climate change brings more extreme weather events, makes infrastructure more vulnerable, and increases social challenges across the state. By understanding these impacts, policymakers, communities, and individuals can create effective strategies and interventions to reduce risks, adapt to evolving conditions, and build a more resilient future for Nebraska's communities and the built environment.

Climate change has wide-ranging impacts on Nebraska's communities and the built environment. First, it poses serious risks to human well-being and livelihoods. We can see this in the escalating frequency and severity of extreme weather and climate events in recent years. Second, Nebraska's buildings, transportation systems, and vital water and power infrastructure are at risk due to climate change. Changes in rain and snow patterns, extreme temperatures, and floods can lead to costly infrastructure damage and disrupt services. Lastly, climate change makes social challenges worse, with marginalized communities bearing a disproportionate burden and existing inequalities growing. Understanding how climate change affects Nebraska's communities and infrastructure is critical to protecting our well-being, improving infrastructure resilience, and striving for social equity.

This chapter examines and evaluates the impacts of climate change on Nebraska's communities and the built environment. It reviews past studies on climate impacts on Nebraska and the scientific data from extreme weather and climate events.

This chapter also discusses the current challenges in climate action and emphasizes opportunities to enhance climate resilience at the community level. By exploring the specific impacts of climate change, we hope to raise awareness of Nebraska's challenges and highlight the importance of building resilience in response to our changing climate.

Climate change impacts on Nebraska's communities

In Nebraska, the effects of extreme weather and climate disasters are becoming increasingly evident as the frequency and intensity of such events continue to rise. These events put communities at risk, affecting their physical, social, and economic well-being and overall quality of life. Over the past decade, Nebraska communities have experienced a higher likelihood of extreme events, resulting in longer durations, wider geographic impacts, more costly damages, and deeper social consequences for urban and rural areas.

Increased likelihood of extreme events

While natural hazards like floods, severe storms, winter snowstorms, tornadoes, and heat waves are a natural part of climate variability, climate change can amplify these events and their impacts on communities and the built environment. National-level research predicts more frequent flood events in Nebraska (Figure 2.12). The total U.S. population exposed to severe flooding is estimated to be 2.6 to 3.1 times higher than previous estimates, with this risk likely heightened by climate change (Wing et al., 2022). Research provides strong evidence of an increasing frequency of flooding across the central U.S. (Mallakpour & Villarini, 2015). Additionally, flood events have increased across most of the Midwest in the past 50–70 years (Neri et al., 2019). Records of Nebraska's extreme weather and climate events align with national-level predictions (Chapters 2 and 3).

According to the National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information (NCEI) datasets (2024c), the frequency of billion-dollar disasters has statistically increased over the past four decades in Nebraska. Billion-dollar disasters are weather and climate events where the overall damage costs (across all affected areas) reach or exceed \$1 billion, adjusted for inflation. It is essential to acknowledge that disaster impacts are a combination of risk factors (such as population growth, density, and material wealth) and the effects of climate change and variability.

From January 1, 1980, to December 31, 2024, Nebraska experienced 66 weather and climate disaster events, where total losses from each event exceeded \$1 billion (NOAA NCEI, 2024c). These major extreme weather and climate events, categorized as billion-dollar disasters, included 13 droughts, 5 floods, 2 freezes, 44 severe storms, 1 wildfire, and 1 winter storm (Figure 10.1).

From 1980 to 2024, Nebraska was affected by an average of 1.5 billion-dollar events per year (NCEI, 2024c). However, the most recent five years (2019 to 2023) show an increase to an average of four events per year (NOAA NCEI, 2024c). By the decade (Figure 10.2), Nebraska was affected by 5 billion-dollar weather and climate events during the 1980s, 4 during the 1990s, 15 during the 2000s, and 20 events from 2010 to 2019 (NOAA NCEI, 2024c). From 2020 to 2024, over 20 major disaster events have affected Nebraska, with 16 of these from 2022 to 2024.

The three most frequent types of billion-dollar events affecting Nebraska from 1980 to 2024 include severe storms, drought, and flooding (NOAA NCEI, 2024c). Over the past four decades, severe storms have accounted for 66.7% of all billion-dollar events affecting Nebraska, droughts for 19.7%, and flooding for 7.6% of the total events (NOAA NCEI, 2024c). Severe storms and floods are closely related, with severe storms often leading to flood disasters.

The frequency and damage costs of extreme weather events, particularly severe storms, droughts, and floods, have increased significantly

from 2020 to 2024 compared to 1980 to 1999.

According to the 2021 Nebraska State Hazard Mitigation Plan (NEMA, 2021), between 1980 and 1999, 10 federal-level disaster declarations were made for severe storms. However, in the past two decades (2000 to 2019), the number of severe storms, ice storms, and floods resulting in federal disaster declarations rose to 27. These disaster declarations, made by the president based on the governor's request, activate an array of federal programs and funding to support state and local governments in responding to and recovering from major natural disasters.

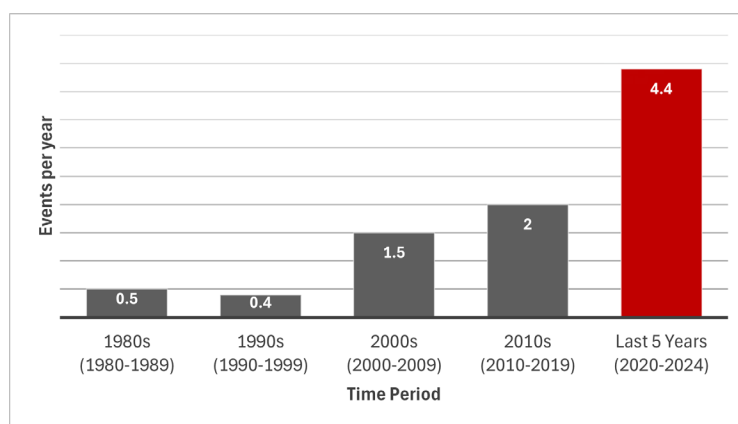


Figure 10.1. The number of events per year for the billion-dollar disaster events that affected Nebraska communities from 1980 to 2024. (Source: NOAA NCEI, 2024c, <https://www.ncei.noaa.gov/access/billions/summary-stats/NE/1980-2024>)

