

DECEMBER 2024

WORCESTER, MASSACHUSETTS

WINTER CLIMATE ADAPTATION



Prepared for



The City of
WORCESTER

Prepared by

**HASSAN DAJANA
CAMILA GOMEZ**



WPI

COMMUNITY CLIMATE
ADAPTATION PROGRAM

SUMMARY

Winter Climate Change Trends

Climate change is transforming winter conditions in Worcester, Massachusetts, resulting in warmer winters and shifting precipitation patterns, resulting in less predictable weather. Historically, winter precipitation tended to fall as snow. Now, projections indicate that rising temperatures will increasingly turn what might have been snowfall into rain or freezing rain. These rising winter temperatures will lead to wetter winters with more intense snowstorms due to the atmosphere's enhanced capacity to hold moisture. Past trends (2000 - 2024) and future projections (2030 - 2090) under both moderate (RCP 4.5) and high (RCP 8.5) greenhouse gas scenarios show a clear upward trend in winter temperatures and total precipitation, reinforcing the likelihood of fewer days at or below freezing and more mixed-precipitation events. Variable Factors such as the polar vortex and jet stream shifts add to the unpredictability of winter storms. Climate change is reshaping these winter conditions in Worcester, Massachusetts, and these changes have many long-lasting implications for the city's infrastructure, vulnerable populations, and emergency preparedness.

Infrastructure Vulnerabilities

Infrastructure in Worcester, such as stormwater drains, roads, vegetation, electric utilities, and telecommunication networks, face multiple climate-related stresses. Heavier winter rains may cause more runoff, especially if it occurs over frozen ground, leading to overburdened drainage systems and increased flood risks. Roads are damaged by freeze-thaw cycles, leading to cracks and potholes. The City of Worcester and National Grid have collaborated on vegetation management - reducing power outages through systematic tree trimming. However, heavy snow and ice accumulation on trees threaten power lines and properties with an increased risk of road blockages. While undergrounding power lines could enhance grid resilience, high installation costs remain a barrier. Another pressing issue is telecommunication network reliability. Broadband internet connectivity is vital for residents and emergency responders, yet many reported losing internet access during severe winter weather events.

Social Vulnerabilities

Social vulnerabilities will be amplified under changing winter conditions. Non-English speakers or newcomers face difficulties understanding severe weather warnings and preparedness measures. Their unfamiliarity with winter conditions can lead to inadequate preparation, heightening their risk during extreme events. The elderly and disabled populations confront their challenges, including clearing sidewalks and driveways after snow or ice storms. This can be very challenging, raising the risks of isolation and injury and negatively impacting their accessibility and mobility. Although Worcester has a list of organizations that offer seasonal assistance for such tasks, awareness and accessibility of these resources need improvement. Ensuring every resident can access help, including those not easily reached through digital communications, is crucial as storms become more variable and intense. People who experience homelessness are especially vulnerable, as exposure to severe cold and ice may lead to serious health risks. Shelter capacity in Worcester is often insufficient to meet the demands during harsh winter conditions. Emergency shelters and warming centers are available, but with the homeless population expected to rise, the city must identify additional resources and strategies to ensure safe refuge for people experiencing homelessness.

Furthermore, disruptions to social services like schools can have ripple effects throughout the community. Unplanned school closures are more likely as severe winter storms become intense and less predictable. Such closures disproportionately affect lower-income families who depend on school meals and may have limited childcare options if they work outside the home. Even short closures can strain household resources, forcing parents and caregivers to choose between income and care responsibilities. Over time, these disruptions can exacerbate educational inequalities and stress community resilience.

RECOMMENDATIONS FOR INFRASTRUCTURE VULNERABILITIES

Drainage systems

Review the stormwater and combined sewer systems to manage the expected increased winter rainfall. Worcester is currently developing its Stormwater System and Green Infrastructure Master Plan. We recommend the city incorporate the impact of increased runoff from impervious surfaces and the increased precipitation in the rain on the stormwater management system during the winter months. Additional analysis could review the increased runoff coefficient in the winter and identify which areas might be most affected to modify the capacity to handle high volumes if necessary. Successful adaptation requires assessing the drainage system's capacity to handle winter storm runoff. If runoff exceeds design limits, additional measures like permeable surfaces or infrastructure upgrades would be needed to prevent flooding.

