Arizona Climate Impacts and Costs

The climate crisis is accelerating in Arizona, posing increased risks and burdening residents with the costs of adapting to a rapidly changing environment. Arizona will experience increasing drought conditions, hotter temperatures, and changes to precipitation patterns in the coming years.[1] Even if fossil fuel emissions and atmospheric concentrations of greenhouse gasses eventually stabilize through climate action, the severity of these events will continue to rise as we adjust to the new reality of the climate crisis. Below we outline the impacts of climate change Arizona faces and some of the potential costs associated with these impacts. This list is not exhaustive and other costs may be incurred as a result of additional climate change impacts.

Drought

Arizona is one of the driest states in the nation, receiving an average of 13 inches of annual precipitation. Average annual precipitation has decreased by 0.92 inches per decade from 1991-2020, which has caused a prolonged drought since 1994.[2] [3] According to NOAA's National Centers for Environmental Information, drought was the second most expensive natural disaster — costing at least $249 billion — in the U.S. over the last three decades.[4] While further changes in average annual precipitation are uncertain in Arizona, springtime precipitation is projected to decrease. Further, droughts that do occur are projected to become more intense during the cool season, as increasing temperatures increase evapotranspiration (transfer of water from plants and soil into the atmosphere).[5]

Drought causes water security issues, which will impact a majority of water resources, both local and imported.[6] Lake Mead — a reservoir fed by the Colorado River — supplies 36% of Arizona's water. Lake Mead is threatened by decreased snowpack[7] and its elevation has dropped over 150 feet (71% decline in volume) since 2000.[8] In both 2022 and 2023, the federal government declared a water shortage for Lake Mead that reduced the amount of water available to Arizona.[9] These water shortages are predicted to increase in frequency due to climate change,[10] prompting a deal in May 2023 between Arizona, Nevada, and

[1] EPA, "What Climate Change Means for Arizona." https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-az.pdf
[2] EPA, "Saving Water in Arizona." https://19january2017snapshot.epa.gov/www3/watersense/docs/arizona_state_fact_sheet.pdf
[3] "Climate." https://azclimate.asu.edu/climate/
[4] Adam Smith, "2010-2019: A landmark decade of U.S. billion-dollar weather and climate disasters," 2020. http://www.climate.gov/news-features/blogs/beyond-data/2010-2019-landmark-decade-us-billion-dollar-weather-and-climate.
[5] NOAA, "Arizona State Climate Summary." https://statesummaries.ncics.org/downloads/Arizona-StateClimateSummary2022.pdf
[6] Negin Ashoori, David Dzombak, and Mitchell Small, "Sustainability Review of Water-Supply Options in the Los Angeles Region," *Journal of Water Resources Planning and Management* 141, no. 12 (December 1, 2015): A4015005. https://doi.org/10.1061/(ASCE)WR.1943-5452.0000541.
[7] Gibson and Jones, "Clark County, Nevada: Climate Vulnerability Assessment." https://allinclarkcounty.com/resources/ID_59/Documents/CC_CVA_FINAL_LR.pdf
[8] "Water Shortages"; Hannoun and Tietjen, "Lake Management under Severe Drought." https://www.snwa.com/water-resources/drought-and-shortage/index.html; https://onlinelibrary.wiley.com/doi/full/10.1111/1752-1688.13090
[9] ibid
[10] ibid

California to conserve Colorado River water.[11] As a part of this deal, Arizona will have to cut its Lake Mead water use by 21%.[12]

Worsening drought conditions due to climate change in Arizona increase the risk and occurrence of wildfires,[13] impacting human health and air quality. A study from Climate Central shows that Arizona experiences between 44 and 55 more fire weather days each year compared to the 1970s, depending on location.[14] Springtime wildfires have now become the norm in Arizona. In 2022, an early season fire destroyed 25 buildings and burned more than 19,700 acres of land.[15] The Environmental Protection Agency estimates the cost nationwide to treat long-term health impacts from exposures to wildfire and wildfire generated air pollution is $450 billion. The same analysis estimated that short-term exposure (2008-2012) led to premature death and hospitalizations totaling $63 billion.[16] Wildfires are also costly to fight and control. Fire suppression — which includes expenditure on aviation, vehicles, and fire crew — cost the U.S. $3.7 billion in 2022.[17] From 2018-2022, Arizona had 9,598 wildfires that burned over 2.1 million acres of land. On average, the cost of putting out a wildfire is $74,409.[18] Since 1980, the U.S. has experienced an increasing number of wildfires that cost over $1 billion per event. These large wildfires cost the U.S. $13.2 billion per year from 2018-2022, significantly more money than in the 1980s where there were no billion dollar wildfires in the U.S (CPI adjusted).[19]