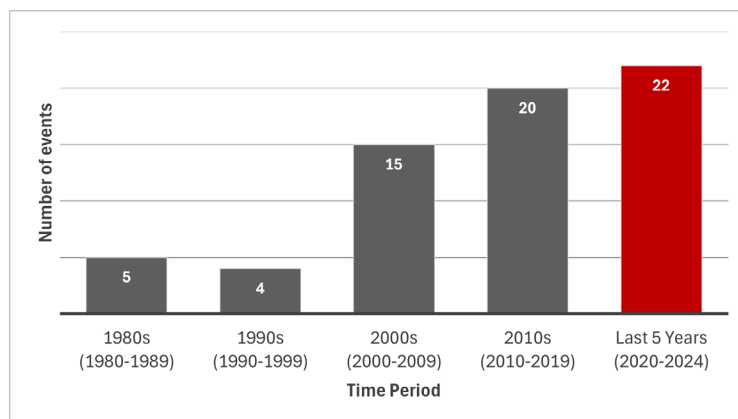


Figure 10.2. Number of billion-dollar disaster events that affected Nebraska communities from 1980 to 2024. (Source: NOAA NCEI, 2024c, <https://www.ncei.noaa.gov/access/billions/summary-stats/NE/1980-2024>)

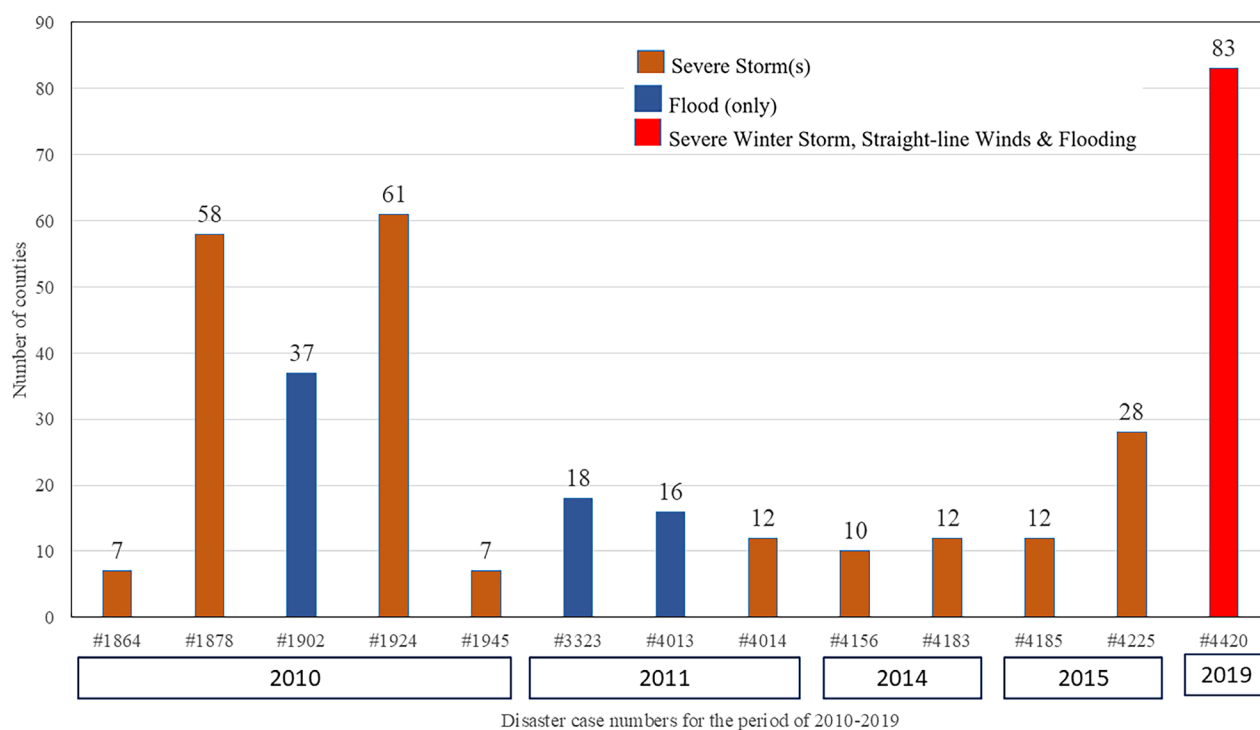


Figure 10.3. Federal major disaster declarations related to flooding in Nebraska from 2010 to 2019. (Source: NEMA, 2021)

Figure 10.3 shows the occurrence of federal disaster declarations in Nebraska communities between 2010 and 2019—nine for severe storms, three for floods, and one each for a severe winter storm, straight-line winds, and flooding-related events.

Broader geographic impacts

Extreme weather and climate disasters have significantly impacted all areas of Nebraska, affecting rural and urban regions over the past decades. The drought of 2012 affected 86 out of Nebraska's 93 counties (NEMA, 2021). Between 1980 and 2024, 13 major droughts (billion-dollar events) have widely affected Nebraska (NOAA NCEI 2024c). These droughts have widely disrupted urban and rural economic activities such as drinking water, agriculture, and recreation (NEMA, 2021).

Since 2008, Nebraska has experienced 482 tornadoes, impacting every county in the state (NEMA, 2021). These severe events also significantly impacted various communities across Nebraska.

From 1996 to 2019, flooding impacted every county in Nebraska, causing varying degrees of damage (NEMA, 2021; NeDNR, 2022). The scale of the historic flood in 2019 was vast, resulting in state or federal disaster declarations for 104 cities, 84 counties, and 5 tribal nations in Nebraska (NeDNR, 2022; State of Nebraska, 2021).

Prolonged durations

Nebraska communities have faced long-lasting impacts from extreme weather and climate disaster events. The severe drought that began in 2011 persisted through 2012 before concluding in 2013 (NDMC, 2024). The University of Nebraska—Lincoln Conservation and Survey Division (Young et al., 2018) found that it took over five years for the High Plains Aquifer's groundwater levels to return to normal, significantly affecting Nebraska's agricultural economy (Table 10.1, community highlight 1).

Another major event in Nebraska's history was the flooding disaster in March 2019. The Federal Emergency Management Agency (FEMA) defined this

flood as an extended-duration event, with a 128-day FEMA Incident Period, lasting from March 9 to July 14, 2019. Encompassing winter storms, high winds, and flooding, this historic event resulted in two deaths and hundreds of air and boat rescues, as well as the failure of the Spencer Dam on the Niobrara River. Many residents were isolated from their homes and workplaces for days, and the city of Fremont was completely closed off due to flooded highways. Furthermore, the cleanup of debris and sand in affected fields has taken years to complete, with flood-recovery processes extending over years and, in some cases, up to a decade (Table 10.1, community highlight 2).

