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

2024 Climate Change Impact Assessment Report

Supplemental Report: Adaptation, Risks, and Impacts

Photo courtesy: Grace Carey, Platte Basin Timelapse.

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Introduction

By leveraging existing resources and opportunities, Nebraskans can anticipate, plan for, and adapt to a changing climate. Climate impacts will vary across different parts of Nebraska, with local communities having various levels of awareness and understanding of the risks and vulnerabilities they face.

If greenhouse gas emissions keep rising at the current pace, Nebraska's average annual temperature could increase by 5–6°F in the next 25 years (relative to 1950–2014), and by up to 11.5°F by the end of the century (Chapter 4). With this level of warming, temperatures would exceed the hottest annual average temperatures – those of the Dust Bowl era. In Nebraska, warmer temperatures manifest as more frequent and severe heat waves, intense rainfall, and drought—all of which affect communities, ecosystems, and the state's economy.

The choices society makes today will shape Nebraska's climate future. Without meaningful mitigation, extreme weather and its harmful climate impacts will intensify, resulting in greater damage and higher economic costs for the state (USGCRP, 2023).

Recognizing this, the Nebraska Department of Environment and Energy (NDEE) has taken important steps (NDEE, 2024b):

- In 2023, NDEE received a $3 million EPA planning grant to develop Nebraska's first statewide climate action plan. This process involved consultation with stakeholders across the state and resulted in a Priority Climate Action Plan identifying high-impact strategies to reduce emissions through voluntary actions and financial incentives.
- In 2024, NDEE secured a $307 million EPA implementation grant—the largest federal grant in its history—to implement these mitigation actions over the next five years.[1]

This supplemental report builds on those efforts, as well as those undertaken by agencies, organizations, and communities across the state. With limited time (1 year) and resources ($150,000), this supplemental report is designed to support concerned decision-makers and community members across Nebraska as they navigate climate impacts and the risks they are facing. It:

- Provides a menu of recommended strategies and example actions to reduce vulnerabilities and build resilience.
- Aligns with the climate risks identified in the focus topics (Chapters 5–12)
- Draws from paleBLUEdot's extensive analysis of climate resilience actions, trends, and best practices from
- Provides a menu of strategies and example actions are provided to reduce vulnerabilities and build resilience, based on the report's findings, Nebraska's climate risks (Chapters 5–12), and paleBLUEdot's national review of 77 climate vulnerability assessments and adaptation plans (Appendix C).
- Integrates Nebraska-specific guidance documents and research, reviewed by EOR, to ensure recommendations are relevant to local conditions.

Guide to this supplemental report

This supplemental report consists of the following components for each focus topic in chapters 5 through 12.

Part 1: Options and Opportunities

Key messages related to each focus topic are repeated for quick reference.

Adaptation and resilience options and opportunities

This section provides recommendations for strategies

[1] *The current status of this grant can be found at NDEE's ONE RED website: https://dee.nebraska.gov/aid/one-red-opportunity-nebraska-reducing-emissions-decarbonization/one-red-implementation-grant.*

and examples of detailed actions that can be implemented to address the climate vulnerabilities and risks outlined in the Focus Topics (chapters 5–12). These recommendations intend to provide initial guidance to this broad audience of decision-makers seeking ideas on increasing Nebraska's resilience. Ideally, these preliminary recommendations, in conjunction with the findings of scientific assessment, should be used as a foundation for creating state- and community-specific climate action and resilience plans.

Example actions that support each strategy recommendation are based on the findings found in each of the Focus Topics (Chapters 5–12) and through an extensive national audit of climate and resilience actions, trends, and best practices. The audit effort included the following:

- paleBLUEdot staff reviewed all available state climate vulnerability assessments and adaptation plans. The team surveyed all 50 states and the District of Columbia for relevant plans. In total, 77 plans were identified and reviewed for relevant examples of resilience actions across sectors that aligned with the Focus Topics included in Nebraska's 2024 Climate Change Impact Assessment Report.
- EOR staff reviewed a range of climate and climate-related guidance documents developed for communities in Nebraska. These documents included various plans and reports that address how climate change might impact different areas of the state and what actions can be taken to adapt to these changes.

A complete list of the plans and documents reviewed can be found in Appendix C.

Actions are organized by those that could be implemented by state leadership and agencies; those that could be implemented by tribal, local governments, or public power districts; those that the agricultural community could implement; and those that businesses, households, and individuals. Note: not every level of decision-making is available for every focus topic.

A searchable database of these options will be available on the Nebraska State Climate Office website at https://nsco.unl.edu.

Part 2: Risk assessment and impact summaries

Climate hazard risk assessment

These charts highlight the overall comparative risk of each climate hazard by Focus Topic, supporting effective resilience planning and implementation within limited funding and resources constraints. Climate change affects everyone, making it essential to prioritize risks without overlooking any hazard or population, regardless of their vulnerability status. While identifying overall risk levels helps with comparative prioritization, all risks must be evaluated and monitored. Risks classified as low or moderate at the state level may still pose high or very high risks to specific regions or communities within Nebraska.

Climate risks are ranked by confidence (Box 1.3) in future change (Chapter 4) and impact (Chapters 5 - 12). Overall hazard risks are estimated by multiplying confidence in future change by impact level and timeframe using the values described below.

Confidence in future change:
Low = 1; Medium = 2;
Medium-High = 2.5; High = 3; Very High = 4

Impact Level:
Low = 1; Moderate = 2; High = 3

Timeframe:
Long-term = 1; Medium-term = 2;
Short-term = 3; Current = 4

Comparative risk levels are determined based on the total scores as follows: Very Low < 4; Low < 8; Moderate < 17; High < 26; Very High ≥27

Climate impacts summary

These charts summarize the potential impacts identified or anticipated in each Focus Topic's vulnerability assessment chapter (Chapters 5–12). The impacts are organized by the climate hazards most relevant to that Focus Topic and were developed by paleBLUEdot LLC and EOR, in consultation with the report's climatologists and each Focus Topic's chapter author.

Part 1: Options and opportunities

Water

Key messages

1. Changes in precipitation impacting water availability intersect multiple issues, including energy, health, agriculture, and more.
2. Nebraska's residents and agriculture sector rely heavily on the state's groundwater resources for irrigation and drinking water.
3. If appropriately managed, groundwater will continue to be Nebraska's best resource for resiliency against future climate change.
4. Climate change will have complex impacts on Nebraska's water, likely affecting both groundwater and surface water quantity and quality. These impacts will ripple throughout Nebraska's economy, communities, and environment.
5. With climate change, irrigation water demand will likely increase as the growing season becomes longer and the rate of evapotranspiration increases.
6. At the state level, the trends in groundwater-level changes tend to follow the trends in precipitation.
7. Drought impacts on Nebraska's groundwater and surface water may be more severe as the climate warms.

Adaptation and resilience options and opportunities

Strategy W1: Protect and restore water resource ecosystem functions and values.

Protection of existing water resources provides a proactive, cost-effective way to maintain ecosystem functions and values, including groundwater recharge, filtration, and flood storage capacity. In particular, wetlands protection is integral to this process, given the challenges of locating suitable sites for replacement wetlands that replicate their functions and values. Restoration of functions and values of degraded water resources offers the opportunity to restore groundwater recharge, filtration, and flood storage capacity while also realizing co-benefits such as habitat creation.

Example state actions

- W1-1: Review and update Natural Resource District rules to align with best practices for water resource protection from other states.
- W1-2: Ensure no net loss of wetland area.

- W1-3: Increase grant opportunities for climate change adaptation projects and prioritize the funding of projects that incorporate climate change impacts in project design and implementation.
- W1-4: Develop an assistance program to help property owners put lands into conservation easements to retain ecosystem services.
- W1-5: Provide funding and technical assistance for green infrastructure, best management practices, and nature-based adaptation.

Example local government and public power actions

- W1-6: Protect and restore lake, river, stream, and wetland buffers.
- W1-7: Protect and restore deep pools in streams for cool water aquatic life (refugia).
- W1-8: Expand water conservation education and outreach programs and materials to address audience-specific interests related to topics such as water conservation, water quality, and recreation.
- W1-9: Improve water management to sustain aquatic ecosystems.
- W1-10: Fund and enhance stream and lake quantity and quality monitoring.

Example agricultural community actions

- W1-11: Implement sustainable farming practices such as those described in Table SR 8 to improve water quality and preserve water quantity.

Example business, household, and individual actions

- W1-12: Plant native landscape species that require less irrigation (i.e. turf conversion).
- W1-13: Direct downspouts to rain gardens and/or vegetated areas so stormwater runoff is intercepted and allowed to infiltrate into the groundwater system.
- W1-14: Incorporate local knowledge into local conservation and restoration efforts.

Strategy W2: Adaptively manage groundwater

Nebraska relies heavily on its groundwater resources for agricultural irrigation and drinking water. To date, steps, including local regulation and restrictions on high-capacity wells, are helping to slow decreasing groundwater levels. Despite current human intervention to move toward a more sustainable groundwater balance, changes in high and low precipitation years will complicate efforts to reach this balance. Efforts will be required to continue conserving water, especially in dry years, and aid in the recharge of groundwater in wet years.

Example state actions

- W2-1: Work with water compact members to develop strategic pathways for future water allocations.
- W2-2: Develop a statewide strategy for groundwater recharge.

Example local government and public power actions

- W2-3: NRDs adaptively manage water pumping regulations.
- W2-4: Continue groundwater monitoring.
- W2-5: Proactively adjust water supply management practices and programs to account for climate change impacts to both water supply availability and source water quality.
- W2-6: Promote nature-based solutions, such as restoring riparian habitats and wetlands, to enhance groundwater recharge and improve water quality.
- W2-7: Expand water conservation education and outreach programs and materials to address audience specific interests related to topics such as water conservation, water quality, and recreation.
- W2-8: Adopt a citywide policy promoting water recycling for non-potable uses.

Example agricultural community actions

- W2-9: Implement sustainable farming practices such as those described in Chapter 8 Strategy #1 to improve water quality and preserve water quantity.
- W2-10: Reduce excess nutrients in groundwater.
- W2-11: Enhance groundwater recharge and storage by storing excess water during wet periods.
- W2-12: Implement water conservation measures and improve irrigation efficiency in agriculture.

Example business, household, and individual actions

- W2-13: Conserve potable (drinking) water.
- W2-14: Consider installing rain barrels and watering gardens with rainwater.

Strategy W3: Prepare for increased occurrences of flood and drought conditions

Major flooding and drought events represent the extreme highs and lows of water that pose threats to property, economic activity, human health and well-being, infrastructure, recreation, and more. As natural processes are exacerbated by climate change, proactive efforts to adapt to these changing processes will be critical to reducing the state's vulnerability and helping to manage resources needed in response to major events.

Example state actions

- W3-1: Help regions improve preparation for drought.
- W3-2: Prioritize investment in dam and levee repairs based on their potential hazard.
- W3-3: Update floodplain mapping to account for projected increases in major flood events.

Example local government and public power actions

- W3-4: Protect and restore water resources with the potential for high functions and values related to flood and drought mitigation.
- W3-5: Promote water storage and management to hold and distribute water following large precipitation events.
- W3-6: Develop hydrologic and hydraulic models for larger communities to conduct flood risk/vulnerability assessments using projected rainfall conditions (i.e., redefine riverine flood hazard zones to match the projected expansion of flooding frequency and extent).
- W3-7: Improve public education about the risks of developing in sensitive areas.
- W3-8: Apply green infrastructure strategies and adopt green and complete street design standards.
- W3-9: Maintain and restore wetlands.
- W3-10: Require new development or redevelopment to capture and infiltrate the first 1 or 1.5 inches of rain.
- W3-11: Restrict development in areas buffering water bodies or wetlands
- W3-12: Acquire properties at risk of flooding, use the land for infiltration, and help the property owners resettle in the community.

Example agricultural community actions

- W3-13: Improve the absorptive capacity of farmland through the encouragement and cost-sharing of agricultural best management practices.

Example business, household, and individual actions

- W3-14: Improve the absorptive capacity of farmland through the encouragement and cost-sharing of agricultural best management practices.
- W3-15: Convert turf to native, drought-tolerant native species.

Energy

Key messages

1. Energy-related emissions (fossil fuel burning for electricity, transportation, heat, steam, and fertilizer production) are Nebraska's leading cause of greenhouse gas emissions.
2. Nebraskans consume energy directly (fuel and energy purchases) and indirectly (in products and services).
3. Reducing emissions can have a positive financial impact (reduced energy and fertilizer costs).
4. Nebraskans will need to consider where the most significant impacts from energy efficiency and fuel switching can be made at all levels. This includes residential (heating and cooling), commercial (heating and cooling), transportation (vehicles), business-level policy, local policy, state-level policy, and national policy.
5. Emissions reduction goals should be compatible with reliability goals.

Adaptation and resilience options and opportunities

Strategy E1: Accelerate decarbonization of Nebraska's energy systems.

Decarbonizing Nebraska's energy systems is crucial for reducing greenhouse gas emissions and mitigating climate change. Nebraska's energy consumption significantly impacts climate change primarily through burning fossil fuels, accounting for 69% of the state's total energy use. These emissions contribute to global warming and climate change. Additionally, burning fossil fuels releases air pollutants, including particulates, volatile organic compounds, and nitrogen oxides, which further degrade environmental quality. Transitioning to cleaner energy sources like wind, solar, and biofuels can lower emissions, improve air quality, and enhance public health. Additionally, decarbonization can lead to economic benefits by adopting more efficient technologies and creating new jobs in the renewable energy sector. Preparing for climate risks and extreme weather events is also essential to ensure the reliability and resilience of Nebraska's energy infrastructure.

Example state actions

- E1-1: Establish a State of Nebraska Electricity Renewable Energy Standard to support and align with existing public utility 100% clean energy goals.
- E1-2: Increase state electricity procurement to 100% renewable by 2040.
- E1-3: Adopt solar-ready and renewable-energy generation building code requirements.
- E1-4: Investigate options for establishing a Renewable Fuels Standard (RFS) for heating fuels.
- E1-5: Study the feasibility of encouraging greater utility-scale renewable energy development by reducing property taxes on new renewable energy in Nebraska.
- E1-6: Include non-energy benefits of low- and zero-emission energy generation in cost assessment requirements of public utility Integrated Resource Planning (IRP) and State of Nebraska capital planning.

- E1-7: Finance programs, incentives, policies, and research for increased capture of the significant opportunity in Nebraska for renewable energy adoption.

Example local government and public power actions

- E1-8: Update zoning codes to identify and address alternative energy systems and their use on private property.
- E1-9: Coordinate and promote separate residential and commercial Solar Group Purchase and Electrification Group Purchase campaigns to reduce the cost of solar PV, solar thermal, and heat pump adoption through volume purchasing power and district-level planning.
- E1-10: Identify and deploy the next generation of electric grid technologies (https://www.energy.gov/sites/default/files/2022-05/Next%20Generation%20Grid%20Technologies%20Report%20051222.pdf).
- E1-11: Include non-energy benefits of low- and zero-emission energy generation in cost assessment of public utility Integrated Resource Planning (IRP).
- E1-12: Explore the creation of green hydrogen or an energy efficiency utility.