Not only are fires costly to fight, residents and workers are often forced to evacuate, disrupting lives and work.[20] In 2022, the Contreras fire forced astronomers to evacuate from their workplace at the Kitt Peak National Observatory.[21] Wildfires have become so severe in California that some major insurance companies have pulled out of the home insurance

[11] Bush, "Three States Agree to Reduce Water Usage so the Colorado River Doesn't Go Dry." https://www.nbcnews.com/science/science-news/arizona-california-nevada-cut-water-usage-drought-hit-colorado-river-rcna85567
[12] Krol, "Feds Cut Colorado River Allocation for Nevada, Arizona in 2023." https://www.rgj.com/story/news/2022/08/16/colorado-river-allocation-nevada-arizona-2023-drought/10342794002/
[13] Scasta, Weir, and Stambaugh, "Droughts and Wildfires in Western U.S. Rangelands." https://www.sciencedirect.com/science/article/pii/S0190052816300256
[14] "Wildfire Weather: Analyzing the 50-Year Shift across America." https://assets.ctfassets.net/cxgxgstp8r5d/1RwlNCKT1zYQFz5NtKW9ue/9a843df6ca96446b1f507a1acabfe0bc/FINAL-Fire_Weather_2023__EN_.pdf
[15] Healy, "Arizona Wildfires Seize on Chaotic Winds and Parched Forests." https://www.nytimes.com/2022/04/20/us/wildfire-arizona-flagstaff-tunnel.html
[16] Jesse Roman, Angelo Verzoni, and Scott Sutherland, "The Wildfire Crisis: Greetings from the 2020 Wildfire Season," *National Fire Protection Association Journal*, 2020. http://www.nfpa.org/News-and-Research/Publications-and-media/NFPA-Journal/2020/November-December-2020/Features/Wildfire.
[17] Jennifer L, "Wildfires Cost Over $148B and 30% of Emissions," Carbon Credits, January 30, 2023. https://carboncredits.com/wildfires-cost-emissions/; Western Fire Chiefs Association, "What Is the Financial Cost of a Wildfire?," December 7, 2022. https://wfca.com/articles/cost-of-wildfires/.
[18] Bishop, "Wildfire Statistics." https://www.valuepenguin.com/homeowners-insurance/wildfire-statistics
[19] NOAA, "U.S. Billion-Dollar Weather and Climate Disasters" https://www.ncei.noaa.gov/access/billions/
[20] Murphy, "Hundreds Are Forced to Evacuate From Western Arizona Wildfire." https://www.nytimes.com/2021/04/26/us/kingman-wildfire-pine-lake-arizona.html
[21] Bohra, "Arizona Wildfire Destroys Observatory Buildings." https://www.nytimes.com/2022/06/19/us/wildfire-arizona-kitt-peak-observatory.html

market.[22] This could easily become a reality in Arizona as wildfire frequency and severity increase.

Potential Costs Related to Drought

Water Management

- Purchase of water during water-scarce times.[23]
- Public health costs related to increased exposure to water-borne illnesses.[24]
- Replace old pipelines and related infrastructure that have water leak issues.[25]
- Building water conservation infrastructure.
- Upgrade water treatment, wastewater treatment, and other energy infrastructure.[26]
- "Maintain and expand urban and community tree canopy and support ongoing efforts to expand drought-tolerant trees."[27]
- Maintenance of sufficient outflow from Lake Mead (and other drinking water reservoirs) to ensure water quality and quantity.[28]

Wildfires

- Increase fire suppression, including staffing, equipment, and aviation.
- Rebuild or relocate damaged properties and public infrastructure, such as homes and utility lines.
- Relocate public infrastructure where necessary.
- Update power lines to withstand dust from wildfires.
- Implement fire mitigation strategies for the future like burying utility lines underground.
- Plan for and disburse community aid after wildfires.
- Implement fire detection strategies, like solar-powered sensors.[29]
- Rehabilitate the landscape post-fire to reduce the risk of erosion and invasive species and mitigate future fire risk.
- Increased hospitalization costs for asthma attacks and other chronic health conditions (resulting from decreased air quality due to wildfire smoke).