From January 2000 through June 2020, 53 counties reported 14 days of excessive heat events. During these 20 years, the state experienced 10 extreme heat events, resulting in a recurrence interval of 0.5% in any given year (NEMA, 2021). For instance, in 2018 and 2019, the city of Beatrice and three counties—Hayes, Frontier, and Hitchcock—identified extreme heat as a major hazard (NEMA, 2021). In contrast, data on extreme cold or wind chill events during the same period showed that many Nebraska communities were affected for more than 36 days (NEMA, 2021).

Higher costly damage

The costs associated with billion-dollar events affecting Nebraska from 1980 to 2024 have significantly increased (NCEI, 2024c). Figure 10.4 shows the percentage of costs for major billion-dollar disaster events that affected Nebraska communities from 1980 to 2024. From 1980 to 1989, the costs accounted for 11.9% of the total; from 1990 to 1999, they accounted for only 4.6%; from 2000 to 2009, they rose to 14.2%; and from 2010 to 2019, the costs dramatically increased to 42.7% of the total (NCEI, 2024c). The trend has continued into the 2020s, with costs from the last five years reaching 26.6% of the total and the three years (2021 to 2023) reaching 22.7% of the total costs from 1980 to 2024 (NCEI, 2024c).

The top three costliest extreme disaster types for the billion-dollar events affecting Nebraska from 1980 to 2024 are drought, severe storms, and flooding (NCEI, 2024c). Over the past four decades, drought has been the costliest disaster type in Nebraska, accounting for

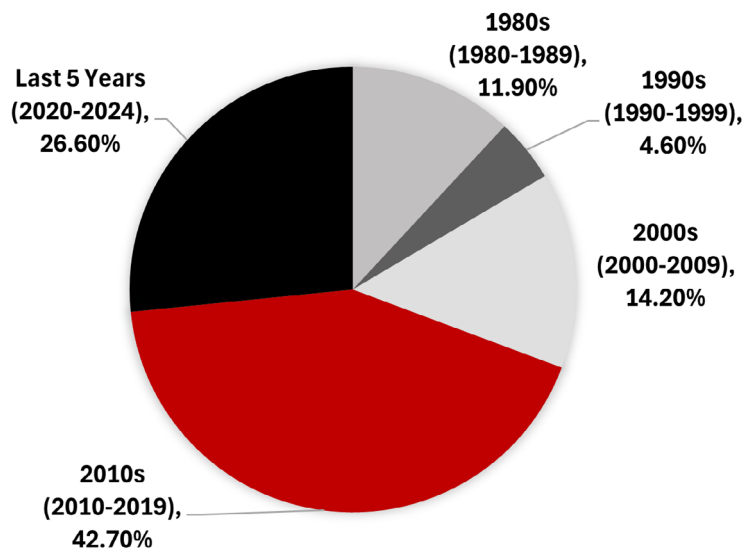


Figure 10.4. The percentage of total cost for the billion-dollar disaster events that affected Nebraska communities from 1980 to 2019. (Source: NCEI, 2024c. "Select Time Period Comparisons of Nebraska Billion-Dollar Drought, Flooding, Freeze, Severe Storm, Tropical Cyclone, Wildfire, and Winter Storm Statistics [CPI-Adjusted]")

44.5% of the total costs from the billion-dollar events. Severe storms have led to 41.6% of the total costs, and flooding has accounted for 13.4% (NCEI, 2024c).

Nebraska has suffered costly damage from various natural disasters driven by extreme weather and climate disaster events. Between 2008 and 2020, the state experienced 13 federal disaster declarations, including tornadoes, resulting in over \$158 million in federal public assistance (NEMA, 2021). Tragically, tornado events in Nebraska have caused 6 fatalities and 103 injuries from 2008 to 2020 (NEMA, 2021). In addition to tornadoes, severe storms and floods have inflicted significant losses on Nebraska communities. In 2024 alone, at least four major federal disaster declarations were issued for Nebraska, including severe storms or winter storms, straight-line winds, tornadoes, and flooding, occurring between April and September (Table 10.1, community highlight 3).

The public assistance funds obligated to floods in Nebraska from 2010 to 2019 are shown in Figure 10.5. In the recent three-year period from 2018 to 2020, flood-related property losses reached a staggering \$623,043,000, which is 1.5 times higher than the total flood losses recorded in the previous ten-year period

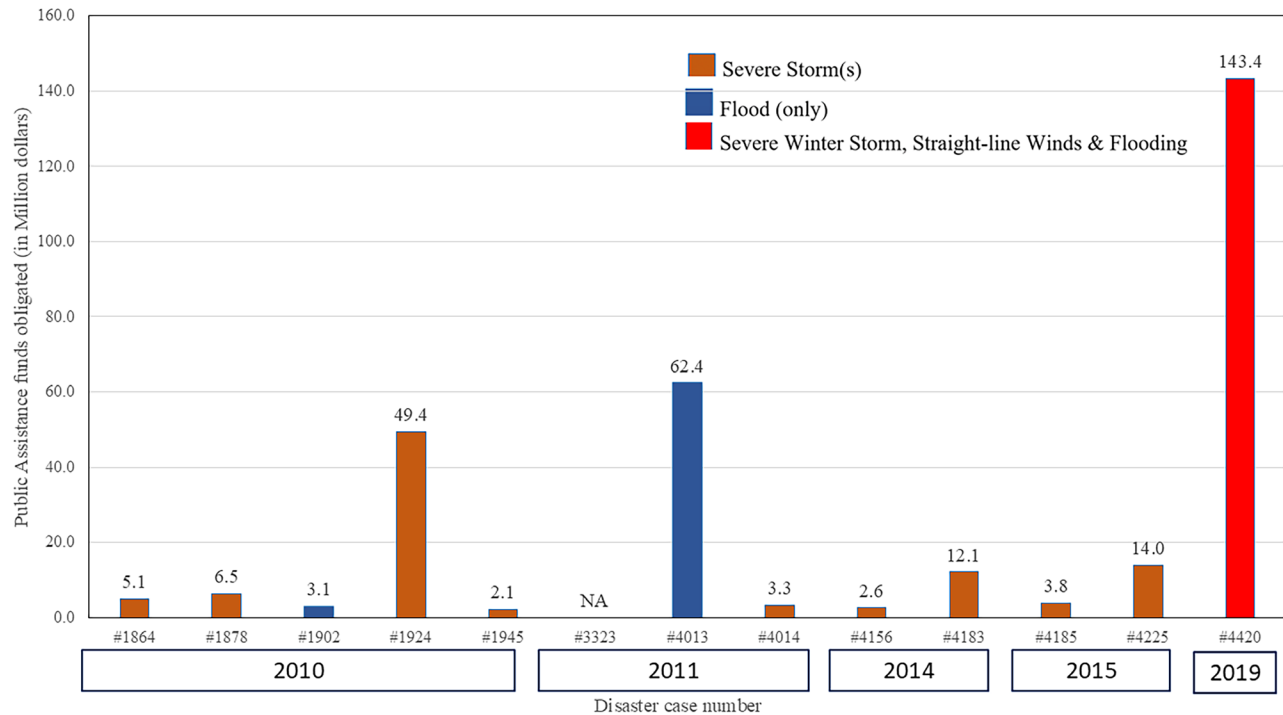


Figure 10.5. Public assistance funds obligated (in millions of dollars) related to floods in Nebraska from 2010 to 2019. (Source: NEMA, 2021) Nebraska from 2010 to 2019. (Source: NEMA, 2021)