Example business, household, and individual actions

- E1-13: Install solar photovoltaic (PV) or solar thermal panels at your home or business and receive a 30% federal tax credit.
- E1-14: If you don't own your home (or if your home is not suitable for solar), support solar development by subscribing to community solar or purchasing renewable energy through your utility.
- E1-15: Replace your business's or home's heating and cooling system and appliances like ranges, water heaters, and clothes dryers with energy-efficient electric options like heat pumps.

Strategy E2: Accelerate energy efficiency improvements to buildings and industrial uses and processes.

Increasing the energy efficiency of Nebraska's energy systems is vital for adapting to climate change. Energy efficiency can improve the resilience of Nebraska's energy systems during climate impacts like heat waves or extreme weather events through reduced energy demand, enhanced reliability, cost savings for reinvestment, and flexibility. Increased energy efficiency also lowers reliance on fossil fuels, reducing greenhouse gas emissions, and improving air quality. Additionally, energy efficiency can lead to cost savings for consumers and businesses, making the energy system more resilient and sustainable. Efficient energy use also supports the integration of renewable energy sources, further reducing environmental impact and enhancing the reliability of the energy infrastructure in the face of extreme weather events and other climate-related challenges.

Example state actions

- E2-1: Adopt and maintain state building codes to within one cycle of current best practices for energy efficiency.
- E2-2: Establish an Energy Efficiency Resource Standard establishing annual energy efficiency savings program goals for utilities.

- E2-3: Support the State of Nebraska agency and publicly funded projects that address deferred maintenance, energy efficiency, and alternative energy with the greatest potential for emissions reductions in the immediate future.
- E2-4: Include non-energy energy efficiency benefits in public utility Integrated Resource Planning (IRP) cost assessment requirements and State of Nebraska capital planning.
- E2-5: Expand energy efficiency programs for residential and commercial buildings.
- E2-6: Explore the development of a Nebraska Energy Saving Mortgage to provide a tiered incentive encouraging the purchase and construction of highly efficient homes. Example, State of Colorado.
- E2-7: Establish State of Nebraska Appliance Standards that set energy efficiency targets for appliances.

Example local government and public power actions

- E2-8: Adopt and maintain building codes to within one cycle of current best practices for energy efficiency.
- E2-9: Require projects receiving city financial incentives or support to be built to meet or exceed an electricity and heating renewable energy standard.
- E2-10: Develop and expand meter-based incentive programs targeted at energy efficiency.
- E2-11: Establish an energy reporting program, or Energy Benchmarking, for homes and commercial buildings, including existing private buildings, existing public buildings, and new construction.
- E2-12: Promote energy conservation and efficiency through outreach, communication, and community and public engagement.
- E2-13: Advance the deployment of energy storage projects. Example, business, household, and individual actions.
- E2-14: Conduct an energy audit on your business or home to identify energy efficiency and cost-saving improvements.
- E2-15: Implement ongoing energy efficiency changes, such as using smart thermostats, adjusting your thermostat temperature to slightly warmer in the summer and cooler in the winter, using ENERGY STAR–certified appliances, and adopting other energy efficiency strategies recommended by your utility.

Strategy E3: Strengthen the energy sector's ability to handle climate-related disruptions, adapt to supply changes, and meet rising energy demand.

Strengthening Nebraska's energy sector to handle climate-related disruptions, adapt to supply changes, and meet rising energy demand will enhance the state's resilience. Preparedness for extreme weather and investing in resilient infrastructure improvements can minimize the impact of events such as heat waves, droughts, and floods. Diversifying energy sources, increasing flexibility in energy generation, and increasing energy storage ensure reliability amid supply changes, such as the retirement of coal and nuclear plants and the rise of natural gas, wind, and solar. Combined with energy efficiency improvements, these efforts can collectively build a robust energy system that can withstand disruptions, adapt to evolving conditions, and meet future needs.

Example state actions

- E3-1: Collaborate with Nebraska Public Utilities to identify, pilot, and implement a variety of energy efficiency, load management, and distribution system operation methods to reduce peak demand.
- E3-2: Collaborate with Nebraska Public Utilities to identify, pilot, and implement a variety of backup power supplies, intelligent controls, smart analytics, microgrids, and distributed generation to better respond to disruptions.
- E3-3: Create an Energy Storage Standard establishing energy storage capacity deployment or procurement goals for utilities.
- E3-4: Include benefits of energy storage such as peak demand reduction, frequency regulation, energy arbitrage, increased resilience, reduced land use, and jobs creation in cost assessment requirements of public utility Integrated Resource Planning (IRP) and State of Nebraska capital planning.
- E3-5: Support a wide variety of energy storage ownership, application, and business models through incentives and programs.

Example local government and public power actions

- E3-6: Ensure that new or substantially modified jurisdictional electric transmission facilities are designed, built, and operated for resiliency regarding heavy precipitation and flooding, extreme temperature events, severe weather events, wildfires, and physical/cyber security threats.
- E3-7: Develop energy storage programs for all customer types to reduce peak demand, support electric grid reliability, and improve the effectiveness of solar and other renewable energy options.
- E3-8: Ensure equitable implementation of grid resilience actions by partnering with high-risk neighborhoods and non-governmental organizations to develop resilience hubs—community facilities that offer power and other services during times of need.
- E3-9: Expand district heating, cooling, and microgrids through district-level planning and a potential requirement for new large buildings to study the costs and benefits of connection.
- E3-10: Conducted a community-wide grid capacity, resilience, and conditions assessment, including recommendations identifying renewable energy capacities and potentials, including renewable energy backup.
- E3-11: Identify and prioritize solar, energy storage, and microgrid backup power projects at mission-critical community facilities.

Ecosystems

Key messages:

1. Change is driving rapid ecosystem transformations.
2. Species changes and biodiversity loss are accelerating.
3. Impacts on ecosystem services create risks and opportunities.

Adaptation and resilience options and opportunities

Strategy ES1: Enhance the resilience and adaptive capacity of ecosystems.

Ecosystem transformation refers to significant and lasting changes in an ecosystem's structure, function, and composition. Historically, this transformation has been driven by human alteration to the landscape (i.e., urbanization, industrialization, agricultural expansion), but more recently, it has been driven by climate change. Nebraska's ecosystems are experiencing and are expected to undergo significant transformations due to climate change. These changes affect the state's prairies, agricultural landscapes, wetlands, and riparian systems. This affects the state's wildlife and the migratory species that access Nebraska's landscapes on their way to critical habitats used for reproduction and overwintering. As the Nebraska Natural Legacy Project reports, much of the state's existing natural habitat and the biological diversity it supports reside on lands under private ownership.

Example state actions

- ES1-1: Increase collaboration and communication.
- ES1-2: Improve conservation programs and incentives.
- ES1-3: Focus conservation on the best opportunities (i.e., restore and conserve natural ecosystems with an emphasis on native prairies and wetlands).
- ES1-4: Promote management that is more compatible with conserving biological diversity (i.e., utilize the Resist-Accept-Direct (RAD) framework to guide adaptive ecosystem management).
- ES1-5: Maintain and expand the network of public and private conservation lands.
- ES1-6: In collaboration with the Nebraska Department of Education, seek to address important issues related to biological diversity in state education content standards—specifically, but not limited to, state science standards. Additionally, work with the Nebraska Department of Education to adopt and incorporate the Nebraska Environmental Literacy Plan. This plan seeks to develop environmentally literate students and ensure that all students, by the time they graduate high school, are knowledgeable about Nebraska's natural resources and environmental issues and are willing to act on this knowledge to help conserve our natural legacy and solve our environmental problems.
- ES1-7: Demonstrate success by establishing and promoting Natural Legacy Demonstration Sites across Nebraska.

- ES1-8: Restore grassland systems with an emphasis on controlling woody plant encroachment, particularly eastern red cedar.
- ES1-9: Support existing cooperatives, such as the Nebraska Invasive Species Project, with the intent to organize a diverse network of agencies and organizations to gather and share information about invasive species, new control measures, control efforts that are underway, distribution of invasive species, and funding issues. Collaboratively develop and widely distribute a list of all known invasive species that threaten the state's biological diversity and develop best management practices that can be used to control or reduce the spread of those species.
- ES1-10: Seek to remove or create bypass structures around dams and other impediments that restrict the natural movement of aquatic species.

Example local government and public power actions

- ES1-11: Support progress toward sustainable development.
- ES1-12: Collaborate with planning commissions, county commissions, and building associations to site new development to reduce fragmentation of existing natural communities.
- ES1-13: Identify sites conducive to greenway development and provide resources and support to help communities engage in collaborative planning to develop long-term strategies that meet conservation, economic, and recreational goals (i.e. create a GIS layer that identifies priority areas that local units of government or NGOs can use to prioritize activities such as greenway development).
- ES1-14: Support existing programs that promote the development of natural communities (e.g., prairies, wetlands, native woodlands) at schools, parks, government offices, housing developments, businesses, etc., that the public can use to learn about biological diversity.
- ES1-15: Sponsor wildlife-related events (e.g., eagle viewing days, crane celebrations, hunter breakfasts, fishing tournaments) that have recreational, educational, and entertainment value and provide community economic benefits.
- ES1-16: Work with partners, such as Cooperative Extension, to develop and conduct workshops for landowners, producers, community leaders, conservation practitioners, educators, and others on topics such as prairie conservation, at-risk species management, invasive control, forest management, aquatic resources, available cost-share programs for projects, and so on.
- ES1-17: Use multiple media outlets (e.g., television/radio, print advertisements, internet, billboards, public displays) to increase awareness and support for Nebraska's biological diversity and inform the public of progress made to conserve species and habitats.
- ES1-18: Control invasive species in natural ecosystems.

Example agricultural community actions

- ES1-19: Raise awareness about the role of farming and ranching in biological diversity conservation. Develop mentoring programs for landowners regarding ecologically sound farming and ranching practices. Create farmer-to-farmer networks where landowners can share information and help each other with projects.
- ES1-20: Develop and implement early detection and rapid response programs for invasive species, pests, and pathogens.
- ES1-21: Use and promote restoration and management techniques that utilize native, locally adapted species whenever possible. Discourage the use of nonnative species in restoration/management projects.
- ES1-22: Discourage the placement of woody plantings and food plots within natural grassland communities, especially when it will result in increased fragmentation.

Example business, household, and individual actions

- ES1-23: Increase participation in nature-based recreation.
- ES1-24: Raise awareness about the role of urban/suburban backyards in biological diversity conservation. Develop mentoring programs for landowners regarding ecologically sound landscaping and gardening practices. Create neighbor networks where landowners can share information and help each other with projects.
- ES1-25: Use and promote restoration and management techniques that utilize native, locally adapted species whenever possible. Discourage the use of nonnative species in restoration/management projects.

Strategy ES2: Species changes and biodiversity loss are accelerating. Facilitate species and ecosystem adaptation to climate change.

Climate change is influencing species and ecosystems by altering fundamental interactions with other species and the physical environment, leading to a cascade of impacts throughout ecosystems. Climate change is already having a significant impact on species including shifts in species distributions (i.e., shifting their distribution to higher/cooler elevations or latitudes), changes in phenology or timing of annual life-cycle events of species (i.e., shifts to breeding, hibernation, migration, or pollination), and decoupling of coevolved interactions (i.e., emergence of an insect may become out of sync with the flowering time of its host plant). In addition, climate change is expected to alter ecological processes such as fire patterns and hydrology and exacerbate a number of non-climate stressors such as habitat loss and fragmentation, pollution, and the spread of invasive species, pests, and pathogens.

Example state actions

- ES2-1: Protect and maintain a network of conservation areas thereby promoting biodiversity corridors to support species migration and adaptation. Focus on areas that offer the best opportunities to conserve the full array of biological diversity and the best chances for success as identified in the Nebraska Natural Legacy Project.
- ES2-2: Improve the quality of public lands critical to conserving biological diversity by using management approaches such as prescribed burns and grazing appropriate to local plant communities.

- ES2-3: Address major knowledge gaps regarding how fish and wildlife populations will persist in changing environments.
- ES2-4: Develop and distribute a "best management practices guide" on prescribed burning that can be used to improve the management of grasslands, woodlands, and riparian areas for biological diversity. Include information on sources of technical information, funding programs, equipment needed, and so on.
- ES2-5: Utilize an adaptive management approach in implementing adaptation strategies.
- ES2-6: Develop and distribute a "best management practices" guide on grazing that can be used to improve the management of grasslands and riparian areas for biological diversity. Include information on sources of technical information, funding programs, wildlife-friendly fencing specifications, and so on.
- ES2-7: Promote and support the development of locally based grazing cooperatives and incentive programs that can facilitate grazing of playa wetlands, small disjunct prairie sites, woodlands, and other sites with low grazing income potential.
- ES2-8: Develop an integrated water management plan for all water uses throughout the state.
- ES2-9: Strengthen existing or establish new statewide partnerships for promoting wetland, river, and stream conservation.
- ES2-10: Evaluate the impacts of new dams, additional groundwater and surface water withdrawals, channelization, and levy/dike construction on biological diversity.
- ES2-11: Collaborate with natural resource organizations and others to develop a list of preferred plant materials (e.g., trees, shrubs, grasses, forbs) that can be used in urban and rural settings with little threat to biological diversity. Develop guidelines that will help ensure that potentially invasive species do not spread to natural communities.
- ES2-12: Develop guidelines for applying herbicides and using biocontrols targeted at invasive species so impacts on biological diversity are minimized.
- ES2-13: Initiate a public outreach campaign on the impacts of invasive species on biological diversity.
- ES2-14: Incentivizes private landowners to maintain natural habitats and cooperatively manage large blocks of habitat as complexes that conserve biological diversity.
- ES2-15: Work with agricultural and conservation partners to prioritize the installation of conservation buffers, conservation tillage practices, and so on, within watersheds where the benefits to biological diversity would be highest.
- ES2-16: Conduct inventories to identify additional Biologically Unique Landscapes that contain high-quality examples of ecological communities and populations of at-risk species.
- ES2-17: Continue inventory of the currently described Biologically Unique Landscapes to better identify areas within them where multiple conservation objectives can be met.
- ES2-18: Provide information to conservation planners and practitioners to help focus conservation actions. Decision-support tools (e.g., GIS data, models) may be used to evaluate options.
- ES2-19: Work to ensure that high-quality occurrences of all terrestrial and aquatic community types in Nebraska are protected and managed for the long term.
- ES2-20: Work to ensure that occurrences of viable populations of at-risk species are under long-term protection and management.
- ES2-21: Monitor changing conditions and population fluctuations to adapt management efforts better as needed.
- ES2-22: Start a natural areas program (modeled after successful programs in other states) that identifies and protects biologically unique sites that are managed to perpetuate Nebraska's biological diversity.
- ES2-23: Through conservation easements, facilitate the long-term protection of biologically important lands enrolled in short-term conservation programs (e.g., the Conservation Reserve Program, and private lands programs).

- ES2-24: Seek opportunities to improve management on publicly owned lands not part of the conservation network (e.g., Bureau of Education Land Fund holdings) to increase benefits to biological diversity.

Example local government and public power actions

- ES2-25: Consider the impacts of land-use change on habitat loss and fragmentation.
- ES2-26: Identify and seek to overcome barriers that limit the ability of managers and private individuals to conduct prescribed burning on private and public lands.
- ES2-27: Seek to maintain or restore the natural hydrology of rivers, streams, and wetlands to sustain biological diversity and ecosystem function. Accomplish this through the use of voluntary incentives, sound bioengineering solutions, and through collaborative decision-making.
- ES2-28: Promote land acquisition policies founded on willing seller/willing buyer principles, maintain the local tax base, and provide equitable compensation to landowners.