Investigate incorporating permeable surfaces in areas prone to flooding. Incorporating permeable surfaces in Worcester can significantly reduce runoff from increased winter rainfall. Permeable materials, such as porous asphalt and pervious concrete, allow water to infiltrate directly into the ground rather than overflowing the stormwater system. These materials facilitate water absorption, decreasing the runoff volume and reducing the risk of flooding. Successful adaptation requires running a pilot program comparing the frequency of flooding events before and after in piloted areas where these materials were utilized.

Evaluate incorporating bioretention systems for stormwater flooding. Bioretention systems, such as bioswales and rain gardens, are vegetated basins that can treat and control stormwater runoff. They can protect low-lying vulnerable areas from flooding. The design of these systems reduces peak flows and water velocity from intense rain during storm events. They can be implemented in urban areas, roadways, and parking lots. The city is running a pilot Sustainable Yard Design initiative at four properties to mitigate flooding. This initiative is one such example of a nature-based solution to reduce the risk of flooding, and we recommend incorporating these initiatives in more flood-prone places around the city.

Roads

Assess the incorporation of eco-friendly deicing agents. The city's current road pretreatment and snow-clearing process involves using salt, pretreated salt, and sand to treat roads during storms, deploying city resources, and hiring plowers to clear routes afterward. Priority is given to main arteries, with pretreated salts used on roadways with steep slopes. Winter climate change is expected to result in more ice, so incorporating a mixture of salt brine and beet juice as an environmentally friendly deicing agent could be a solution; the sugar content in the beet juice and salt brine reduces the freezing point of water, enabling ice to melt at lower temperatures. Additionally, it would reduce the amount of salt required for deicing, minimizing environmental harm. Further benefits include reduced corrosiveness to roads and vehicles and eco-friendly runoff that does not harm water bodies.

Determine the feasibility of implementing permeable pavement design in future infrastructure projects. We recommend that the city assess the feasibility of permeable pavement designs for roads in future infrastructure projects. Building such pavements would help rainwater infiltrate into the ground and reduce its impacts on roadways. The freeze-thaw cycles could result in the creation of cracks and potholes that might be harmful to the roadway infrastructure. Developing permeable pavement designs would be a proactive long-term adaptation strategy for enhancing the city's resilience.

Consider employing roadway materials that can support rapid temperature fluctuations. To proactively reduce the risk of forming cracks and potholes, we recommend using cold-weather-resistant asphalt that can withstand rapid temperature fluctuations. Using such materials would decrease repair costs and increase the durability of road surfaces.

RECOMMENDATIONS FOR INFRASTRUCTURE VULNERABILITIES

Telecommunication Networks

Evaluate expanding broadband internet options. A single service provider, Spectrum, provides broadband internet in Worcester. Alternative mobile options are available, but the established broadband infrastructure is only available through Spectrum. Expanding broadband infrastructure to include additional providers would enhance the city's resilience, especially for those relying only on broadband connectivity.

Explore the feasibility of having a backup satellite internet service. The city could consider acquiring a satellite-based internet service like Starlink, which could serve as a reliable backup during winter storms. This service could support critical operations, ensure uninterrupted connectivity, and facilitate life-saving services during emergencies.

Electrical Infrastructure

Conduct a cost-benefit analysis of targeted modernizations in areas at high risk. We recommend conducting a cost-benefit analysis to evaluate the possibility of undergrounding power lines in areas highly prone to winter storm impacts. A phased approach could be implemented, prioritizing the most vulnerable areas. While the initial investment may be significant, the long-term benefits, such as fewer outages and improved resilience, will likely outweigh the upfront costs. National Grid is working on its Future Grid Plan, ensuring that Worcester's electrical infrastructure is made more resilient to winter storms through this intervention should be one focus for the city.