from 1996 to 2017, totaling \$543,243,600 (NEMA, 2021). Hazardous weather and climate events during 2019 were particularly devastating, claiming the lives of five individuals and injuring seven others. Data on flood losses indicate a rising trend in the number of flood events affecting the state over recent years (2019 to 2023), along with an increased vulnerability of property and the agricultural economy (NEMA, 2021). The damage caused by these events in 2019 was substantial, with property losses exceeding \$640.5 million and crop damages amounting to \$27.7 million (NEMA, 2021; NeDNR, 2022). Altogether, the cumulative impact of these damages reached \$668.2 million, positioning Nebraska as the fourth highest-ranking state in terms of costs associated with such events in 2019 (NEMA, 2021; NeDNR, 2022). The estimated damage caused by the 2019 flooding exceeded \$1.3 billion, including infrastructure losses of \$449 million, crop losses of \$440 million, and cattle losses of \$400 million (NEMA, 2021; NeDNR, 2022; Schwartz, 2019; Wright & Brackett, 2019).

Deeper social impacts

Nebraska communities have not only faced economic losses from these extreme weather and climate events but have also endured profound social impacts. The aftermath of extreme events often involves the displacement of residents, leading to various social challenges (Table 10.1, community highlight 4).

During the historic flood in 2019, access to clean water and essential services was severely disrupted across the state. Many communities along the Missouri River, Platte River, and Elkhorn River faced mandatory or voluntary evacuations as floodwaters inundated their regions. The 2019 flood hit households hard, with 80% of the damage reported for owner-occupied units and 20% for renter-occupied units (State of Nebraska, 2021). Many residents lacked adequate insurance, with approximately 81.7% of homeowners lacking flood insurance and 23.3% lacking general home insurance (State of Nebraska, 2021). More than 95% of renters lacked flood or renter's insurance (98.2% and 97.4%, respectively). For households with

flood insurance, National Flood Insurance Program (NFIP) data indicates that 1,026 claims were paid out after the 2019 disaster, with \$5,994,846 in advance payments and \$39,673,497 in total payments as of July 29, 2019 (State of Nebraska, 2021).

Disadvantaged communities and underserved populations are disproportionately affected by floods and severe storms. Extreme weather and climate events cause property damage, displacement, and economic burdens, particularly for vulnerable populations (Chapter 9). A 2016 report by the Nebraska Department of Natural Resources finds that Hispanic residents are disproportionately likely to live in floodplains in Nebraska communities (Table 10.1, community highlight 5). In addition, over 10,000 residents living in Nebraska floodplains rent their homes. Renters are, on average, at lower income levels than homeowners, and very few (less than 0.04%) have flood insurance, leaving them vulnerable to devastating losses when floods occur (Paine, 2016). For example, one death was reported due to excessive cold on January 22–23, 2003, when a homeless man in the Omaha area suffered severe frostbite and passed away several days later (NCEI, 2024a; NEMA, 2021). In May 2024, floods washed out an unhoused encampment in Omaha, forcing individuals to seek higher ground to escape the danger. Individuals who are disabled, elderly, have mobility issues, have limited income, or reside in low-lying areas or floodplains are among the most susceptible to extreme weather and climatic events related to climate change (Hayden et al., 2023).

Impacts of extreme weather and climate events on the built environment

Nebraska's built environment is increasingly vulnerable to extreme weather and climate events, which can be amplified by climate change. These vulnerabilities directly impact the integrity and functionality of the state's infrastructure. Addressing these infrastructure vulnerabilities and enhancing their resilience to climate change is essential, as this will contribute to the state's stability, prosperity, and security. By identifying these risks and taking action, Nebraska can better protect its urban and agricultural

systems and lay the foundation for sustainable growth and prosperity in a changing climate.

Extreme weather and climate events, such as tornadoes and severe storms, subject structures to heightened wind forces, heavy rainfall, and floods (Al-Humaiqani & Al-Ghamdi, 2022). These conditions can lead to structural failures, roof damage, and the destruction of buildings. Additionally, extreme droughts can cause foundational shifts in buildings, bridges, and water lines (Robinson & Vahedifard, 2016). Roads and bridges are also at risk of erosion, landslides, and washouts caused by intense rainfall or flooding, compromising transportation and telecommunication networks and impeding connectivity within and between communities. The rising frequency and intensity of extreme weather events also contribute to higher maintenance costs for infrastructure (Venner & Zarnurs, 2012). Extreme temperatures, including heat waves and freezing conditions, accelerate material deterioration, resulting in cracks, corrosion, and a reduced lifespan for buildings, roads, bridges, equipment, and facilities.

For example, the historic 2012 drought caused significant damage to various infrastructures, including building foundations, private and municipal wells, water mains, and trails. As soils dried, they shifted and sank, damaging foundations. From May to July 2012, Omaha reported 178 water main breaks due to drought conditions (NEMA, 2021). The combination of extreme heat, drought, and increased water usage increased pressure on the city's water lines, causing some to crack. At least 81 municipal water systems in Nebraska experienced drought-related water supply issues during the 2012 drought (NEMA, 2021).

Water, energy supply, transportation, healthcare, telecommunication, and information services are essential components of Nebraska's critical infrastructure. These interconnected and interdependent systems are susceptible to disruptions caused by extreme weather and climate events. A significant example of this vulnerability is the devastating flood of 2019, which resulted in infrastructure losses estimated at \$449 million (NeDNR, 2022; Schwartz, 2019; Wright & Brackett, 2019). The severe impacts affected roads, bridges, levees, water and sewer systems, electrical infrastructure, and other properties (NeDNR, 2022). The 2012 drought and 2019 flood impacted the water supply

infrastructure of the city of Lincoln. These examples demonstrate how extreme weather and climate events have impacted Nebraska's built environment, notably its water, transportation, levee, and dam infrastructure.