Example agricultural community actions

- ES2-29: Promote management that is more compatible with conserving biological diversity. Collaborate with farmers, ranchers, and conservation organizations to identify opportunities and share responsibility for conserving biological diversity.
- ES2-30: For select grasslands, evaluate the use of patch-burn grazing and other grazing systems that combine the interaction of fire and grazing to mimic presettlement disturbances. The timing, intensity, and duration of any fire-grazing system needs to be carefully planned and implemented. Biologists and ranchers should carefully coordinate management strategies.
- ES2-31: For woodland and forest systems, particularly in western Nebraska, use mechanical tree thinning and prescribed fire to increase the system's resiliency to wildfires.
- ES2-32: Use locally adapted native seed sources for pasture and rangeland seedings.
- ES2-33: Utilize livestock grazing/haying systems with built-in drought management contingencies (e.g., grass banking).
- ES2-34: Implement diverse haying strategies (e.g., on wet meadows) that stagger timing and height of cutting, promote increased plant and animal diversity, and avoid peak nesting periods for grassland birds.
- ES2-35: Implement wildlife-friendly conservation buffers, grassed waterways, sediment traps on lands adjacent to wetlands, rivers, streams, reservoirs, and lakes to prevent siltation and protect water quality.
- ES2-36: Implement water conservation measures such as more water-efficient irrigation systems, xeriscape landscaping, and water-conserving appliances.
- ES2-37: Utilize integrated pest management (e.g., non-chemical controls such as biocontrol, tillage, and spot spraying) to minimize impacts on biological diversity.
- ES2-38: Implement conservation practices such as filter strips, grassed waterways, sediment control basins, and grassed buffers to minimize the effects of fertilizers and pesticides on wetlands, streams, rivers, and reservoirs.

- ES2-39: Implement management practices that limit the impacts of nutrients, sedimentation, bacteria, and pesticides to help protect water quality. Examples include, among others, nutrient application on cropland, sediment control on construction sites, incentives for organic and low-chemical farming.

Example business, household, and individual actions

- ES2-40: Protect additional (private) lands through acquisition and conservation easements and by implementing voluntary and incentive-based conservation actions on private lands.
- ES2-41: Learn more about using fire to control woody plant invasion or revitalize grasslands by participating in a workshop hosted by the Prescribed Burn Task Force and Great Plains Fire Learning Network.
- ES2-42: Consult with species experts and perform pre-burn evaluations to minimize impacts on species that may lack the ability to recolonize a site following burning.
- ES2-43: Assess possible risks of invasive species spread from commercialized wildlife operations and take appropriate preventative measures.
- ES2-44: Use restoration and management techniques that utilize native, locally adapted species whenever possible.

Strategy ES3: Recognize the value of ecosystem services in promoting climate adaptation.

Ecosystem-based adaptation is a strategy for adapting to climate change that harnesses existing nature-based solutions and ecosystem services such as providing clean water, local air and climate regulation, and risk and disease protection. By addressing increasing pressures on ecosystems, the State of Nebraska will increase its resilience to climate change, benefiting economic development, urban and rural communities, and fish and wildlife populations.

Example state actions

- ES3-1: Promote the value of naturally meandering rivers and streams, the role of floodplains as habitat, and the need to maintain or closely simulate the natural hydrograph of rivers and streams to benefit biological diversity.
- ES3-2: Seek to maintain or restore the natural hydrology of rivers, streams, and wetlands to sustain biological diversity and ecosystem function. Accomplish this using voluntary incentives, sound bioengineering solutions, and collaborative decision-making.
- ES3-3: Facilitate cross-sectoral collaboration and develop integrated policies and frameworks.

Example local government and public power actions

- ES3-4: Increase awareness and understanding of the benefits of nature-based solutions.
- ES3-5: Advocate for increased adaptation funding and promote innovative financing mechanisms.
- ES3-6: Prioritize capital improvement projects that provide stacked benefits/ecosystem services to the community.
- ES3-7: Plant native vegetation within the road right-of-way to provide stormwater management and pollinator habitat.
- ES3-8: Increase tree canopy in the urban landscape.
- ES3-9: Promote ecotourism/recreational opportunities.

Example agricultural community actions

- ES3-10: Improve soil health to address water and nutrient cycling, reduce potential climate impacts, and confer broader ecosystem services.
- ES3-11: Install prairie strips—strategically placed native prairie plantings in crop fields—to improve soil health and water quality and provide critical habitat for wildlife and pollinators.

Example business, household, and individual actions

- ES3-12: Convert turf/lawns to native vegetation to provide stormwater management and pollinator habitat.

Agriculture

Key messages

1. Observed and projected changes to temperature and precipitation trends have the potential to significantly impact crop and rangeland productivity, necessitating adaptation efforts.
2. The most important potential impacts on agriculture in Nebraska include increasing rainfall variability, shifts to rainfall seasonality, increases in drought intensity, increased temperatures, decreased days with very cold temperatures, increased wildfires, and increased hail frequency and intensity. Such impacts have the potential to significantly reduce field crops and rangeland productivity.
3. Field crop adaptation options include improvements to plant genetics, management shifts to crops grown and/or cropping systems, and soil and water management shifts.
4. Rangeland adaptation options include heterogeneity-based rangeland management (e.g., pyric herbivory) and shifts to the kind (e.g., species) and class of animal to better adapt to expected challenges.

Adaptation and resilience options and opportunities

Strategy A1: Promote sustainable farming practices, such as soil conservation, water management, and integrated pest management, to ensure long-term resilience in Nebraska's agricultural systems.

Example state actions

» A1-1: Support the implementation of agricultural best management practices (BMPs) through grants and cost-sharing opportunities.

Example local government and public power actions

» A1-2: Support the implementation of agricultural BMPs through regulatory and permitting alignment and cost-sharing opportunities.

Example agricultural community actions

- A1-3: Increase implementation of soil management practices associated with improving soil health. Practices such as conservation tillage, cover crops, perennial crops, and crop rotation are known to improve water retention, reduce runoff, and potentially decrease the need for fertilizer inputs and herbicide use. Soil health practices can potentially buffer negative climate impacts in both flooding and drought conditions.
- A1-4: Prioritize residue management practices that armor soil throughout the year for erosion prevention.
- A1-5: Shift to perennial crops that provide soil protection year-round.
- A1-6: Implement conservation irrigation efforts, including shifts to irrigation technologies such as methods of application and scheduling of application, shifts to crops grown, and improved crop genetics for water use.
- A1-7: Optimize irrigation resources.
- A1-8: Install on-farm drainage systems, such as retention ponds or drainage ditches that can help manage excess water and prevent flooding.
- A1-9: Use cattle exclusions (i.e., fencing) and develop alternative water supply systems such as off-takes from natural systems into watering areas.
- A1-10: Efficient irrigation techniques, such as drip irrigation and soil moisture sensors, can help farmers manage water use more effectively, reducing the impact of higher water demands.
- A1-11: The risk of increased pests necessitates best management practices such as scouting and timely pest management, which could interfere with the vernalization requirements of cool-season crops.

Strategy A2: Maintain field crop productivity into the future by implementing crop diversification practices and transitioning to climate-resilient crop systems and agricultural practices.

Variability in precipitation patterns and annual and seasonal shifts in temperature are causing heat and water stress, which will impact future corn and soybean yields. Estimates of crop productivity in the future project yield decline, with some research projecting less biophysically suitable conditions for corn and soybean by the end of the 21st century without further adaptation efforts (Burchfield, 2022). Impacts on wheat yields are mixed. Estimates of crop productivity project yield declines, while others suggest that wheat production could shift toward cooler conditions, leading to the potential for an increase in wheat acreage in Nebraska.

Example state actions

- A2-1: Support research, extension services, and policies to facilitate the development and adoption of climate-resilient crop genetics, including varieties that are heat-tolerant; resistant to drought; less vulnerable to wind and hail damage, pests and diseases, and waterlogging; have shorter growing cycles; and use nitrogen and phosphorus more efficiently.
- A2-2: Provide reliable support via infrastructure, markets, knowledge, equipment, and more. Such needs present significant challenges for producers and potential new business opportunities. Producers in the region note current time and resource limitations as barriers to shifting which crops are grown (Kasu et al., 2019).

Example agricultural community actions

- A2-3: Conduct participatory breeding programs where farmers collaborate in testing and selecting the most resilient varieties for their areas.
- A2-4: Incorporate genes from wild relatives of corn and soybeans to introduce natural resilience to a broader range of climate stresses.
- A2-5: Identify crops that may be more biophysically adapted to be incorporated into future cropping systems (i.e., a recent report projecting the potential for crops grown in Kansas by 2050 found opportunities associated with a shift from crops with lower water demand, such as planting sorghum instead of corn, millet instead of soybean, and rye or oats instead of wheat [Suttles et al., 2024]).
- A2-6: Shifting planting timing and/or planting shorter or longer season varieties to accommodate for shifts in rain (UNL, n.d.).
- A2-7: Diversifying crops could avoid summer water-related stress and damage.
- A2-8: Diversify crops and minimize summer annual crops; use more drought- and heat-tolerant varieties of corn, soy, and wheat.
- A2-9: Including more winter annual or cool-season crops in rotation optimizes rainfall utilization: the main crop is harvested before summer drought, and increased use of different types of crops diversifies the risk of rainfall variability.
- A2-10: Growing a variety of crops, especially those tolerant to waterlogged conditions, can help farmers spread risk and reduce the overall impact of extreme rainfall on their operations.
- A2-11: A longer growing season presents expanded opportunities for cover cropping, relay cropping, and perennial grain or forage crops, as well as the potential for increased livestock integration on cropland. Utilize tools such as advances in plant breeding and crop and climate models to support optimizing such cropping systems.
- A2-12: Shift planting timing by planting shorter season crops or alternative crops could avoid crop water stress with more variable rainfall.
- A2-13: Reduce seeding rates (UNL, n.d.).
- A2-14: More frequent applications of inputs to reduce losses (i.e., split application of nitrogen) (UNL, n.d.).

Strategy A3: Maintain rangeland productivity into the future by implementing heterogeneity-based rangeland management (HRM), which is a conservation and land management approach that emphasizes maintaining and promoting variability in vegetation structure, composition, and function across rangelands.

Example state actions

- A3-1: Lower stocking rates to accommodate fluctuations in streamflow and water availability.
- A3-2: Consider lowering stocking rates to accommodate increasing aridity and subsequent declines in forage production across the state.
- A3-3: Woody plant encroachment into grasslands significantly threatens rangeland livestock production, specifically in highly productive grassland ecosystems like the tallgrass prairie (Engle et al., 2008).
- A3-4: Develop and distribute a "best management practices" guide on grazing that can be used to improve the management of grasslands and riparian areas for biological diversity. Include information on sources of technical information, funding programs, and wildlife-friendly fencing specifications (Schneider et al., 2011).

Example local government and public power actions

- A3-5: Increase the use and frequency of prescribed fire to improve forage conditions and utilize grazing management practices that capitalize on vegetation recovery (and high forage quality) immediately following a fire.

Example agricultural community actions

- A3-6: Shifts to the kind (i.e., species) and class of animal to better adapt to expected challenges (i.e., consider the adoption of bison as a potential alternative to traditional livestock to cope with the effects of climate change).
- A3-7: Altering the class of animal (e.g., moving from cow-calf to stocker steers) or increasing the diversity of animal kinds and classes in a livestock operation to better balance the risk and uncertainty of future climate change effects.
- A3-8: Change the kind and class of livestock to capitalize on changes to the forage base.
- A3-9: Consider changing the kind and class of animal to those better suited to changing aridity and humidity.
- A3-10: Utilize grazing systems that capitalize on increased forage quality following fire (pyric herbivory) but at moderate (i.e., 20–25% harvest use efficiency) stocking rates to avoid steep declines in range condition and heterogeneity.
- A3-11: Reduce restrictions to animal movement and increase the total available area to overcome increased spatial variability in water resources over time.
- A3-12: Change animal grazing timing, kin and class of animal, or multispecies grazing to capitalize on changing forage quality in time.
- A3-13: Promote landscape heterogeneity through managed disturbances.

- A3-14: Improved ventilation and cooling systems, such as fans, sprinklers, and shade structures, can help livestock cope with higher nighttime temperatures and reduce heat stress.
- A3-15: Develop and maintain permanent or semi-permanent water facilities (e.g., water tanks) to meet their livestock's basic physiological requirements during drought.
- A3-16: Promote and support diverse grazing/haying systems on private and public lands that enhance biological diversity and sustain natural communities. Initiate research that evaluates the effectiveness and profitability of biological diversity-friendly grazing/haying systems (e.g., reduced stocking rates, rotational systems) (NE Natural Legacy Project, 2011).
- A3-17: Promote and support the development of locally based grazing cooperatives and incentive programs that can facilitate grazing of playa wetlands, small disjunct prairie sites, woodlands, and other sites with low grazing income potential (Schneider et al., 2011).
- A3-18: Support diverse haying strategies (e.g., on wet meadows) that stagger timing and height of cutting, promote increased plant and animal diversity, and avoid peak nesting periods for grassland birds (Schneider et al., 2011).
- A3-19: Promote the use and availability of locally adapted native seed sources for pasture and rangeland seedings (Schneider et al., 2011).
- A3-20: Promote livestock grazing/haying systems with built-in drought management contingencies (e.g., grass banking).

Strategy A4: Enhance the agricultural community's resilience to climate change by increasing access to financial resources, technical support, and innovative solutions.

Example state actions

- A4-1: Seek and promote economic alternatives that help reduce further conversion of important rangelands and pastures to cropland (Schneider et al., 2011).
- A4-2: Seek and promote economic alternatives that help reduce further conversion of important rangelands and pastures to cropland.
- A4-3: Establish and expand funding programs (e.g., grants, low-interest loans, and subsidies) to help farmers adopt climate-smart practices and technologies.
- A4-4: Develop crop insurance programs tailored to address risks associated with climate variability (e.g., drought, floods, and temperature extremes).
- A4-5: Facilitate access to carbon markets and incentive programs for practices that sequester carbon and reduce greenhouse gas emissions.
- A4-6: Expand agricultural extension services with expertise in climate adaptation, including tailored solutions for local conditions.
- A4-7: Focus on equitable access to financial and technical resources, especially for marginalized communities within the agricultural sector.

Example local government and public power actions

- A4-8: Advocate for policies prioritizing climate adaptation funding for smallholder and underserved farmers.

Example agricultural community actions

- A4-9: Ensure the supply of cover crop seed meets the increasing demand under future climate conditions.
- A4-10: Support research and demonstration projects to showcase best practices and emerging technologies.
- A4-11: Develop and promote tools like decision-support software, weather prediction apps, and precision agriculture technologies to guide climate-adaptive farming.
- A4-12: Offer training on using data-driven technologies to optimize yields while conserving resources.
- A4-13: Participate in peer-learning opportunities and farmer-led innovation networks to foster knowledge-sharing and collaboration.

Human Health

Key messages

1. Climate change is associated with adverse health outcomes in Nebraska, including heat-related morbidity and mortality during heat waves, physical and mental health impacts during drought and flood events, and increased risk of certain infectious diseases like West Nile virus due to changing temperature and precipitation patterns.
2. Some Nebraskans are more impacted by the health impacts associated with climate change than others.
3. Adaptation and mitigation efforts addressing the health impacts of climate change can protect Nebraskans.