Local planning and regulation

- Organize public participation and staffing in the creation of water scarcity management plans.[30]

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[22] The Associated Press, "Surge in U.S. Thunderstorms" https://www.cbc.ca/news/business/swiss-re-insurance-damage-1.6932920
[23] Zoë Roller et al., "Closing the Water Access Gap in the United States: A National Action Plan," Dig Deep and US Water Alliance, 2022. https://static1.squarespace.com/static/5e80f1a64ed7dc3408525fb9/t/6092ddcc499e1b6a6a07ba3a/1620237782228/Dig-Deep_Closing-the-Water-Access-Gap-in-the-United-States_DIGITAL_compressed.pdf.
[24] ibid
[25] CISA, "Drought and Infrastructure - A Planning Guide" https://www.cisa.gov/sites/default/files/publications/Drought_and_Infrastructure_A_Planning_Guide_508c.pdf
[26] ibid
[27] Gibson and Jones, "Clark County, Nevada: Climate Vulnerability Assessment."
[28] Hannoun and Tietjen, "Lake Management under Severe Drought." https://onlinelibrary.wiley.com/doi/full/10.1111/1752-1688.13090
[29] Jennifer L, "Wildfires Cost Over $148B" https://carboncredits.com/wildfires-cost-emissions/
[30] CISA, "Drought and Infrastructure - A Planning Guide"

- Develop tools for monitoring ground and surface water resources for public use.[31]

Education and awareness programs

- Public education, outreach, and awareness campaigns about water conservation.[32]
- Increase public outreach to encourage wildfire risk management; educate residents in wildfire safety, technical assistance availability, funding sources, and best practices.

Summary of Costs from Drought:

Fire prevention and recovery, water security and water treatment, infrastructure damages, public health, and education and awareness.

Temperature Extremes

Climate change will cause more extreme temperatures in Arizona. Average annual temperatures in Arizona have increased by about 2°F over the past century[33] and are projected to increase an additional 3.5 to 9.5°F by the end of the century.[34] Extreme heat poses threats to infrastructure and labor. A recent study concludes that increased temperature in Arizona will lead to 3 times more mechanical failures to power infrastructure.[35] Further, labor losses of about $1.7 million annually due to extreme heat have recently been attributed to climate change, and these losses are projected to increase due to climate change.[36]

July 2023 was the hottest month in the history of global temperature records,[37] and the World Weather Attribution group showed that this extreme heatwave was made much more likely by climate change.[38] Phoenix, Arizona, experienced 31 days in a row of temperatures at or above 110°F. In Maricopa County, nearly 500 people died from heat-related illness this past summer. Sadly, 122 of those deaths occurred indoors where air conditioning was either not present or not working.[39] According to the Center for Climate Integrity, Arizona will face over $138 million in climate-driven school cooling costs by 2025, impacting almost one

[31] ibid
[32] ibid
[33] EPA, "What Climate Change Means for Arizona."
[34] Garfin et al., "Ch. 20."
https://nca2014.globalchange.gov/downloads/low/NCA3_Full_Report_20_Southwest_LowRes.pdf
[35] Burillo, Chester, and Ruddell, "Electric Grid Vulnerabilities to Rising Air Temperatures in Arizona."
https://www.sciencedirect.com/science/article/pii/S1877705816301801
[36] Zhang and Shindell, "Costs from Labor Losses Due to Extreme Heat in the USA Attributable to Climate Change."
https://link.springer.com/article/10.1007/s10584-021-03014-2
[37] NASA, "July 2023 Was the Hottest Month on Record."
https://earthobservatory.nasa.gov/images/151699/july-2023-was-the-hottest-month-on-record#:~:text=July%202023%20was%20hotter%20than,said%20GISS%20Director%20Gavin%20Schmidt.
[38] Zachariah et al., "Extreme Heat in North America, Europe and China in July 2023 Made Much More Likely by Climate Change."
https://spiral.imperial.ac.uk/bitstream/10044/1/105549/8/Scientific%20Report%20-%20Northern%20Hemisphere%20Heat.pdf
[39] Chow, "Arizona's Maricopa County Shatters Record for Heat Deaths."
https://www.nbcnews.com/science/science-news/arizonas-maricopa-county-shatters-record-heat-deaths-rcna122478

million students.[40] Extreme heat and associated public health impacts will only get worse as the climate crisis accelerates.