The 2019 flooding caused severe damage to Nebraska's built environment and infrastructure, with cascading impacts across many sectors. The estimated cost to repair infrastructure is valued at over \$640 million and potentially higher (State of Nebraska, 2021). For example, several fire stations were damaged during Winter Storm Ulmer, which preceded the 2019 flood event. The most notable were the Fremont Rural Fire Station and the North Bend Fire District. North Bend reported spending \$30,000 on repairs, though estimated mitigation costs range from \$3 to \$4 million (State of Nebraska, 2021). Infrastructure remains vital as the backbone of community and commerce, connecting homes to businesses and their larger communities. Post-disaster recovery and mitigation may take years, affecting community economics.

Impacts on water, fire, and energy infrastructure

Extreme weather and climate disaster events can directly impact water and electricity infrastructure. Records from the past four decades indicate a trend toward increased frequency and intensity of rainfall events and extreme temperature days (Chapters 2 and 3), heightening water and energy infrastructure risks.

For example, flooding posed significant threats to two nuclear power plants along the Missouri River on June 20, 2011. Similarly, the March 2019 flood on the Niobrara River threatened the Cooper Nuclear Station downstream near Brownville, Nebraska (NEMA, 2021; NeDNR, 2022). Additionally, this flood directly affected drinking water infrastructure and resulted in power outages in and around the well fields of the water treatment plant near Ashland, Nebraska. The loss of water production capacity prompted the City of Lincoln to impose mandatory and voluntary water use restrictions.

Prolonged periods of lower precipitation also have significant implications for communities, leading to droughts and water scarcity and exacerbating various water-related issues. Droughts and water scarcity present formidable challenges, impacting agriculture, food production, access to clean water, sanitation, hygiene, and public health as well as amplifying social inequities. From June to August 2012, Nebraska experienced a record drought. The prolonged hot, dry weather and sporadic rainfall resulted in devastating consequences, including the Wellnitz Fire and property damage totaling \$215,050,000 across 86 counties (NEMA, 2021). Multiple studies have found that climate change has already led to an increase in wildfire season length, wildfire frequency, and amount of area burned (Chapter 2). The 2012 Nebraska wildfire season was the worst on record, and 2022 was the second worst in terms of acres lost to wildfire (*El Dorado News-Times*, 2023). Dry conditions both years contributed to devastating wildfires across Nebraska. Wildfires have severely impacted Nebraska's rural communities, stressing volunteer fire departments, causing injuries and deaths among volunteer firefighters, and resulting in millions of dollars in property damage yearly (Table 10.1, community highlight 6).

The 2023–2024 drought led to water shortages in reservoirs, streams, and wells, posing risks of water emergencies. On June 1, 2023, the city of Lincoln and Lancaster County experienced exceptional drought conditions for the first time since 2020, according to the U.S. Drought Monitor (NDMC, 2024), prompting authorities to suggest voluntary water conservation.

Moreover, heat waves, extreme cold events, and windstorms can disrupt energy infrastructure, including power grids and transmission lines, due to increased strain and potential damage. These disruptions can result in power outages, further exacerbating the challenges associated with meeting energy demands during extreme weather conditions (Table 10.1, community highlight 7).

Impacts on transportation infrastructure

Climate change can significantly impact transportation systems, affecting both the functionality of transportation networks and trade-related economic activities (Liban et al., 2023). Transportation routes, including roads, rail segments, bridges, trails, and bicycle lanes, are vulnerable to flood inundation and storm damage (e.g., washed-out roadways, downed power lines, or trees), hindering the movement of goods and people. Extreme weather events such as floods, blizzards, and severe thunderstorms can damage and render roads, bridges, and railways impassable. Increased rainfall can trigger erosion, further closing transportation routes, causing delays and limited accessibility. Repairing post-disaster transportation systems, such as roads, bridges, and local trails, incurs significant costs, posing a financial burden for many local communities in Nebraska during post-disaster recovery. The interruption of transportation networks can disrupt supply chains, resulting in delivery delays and increased costs. Industries reliant on efficient transportation, such as manufacturing, agriculture, and tourism, may experience reduced productivity and economic losses.

For example, the 2019 flood event caused significant damage to transportation infrastructure across Nebraska, with the damage currently estimated at \$429 million (State of Nebraska, 2021). This catastrophe affected local, state, and federal transportation networks, leading to the closure of 3,300 miles of state highways and 27 state highway bridges, roughly one-third of Nebraska's state highway system (State of Nebraska, 2021). Flooded roads and broken bridges prevented entry and exit, disrupting transportation, compromising critical emergency routes, isolating communities, and leading to travel delays. In particular, the Spencer Dam breakage destroyed three bridges, including the Highway 281 bridge over the Niobrara River (NeDNR, 2022). The damaged bridges forced drivers to take a detour of over 127 miles, significantly hampering emergency response and flood-recovery efforts in the region (NeDNR, 2022). Local bridges in the city of Fremont were also washed away, and floodwaters blocked critical emergency routes on land

(NeDNR, 2022). Local jurisdictions have struggled with extensive damage to streets and culverts, which are still in various stages of repair. Significant work remains for years to fully restore the state's transportation infrastructure (State of Nebraska, 2021).

Impacts on levee and dam infrastructure

Levee and dam infrastructure are at significant risk of damage or complete destruction, exacerbating the challenges faced during flooding incidents. In the spring and summer of 2011, heavy rainfall and high water levels caused levee breaches along the Missouri River chain of reservoirs. The United States Army Corps of Engineers (USACE) responded by investing over \$2 million in levee repairs in Omaha and nearly \$1 million in Sarpy County (NEMA, 2021; NeDNR, 2022). In May 2015, the city of Lincoln faced a critical situation as its levees approached capacity, leading to significant water pooling in some neighborhoods along Salt Creek.

In the 2019 flood event, over 350 miles of levees on the Missouri, Platte, and Elkhorn Rivers and tributaries experienced significant flood damage due to the more than 40 breaches that occurred (NEMA, 2021; NeDNR, 2022). Levees along the Platte and Missouri Rivers received the most damage as both river systems reached record heights. Damage to levee systems forced the evacuations of tens of thousands and necessitated the rescue of hundreds of individuals by air and boat.

Repairing the damaged levees requires substantial funding to ensure resilience against future floods. The devastating levee breaches in March 2019 severely damaged communities, leading to far-reaching social, infrastructure, and economic consequences (NEMA, 2021; NeDNR, 2022). In addition to the loss of lives and damaged infrastructure, flooding across vast agricultural lands severely impacted production and compounded the already substantial economic losses incurred during the 2019 event.