Adaptation and resilience options and opportunities

Strategy H1: Mitigate the impacts of climate change on public health.

Implementing measures to adapt to and mitigate the health impacts of climate change can protect Nebraskans. This includes developing climate action and resilience plans that enhance emergency preparedness, improve air quality, set emission reduction targets, and enhance public health initiatives.

Example state actions

- H1-1: Identify, prioritize, and incorporate climate change mitigation and adaptation strategies into health planning and regulations. Include actions that promote healthy living and reduce greenhouse gas emissions and toxic pollutants.
- H1-2: Consider climate resilience, health benefits, future climate, and cumulative impacts, including historical burdens, in cost assessment requirements for the State of Nebraska planning and investment decisions.
- H1-3: Incorporate current information about climate change projections and impacts into state and local emergency planning efforts and emphasize climate-related disaster preparedness in emergency response plans, including the Emergency Operations Plan, Behavioral Health All-Hazards Disaster Response and Recovery Plan, and Department of Health and Human Services Disaster Plan.
- H1-4: Collaborate with local governments to help incorporate healthy living strategies into land-use planning and regulations. These include development that concentrates growth in compact, walkable urban centers to avoid sprawl.
- H1-5: Increase public health capacity, funding, collaboration, and adaptation resources for local public health departments, local governments, and agencies supporting Nebraska's vulnerable populations.
- H1-6: Work with partner agencies on policies to improve and protect air quality and water security based on health and environmental data, implement health-based standards, and remain proactive in identifying emerging contaminants, vectors, and diseases of concern related to climate change.

- H1-7: Implement enhanced surveillance of vectors and related diseases.
- H1-8: Implement better surveillance for injury and other flood-related health outcomes, including increased syndromic surveillance for flood events.
- H1-9: Improve our understanding of human health impacts of climate change and extreme weather through continued interdisciplinary studies at the University of Nebraska and with agency scientists. Further work needs to focus on better understanding the risks, identifying the areas and populations at greatest risk, and exploring new methods to address the identified risks.

Example local government and public power actions

- H1-10: Partner with area agencies to develop a Natural Disaster Response, Relief, and Recovery Plan. Focus on communications, property adaptation and resiliency, housing needs, risk assessment, land acquisition, and critical infrastructure resilience. Identify the location of critical facilities, including hospitals, medical service providers, senior homes, childcare facilities, shelters, major and alternate transportation routes, public transit facilities, and locations where hazardous chemicals are used or stored.
- H1-11: Improve health and transportation system resilience to floods using updated NOAA Atlas 14 precipitation projections.
- H1-12: Conduct a needs assessment of accessible community centers for extreme weather or other emergencies. Create a development improvement plan, if needed.
- H1-13: Develop post-flood vector control plans.

Example business, household, and individual actions

- H1-14: Put together an emergency preparedness kit for your household or business.
- H1-15: Prepare your home for the extremes. Understand the risk of extreme weather, extreme temperatures, flooding, or wildfire, and take action to safeguard your home or business.

Strategy H2: Build resilience in climate-vulnerable communities.

Climate change disproportionately impacts vulnerable communities, including people of color, Indigenous populations, low-income groups, and those with chronic health conditions. Addressing their specific needs reduces health disparities, promotes equity, and improves outcomes by mitigating climate-related health issues like heat illnesses, respiratory conditions, and mental health challenges. Strengthening infrastructure and emergency response systems in these communities enhances preparedness for extreme weather, reducing injury, illness, and death risks.

Example state actions

- H2-1: Collaborate with local health departments and communities facing climate and health inequities to develop a shared vision and action plan for protecting health equity and well-being in a changing climate.
- H2-2: Actively engage with priority communities in a coordinated and well-resourced way so underrepresented voices are centered in the development of climate policies, programs, and public investments
- H2-3: Improve wildfire smoke guidance for schools, children, and other vulnerable populations, including low-income populations, communities of color, and tribal communities.

- H2-4: Encourage the development of climate vulnerability assessment and action plans in communities and cities across the state
- H2-5: Enhance the ability of local organizations to understand climate risks and reach vulnerable populations.
- H2-6: Increase air quality monitoring, particularly in rural communities.
- H2-7: Set up temporary respiratory health clinics or expand telehealth services in areas affected by wildfires.
- H2-8: Develop community mental health programs and peer support networks in agricultural communities.

Example local government and public power actions

- H2-9: Improve weatherization and energy efficiency in under-resourced and vulnerable communities.
- H2-10: Establish heating and cooling centers in under-resourced and vulnerable communities, supported by renewable energy generation and battery backups.
- H2-11: Install and maintain additional shade structures, tree canopy, water features, and drinking water stations in public spaces. Target early adoption for areas identified as having high potential for urban heat island impacts, particularly within under-resourced and vulnerable residential neighborhoods.

Strategy H3: Implement public health initiatives that educate Nebraskans on the impacts of climate change and the health benefits of adaptation and mitigation efforts.

Educating the public raises awareness about the specific health risks associated with climate change, such as heat-related illnesses, respiratory conditions, and vector-borne diseases, enabling individuals to take proactive measures to protect themselves. Meanwhile, understanding the health benefits of adaptation and mitigation efforts, such as improved air quality, reduced heat exposure, and enhanced mental health, motivates individuals and communities to participate in and support these efforts.

Example state actions

- H3-1: Improve education and messaging regarding Nebraska's priority climate impact risks and actions to protect health, especially for populations with greater vulnerability and risk.
- H3-2: Convene an expert workgroup to assess the state's existing climate, health education, and communication capacity. Then, establish a communication protocol that includes best practices for communicating climate and health risks, vulnerabilities, and adaptation opportunities, with attention paid to impacts on underserved or overburdened communities.
- H3-3: Expand training and education of health and social services providers, including mental health agencies, to build capacity to respond appropriately to human health risks of climate change.
- H3-4: Educate other sectors of state government about public health climate change impacts and adaptation.

Example local government and public power actions

- H3-5: Provide vulnerable populations with information on what they need to know and how to prepare for and address the risks of climate change.
- H3-6: Promote indoor air quality improvements, including use of air purifiers and proper ventilation.
- H3-7: Engage and motivate citizens and organizations to take action to build resilient communities.
- H3-8: Establish an Adopt-a-Neighbor campaign, or "neighborhood resilience watch," to create neighborhood-level support for vulnerable individuals during extreme weather events and emergencies.

Communities and the Built Environment

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.

Adaptation and resilience options and opportunities

Strategy C1: Enhance Nebraska's infrastructure resilience.

Strengthening roads, bridges, and rail systems can ensure reliable access to emergency services and supply chains during floods or severe storms while modernizing water systems can safeguard water quality and availability in the event of droughts or infrastructure damage. Similarly, upgrading energy grids to withstand extreme heat, ice storms, and high winds can prevent widespread power outages, critical for maintaining public safety, healthcare, and economic stability. By proactively investing in resilient infrastructure, Nebraska communities can reduce recovery costs, protect vital resources, and build a foundation for sustainable growth in an era of climate uncertainty.

Example state actions

- C1-1: Develop a Climate Mitigation and Resilience Plan for the State of Nebraska.
- C1-2: Require consideration of climate risks, response strategies, and adaptation standards in capital planning, including the site selection, design, and construction of state-funded infrastructure projects.
- C1-3: Require incorporation of climate impacts and response strategies in the state's long-range transportation plans; mode-specific plans for highways, rail, aviation, and ferries; and regional transportation plans.
- C1-4: Develop transportation design and engineering guidance to minimize climate change risks.
- C1-5: Advance the adoption and enforcement of progressive building codes and design standards to reduce the vulnerability of structures to climate-related hazards.
- C1-6: Adopt regulatory and incentive programs to encourage state, tribal, and local transit organizations, public works departments, utilities, and other partners to demonstrate awareness of infrastructure and system climate risk vulnerabilities and implement resilience measures.

- C1-7: Identify existing or establish new Nebraska-specific tools to share with local governments, state and tribal agencies, and local communities to help them understand key vulnerabilities to climate impacts and what actions can be taken.

Example local government and public power actions

- C1-8: Integrate climate change into county, municipal, and public power district planning documents and initiatives to help guide local actions.
- C1-9: Evaluate the vulnerability of critical energy and communication infrastructure to the impacts of climate change, including risks of damage and the potential for disruptions and outages from flooding, extreme heat, wildfires, erosion, and extreme weather events.
- C1-10: Evaluate the vulnerability of critical transportation infrastructure and integrate climate adaptation and resilience principles into design, construction, and operation.
- C1-11: Improve or enhance the permitting of infrastructure projects with established climate resilience and mitigation guidance and standards.
- C1-12: Update stormwater design standards to address expected changes in precipitation, focus on low-impact development techniques, address flash flooding, and preserve natural streams and wetlands to reduce flood risks and improve storage during extreme weather events.
- C1-13: Create and implement a plan to conserve and protect floodplains, reducing development impact. Focus on preserving floodplains and restoring native habitats.
- C1-14: Establish a program for acquiring residential properties and local businesses that repeatedly suffer flood damage.

Strategy C2: Promote climate-informed land-use planning.

Integrating climate projections into land-use planning is essential for strengthening community resilience across Nebraska. Communities can develop effective mitigation strategies by assessing localized climate impacts and identifying vulnerable areas—such as floodplains, drought-prone regions, and zones at risk of extreme weather. These include updating zoning regulations to limit development in high-risk areas, implementing green infrastructure to manage stormwater, and revising building codes to ensure structures withstand extreme conditions. Using climate data in planning helps protect residents, safeguard infrastructure, reduce economic losses, and promote sustainable development, ensuring Nebraska is better prepared for future challenges.

Example state actions

- C2-1: Develop specific and actionable guidelines and technical assistance to local communities on sustainable, resilient, and equitable land-use and community development planning that explicitly considers climate change impacts and resilience.
- C2-2: Evaluate and propose revisions of laws and rules that govern land use and other programs to effectively address resilience to climate change impacts.
- C2-3: Review, revise, and enhance building and site design standards in flood and wildfire hazard zones to improve resilience.
- C2-4: Provide outreach and education to local governments on opportunities to reduce risks from climate change in their communities via updates and changes to local land-use ordinances.

Example local government and public power actions

- C2-5: Identify and address land use and infrastructure creating disproportionate risks for minority and low-income communities.
- C2-6: Incorporate climate risk reduction strategies into the community's comprehensive plan, watershed plan, hazard mitigation plan, emergency management plan, or program operational guidance materials.
- C2-7: Avoid development in highly vulnerable areas and promote sustainable development in appropriate, less vulnerable areas. Adopt zoning changes or special overlay districts to designate high-risk areas of flooding or wildfires.
- C2-8: Implement the transfer of development rights or other incentives to enable developers to increase densities on low flood-risk parcels while keeping flood-prone areas undeveloped.
- C2-9: Facilitate informational events and resources to educate residents and businesses on topics related to sustainability and resilience.
- C2-10: Implement urban tree canopy and forest management plans and practices to retain biodiversity, resilience, and ecosystem function and services.
- C2-11: Ensure that facilities that serve vulnerable populations are resilient to climate hazards and have established best practices for responding to emergencies such as flooding, power outages, and extreme heat.
- C2-12: Connect with existing community groups and facilitate the creation of new ones to focus on resiliency regarding extreme weather events, safety in outdoor recreation, and environmentally themed community involvement activities.

Strategy C3: Increase the resilience of Nebraska communities by fostering greater self-reliance.

Implementing initiatives that promote sustainable food systems, regenerative agriculture, green industries, and local economic development can significantly enhance the resilience of Nebraska communities. Supporting local food production, renewable energy projects, and environmentally responsible businesses reduces dependence on external resources, improves food security, and strengthens self-reliance. These efforts also benefit public health by reducing pollution, increasing access to nutritious food, and promoting cleaner, more efficient systems. By creating jobs and stimulating local economies, such initiatives build stronger, healthier, and more adaptable communities while fostering long-term environmental and economic sustainability.

Example state actions

- C3-1: Develop a Nebraska Green Job Youth Corps program that prioritizes workforce development and economic diversification while providing temporary work and training opportunities for young adults in natural resource management, resilient agricultural development, conservation, renewable energy, or other sustainability professions.
- C3-2: Conduct a resilient-economy development assessment. Identify the economic potential and entrepreneurial and job development opportunities derived from adaptation, mitigation, and resilience actions in the Nebraska economy. Specifically, scenarios for potential impacts on low/moderate income and other vulnerable populations should be evaluated.

- C3-3: Working with the University of Nebraska system, identify key opportunities for green-technology-led economic development, prioritize areas that assist with climate change transitions and mitigation, and institute seed-granting opportunities and research capacity-building efforts to grow the state's university expertise and competitiveness.
- C3-4: Establish a Nebraska Green Tech and Business Incubator to support the establishment of innovative energy and sustainability-driven businesses within Nebraska.
- C3-5: Establish a Nebraska Green Bank to support resilient economic development. See Inflation Reduction Act funding and Federal Green Bank for resources.
- C3-6: Promote local and community-based agriculture throughout Nebraska to reduce transportation needs and increase food access, especially in underserved communities.
- C3-7: Establish or expand an Emerging Farmer Program and similar programs to support farmers and agricultural/food entrepreneurs, with particular attention to regenerative practices and advancing inclusion and equity.
- C3-8: Establish consortiums to hold round-table discussions with large employers and industries key to the Nebraska economy, as well as important emerging sectors, to understand potential short-, near-, and long-term impacts to employment sector resilience and coordinate in identifying resilience actions.

Example local government and public power actions

- C3-9: Ensure key business infrastructure is recognized in the community's general hazard mitigation and emergency response plans.
- C3-10: Focus community business development efforts on businesses with lower impacts on natural resources and promote green job creation.
- C3-11: Consider climate change–related risks to local supply chains in implementing the community's economic development strategy.
- C3-12: Collaborate with partners to hold round-table discussions with large employers and industries key to the community's economy and resident employment to understand potential short-, near-, and long-term impacts to employment sector resilience and coordinate in identifying resilience actions.
- C3-13: Revise zoning ordinances to remove barriers to urban agriculture: yard and rooftop food production, beekeeping, front-yard gardens, edible landscaping, and foraging. Examine and pursue other policy levers to increase food production within the community. Utilize available and appropriate parks and recreation lands for urban farming and food production.
- C3-14: Review/update code to provide incentives for multi-unit buildings and developments/subdivisions and commercial developers to preserve topsoil, use finished compost for soil amendment, and provide space for backyard or community gardens.
- C3-15: Plant fruit and nut trees in appropriate city-owned properties and rights-of-way throughout the city. Explore partnerships with local organizations to collect and distribute fruit and nuts from planted trees.

Example business, household, and individual actions

- C3-16: Access information on sustainable business practices through resources like **MIT**, **the University of New Hampshire**, or the **Green Business Benchmark**.
- C3-17: Create a **Disaster Preparedness Plan** or **Preparedness Toolkit** for your business.
- C3-18: Start a vegetable garden in your yard.
- C3-19: See if there is a **community garden** near you, or work with others to start a community garden so you can grow your own food.
- C3-20: Plant fruit or nut trees or shrubs on your property that are well suited for **the hardiness zone**.