Potential Costs Related to Temperature Extremes

Structure and Infrastructure Projects

- Energy efficiency retrofits in public and private buildings and housing, including costs for the design and development of energy efficiency standards.
- Increased cooling costs for all public buildings, including green roofs or cool roofing systems on public buildings and new AC installation or upgrade costs for schools.
- Increased road damage and repair due to more frequent extreme heat events.
- Plan for and increase capacity for increased energy demands due to both increased daytime and nighttime temperatures.
- Upgrade electric infrastructure to avoid mechanical failure by using thermal resistant parts and smart grid power flow controls.[41]
- Remove turf and replace it with trees for water conservation and to counter heat islands.[42]
- Increase high-albedo surfaces on buildings, roads, or where feasible.[43]
- "Implement heat reduction strategies including, shade structures, cool pavements, and cool roofs, at parks and recreational sites."[44]

Public Health Projects

- Build and manage more cooling centers, including staffing and tracking of high-risk individuals.
- Formalize a network of well-resourced mobile crisis intervention services to engage communities of concern during emergency and non-emergency situations.[45]
- Increased demand for publicly financed air conditioning targeted to low income families and public housing.
- Control the increase of vector borne illness — education and physical and chemical controls for ticks and mosquitos.
- Treat victims of vector borne illness.
- Treat victims of heat induced illness.
- Increase in asthma attacks requiring hospitalization (resulting from increased heat and ground level ozone, and the increase in airborne allergens).
- Reduce the urban heat island effect by planting trees.
- Protect drinking water supplies from hazardous algae blooms.

[40] Center for Climate Integrity, "Hotter Days, Higher Costs: The Cooling Crisis in America's Classrooms." Center for Climate Integrity, 2021. https://coolingcrisis.org.
[41] Burillo, Chester, and Ruddell, "Electric Grid Vulnerabilities to Rising Air Temperatures in Arizona."
[42] Gibson and Jones, "Clark County, Nevada: Climate Vulnerability Assessment."
[43] Sen et al., "Cool Pavement Strategies for Urban Heat Island Mitigation in Suburban Phoenix, Arizona." https://www.mdpi.com/2071-1050/11/16/4452
[44] ibid
[45] ibid

Summary of Costs from Temperature Extremes:

Public health costs (e.g., medicare/medicaid), AC installation and improvement where needed, establishing new cooling centers, planting trees to reduce urban heat islands, and protecting drinking water supplies.

Flooding and Water Quality – Extreme Precipitation and Decreased Snowpack

Precipitation in Arizona varies from year to year, impacting streamflow and snowpack. In Arizona, surface water runoff and soil erosion due to climate change induced extreme precipitation events is projected to increase by up to 92% by 2050 as compared to 1970-1999.[46] As the atmosphere warms and holds more water, the monsoon season poses an ever-increasing threat to Arizona residents. Intense thunderstorms during monsoon season often cause flash flooding, which can be life-threatening.[47] Flooding is also exacerbated in areas recently burned by wildfires.[48] In developed and dry areas — like Phoenix and Tucson — soil compaction (shrinking) during drought and soil expansion (swelling) during extreme storms can cause damage to homes, sidewalks, pipelines, and streets.[49]

Increasing temperatures also cause earlier snow melt, and more precipitation in the form of rain instead of snow. Arizona primarily gets its water from the Colorado River and other surface waters and receives the largest share of Colorado River water among the southwest states.[50] Similar to drought, reduced snowpack and an earlier melting cause many impacts to drinking water quantity and quality. As a result of a combination of factors, including climate change, Arizona has begun restricting population growth in some areas due to a concern that there will not be enough water for residents.[51]

Potential Costs Related to Flooding and Water Quality

Structure and Infrastructure Projects

- Remove, relocate, acquire, or demolish structures to minimize future flood losses.
- Install, reroute, increase capacity, or implement a routine cleaning plan of the storm drainage system.
- Add extra culverts, increase dimensions of existing culverts, or implement routine cleaning and repairing.
- Install detention or retention basins, relief drains, spillways, drain widening/dredging or rerouting, etc.
- Inspect and maintain drainage systems and flood control structures (dams, levees, etc.).

[46] Zhang et al., "Modeling Climate Change Effects on Runoff and Soil Erosion in Southeastern Arizona Rangelands and Implications for Mitigation with Conservation Practices." https://www.jswconline.org/content/67/5/390
[47] Heyward, "Monsoon Rains Wash Cars off the Road in Arizona, with Warnings of More Flash Floods to Come." https://www.nytimes.com/2021/07/22/us/arizona-flooding.html
[48] Anthes, "How Megafires Are Remaking the World." https://www.nytimes.com/2023/10/15/science/climate-wildfires-ecosystems.html
[49] Arizona Geological Survey, "Problem Soils." https://azgs.arizona.edu/center-natural-hazards/problem-soils
[50] McNabb and Swenson, "Water Crisis in the Southwest." https://link.springer.com/chapter/10.1007/978-3-031-27380-3_10
[51] ibid