Challenges facing Nebraska's communities in climate change

This section highlights the existing challenges Nebraska's communities face in addressing climate change. To account for the differing capacities of urban and rural areas, we follow the classification criteria provided by the U.S. Census Bureau (USCB), which is based on housing units or population size. According to the 2022 USCB delineation criteria, based on the 2020 census, a "rural community" is defined as one with fewer than 2,000 housing units or fewer than 5,000 residents. Conversely, an "urban community" is defined as having at least 2,000 housing units or 5,000 residents (U.S. Census Bureau, 2024).

Challenges in Nebraska's urban communities

Urban communities in Nebraska are experiencing increasing population growth, and higher population density, which can worsen the impacts of climate change through extreme weather events like droughts, floods, severe storms, and wildfires. Urban areas, characterized by gradual population growth and land development, are prone to heightened vulnerabilities (Dodman et al., 2022). Increased flood frequency and magnitude (Figure 2.12) combined with population trends, land-use development plans, and employment opportunities means that the eastern third of Nebraska will continue to bear a disproportionate burden of flood impacts compared to other parts of the state (Abedin et al., 2024). These counties and communities also face greater exposure to potential economic losses due to the region's concentration of critical infrastructure and housing developments.

Dodge County in eastern Nebraska has been identified as having a higher percentage of changes in the exposure of developed areas within flood zones from 2001 to 2011 compared to the national average (Abedin et al., 2024). Similarly, Douglas, Sarpy, Lancaster, and other eastern Nebraska counties

face comparable challenges. When looking at the exposure for the most devastating floods—those with 100-year return periods, researchers (Tale et al., 2021) found that areas along the Platte, Missouri, and Elkhorn Rivers in the eastern third of the state, which contain the highest population concentrations, are especially vulnerable to extreme flood disasters.

With climate change, the frequency of heavy rainfall events is expected to increase (Chapter 4), raising the risk of flooding and potentially leading to repetitive losses as the occurrence and intensity of storms grow. The top 10 counties in Nebraska for flood insurance coverage from 1978 to 2020 were Douglas, Lancaster, Sarpy, Dodge, Cass, Saunders, Buffalo, Platte, Lincoln, and Dawson. The top 10 counties for flood insurance claims during the same period were Sarpy, Douglas, Dodge, Cass, Buffalo, Saunders, Madison, Washington, Lancaster, and Richardson.

Recent major floods, including the 2011 flood along the Missouri River and the 2019 floods along the Elkhorn and Platte Rivers, have altered river channels and floodplains, rendering existing floodplain maps inaccurate or underestimated. As a result, many communities in eastern Nebraska, such as Bellevue, Hooper, North Bend, Inglewood, King Lake, La Platte, La Vista, Valley, Venice, and Waterloo, lack adequate protection for future extreme flood events.

The increase in extreme events could result in insurers leaving the state—which has happened in California, Colorado, and Florida (Lin, 2023)—and would have cascading effects on Nebraska's economy. This includes the need to maintain infrastructure to remain eligible for federal funding and the growing recognition that wildfires are becoming more common in Nebraska.

Although the probability of an individual levee failing in a given year remains relatively low, the cumulative risk of multiple levees experiencing failure is considerable (NEMA, 2021). Large-scale events like the 2011 Missouri River flood and the 2019 flood across Nebraska have put immense strain on numerous levee systems, making simultaneous failures a possibility, which may affect urban communities. These counties will remain vulnerable to floods and related extreme weather and climate events under climate change scenarios (Chapter 4).

Challenges in Nebraska's rural communities

Rural Nebraska faces numerous challenges and obstacles in responding to climate change. These limitations stem from various factors that need to be addressed to enhance their institutional capabilities. By examining these challenges in detail and proposing potential solutions, rural communities can be empowered to tackle climate change effectively.

First, rural communities often face economic, social, and structural barriers. These include aging populations, declining numbers, and lower average incomes, which can limit their capacity to address climate change (Hu et al., 2018). Most of Nebraska is rural, and 73% of Nebraska counties lost population between 2010 and 2020 (Burkhart-Kriesel, 2022). Shrinking populations, coupled with tough economic times, have reduced the ability to take proactive actions against climate change and extreme weather and climate events. For example, the village of Winslow was completely inundated by flooding in March 2019. As a result, many residents expressed willingness to relocate the village to a higher and safer location, though some chose not to move out of the floodplain. Despite state and federal aid availability, the recovery process has taken much longer than expected. Five years later, in October 2024, the village remains in the recovery phase, leading to a loss of residents and the revenues needed to rebuild the community.

Aging infrastructure is another significant challenge, with many rural areas having outdated and deteriorating roads, bridges, water systems, and energy grids that are ill-prepared for the increasing impacts of climate change. Most dams that fail in Nebraska are small low-hazard potential dams located in rural areas (NeDNR, 2022). Many rural areas lack digital flood hazard maps or digital databases to help evaluate the potential impacts of these aging infrastructure systems on communities and agricultural lands. A lack of access to expertise and technical knowledge within rural communities poses another significant challenge, hampering their ability to implement sustainable practices and adopt climate-friendly strategies.

Limited financial and other resources also present

challenges for investing in climate change initiatives in rural areas (Hu et al., 2018). Rural communities and Tribes often lack the capacity to adapt to and mitigate harm from climate change, lacking “the staffing, resources, and expertise—to apply for funding, fulfill complex reporting requirements, and design, build, and maintain infrastructure projects over the long term” (Headwaters Economics, n.d.). The research highlighted in the Fifth National Climate Assessment states that Nebraska ranks among the 10 states where the greatest share of communities have a capacity lower than the national medium, making them less competitive for assistance (Knapp et al., 2023).

Additionally, the new Federal Flood Risk Management Standard (FFRMS) may result in higher compliance costs or reduced investments, as federal funding will now be subject to stricter standards (FEMA, 2024). Many communities in Nebraska depend on federal funding to support capital improvement projects (Fischer, 2024), many of which are in flood-prone areas, including the 1% and 0.2% annual chance flood zones – also known as the 100-year and 500-year floodplains. These communities will face increased financial challenges in meeting the new standards and requirements.