Trees

Select tree species that are resistant to ice and heavy snow.

The city of Worcester is currently working on its Urban Forest Master Plan. We recommend incorporating species that are resistant to the effects of ice/snow storms. Of the top 10 types of trees in the city, 17% of trees are sensitive to the impacts of heavy snow and ice (Cherry, Honey locust, Callery Pear and Silver maple), while 36% of trees are resistant from ice and heavy snow (Norway Maple, Littleleaf Linden, Northern White Cedar). Incorporating more resistant species will reduce the risk of storm-related tree damage. However, it is important to note that Maples, particularly Norway Maple, may not be ideal due to their susceptibility as hosts to the Asian long-horned beetle, which has caused significant damage in Worcester.

Continue existing coordination on tree trimming with National Grid.

Worcester has an established coordination mechanism with National Grid, which trims and prunes branches five feet around the power lines. This coordination and communication has effectively minimized power outages caused by tree branch breakage, resulting in fewer disruptions than initially anticipated. We recommend maintaining this effective coordination by conducting regular tree maintenance and implementing tabletop exercises between the city and the National Grid. These exercises could comprise one session at the start of winter to proactively plan and prepare and another at the end of the season to review performance and find ways to improve collective challenges faced.



COURTESY: WORCESTER TELEGRAM/ASHLEY GREEN

RECOMMENDATIONS FOR SOCIAL VULNERABILITIES

Non-English Speaker and Newcomers

Make multilingual emergency information for winter storms more accessible. Worcester has ALERTWorcester, an automated emergency communication system application available in 23 different languages, where the city shares critical information, such as severe weather alerts. However, many residents might not be aware of this app. We recommend creating campaigns to promote this app so newcomers and non-English-speaking community members can access the information disclosed. According to the Worcester Almanac 2023, the languages spoken in the city that are not included in the ALERTWorcester app are Twi, Vietnamese, Arabic, and Albanian. We recommend incorporating these languages into the app.

Update the Emergency Communications website for disaster preparedness. The city of Worcester's Emergency & Communications Management Department currently features disaster preparedness resources under the "Ready.gov - Plan ahead for Disasters" section. While this provides valuable general guidance, we recommend adjusting the content to focus on the specific hazards the city is most likely to experience. According to the MVP Plan, ice/snow storms, floods, and extreme heat are among the most pressing local climate hazards. Updating the website to prioritize these risks will better support resident's preparedness efforts, align with the city's climate resilience goals, and provide timely actionable information that reflects the seasonal nature of these hazards.

Develop and implement education programs on emergency preparedness before, during, and after winter storms. This is crucial for individuals with limited prior experience of winter storm impacts. Key topics could include safe driving practices on icy roads, remaining safe during extended power outages, and utilizing reliable communication channels, apps, and other tools, for timely updates. This information could be disseminated through accessible guides and community workshops. The city's Snow Emergency Guideline provides essential details on winter preparedness, however it is only available in English. Expanding these resources to include translations into multiple languages and incorporating visual aids would ensure inclusivity.

Elderly and Disabled

Build partnerships with college campuses and organizations to increase the number of available volunteers. Elderly and disabled residents would be better equipped to tackle the challenges of winter storms if resources were available to assist them with shoveling to clear their sidewalks and pathways to ensure mobility. The city has some partnerships in place with community organizations and college campuses. However the assistance available is restricted to specific areas and limited volunteers. We recommend building upon the city's existing partnerships. By reaching out to other institutions, more resources could be mobilized to assist older people and people with disabilities in times of need during winter storms, increasing the resilience of these community members to winter storms.

Leverage multi-channel communication strategies to share services. The city shares information about the services to help the elderly and disabled population through its website and applications, and many of the elderly and disabled appear to have limited access to such information available digitally. If the same information is distributed through a multi-channel approach that includes but is not limited to radio, newspapers, libraries, and stores through brochures and pamphlets, it will increase the likelihood of the information reaching the right audience at the right time. It will be beneficial to communities in need.