- Inspect bridges in order to identify and/or implement repairs or retrofits or clean under low bridges.
- Resurface roads with more permeable pavement and concrete.
- Avoid soil compaction during development and construction by limiting heavy construction equipment, adding high permeable sediments (e.g., sand), and/or limiting the removal of vegetation.[52]
- Restore soils post-construction using ripping techniques or adding soil organic matter to increase soil permeability.[53]
- Elevate roads and bridges above the base flood elevation (BFE)[54] to maintain dry access.
- Elevate structures above the BFE, or relocate utilities, water heaters, etc. above BFE.
- Floodproof inside of municipal buildings, for example by installing check valves, sump pumps, or backflow prevention devices.
- Floodproof wastewater treatment facilities located in flood hazard areas.
- Floodproof water treatment facilities located in flood hazard areas.
- Protect emergency operations by requiring or moving all emergency operations centers, police stations, and fire department facilities outside of flood-prone areas.
- Protect critical and emergency facilities by requiring all critical facilities be built one foot above the 500-year flood elevation (to meet requirements of FEMA Executive Order 11988).[55]
- Protect critical and emergency facilities from floods using any other technique, for example, raising components above BFE, installing pumping systems or back-up generators for pumping, building dikes, or stabilizing banks.

Natural Flood Mitigation

- Protect and enhance natural floodplain mitigation features or install green infrastructure to help prevent flooding.
- Implement new rangeland management policies and practices to adapt to increase soil erosion and runoff.[56]

Water Management

- Please refer to "Water Management" costs from the Drought section, as they also apply to decreased water quantity and quality from reduced snowpack.

Local Planning and Regulation

- Update flood risk maps and flood zones.
- Develop a floodplain management plan.
- Adopt a stormwater management or drainage plan.
- Adopt, apply, and enforce building codes to ensure buildings can withstand flooding.

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[52] "Low Impact Development in Northern Nevada." https://extension.unr.edu/publication.aspx?PubID=3418
[53] ibid
[54] Base flood elevation (BFE), as defined by FEMA, is "the elevation of surface water resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year."
[55] Federal Emergency Management Agency, "Executive Order 11988: Floodplain Management," www.fema.gov/executive-order-11988-floodplain-management.
[56] Zhang et al., "Modeling Climate Change Effects on Runoff and Soil Erosion in Southeastern Arizona Rangelands and Implications for Mitigation with Conservation Practices." https://www.jswconline.org/content/67/5/390

- Obtain easements to use privately-owned land for temporary water retention and drainage.
- Join or improve compliance with the National Flood Insurance Program (NFIP).[57]
- Preserve floodplains as open space using any of several land use planning tools: develop a plan that targets hazard areas for acquisition, reuse, and preservation; a land banking program; use of transfer of development rights to keep floodplains vacant; easements to prevent development; or acquiring properties in the floodplain and turning them into open space.

Education and awareness programs

- Increase public outreach to encourage flood insurance purchase; educate residents in flood safety, flood mitigation, technical assistance availability, funding sources, and best practices.
- Locate new utilities and critical facilities outside of susceptible areas.
- Identify, map, or track erosion hazard areas.

Summary of Costs from Flooding and Water Quality

Floodproof buildings, relocate infrastructure in especially flood prone areas, improve drainage systems and flood control structures, elevate infrastructure (buildings, roads, and bridges) where needed, restore natural flood protection, develop and implement comprehensive flood management plans, preserve floodplains, and increase public awareness of flooding.

Other Extreme Weather

Since 1980 severe weather has cost U.S. taxpayers more than $1.75 trillion.[58] Winter storms and freezes are other extreme weather events that are likely to impact Arizona.

Potential Costs Related to Other Extreme Weather

Structure and infrastructure projects

- Increased costs of storm recovery and clean-up.
- Protect power lines through pruning trees.
- Bury overhead power lines or install systems that allow small sections of power lines to fail rather than the complete system.

Other Public Health Costs

Other plausible impacts from climate change that would incur public health costs are increased allergen levels, food- and waterborne infections, and zoonotic diseases.[59]

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[57] U.S. Federal Emergency Management Agency (FEMA), The National Flood Insurance Program (NFIP), at www.fema.gov/national-flood-insurance-program Policy Information by State (https://nfipservices.floodsmart.gov//reports-flood-insurance-data), accessed September 26, 2023; Nevada has over 9,500 policies covering over $2.5 billion.
[58] Environmental Defense Fund, "Arizona and the Rising Cost of Extreme Weather." https://www.edf.org/sites/default/files/content/DatuOnePager%20Arizona.pdf
[59] Carmen Milanes et al., "Indicators of Climate Change" https://oehha.ca.gov/media/epic/downloads/04treemortality.pdf