Physical isolation is yet another obstacle, with geographical remoteness resulting in limited access to resources, services, and infrastructure, hindering the adoption of climate-friendly practices and technologies (Cain, 2021). Reports indicate that the remoteness of rural Nebraska communities increases their vulnerability to extreme weather and climate events. The 2020 Nebraska Rural Poll (Vogt et al., 2021) reported that over half of rural Nebraskans say their community was harmed at least moderately by extreme weather events in 2019. They reported longer distances to stores, damage to homes, and increased levels of anxiety and stress. The smallest Nebraska communities appear to be experiencing the most harm, with more than 45% of these residents reporting having to drive extra miles for shopping because of the extreme weather events in 2019. Driving extra miles for work, school, shopping, or health care is particularly difficult for rural Nebraska residents living in geographically remote regions (over a 60-minute drive) from grocery stores, gas stations, and essential health care services. According to the USDA Economic Research Service,

over 95,000 Nebraska residents were geographically remote from essential services in 2010 (USDA ERS, 2024b). Moreover, rural communities often lack economic diversity, relying heavily on a single industry, primarily agriculture, making them vulnerable to climate change impacts such as extreme drought or floods.

Opportunities and policy recommendations to improve climate resilience in Nebraska's communities and built environments

Communities can take a comprehensive approach to reducing the risks associated with climate change by adopting a combination of mitigation and adaptation strategies. Integrating measures such as land-use planning and regulations, infrastructure upgrades, preservation of natural systems, and promoting education, awareness, engagement, and collaborations will contribute to building resilience and adapting to the challenges posed by weather and climate extreme events (Berke et al., 2009; Fu & Tang, 2013; Hu et al., 2018).

Several Nebraska communities have taken proactive measures to address climate change (Hu et al., 2018). The City of Lincoln has laid a solid foundation for building a more resilient city by releasing its first environmental plan, the *Lincoln Environmental Action Plan (LEAP)*, in 2017. Building upon this, the City of Lincoln developed the *2021–2027 Climate Action Plan* in 2021, which identified 12 key areas where the city faces risks from the intersection of climate impacts with existing social and infrastructure vulnerabilities (City of Lincoln, 2021). Similarly, the Omaha City Council released a draft climate action plan that addresses

climate change in 2024 and recommends solutions to mitigate climate risks in the Omaha area (City of Omaha, 2024). These plans demonstrate Lincoln's and Omaha's commitment to addressing climate change and finding practical solutions. The City of Beatrice has also implemented a buyout and relocation program to move property owners out of flood-prone areas. The City of Fremont and Dodge County have made significant non-structural mitigation efforts in the areas most at-risk for floods since the 2019 event. This proactive approach helps protect the most vulnerable residents and businesses from the impacts of flooding and promotes long-term resilience. Overall, these examples highlight the progress being made in Nebraska to enhance climate resilience and safeguard communities and their built environments. By prioritizing these efforts and seeking innovative solutions, Nebraska can better adapt to climate change and protect its residents from future weather and climate challenges.

Limited resources and capabilities mean that rural communities typically cannot develop their climate action plans. However, they can actively participate in regional planning efforts that seek regional solutions (Table 10.1, community highlight 8). Rural communities, particularly small and isolated ones, are highly encouraged to engage in regional hazard mitigation planning organized by each natural resources district. Doing so makes them eligible for potential disaster funds to combat climate-induced extreme hazards. Regional hazard mitigation planning involves identifying major weather and climate events, evaluating their impacts, and prioritizing key mitigation measures. In addition, rural communities are encouraged to collaborate with regional economic development districts to seek external funding opportunities. This collaboration can enhance economic capabilities and help address future climate risks. Furthermore, rural communities are also encouraged to partner with the University of Nebraska system to help identify key local challenges and practical solutions. The university can provide expertise in rural development and climate actions, further supporting rural communities' resilience efforts. By actively participating in regional planning, collaborating with economic development districts, and engaging with the university system, rural communities can access resources, funding, and expertise to enhance their resilience and

effectively address weather and climate challenges.

Climate-informed land-use planning and design

Climate-informed land-use planning and design are essential for building climate resilience in Nebraska communities, particularly in eastern Nebraska, where land development is more prevalent. By integrating climate projections and data into planning processes, communities can identify vulnerable areas and develop mitigation strategies. This includes considering the impacts of extreme weather and climate events when designing land-use scenarios, implementing zoning regulations, and establishing building codes (Hu et al., 2018; Tang et al., 2010). Climate-informed planning promotes the development of resilient and adaptive communities better equipped to withstand and recover from climate impacts. For instance, effective land-use planning and regulations can discourage new construction in flood-prone areas and require that existing structures meet resilience standards.

Infrastructure upgrade and retrofitting

Infrastructure upgrades and retrofitting are effective approaches for enhancing climate resilience (Sandink & Binns, 2021). By assessing the vulnerabilities of existing infrastructure, communities can identify areas that require improvements or modifications to withstand the impacts of climate change. This may involve retrofitting buildings to enhance their structural integrity against strong winds, flooding, wildfire, or heat stress.

Preserving natural systems

Preserving natural ecosystems is an ecological approach to reducing the impacts of extreme climate events on communities and the built environment (Brody & Highfield, 2013). These strategies focus on minimizing damage and preserving the functionality of natural systems to mitigate climate-induced flood risks. Activities such as wetland restoration, protection and enhancement of natural floodplains, and adopting sustainable stormwater management practices are key to achieving this. Preserving and restoring natural systems can mitigate flood risks and provide additional

benefits, including improved water quality and enhanced biodiversity (Table 10.1, community highlight 9).

Education, engagement, and collaborations

Education, engagement, and collaboration are crucial to addressing climate risks (Hu et al., 2018; Z. Tang et al., 2010; Woodruff & Stults, 2016). Increasing knowledge and awareness among stakeholders and the public is essential for driving concrete actions. By promoting public awareness and understanding of climate change's impacts, communities can encourage sustainable practices, informed decision-making, and active participation in resilience efforts. Collaborative decision-making processes ensure that adaptation measures are context-specific, culturally sensitive, and inclusive, enhancing their effectiveness and sustainability. Engaging community members, stakeholders, and local organizations in planning and implementation ensures that adaptation initiatives reflect the needs and priorities of the community. This participatory approach empowers individuals, fosters ownership, and garners support for adaptation initiatives. Partnerships and cooperation leverage collective wisdom and resources for effective climate adaptation strategies. Collaborating with stakeholders such as elected officials, planners, engineers, and community members is vital for successful implementation. For example, the Invitational Drought Tournament exercises organized by the National Drought Mitigation Center have proven to be an effective platform for engaging stakeholders in conflict resolution during extreme events (Hill et al., 2014; Wilhite et al., 2014). Implementing these policies requires a multi-stakeholder approach involving government agencies, urban planners, architects, developers, community organizations, and residents (Table 10.1, community highlight 10).