Web resources

- https://mitsloan.mit.edu/sites/default/files/2022-06/MITSloan-SustainabilityArticlePublication-F.pdf
- https://open.umn.edu/opentextbooks/textbooks/142
- https://www.greenbusinessbenchmark.com/
- https://www.lisc.org/our-resources/resource/climate-change-preparedness-toolkit-business-development-organizations/
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Indigenous Peoples

Key messages

1. Weather and climate impacts are disproportionately strong in Indigenous communities.
2. Adaptation work is taking place locally with Tribal-led efforts.
3. Self-determination, recognition of rights and sovereignty, and the ability to reclaim and/or reimagine culture are keys to success.

Adaptation and resilience options and opportunities

Strategy I1: Promote self-determination and sovereignty.

Promoting Native American community self-determination and sovereignty strengthens both Tribal and state resilience by fostering sustainable land stewardship and cultural preservation. Supporting Indigenous communities in reclaiming and managing their lands, recognizing their rights, and enabling self-governance empowers Tribes to implement traditional ecological knowledge and practices that enhance environmental resilience. These efforts improve the state's ability to address climate challenges while preserving biodiversity and cultural heritage. Collaborative partnerships with Tribal nations also build mutual trust and shared capacity, creating a more unified and adaptive approach to resilience that benefits the entire state

Example state actions

- I1-1: Establish mechanisms to empower Indigenous communities and organizations to participate in appropriate state agency processes.
- I1-2: Support Indigenous communities in developing their climate adaptation plans, tailored to their specific needs and priorities, based on their traditional knowledge and cultural practices.
- I1-3: Advocate for and support secure land tenure for Indigenous communities, recognizing their role as stewards of critical ecosystems and ensuring their ability to manage land sustainably in the face of climate change.
- I1-4: Provide technical assistance, funding, and training opportunities to Indigenous communities to build capacity for climate adaptation planning and implementation.
- I1-5: Collaborate with Indigenous communities to identify and support strategies to protect and maintain cultural heritage sites, practices, and traditional food sources threatened by climate change across Nebraska.

Example tribal government actions

- I1-6: Develop a community climate adaptation and mitigation plan. Include a focus on energy and food sovereignty.
- I1-7: Invest in training and education for Tribal members, including youth, to build capacity in areas like climate science, environmental management, and policy advocacy.

- I1-8: Actively participate in state and federal decision-making processes related to climate change, ensuring Tribal interests are represented and respected.
- I1-9: Advocate for policies that protect Tribal lands and ensure access to necessary resources for adaptation efforts, such as water rights and funding for climate resilience projects.
- I1-10: Share knowledge and best practices with other Tribes facing similar climate challenges, creating a network of support and collaboration.

Strategy I2: Integrate Indigenous knowledge systems in planning.

Integrating Indigenous knowledge systems into climate resilience planning enhances a state's ability to adapt to and mitigate climate impacts. Developed over generations, Indigenous knowledge offers sustainable resource management practices, improved risk assessment, and locally relevant adaptation strategies. Incorporating these insights supports environmental sustainability, preserves cultural heritage, and fosters equitable policies that respect Indigenous rights and priorities. Engaging Indigenous communities in planning ensures inclusive and ethical decision-making, creating climate strategies that benefit both the environment and the diverse communities it sustains.

Example state actions

- I2-1: Establish formal consultation processes with Indigenous communities to gather knowledge about local ecosystems, climate patterns, and adaptation strategies for inclusion in state planning and programs.
- I2-2: Facilitate workshops and dialogues to share scientific knowledge with Indigenous communities and vice versa.
- I2-3: Empower and support Indigenous communities to lead research projects focused on their traditional knowledge and provide a venue for sharing the research findings with other communities throughout Nebraska.

Example tribal government actions

- I2-4: Regularly consult with elders and traditional knowledge holders to gather insights on past climate patterns, resilience, and adaptation strategies. Integrate knowledge in community plans, communications, and programs.
- I2-5: Empower young people to learn and actively participate in integrating Indigenous knowledge into community plans.
- I2-6: Partner with scientists to design research questions incorporating Indigenous knowledge and perspectives.

Strategy I3: Strengthen food sovereignty and traditional knowledge and practices.

Supporting tribal food sovereignty strengthens statewide climate resilience by promoting sustainable and self-reliant agricultural systems. Tribal communities use diverse farming methods adapted to local ecosystems, enhancing soil health and reducing risks from climate-related crop failures. Local food systems decrease dependence on vulnerable supply chains, ensuring food stability during disruptions. Indigenous ecological knowledge provides valuable strategies for resilient farming and land management. These practices also boost ecosystem services like water filtration, carbon storage, and biodiversity while empowering communities to address climate challenges collectively. Investing in tribal food sovereignty builds stronger, more resilient agriculture and communities statewide.

Example state actions

- I3-1: Work with Indigenous communities to identify and protect critical habitats for culturally important plants and animals, including wildlife management and plans that consider Indigenous needs.
- I3-2: Facilitate market access for Indigenous food producers by connecting them with consumers and supporting the development of local food systems.
- I3-3: Foster partnerships between state agencies, federal agencies, Tribal governments, and nonprofit organizations to effectively address climate change impacts on tribal food systems.

Example tribal government actions

- I3-4: Explore the development of a community-wide community-supported agriculture (CSA) program focused on increasing affordable access to fresh fruits and vegetables for food-insecure and low-income community members. Offer a tiered system within the CSA program to prioritize and incentivize local farmers using or transitioning to regenerative agriculture practices.
- I3-5: Establishing a seed-keeping bank to support local growers and traditional values.
- I3-6: Develop and implement youth and adult curriculum around local food, climate change, and food security through Indigenous and traditional practices.
- I3-7: Create an Agriculture Resource Management Plan and consider climate change in production and foraging goals and objectives.

Climate Justice and Equity

Key messages

1. Social systems are changing the climate with inequalities in harms and benefits to different social groups.
2. Low-income people of all racial groups and communities of color in Nebraska are likely to face greater exposure to increasing risks from climate change and be more vulnerable to negative climate-related impacts.
3. Climate change–related impacts are likely to reproduce or expand social inequalities in Nebraska without new policy interventions related to housing, workplace protections, and energy.
4. Climate justice requires that all communities be meaningfully and equitably involved in planning for the transitions necessary to adapt to unstoppable climate changes underway and reduce emissions to prevent more extreme future changes.

Adaptation and resilience options and opportunities

Strategy CJ1: Increase community involvement and empowerment.

Climate resilience within Nebraska can be improved through actively involving and empowering vulnerable and marginalized communities in adaptation planning and decision-making. Developing policies that ensure these communities have a platform to voice their concerns and priorities fosters inclusive solutions that reflect diverse needs. Incorporating local knowledge and perspectives into policy development strengthens the relevance and effectiveness of strategies and builds trust and collaboration. Empowering communities in this way enhances their capacity to adapt to climate challenges while ensuring equitable and sustainable outcomes for all.

Example state actions

- CJ1-1: Identify and prioritize communities disproportionately affected by climate change and historically underserved in resource allocation. Use mapping tools and data to develop equitable criteria for recognizing these communities and creating opportunities for their inclusion in state planning and program development.
- CJ1-2: Develop a public engagement plan to capture and prioritize experiences, perspectives, ideas, and strategies most important to community members disproportionately affected by environmental and climate change impacts.
- CJ1-3: Establish mechanisms to empower community members and organizations to participate in appropriate state agency processes.

Example local government and public power actions

- CJ1-4: Establish sustained outreach and engagement efforts that seek to build and maintain direct relationships with under-resourced, traditionally marginalized, and climate-vulnerable populations within the community. Organize regular community meetings focusing on different demographics and locations to address climate action concerns and build awareness of opportunities for the community.
- CJ1-5: Provide education and resources about climate risks to the public, especially those most vulnerable to the potential impacts of high heat and extreme weather.
- CJ1-6: Support the capacity of neighborhood and community groups to implement climate mitigation and adaptation initiatives.

Strategy CJ2: Prioritize targeted investment in vulnerable communities.

Prioritizing investments in infrastructure, housing, and energy efficiency improvements in vulnerable, low-income, and minority communities can strengthen Nebraska's climate resilience. Expanding programs like the Weatherization Assistance Program (WAP) reduces energy burdens, improves living conditions, and promotes affordability. Additionally, creating green spaces and implementing climate-resilient infrastructure in these areas can enhance environmental and social benefits while mitigating climate impacts. To ensure equity, policies should prevent displacement, allowing communities to directly benefit from these improvements. By addressing systemic inequalities, such targeted investments build stronger, more resilient communities while advancing environmental justice.

Example state actions

- CJ2-1: Prioritize state investment and support local government investment in projects and programs that explicitly address climate change impacts and support new or ongoing access to health, safety, job opportunities, natural and cultural resources, and a better quality of life in underserved and overburdened communities.
- CJ2-2: Expand and accelerate weatherization and efficiency improvements for vulnerable communities. Explore revisions to funding and prioritization formulas for the Weatherization Assistance Program (WAP) to ensure distribution equitably addresses impacts, resilience, mitigation opportunity, and support of vulnerable communities where funding is most needed and can have the greatest impact.
- CJ2-3: Commit resources to develop working relationships, information exchange, and trust between agencies and underserved and overburdened communities affected by climate adaptation planning and implementation processes.
- CJ2-4: Examine the socioeconomic impacts of climate change on local communities and identify opportunities to provide climate change adaptation assistance.

Example local government and public power actions

- CJ2-5: Explore the development of one or more Green Zones, a place-based policy initiative aimed at improving health and supporting economic development using environmentally conscious efforts in communities that face the cumulative effects of environmental pollution, as well as social, political, and economic vulnerability.
- CJ2-6: Explore opportunities to broaden the community's economic base with diversification initiatives, such as targeting the development of emerging clusters or industries that build on the region's unique assets and competitive strengths and provide stability during downturns that disproportionately impact any single cluster or industry.
- CJ2-7: Develop a transparent and inclusive decision-making framework designed to achieve climate, equity, safety, health, and prosperity goals.

Strategy CJ3: Increase equitable access to resilience, clean energy, and jobs.

Climate resilience within Nebraska can be enhanced by increasing equitable access to clean energy, resilience resources, and economic opportunities. Promoting the clean energy transition ensures benefits such as job creation, reduced pollution, and lower energy costs are shared equitably. This includes investing in training and employment opportunities for workers from disadvantaged communities in the clean energy sector and ensuring public utilities and renewable energy projects prioritize fair labor practices and community benefits. Additionally, addressing the rising costs of insurance—exacerbated by climate impacts—through subsidies, expanded coverage options, or risk reduction strategies can protect vulnerable populations from financial strain. Together, these efforts create a more inclusive and resilient economy while fostering environmental and social equity.

Example state actions

- CJ3-1: Improve enforcement of worker-related environmental protections and create protections for state employees where absent.
- CJ3-2: Establish a consortium of experts, including groups such as the Western Governors Association, to evaluate options for addressing the rapidly rising insurance cost for businesses, homeowners, and individuals driven by national and regional climate change impacts. Explore options for insurance regulation, incentives, or programs to reduce costs and increase competition.
- CJ3-3: Collaborate with local community leaders, design professionals, developers, and contractors to identify synergistic sustainability, resilience, and mitigation strategies that meet larger climate goals while supporting housing availability, affordability, and workforce development.
- CJ3-4: Promote and support affordable housing in safe areas across the state (e.g., by providing incentives and removing obstacles to building affordable housing in lower-risk areas).
- CH3-5: Establish incentives to support clean energy installations serving under-served and vulnerable communities.

Example local government and public power actions

- CJ3-6: Explore establishing an incentive or cost-sharing program to reduce the costs of solar PV for income-qualified homeowners.
- CJ3-7: Coordinate with partners, including local unions, to develop and promote job training programs to equip individuals with valuable, future-oriented skills that contribute to climate resilience while also providing pathways to employment, particularly for those in disadvantaged communities.
- CJ3-8: Conduct a study to Identify economic opportunities possible through climate resilience and mitigation actions, especially those that can provide opportunities for the community's vulnerable populations and advancement of entrepreneurship.
- CJ3-9: Create an Affordable Housing Plan to identify current and future needs for affordable housing, including scenarios anticipating climate immigration and migration potentials.

Part 2: Risk assessment and impact summaries

Water

Climate hazard risk assessments

Table SR 1. Summary of the water and climate hazard risk assessment

HAZARD	CONFIDENCE IN FUTURE CHANGE (Trends + Projections)	IMPACT LEVEL (Sensitivity Summary)	TIMEFRAME	RISK (Confidence x Impact x Timeframe)
Annual Temperatures (Warmer)	Very High	High	Short-term	Very High
Winter Temperatures (Warmer)	Very High	Moderate	Short-term	High
Spring Temperatures (Warmer)	Very High	Moderate	Short-term	High
Summer Temperatures (Warmer)	High	High	Short-term	Very High
Fall Temperatures (Warmer)	Very High	Moderate	Short-term	High
Heat Waves (More intense)	High	High	Medium-term	High
Cold Waves (Fewer)	High	Moderate	Short-term	High
Nighttime Temperature (Warmer)	Very High	Moderate	Short-term	High

HAZARD	CONFIDENCE IN FUTURE CHANGE (Trends + Projections)	IMPACT LEVEL (Sensitivity Summary)	TIMEFRAME	RISK (Confidence x Impact x Timeframe)
Annual Precipitation Changes	Low	High	Not known	Not known
Winter Precipitation (Increased)	High	Moderate	Short-term	High
Spring Precipitation (Increased)	Medium	Moderate	Long-term	Very Low
Summer Precipitation (Decreased)	Medium	High	Long-term	Low
Fall Precipitation Changes	Low	Moderate	Not known	Not known
Extreme Precipitation (Increased)	High	High	Medium-term	High
Drought (Increased)	Medium-High	High	Long-term	Low
Wildfires (Increased)	Medium-High	Low	Long-term	Very Low
Severe Thunderstorms (Increased)	Medium	Low	Long-term	Very Low
Hailstorms (Increased)	High	Low	Long-term	Very Low
Tornado Impacts	Low	Not Known	Not known	Not known
Snow Cover (Decreased)	High	Moderate	Short-term	High

Climate impacts summary

Table SR 2. Summary of the potential climate impacts and adaptation considerations

HAZARD	POTENTIAL IMPACT—SURFACE WATERS	POTENTIAL IMPACT—GROUNDWATER	ADAPTATION CONSIDERATIONS
Annual Temperatures (Warmer)	Warm water temperatures foster the growth of harmful algae blooms (HABs), which can release toxins harmful to aquatic life, livestock, and human health. Algal blooms also reduce oxygen levels in the water, leading to fish kills. Economic impacts may occur in the recreational sector. Longer growing seasons increase demand for irrigation water and impact water quality. Warmer temperatures would contribute to the growth of harmful organisms. Reduced dissolved oxygen levels would harm aquatic life. Smaller volumes of water would lead to higher concentrations of pollutants. Declining water levels due to increased evaporation can reduce the amount of water available for drinking, irrigation, hydropower, and other uses. Evaporation can destroy wetland habitats, leading to the loss of critical ecosystems that provide water filtration, flood control, and habitat for wildlife.	This increases water demand across sectors from agricultural irrigation to urban water use, increasing groundwater demand. More evapotranspiration (ET) will require more supplemental irrigation to produce the same yield and reduced aquifer recharge.	Implement soil cover to reduce temperature and evaporation. Nebraska Natural Resource District (NRD) regulations limit the amount of water pumped from aquifers, limiting the impact on groundwater levels. Create deep pools in streams for cool-water aquatic life.