Unhoused

Expand warming centers. The unhoused population would benefit significantly from increased access to warm places during the winter storms. We recommend designating additional spaces as warming centers across the city to provide refuge during extreme weather events. These centers should offer a warm environment where individuals can protect themselves from harsh winter conditions. To maximize their effectiveness, accessible communication strategies should be implemented to inform the unhoused population about the availability and location of these resources.

RECOMMENDATIONS FOR SOCIAL VULNERABILITIES

School Closures

Evaluate students' food insecurity and partner with community organizations for short-term relief during extended closures. One way to manage this proactively is to coordinate with school officials to identify food-insecure students and let their caregivers know what services and resources they can utilize in their time of need.

Partner with local daycares for temporary childcare. When schools close during winter storms, working parents often face the difficult decision between caring for their children or fulfilling work responsibilities. Establishing or partnering with community organizations for temporary or subsidized daycare services during such times could help parents manage their responsibilities effectively.

Conclusion

The city of Worcester, Massachusetts, is expected to face warmer winters with increased precipitation, predominantly as rain, and more variable and unpredictable winter storms. These shifts will transition from traditional snowfall to freezing rain, sleet, and rain, amplifying challenges like winter flooding due to increased runoff on impervious surfaces. While rising temperatures reduce the probability of snowfall, they also enable the atmosphere to hold more moisture, potentially leading to more intense snowstorms when snow does occur. Additionally, disruptions to internet connectivity are limiting the city's communication infrastructure. Vulnerable populations, including non-English speakers, newcomers, the elderly, disabled, and unhoused individuals, are at heightened risk and require targeted support. School closures during winter storms disrupt education and burden working families. The city has demonstrated proactive leadership through initiatives such as the Green Worcester Sustainability and Resilience Plan, the Stormwater and Green Infrastructure Master Plan, and the Urban Forest Master Plan. Ultimately, the city should use its existing physical infrastructure to adapt to the new weather patterns. It should also develop proactive strategies to cater to its vulnerable residents' needs.

At the top of the list would be better drainage and road maintenance, formulating communications strategies for non-native speakers and newcomers, assisting elderly and disabled residents with snow and ice, and expanding efforts to help people experiencing homelessness.

Further resilience can be achieved by investing in roadway infrastructure improvements, adopting environmentally effective deicing agents, and mobilizing enhanced snow and ice-clearing operations. Such efforts require an all-inclusive and iterative strategy for community planning and development that will make Worcester more resilient, keeping its residents protected and prepared against the impacts of climate change. Worcester has the knowledge, plan, and commitment needed to adapt to the challenges of a changing winter climate. By transforming its strategies into action, the city can emerge as a leader in climate resilience among mid-sized U.S. cities, ensuring its residents' safer, more sustainable future.

Acknowledgments

This research study on winter climate adaptation was developed in collaboration with the city of Worcester's Department of Sustainability and Resilience. It was conducted by Muhammad Hassan Dajana and Camila Gomez Gutierrez, Graduate Students in the Community Climate Adaptation Program at Worcester Polytechnic Institute (WPI). The study was advised by faculty advisors Dr. Stephen McCauley and Dr. Sarah Strauss from the Department of Global and Integrated Studies (DIGS) at WPI. The team worked closely with John Odell, Chief of Sustainability & Resilience, and Luba Zhaurova, Director of Projects, Sustainability, and Resilience, to ensure alignment with the city's goals. The fieldwork, analysis, and report preparation for this study took place between January - December 2024. We are extremely thankful to all the city officials, National Grid representatives, climate experts, community organizations, and residents who participated in our research. We hope this work increases Worcester's resilience to winter climate challenges, making it one of the most climate-resilient mid-sized cities in the US.

Authors contact:

Hassan Dajana: mdajana@wpi.edu

Camila Gomez: cgutierrez@wpi.edu