Conclusions

In the past decade, Nebraska has seen a rise in extreme weather and climate events. These have become more frequent, lasted longer, and affected more areas. As a result, these events increased costs and deeply impacted Nebraska's communities and infrastructure.

This chapter shows that climate change presents serious challenges for Nebraska’s communities and infrastructure. The escalating frequency and intensity of extreme weather and climate disaster events, combined with infrastructure vulnerabilities and shifts in precipitation patterns, make it necessary to take proactive measures to lessen these impacts. Reducing risks, protecting lives and property, and building resilient communities requires action. This can be achieved by incorporating climate-informed land-use planning and design, upgrading infrastructure systems, promoting public awareness, engaging

the community, coordinating stakeholders, and finding regional solutions. These steps will help Nebraska communities adapt and thrive in the face of climate change. Addressing the impacts of climate change on communities and the built environment requires comprehensive approaches that include adapting, building resilience, and reducing risks. By taking proactive measures, involving community members, making policy changes, and encouraging collective action, Nebraska can lower risks, protect lives and property, and promote sustainable development in the face of a changing climate.

TABLE 10.1. COMMUNITY HIGHLIGHTS.

Community Highlight 1: Drought impacts in McCook

Agricultural losses during extreme drought have ripple effects throughout local communities. The community of McCook, like many other rural Nebraska communities, experienced agricultural losses during the 2012–2013 drought event that rippled throughout local and regional economies. Multiplying the impact, McCook also faced losses to its recreational sector as both reservoir levels and pheasant populations fell due to drought. Because of dust storms, transportation was also hazardous at times (Jedd et al., 2018).

Community Highlight 2: Flooding in Rulo, Brownville, and Nebraska City

Southeast Nebraska communities experienced an extraordinary stretch of consecutive days above the flood stage in 2019. The village of Rulo endured an unprecedented 272 days above flood stage. The village of Brownville endured 271 days above the flood stage, while the city of Nebraska City experienced 270 days of flooding (NeDNR, 2022).

Community Highlight 3: Tornadoes in Lincoln, Elkhorn, Bennington, and Blair

From April 26 to 28, 2024, multiple severe tornado outbreaks caused extensive damage to eastern Nebraska’s homes, businesses, vehicles, agriculture, and infrastructure (NOAA NCEI, 2024c). Lincoln narrowly missed a direct hit as a large tornado touched down outside the city. A local manufacturing facility on the edge of Lincoln was destroyed, and the company’s employees were laid off as a result. The same storm system produced a mile-wide tornado that inflicted heavy damage on Elkhorn, Bennington, and Blair near Omaha (NOAA NCEI, 2024c). Additionally, an EF-3 tornado struck Eppley Airfield near downtown Omaha, destroying several hangars and airplanes (NOAA NCEI, 2024c).

Community Highlight 4: Flood impacts in Norfolk, Fremont, and Winslow

The 2019 flood compelled the city of Norfolk to evacuate a third of its residents, and the city of Fremont became completely isolated, relying on National Guard military convoys to provide essential supplies for several days (NeDNR, 2022). Over 1,500 homes and buildings were affected in Fremont alone, with more than 247 being unsafe for occupation due to extensive damages (NeDNR, 2022). The nearby village of Winslow remained submerged for multiple days, and the road to recovery for these communities is expected to span several years.

TABLE 10.1. COMMUNITY HIGHLIGHTS.

Community Highlight 5: Compounding flood and COVID impacts in Schuyler

The March 2019 flood impacted 79 properties in Schuyler, Nebraska, where over 70% of properties are at risk of flooding and over 65% of floodplain residents identify as Hispanic (Paine 2016; First Street, n.d.). While recovering from flood impacts, the community was further economically impacted by the COVID-19 pandemic when meatpacking workers were sickened and the Cargill meatpacking plant temporarily closed (Stella, 2020).

Community Highlight 6: Wildfire impacts in Elwood, Cambridge, and Purdum

The communities of Elwood, Cambridge, and Purdum all experienced deaths of volunteer firefighters in 2022, and several others were injured or faced lifelong health repercussions (*El Dorado News-Times*, 2023). These communities are among the 449 of 478 fire departments in the state that depend upon unpaid volunteer firefighters. Many rural fire departments in Nebraska are “small and underfunded” (NFS, 2023, p. 5). Recruiting and retaining volunteers is one of the top challenges facing volunteer fire departments, even as they anticipate increased future risk of fires and EMS calls caused by extreme weather, including wind and drought, according to a 2023 survey conducted by Nebraska Public Media News (Kelly & Wheaton, 2023).

Community Highlight 7: Wind impacts in Omaha Metro Area

On July 9, 2021, three storms with 96 mph winds, equivalent to a Category 2 hurricane, caused significant damage to the Omaha Public Power District (OPPD), leading to widespread outages. The complex restoration process took nearly seven days to complete (American Public Power Association, 2021). A windstorm on July 31, 2024, with winds up to 100 miles per hour, resulted in the largest outage event in the Omaha Public Power District’s recorded history. The extreme winds caused widespread tree damage and power outages throughout the Omaha metro area, particularly in Douglas and Sarpy Counties. OPPD reported that nearly 220,000 customers lost power that evening, more than half of the utility’s 412,000 customers (American Public Power Association, 2024).

Community Highlight 8: Building Niobrara’s community climate resilience

The village of Niobrara is collaborating with the University of Nebraska on a project to increase the community’s resilience to climate extremes. Among planning and mitigation efforts, local college student interns are surveying the community to map the assets that might be used in future emergencies, getting grants for tree planting, and gathering digital images that will help the community apply for financial assistance in the future.

Community Highlight 9: Santee Sioux Nation’s climate resilience partnership

In the aftermath of the March 2019 flood, the Nebraska Indian Community College and Santee Sioux Nation Office of Environmental Protection have begun leading efforts to undertake environmental projects that would improve the community’s future climate resilience, like restoring native prairies, monitoring the environment (water and air quality, wildlife) and installing a weather station to improve their monitoring capabilities (Reiner, 2023).

Community Highlight 10: North Platte NRD community drought plan

In 2016, the North Platte Natural Resources District (comprising Sioux, Scottsbluff, Banner, Morrill, and Garden Counties) collaborated with the National Drought Mitigation Center (NDMC) to engage local government, agriculture, education, media, and industry stakeholders in discussing challenges and opportunities for the region during drought (NDMC, 2016) and shaping a community drought plan, finalized in 2018 (North Platte NRD, 2018).