HAZARD	POTENTIAL IMPACT—SURFACE WATERS	POTENTIAL IMPACT—GROUNDWATER	ADAPTATION CONSIDERATIONS
Heat Waves/Extremely Hot Temperatures (More intense)	Declining water levels due to increased evaporation can reduce the amount of water available for drinking, irrigation, hydropower, and other uses. Warm water temperatures foster the growth of HABs, which can release toxins harmful to aquatic life, livestock, and human health. Algal blooms also reduce oxygen levels in the water, leading to fish kills. As water levels decline, pollutants such as agricultural runoff, industrial waste, and wastewater become more concentrated, further degrading water quality and making it more expensive to treat for safe use. Higher water temperatures reduce the amount of dissolved oxygen in the water, which can stress or kill fish, amphibians, and other aquatic species. Wetlands, which rely on stable water levels, are particularly vulnerable to evaporation. This can lead to the loss of critical ecosystems that provide water filtration, flood control, and habitat for wildlife. Low stream flows can disrupt the habitats of fish and other aquatic species that rely on consistent water levels for breeding, feeding, and migration.	More ET, requiring more supplemental irrigation to produce the same yield, and reduced aquifer recharge. Extreme heat increases water demand across sectors, from agricultural irrigation to urban water use, placing additional stress on already limited water supplies.	Implement soil cover to reduce temperature and evaporation. Nebraska NRD regulations limit the amount of water pumped from aquifers and limit the impact on groundwater levels. Create deep pools in streams for cool-water aquatic life.
Cold Waves/Extremely Cold Temperatures (Fewer)	This creates more favorable conditions for invasive species. This will impact lake-mixing regimes and accelerate lake evaporation.	Less snow and more rain will result in lower groundwater recharge rates.	Not identified

HAZARD	POTENTIAL IMPACT—SURFACE WATERS	POTENTIAL IMPACT—GROUNDWATER	ADAPTATION CONSIDERATIONS
Nighttime Temperatures (Warmer)	Warm water temperatures foster the growth of HABs, which can release toxins harmful to aquatic life, livestock, and human health. Economic impacts to the recreational sector. Growth of harmful organisms. Reduce dissolved oxygen levels and harm aquatic life. Concentrate pollutants in smaller volumes of water. Declining water levels due to increased evaporation can reduce the amount of water available for drinking, irrigation, hydropower, and other uses. Loss of wetland habitats from evaporation can lead to the loss of critical ecosystems that provide water filtration, flood control, and habitat for wildlife. Warmer nights can alter the temperature and flow of rivers and streams (fish stress and mortality, altered species distribution, decreased biodiversity).	More ET, requiring more supplemental irrigation to produce the same yield and reducing aquifer recharge.	Creating deep pools in streams for cool-water aquatic life.

HAZARD	POTENTIAL IMPACT—SURFACE WATERS	POTENTIAL IMPACT—GROUNDWATER	ADAPTATION CONSIDERATIONS
Winter Temperatures (Warmer)	Warmer winter and changes in precipitation (reduced snowpack, more precipitation as rain) result in less recharge and more flooding. Later ice-in and earlier ice-out dates have impacts on aquatic ecosystems. With more rainfall and earlier snowmelt, nutrient-rich runoff from agricultural and urban areas can enter rivers and lakes more quickly, leading to eutrophication and HABs. Rapid runoff can carry more sediment, pollutants, and contaminants into water bodies, degrading water quality and increasing the cost of water treatment for drinking supplies. As winter temperatures rise, water bodies may warm earlier in the year, reducing dissolved oxygen levels and affecting aquatic ecosystems. Warmer water can also promote the growth of pathogens and algae, further affecting water quality. A potential benefit may be less salt application on roads. Many aquatic species, such as fish, rely on specific seasonal flow patterns for spawning and habitat. Altered streamflow can disrupt these patterns, harming ecosystems that depend on predictable water availability.	Warming winters disrupt the natural recharge of groundwater, which relies on slow snowmelt and infiltration into soils.	Use soil health best practices to reduce field runoff of nutrients and chemicals, thereby improving soil water-holding capacity and infiltration. Maintain and expand wetland acres for water quality and flood protection. Manage excess flows through diverting or pumping into off-channel wetlands or lakes for groundwater recharge. Maintain and improve levees and other flood protection. Implement riparian buffers to reduce erosion and filter contaminants.

HAZARD	POTENTIAL IMPACT—SURFACE WATERS	POTENTIAL IMPACT—GROUNDWATER	ADAPTATION CONSIDERATIONS
Winter Temperatures (Warmer)	Many reservoirs are designed to capture snowmelt over a period of time, but warmer winters can lead to earlier and faster runoff. Managing water storage can become more difficult, as reservoir operators must balance flood control with the need to store water for future use. This would have impacts to surface water irrigation availability.	Not identified	Not identified
Spring Temperatures (Warmer)	Longer growing seasons increase the demand for irrigation water and impact water quality. Ice conditions combined with winter melt and spring precipitation can contribute to flooding.	This can cause an earlier start to the growing season, higher ET values, reduced soil moisture, an increased need for supplemental irrigation beginning earlier in the season, and reduced aquifer recharge.	Use soil health best practices to reduce field runoff of nutrients and chemicals and improve soil water holding capacity and infiltration. Maintain and expand wetland acres for water quality and flood protection. Manage excess flows by diverting or pumping into off-channel wetlands or lakes for groundwater recharge. Maintain and improve levees and other flood protection. Implement riparian buffers to reduce erosion and filter contaminants.

HAZARD	POTENTIAL IMPACT—SURFACE WATERS	POTENTIAL IMPACT—GROUNDWATER	ADAPTATION CONSIDERATIONS
Summer Temperatures (Warmer)	Declining water levels due to increased evaporation can reduce the amount of water available for drinking, irrigation, hydropower, and other uses. Wetlands could dry up earlier, impacting wildlife habitat. Contribute to an increased risk of wildfire.	This may cause higher ET values, requiring more supplemental irrigation to produce the same yield and reduce aquifer recharge.	Nebraska NRD regulations limit the amount of water pumped from aquifers, limiting the impact on groundwater levels. Use soil cover to reduce temperature and evaporation. Create deep pools in streams for cool-water aquatic life.
Annual Precipitation (Increased)	Changing flow conditions and water quality impacts would result.	Beneficial groundwater recharge would occur if allowed to infiltrate.	Use soil health best practices to reduce field runoff of nutrients and chemicals and improve soil water holding capacity and infiltration. Maintain and expand wetland acres for water quality and flood protection. Manage excess flows by diverting or pumping into off-channel wetlands or lakes for groundwater recharge.
Winter Precipitation (Increased)	Increased potential for large flood events.	If soil is frozen, more rainfall will run off, with decreased recharge. If the soil stays unfrozen, there will be potential for more recharge.	Minimize pre-season agrichemical application through precision application in-season. Use soil health best management practices to reduce field runoff of nutrients and chemicals and improve soil water-holding capacity and infiltration. Use additional agriculture conservation practices.

HAZARD	POTENTIAL IMPACT—SURFACE WATERS	POTENTIAL IMPACT—GROUNDWATER	ADAPTATION CONSIDERATIONS
Spring Precipitation (Increased)	Increased potential for large flood events.	Increase in spring soil moisture, possibly increasing aquifer recharge. Increased potential for more leaching and runoff of early applied fertilizers and other agrichemicals, degrading surface and groundwater quality.	Minimize pre-season agrichemical application through precision application in-season. Maintain and expand wetland acres for water quality and flood protection. Use soil health best management practices to reduce field runoff of nutrients and chemicals, improve soil water holding capacity and infiltration. Use additional agriculture conservation practices.
Summer Precipitation (Decreased)	Reduced streamflow and reservoir refilling.	Decreased soil moisture values and increased need for supplemental irrigation to produce the same crop yield could result in lower groundwater levels.	Nebraska NRD regulations limit the amount of water pumped from aquifers, limiting the impact on groundwater levels. Use soil health best management practices to improve soil water holding capacity and infiltration. Plant native landscape species that require less irrigation.
Fall Precipitation (Decreased)	Reduced streamflows and reservoir refilling.	Less potential for aquifer recharge. Longer landscape irrigation season, increasing total groundwater use.	Use soil health best management practices to improve soil water holding capacity and infiltration. Plant native landscape species that are more drought tolerant.

HAZARD	POTENTIAL IMPACT—SURFACE WATERS	POTENTIAL IMPACT—GROUNDWATER	ADAPTATION CONSIDERATIONS
Extreme Precipitation (Increased)	Greater erosion and runoff damaging agricultural and other land would occur, as would water quality impacts due to sediments, nutrients, and other pollutant runoff. There could be fluctuations in river and stream flow. There would be additional risks of flooding and damage or failure of dams and levees. Runoff contributes to the warming of water resources, impacting cold-sensitive species and the biological integrity of rivers and streams. River travel would be more unsafe or unsuitable. Additional risk of damage to infrastructure and agriculture. Property damage costs and associated costs of recovery would rise. Impacts to wetland hydrology.	Precipitation would be delivered too quickly to infiltrate and recharge the groundwater system.	Use soil health best practices to reduce field runoff of nutrients and chemicals and improve soil water holding capacity and infiltration. Maintain and expand wetland acres for water quality and flood protection. Implement additional agriculture conservation practices. Manage excess flows by diverting or pumping into off-channel wetlands or lakes for groundwater recharge. Maintain and improve levees and other flood protection. Use riparian buffers to reduce erosion and filter contaminants. Upgrade urban stormwater infrastructure.

HAZARD	POTENTIAL IMPACT—SURFACE WATERS	POTENTIAL IMPACT—GROUNDWATER	ADAPTATION CONSIDERATIONS
Drought (Increased)	Reduce flow to hydroelectric power generation sites. Increase fluctuations in river and stream flows. Impacts to wetland hydrology. Cause a loss of habitat areas for species that depend on wetland ecosystems. Reduced natural filtration capacity would lead to poorer water quality downstream. Lower water volumes would concentrate pollutants in rivers, lakes, and reservoirs, making water unsafe for drinking, recreation, or agriculture. Increased temperatures in water bodies can exacerbate pollution and algal blooms, creating unhealthy conditions for aquatic life and making water unsafe for drinking, recreation, and wildlife. The loss of habitats and food sources for fish and other wildlife could lead to declining biodiversity. Vegetation loss, especially in riparian zones, reduces habitat for wildlife and can contribute to soil erosion.	Decreased groundwater recharges from rivers and lakes. Decreased soil moisture values with an increased need for supplemental irrigation to produce the same crop yield, likely resulting in lower groundwater levels.	Nebraska NRD regulations limit the amount of water pumped from aquifers and limit the impact on groundwater levels. Use soil health best practices to improve soil water holding capacity and infiltration. Plant native landscape species that require less irrigation.

HAZARD	POTENTIAL IMPACT—SURFACE WATERS	POTENTIAL IMPACT—GROUNDWATER	ADAPTATION CONSIDERATIONS
Drought (Increased)	Disrupt Indigenous communities and local populations that rely on water bodies for fishing, agriculture, or cultural practices. Reduced opportunities for recreational activities like boating, swimming, and fishing may affect the quality of life and local economies. Increase legal and political conflicts over water rights, tensions between urban and rural users, or upstream and downstream communities, and cross-border disputes over shared rivers.	Not identified	Not identified
Wildfires (Increased)	Burned areas include wetland resources, reducing recreational utility in burned and immediate post-burn years while resources recover. Wildfires can degrade water quality by increasing sediment, ash, and pollutants in water supplies. Water is often diverted for firefighting efforts, straining limited resources even further. Long-term loss of vegetation affects watershed health and can lead to more erosion and poorer water infiltration	Not identified	Not identified
Hailstorms (Increased)	Deterioration in water quality in rivers, lakes, and reservoirs due to the sudden influx of debris and contaminants. Increased crop damage, leading to increased loading of debris and sediment from agricultural landscapes.	This may degrade groundwater quality with excess agrichemicals not taken up by damaged crops, increasing leaching risk.	Minimize pre-season agrichemical application through precision application in-season.

Energy

Climate hazard risk assessment

Table SR 3. Summary of the energy and climate hazard risk assessment

HAZARD	CONFIDENCE IN FUTURE CHANGE (Trends + Projections)	IMPACT LEVEL (Sensitivity Summary)	TIMEFRAME	RISK (Confidence x Impact x Timeframe)
Annual Temperatures (Warmer)	Very High	Low	Short-term	Moderate
Winter Temperatures (Warmer)	Very High	Low	Short-term	Moderate
Spring Temperatures (Warmer)	Very High	Low	Short-term	Moderate
Summer Temperatures (Warmer)	High	Moderate	Short-term	High
Fall Temperatures (Warmer)	Very High	Low	Short-term	Moderate
Heat Waves (More intense)	High	High	Medium-term	High
Cold Waves (Fewer)	High	Low	Short-term	Moderate
Nighttime Temperature (Warmer)	Very High	Low	Short-term	Moderate
Extreme Precipitation (Increased)	High	High	Medium-term	High
Drought (Increased)	Medium-High	Moderate	Long-term	Low

HAZARD	CONFIDENCE IN FUTURE CHANGE (Trends + Projections)	IMPACT LEVEL (Sensitivity Summary)	TIMEFRAME	RISK (Confidence x Impact x Timeframe)
Wildfires (Increased)	Medium-High	High	Long-term	Low
Severe Thunderstorms (Increased)	Medium	High	Long-term	Low
Hailstorms (Increased)	High	High	Long-term	Moderate
Tornado Impacts	Low	High	Not known	Not known

Climate impacts summary

Table SR 4. Summary of the potential impacts on energy

HAZARD	POTENTIAL IMPACT #1	POTENTIAL IMPACT #2	ADAPTATION CONSIDERATIONS
Annual Temperatures (Warmer)	Reduced efficiency of thermal energy systems	Slightly reduced efficiency of solar PV systems	Not identified
Heat Waves/ Extremely Hot Temperatures (More intense)	Reduced efficiency of thermal energy systems	Rising peak demand for cooling	Testing for availability during extreme temperatures
Cold Waves/ Extremely Cold Temperatures (Fewer)	Ice risk to thermal power systems	Ice risk to transmission and distribution systems	Testing for availability during extreme temperatures
Nighttime Temperatures (Warmer)	Reduced efficiency of thermal energy systems	Not identified	Not identified
Winter Temperatures (Warmer)	Reduced efficiency of thermal energy systems	Not identified	Not identified

HAZARD	POTENTIAL IMPACT #1	POTENTIAL IMPACT #2	ADAPTATION CONSIDERATIONS
Spring Temperatures (Warmer)	Reduced efficiency of thermal energy systems	Not identified	Not identified
Summer Temperatures (Warmer)	Reduced efficiency of thermal energy systems	Not identified	Not identified
Fall Temperatures (Warmer)	Reduced efficiency of thermal energy systems	Not identified	Not identified
Extreme Precipitation (Increased)	Flood risk to thermal power systems	Not identified	Not identified
Drought (Increased)	Water availability risk for thermal power systems	Water temperature risk for thermal power systems	Not identified
Wildfires (Increased)	Risk to all generation, transmission, and distribution facilities	Not identified	Prepare for disruptions with robust grid system
Hailstorms (Increased)	Large hail is a risk to solar facilities and other energy infrastructure	Not identified	Not identified
Tornado Events	Risk to all generation, transmission, and distribution facilities	Not identified	Prepare for disruptions with robust grid system

Ecosystems

Climate hazard risk assessment

Table SR 5. Summary of the ecosystem and climate hazard risk assessment

HAZARD	CONFIDENCE IN FUTURE CHANGE (Trends + Projections)	IMPACT LEVEL (Sensitivity Summary)	TIMEFRAME	RISK (Confidence x Impact x Timeframe)
Annual Temperatures (Warmer)	Very High	High	Short-term	Very High
Winter Temperatures (Warmer)	Very High	High	Short-term	Very High
Spring Temperatures (Warmer)	Very High	High	Short-term	Very High
Summer Temperatures (Warmer)	High	High	Short-term	Very High
Fall Temperatures (Warmer)	Very High	High	Short-term	Very High
Heat Waves (More intense)	High	High	Medium-term	High
Cold Waves (Fewer)	High	High	Short-term	Very High
Nighttime Temperatures (Warmer)	Very High	High	Short-term	Very High
Annual Precipitation Changes	Low	High	Not known	Not known

HAZARD	CONFIDENCE IN FUTURE CHANGE (Trends + Projections)	IMPACT LEVEL (Sensitivity Summary)	TIMEFRAME	RISK (Confidence x Impact x Timeframe)
Winter Precipitation (Increased)	High	High	Short-term	Very High
Spring Precipitation (Increased)	Medium	High	Long-term	Low
Summer Precipitation (Decreased)	Medium	High	Long-term	Low
Fall Precipitation Changes	Low	High	Not known	Not known
Extreme Precipitation (Increased)	High	High	Medium-term	High
Drought (Increased)	Medium-High	High	Long-term	Low
Wildfires (Increased)	Medium-High	High	Long-term	Low
Severe Thunderstorms (Increased)	Medium	Moderate	Long-term	Very Low
Hailstorms (Increased)	High	Moderate	Long-term	Low
Tornado Impacts	Low	Not Known	Not known	Not known
Snow Cover (Decreased)	High	High	Short-term	Very High

Climate impacts summary

Table SR 6. Summary of the potential impacts on ecosystems

HAZARD	POTENTIAL IMPACT #1	POTENTIAL IMPACT #2	ADAPTATION CONSIDERATIONS
Annual Temperatures (Warmer)	Changes in animal phenology	Not identified	Not identified
Heat Waves/ Extremely Hot Temperatures (More intense)	Exceeds critical thermal maximum for fishes	Not identified	Not identified
Cold Waves/ Extremely Cold Temperatures (Fewer)	Increase in disease	Not identified	Not identified
Nighttime Temperatures (Warmer)	Increased heat stress	Not identified	Not identified
Winter Temperatures (Warmer)	Changes in animal phenology	Not identified	Not identified
Spring Temperatures (Warmer)	Changes in animal phenology	Not identified	Not identified
Summer Temperatures (Warmer)	Changes in animal phenology	Not identified	Not identified
Fall Temperatures (Warmer)	Changes in animal phenology	Not identified	Not identified
Annual Precipitation (Increased)	Increased availability of water depending on timing and magnitude	Not identified	Not identified
Winter Precipitation (Increased)	Changes in animal phenology	Not identified	Not identified

HAZARD	POTENTIAL IMPACT #1	POTENTIAL IMPACT #2	ADAPTATION CONSIDERATIONS
Spring Precipitation (Increased)	Changes in animal phenology	Not identified	Not identified
Summer Precipitation (Decreased)	Changes in animal phenology	Not identified	Not identified
Fall Precipitation (Decreased)	Changes in animal phenology	Not identified	Not identified
Extreme Precipitation (Increased)	Increased flooding and habitat change in streams	Not identified	Not identified
Drought (Increased)	Drying of streams and loss of connectivity	Not identified	Not identified
Wildfire (Increased)	Habitat loss or gain dependent on species	Not identified	Not identified
Hail (Increased)	Reduced survival of nesting birds	Not identified	Not identified
Tornado Events	Unknown impact on wildlife	Not identified	Not identified

Agriculture

Climate hazard risk assessment

Table SR 7. Summary of the agriculture and climate hazard risk assessment

HAZARD	CONFIDENCE IN FUTURE CHANGE (Trends + Projections)	IMPACT LEVEL (Sensitivity Summary)	TIMEFRAME	RISK (Confidence x Impact x Timeframe)
Annual Temperatures (Warmer)	Very High	High	Short-term	Very High
Winter Temperatures (Warmer)	Very High	High	Short-term	Very High
Spring Temperatures (Warmer)	Very High	High	Short-term	Very High
Summer Temperatures (Warmer)	High	High	Short-term	Very High
Fall Temperatures (Warmer)	Very High	High	Short-term	Very High
Heat Waves/ Extremely Hot Temperatures (More intense)	High	High	Medium-term	High
Cold Waves/ Extremely Cold Temperatures (Fewer)	High	High	Short-term	Very High
Nighttime Temperatures (Warmer)	Very High	High	Short-term	Very High
Annual Precipitation Changes	Low	High	Not known	Not known

HAZARD	CONFIDENCE IN FUTURE CHANGE (Trends + Projections)	IMPACT LEVEL (Sensitivity Summary)	TIMEFRAME	RISK (Confidence x Impact x Timeframe)
Winter Precipitation (Increased)	High	Moderate	Short-term	High
Spring Precipitation (Increased)	Medium	High	Long-term	Low
Summer Precipitation (Decreased)	Medium	High	Long-term	Low
Fall Precipitation Changes	Low	High	Not known	Not known
Extreme Precipitation (Increased)	High	High	Medium-term	High
Drought (Increased)	Medium-High	High	Long-term	Low
Wildfires (Increased)	Medium-High	Moderate	Long-term	Low
Severe Thunderstorms (Increased)	Medium	Moderate	Long-term	Very Low
Hailstorms (Increased)	High	Moderate	Long-term	Low
Tornado Impacts	Low	High	Not known	Not known
Snow Cover (Decreased)	High	High	Short-term	Very High

Climate impacts summary

Table SR 8. Summary of the potential impacts on agriculture

HAZARD	POTENTIAL CROP AGRICULTURE IMPACT	POTENTIAL RANGE & LIVESTOCK IMPACTS	ADAPTATION CONSIDERATIONS
Increased intensity and frequency of drought under all emissions scenarios by mid- and late century. Summer drought is more probable than spring drought (Knapp et al., 2023 p. 11). Analysis of 21st century precipitation data in Nebraska points to a trend of fewer but more intensive droughts (Chapter 3).	Impacts on summer annual crop planting and productivity (corn and soybean). More heavy rain in spring complicates or delays planting, while drought in summer during critical growth periods limits yield potential.	Decreasing livestock production and performance due to declining forage availability and quality with increasing drought frequency and intensity during the summer growing season. Increased wildfire risk, potentially negatively affecting cattle operations. Increased water demand to meet physiological requirements of livestock during times of drought. Changes in rangeland plant communities (i.e., forage base) expected, with potential to impact timing and duration of grazing; along with livestock performance and production. Positive feedbacks between invasive annual grasses and fire are expected to increase the wildfire risk for rangelands, impacting livestock production.	Heterogeneity-based rangeland/grassland management practices can reduce risks and impacts of wildlife—for example, pyric herbivory (literally “fire-driven grazing”)—well known to mitigate the negative effects of drought on livestock weight gain compared to traditional, homogenous, management practices. Reducing seeding rates, optimizing irrigation water use, managing residue for water retention, and planting drought-tolerant varieties or more drought-tolerant crops. Efficient irrigation techniques, such as drip irrigation and soil moisture sensors, can help farmers manage water use more effectively, reducing the impact of higher water demands.

HAZARD	POTENTIAL CROP AGRICULTURE IMPACT	POTENTIAL RANGE & LIVESTOCK IMPACTS	ADAPTATION CONSIDERATIONS
Greater variability in precipitation is very likely to increase in spring, with uncertain change in summer. Across the region, an increase in the heaviest 1% of rainfall days by 24% (Knapp et al., 2023, p. 9; Marvel et al., 2023, fig 2.8 pp. 2–19). The most extreme rainfall events (more than 2 inches per day) are expected to increase across central and eastern Nebraska, especially in the Southeast (Chapter 4). Analysis of 21st century precipitation data in Nebraska points to a lower frequency of extreme precipitation events in summer compared to spring and fall (Chapter 3)	Impacts on summer annual crop planting and productivity (corn and soybean). More heavy rain in spring complicates or delays planting, while drought in summer during critical growth periods limits yield potential.	Not identified	More frequent application of inputs can reduce environmental and profit losses, that is, split application of nitrogen. Residue management can provide erosion prevention and cool soil temperatures in warmer conditions. Shifting planting timing and planting shorter season crops or alternative crops could avoid crop water stress with more variable rainfall. Growing a variety of crops, especially those tolerant to waterlogged conditions, can help farmers spread risk and reduce the overall impact of extreme rainfall on their operations. Installing more effective drainage systems, such as retention ponds or drainage ditches, can help manage excess water and prevent flooding.

HAZARD	POTENTIAL CROP AGRICULTURE IMPACT	POTENTIAL RANGE & LIVESTOCK IMPACTS	ADAPTATION CONSIDERATIONS
There is greater uncertainty in annual precipitation trends compared to temperature trends given Nebraska's intercontinental location and climate. Precipitation is projected to increase in winter and spring, with decreases in summer and no consistent trend for directionality of fall precipitation (Chapter 4). Most climate divisions in Nebraska have seen a short-term decrease in summer precipitation (Chapter 3).	If summer drought increases, it could impact summer annual crops in reproductive or water-critical growth stages. Lower precipitation or drought in fall could impact fall planting conditions and lead to unreliable establishment of winter annual crops.	Forage nutritive value is expected to go down (i.e., %N•kg-2), with increased biomass production from higher rainfall and atmospheric CO_2, with potential for malnutrition in livestock (nutrient dilution effect). Rainfall timing is expected to shift grassland plant communities.	Including more winter annual or cool-season crops in rotation optimizes rainfall utilization: the main crop is harvested before summer drought, and more use of different types of crops diversifies risk of rainfall variability. Disturbances to promote landscape heterogeneity Change animal grazing timing, kin and class of animal, or multispecies grazing to capitalize on changing forage quality in time. Increasing range biodiversity has the potential to improve soil, for example, the relationship between prairie dogs and water infiltration.
Aridity is expected to increase, specifically with an eastward shift of demarcation between a humid east and arid west (Knapp et al., 2023, p. 9).	A potential for shifts and decreases in productivity for a new demarcation line (i.e. central Nebraska), specifically in non-irrigated cropland, with more strain on groundwater resources for irrigated cropland.	Reduced livestock production is expected with increased aridity, via decreased forage productivity. Increased aridity might decrease woody plant cover and invasion, limiting the total area that might be tree dominated as landscapes become more water limited.	This is a more challenging shift for crop production, especially in the east, which may require considering alternative crops that are more drought tolerant, and/or more drought-tolerant varieties of corn, soybean, and wheat. Consider lowering stocking rates to accommodate increasing aridity and subsequent declines in forage production across the state. Consider changing the kind and class of animal to those that are better suited to changing aridity and humidity.

HAZARD	POTENTIAL CROP AGRICULTURE IMPACT	POTENTIAL RANGE & LIVESTOCK IMPACTS	ADAPTATION CONSIDERATIONS
Annual peak streamflow decreased in the west and increased in the east from 1961 to 2020. Larger negatives observed in southwest Nebraska, with slight increases in eastern Nebraska (Knapp et al., 2023, Fig 25.4).	Peak streamflow is a proxy for flooding, which could indicate a potential increase in eastern Nebraska (in addition to shifts in rainfall variability).	Decreased water availability in riparian habitats is likely to negatively impact livestock production in western Nebraska or increase the potential for overgrazing in sensitive riparian ecosystems as arid systems become more water limited.	Many well-known soil management practices can improve soil hydrology and reduce runoff, including conservation tillage, planting cover crops, and residue management. Optimize irrigation resources. Diversify crops or shift to more drought-tolerant options. Lower stocking rates to accommodate fluctuations in streamflow and water availability. Reduce restrictions to animal movement and increase total available area to overcome increased spatial variability in water resources over time.
Decreased runoff is expected from the Colorado River basin, with increased evaporative demand (Knapp et al., 2023, p. 11). Decreasing snowpack and snowmelt runoff are projected (Knapp et al., 2023, p. 9; Coles et al., 2017).	Increased evaporative demand could decrease summer soil moisture. This could increase pressure on groundwater and available irrigation resources, making growing season precipitation even more important and can lead crops to be more vulnerable to drought.	Not identified	Not identified

HAZARD	POTENTIAL CROP AGRICULTURE IMPACT	POTENTIAL RANGE & LIVESTOCK IMPACTS	ADAPTATION CONSIDERATIONS
Average temperatures are projected to increase by 5–6°F by the end of the century, or up to 11.5°F under the high emissions scenario. The number of extremely hot days (90°F or higher) is likely to be two to four times larger than during the historical period. Days above 100°F could increase to over 50 days per year (fewer than 10 in the historical period) (Chapter 4). The number of days with a minimum temperature above freezing increased from 1991 to 2000 compared to 1951–1980 (Chapter 3). Most locations in Nebraska have had record warm temperature months since 2000 (Chapter 3, Figure 12).	Temperature stress decreases photosynthesis. This impacts growth and development in corn; water stress is expected to shift to temperature stress after mid-century. There is potential for an increase of winter annual weeds and overwinter pests with fewer frost-free days. This expands the growing season with a related impact of a shift or increase in plant hardiness zones in the state (USDA FSA, 2023).	Cool-season grass productivity could decrease, with the potential for increased reliance on warm-season grasses for forage (which may also be subject to summer drought risk). Domestic livestock will face increased energetic demand because of increased temperature—e.g., cattle start to show symptoms of heat stress at temperatures over 80°F. Livestock movements could be more restricted to parts of the landscape with high soil moisture or standing water—riparian zones, around water tanks, etc.	Diversify crops and minimize summer annual crops, use more drought- and heat-tolerant varieties of corn, soy, and wheat. For livestock, improved ventilation and cooling systems, such as fans, sprinklers, and shade structures, can help animals cope with higher nighttime temperatures and reduce heat stress.

HAZARD	POTENTIAL CROP AGRICULTURE IMPACT	POTENTIAL RANGE & LIVESTOCK IMPACTS	ADAPTATION CONSIDERATIONS
Fewer very cold days could occur (Knapp et al., 2023, pp. 8–9; Marvel et al., 2023, Fig 2.7 pp. 2–18).	Pests that typically die in the winter could survive and cause more damage (i.e., increased winter annual weeds, expanded pathogens).	This could positively impact livestock production, reducing losses due to extreme low temperatures and snowfall. The livestock production schedule (e.g., calving timing, grazing rotation schedules, etc.) that is usually timed in accordance with weather conditions is expected to change.	A risk of increased pests necessitates best management practices such as scouting and timely pest management, which could interfere with vernalization requirements of cool-season crops.
There could be increased wildfire potential, with a longer fire season and decline in the number of snow-cover days (Knapp et al., 2023, p. 13).	A decline in snow-cover days impacts survival of winter pests. It also creates opportunity from an expanded growing season.	The distribution of invasive annual grasses is expected, which will in turn increase fire frequency. Forage availability for livestock may be reduced (i.e., more is burned). Coupled with drought, this will reduce the livestock production capacity of Nebraska rangelands.	Utilize grazing systems that capitalize on increased forage quality following fire (pyric herbivory), but at moderate (i.e., 20–25% harvest use efficiency) stocking rates to avoid steep declines in range condition and heterogeneity.
Hail may increase in frequency and intensity, with the largest projected increases anticipated in summer (July). (Knapp et al., 2023, p. 10)	Potential damage to winter and summer annual crops is expected, plus the potential for increased crop insurance payouts.	Not identified	Diversifying crops could avoid summer water-related stress and damages.

HAZARD	POTENTIAL CROP AGRICULTURE IMPACT	POTENTIAL RANGE & LIVESTOCK IMPACTS	ADAPTATION CONSIDERATIONS
Atmospheric CO_2 increases (USGCRP, 2023).		This is expected to accelerate a shift from grass-dominated to woody-plant-dominated landscapes across Nebraska, with effects being the strongest in the mesic parts of the state (>700 mm rainfall).	Change kind and class of livestock to capitalize on changes to the forage base. Increase the use and frequency of prescribed fire to improve forage conditions and utilize grazing management practices that capitalize on vegetation recovery (and high forage quality) immediately following fire.

Human Health

Climate hazard risk assessment

Table SR 9. Summary of the human health and climate hazard risk assessment

HAZARD	CONFIDENCE IN FUTURE CHANGE (Trends + Projections)	IMPACT LEVEL (Sensitivity Summary)	TIMEFRAME	RISK (Confidence x Impact x Timeframe)
Annual Temperatures (Warmer)	Very High	Moderate	Short-term	High
Heat Waves/ Extremely Hot Temperatures (More intense)	High	High	Medium-term	High
Nighttime Temperatures (Warmer)	Very High	High	Short-term	Very High
Extreme Precipitation (Increased)	High	High	Medium-term	High
Drought (Increased)	Medium-High	High	Long-term	Low
Wildfires (Increased)	Medium-High	Moderate	Long-term	Low

Climate impacts summary

Table SR 10. Summary of the potential impacts on human health

HAZARD	POTENTIAL IMPACT #1	POTENTIAL IMPACT #2	ADAPTATION CONSIDERATIONS
Annual Temperatures (Warmer)	Change in vector-borne and zoonotic disease due to changing seasons, ecology, and so on.	Not identified	Implement better surveillance of vectors and related diseases. Improve education regarding risks and prevention measures.
Heat Waves/ Extremely Hot Temperatures (More intense)	Increase in heat-related illnesses.	Increases in other negative health outcomes (e.g., cardiovascular diseases, respiratory diseases, mental health impacts)	Increase green spaces and heat-reducing features in urban areas. Improve weatherization and energy efficiency in under-resourced and vulnerable communities. Improve access to cooling centers. Improve messaging regarding heat-health risks for populations with greater vulnerability and risk and increased education regarding behavioral modifications. Encourage development of heat action plans in communities and cities across the state.
Nighttime Temperatures (Warmer)	Increase in heat-related illnesses.	Increases in other negative health outcomes (e.g., cardiovascular diseases, respiratory diseases, mental health impacts).	Increase green spaces and heat-reducing features in urban areas. Improve weatherization and energy efficiency in under-resourced and vulnerable communities. Improve access to 24-hour cooling centers. Improve messaging regarding nighttime heat-health risks for populations with greater vulnerability and risk and education regarding nighttime behavior modifications (e.g., cool sleep, sleep hygiene tips).

HAZARD	POTENTIAL IMPACT #1	POTENTIAL IMPACT #2	ADAPTATION CONSIDERATIONS
Extreme Precipitation (Increased)	Increase in flood-related illnesses and injuries (e.g., drowning, respiratory impacts from mold, mental health outcomes).	Risk of contaminated water sources leading to increased risk of gastrointestinal illnesses.	Implement better surveillance for injury and other flood-related health outcomes, including increased use of syndromic surveillance for flood events. Improve messaging around flood-related health risks and contaminated drinking water. Encourage development of community flood action plans. Improve community preparedness, including educating residents about evacuation route planning and having emergency water and power supplies. Implement community tetanus vaccination campaigns semi-annually. Develop post-flood vector control plans. Offer immediate and long-term mental health support.
	Disruptions to the healthcare system and healthcare access.	Not identified	Improve health system resilience to floods (e.g., elevated power source and back-up generators, waterproof barriers). Improve transportation system resilience to floods (e.g., improve road and bridge infrastructure to maintain emergency vehicle access). Deploy mobile health clinics. Expand telehealth services.

Communities and the Built Environment

Climate hazard risk assessment

Table SR 11. Summary of the communities and the built environment and climate hazard risk assessment

HAZARD	CONFIDENCE IN FUTURE CHANGE (Trends + Projections)	IMPACT LEVEL (Sensitivity Summary)	TIMEFRAME	RISK (Confidence x Impact x Timeframe)
Annual Temperatures (Warmer)	Very High	Moderate	Short-term	High
Heat Waves (More intense)	High	High	Medium-term	High
Annual Precipitation Changes	Low	Low	Not known	Not known
Extreme Precipitation (Increased)	High	High	Medium-term	High
Drought (Increased)	Medium-High	Moderate	Long-term	Low
Wildfires (Increased)	Medium-High	High	Long-term	Low
Severe Thunderstorms (Increased)	Medium	High	Long-term	Low
Hailstorms (Increased)	High	High	Long-term	Moderate
Tornado Impacts	Low	High	Not known	Not known

Climate impacts summary

Table SR 12. Summary of the potential impacts on communities and the built environment

HAZARD	POTENTIAL IMPACT #1	POTENTIAL IMPACT #2	ADAPTATION CONSIDERATIONS
Heat waves/Extremely Hot Temperatures (More intense)	Health, lives	Energy, infrastructure	Services to disadvantaged populations, Infrastructure improvement
Annual Precipitation (Increased)	Infrastructure	Human activities	Monitoring, design standards
Extreme Precipitation (Increased)	Lives, property	Infrastructure, transportation	Land-use planning, zoning, design standard, public education
Drought (Increased)	Economy, health	Infrastructure	Water infrastructure, water conservation education
Wildfire (Increased)	Lives	Property	Warning system, evacuation plan
Hail (Increased)	Property	Human activities	Insurance
Tornado Events	Property, lives	Infrastructure	Design standards, building codes

Indigenous Peoples

Climate hazard risk assessment

Table SR 13. Summary of the Indigenous peoples and climate hazard risk assessment

HAZARD	CONFIDENCE IN FUTURE CHANGE (Trends + Projections)	IMPACT LEVEL (Sensitivity Summary)	TIMEFRAME	RISK (Confidence x Impact x Timeframe)
Annual Temperatures (Warmer)	Very High	Moderate	Short-term	High
Winter Temperatures (Warmer)	Very High	Low	Short-term	Moderate
Spring Temperatures (Warmer)	Very High	Low	Short-term	Moderate
Summer Temperatures (Warmer)	High	Moderate	Short-term	High
Fall Temperatures (Warmer)	Very High	Low	Short-term	Moderate
Heat Waves/ Extremely Hot Temperatures (More intense)	High	High	Medium-term	High
Cold Waves/ Extremely Cold Temperatures (Fewer)	High	Low	Short-term	Moderate
Nighttime Temperatures (Warmer)	Very High	High	Short-term	Very High
Annual Precipitation Changes	Low	Moderate	Not known	Not known

HAZARD	CONFIDENCE IN FUTURE CHANGE (Trends + Projections)	IMPACT LEVEL (Sensitivity Summary)	TIMEFRAME	RISK (Confidence x Impact x Timeframe)
Winter Precipitation (Increased)	High	Moderate	Short-term	High
Spring Precipitation (Increased)	Medium	High	Long-term	Low
Summer Precipitation (Decreased)	Medium	Moderate	Long-term	Very Low
Fall Precipitation Changes	Low	Moderate	Not known	Not known
Extreme Precipitation (Increased)	High	High	Medium-term	High
Drought (Increased)	Medium-High	High	Long-term	Low
Wildfires (Increased)	Medium-High	High	Long-term	Low
Severe Thunderstorms (Increased)	Medium	Moderate	Long-term	Very Low
Hailstorms (Increased)	High	Moderate	Long-term	Low
Tornado Impacts	Low	High	Not known	Not known

Climate impacts summary

Table SR 14. Summary of the potential impacts on Indigenous peoples

HAZARD	POTENTIAL IMPACT #1	POTENTIAL IMPACT #2	ADAPTATION CONSIDERATIONS
Annual Temperatures (Warmer)	Disruption in cultural resource availability	Interference with ceremonial practices	Vulnerability assessment Climate adaptation plan
Heat Waves/ Extremely Hot Temperatures (More intense)	Exacerbated negative health outcomes	Interference with ceremonial practices	Vulnerability assessment Climate adaptation plan
Cold Waves/ Extremely Cold Temperatures (Fewer)	Disruption in cultural resource availability	Interference with ceremonial practices	Vulnerability assessment Climate adaptation plan
Nighttime Temperatures (Warmer)	Exacerbated negative health outcomes in summer	Not identified	Educational awareness Enhanced local health services
Winter Temperatures (Warmer)	Disruption in cultural resource availability	Interference with ceremonial practices	Vulnerability assessment Climate adaptation plan
Spring Temperatures (Warmer)	Disruption in cultural resource availability	Interference with ceremonial practices	Vulnerability assessment Climate adaptation plan
Summer Temperatures (Warmer)	Disruption in cultural resource availability	Interference with ceremonial practices	Vulnerability assessment Climate adaptation plan
Fall Temperatures (Warmer)	Disruption in cultural resource availability	Interference with ceremonial practices	Vulnerability assessment Climate adaptation plan
Annual Precipitation (Increased)	Disruption in cultural resource availability	Interference with ceremonial practices	Vulnerability assessment Climate adaptation plan
Winter Precipitation (Increased)	Elevated flood risk, condition-dependent	Not identified	Local environmental condition tracking Flood insurance assessment and education

HAZARD	POTENTIAL IMPACT #1	POTENTIAL IMPACT #2	ADAPTATION CONSIDERATIONS
Spring Precipitation (Increased)	Elevated flood risk, condition-dependent	Not identified	Environmental condition tracking =Flood insurance assessment and education
Summer Precipitation (Decreased)	Disruption in cultural resource availability	Interference with ceremonial practices	Vulnerability assessment Climate adaptation plan
Fall Precipitation (Decreased)	Disruption in cultural resource availability	Interference with ceremonial practices	Vulnerability assessment Climate adaptation plan
Extreme Precipitation (Increased)	Disruption in cultural resource availability	Interference with ceremonial practices	Vulnerability assessment Climate adaptation plan
Drought (Increased)	Water security	Not identified	Drought plan
Wildfire (Increased)	Exacerbated negative health outcomes	Infrastructure damage	Strengthen community-based air quality alert systems Increase household air quality mitigation measures
Hail (Increased)	Infrastructure damage	Amplified community housing shortage	Provision of pathways for hazard insurance New construction design for increased hazard resilience
Tornado Events	Infrastructure damage	Amplified community housing shortage	Provision of pathways for hazard insurance New construction design for increased hazard resilience

Climate Justice and Equity

Climate hazard risk assessment

Table SR 15. Summary of the climate justice and equity and climate hazard risk assessment

HAZARD	CONFIDENCE IN FUTURE CHANGE (Trends + Projections)	IMPACT LEVEL (Sensitivity Summary)	TIMEFRAME	RISK (Confidence x Impact x Timeframe)
Annual Temperatures (Warmer)	Very High	Moderate	Short-term	High
Heat Waves/ Extremely Hot Temperatures (More intense)	High	High	Medium-term	High
Cold Waves/ Extremely Cold Temperatures (Fewer)	High	Low	Short-term	Low
Nighttime Temperatures (Warmer)	Very High	Low	Short-term	Moderate
Extreme Precipitation (Increased)	High	High	Medium-term	High
Drought (Increased)	Medium-High	Moderate	Long-term	Low
Wildfires (Increased)	Medium-High	High	Long-term	Low
Hailstorms (Increased)	Medium	Moderate	Long-term	Very Low
Tornado Events (Increased)	High	Moderate	Long-term	Low
Extreme Precipitation (Increased)	Low	High	Not known	Moderate

Climate impacts summary

Table SR 16. Summary of the potential impacts on climate justice and equity

HAZARD	POTENTIAL IMPACT #1	POTENTIAL IMPACT #2	ADAPTATION CONSIDERATIONS
Annual Temperatures (Warmer)	Increased energy burdens.	Increased air conditioning use undermining emissions reductions.	Expand and accelerate weatherization and efficiency improvements for vulnerable communities. Ensure building codes address extreme weather risks.
Heat Waves/ Extremely Hot Temperatures (More intense)	Increased health risk to vulnerable workers.	Increased health risk in vulnerable communities.	Improve enforcement of worker-related environmental protections and create protections for state employees where absent. Address land-use and infrastructure that are disproportionate risks for minority and low-income communities. Expand and accelerate weatherization and efficiency improvements for vulnerable communities. Increase access to cooling centers. Ensure building codes address extreme weather risks.
Nighttime Temperatures (Warmer)	Increased health risks to vulnerable households.	Not identified	Expand and accelerate weatherization and efficiency improvements for vulnerable communities. Expand cooling center availability and hours in at-risk communities.
Spring Temperatures (Warmer)	Increased health risks to vulnerable households.	Not identified	Not identified
Summer Temperatures (Warmer)	Increased health risks to vulnerable households.	Not identified	Not identified
Fall Temperatures (Warmer)	Increased health risks to vulnerable households.	Not identified	Not identified

HAZARD	POTENTIAL IMPACT #1	POTENTIAL IMPACT #2	ADAPTATION CONSIDERATIONS
Extreme Precipitation (Increased)	Reductions in affordable housing.	Disproportionate exposure and impact on vulnerable communities with increased racial and class inequalities.	Improve zoning and create equitable managed retreat plans. Improve equity in disaster planning and response policies. Regulate insurance costs and provide competition from public insurance.
Drought (Increased)	Losses for agricultural communities.	Not identified	Diversify rural economies to be less dependent on commodity crop monocultures by equitably sharing benefits of climate mitigation strategies.
Wildfire (Increased)	Strains on rural community resources.	Exacerbation of air-quality-related illnesses.	Manage fire risk. Reduce sources of additional respiratory disease vulnerability.
Hail (Increased)	Reductions in affordable housing.	Disproportionate exposure and impact on vulnerable communities with increased racial and class inequalities.	Regulate insurance costs and provide competition from public insurance. Ensure building codes address extreme weather risks. Improve equity in disaster planning and response policies.
Tornado and High Wind Events (Increased)	Reductions in affordable housing.	Disproportionate exposure and impact on vulnerable communities with increased racial and class inequalities.	Regulate insurance costs and provide competition from public insurance. Ensure building codes address extreme weather risks. Improve equity in disaster planning and response policies. Increase electrical grid resiliency, for example, with distributed generation and storage.