Infrastructure Considerations in a Changing Climate

Maria Hart, Climate Change Adaptation Planning Consultant, Founder of Embed Climate and Rob Montgomery, P.E., Chair, Wisconsin Initiative on Climate Change Impacts Infrastructure Working Group

The Connection Between Infrastructure and Climate

What do storm sewers, water and wastewater treatment plants, bridges, roads, culverts, and dams have in common? They are high-cost infrastructure investments that are typically expected to last from 30 to 100 years. But climate change is forcing infrastructure to perform under conditions that are dramatically different than they were designed for.

"In Wisconsin, we know that the future will be warmer and wetter, with changes in freeze thaw cycles and more frequent extreme rainstorms," said Steve Vavrus, Center for Climatic Research at the UW-Madison and co-director of the Wisconsin Initiative on Climate Change Impacts (WICCI).

Understanding the implications of climate trends can help us **adapt** our infrastructure design and management to reduce risk. Past methodologies that are based on historic patterns won't give us the information we need. As an example, rainfall statistics that describe future conditions are needed to make better decisions on the size and cost of drainage systems.

In addition, our infrastructure itself has a substantial **carbon footprint**[1] that is produced by the fuel used in producing and installing materials like concrete, steel, and asphalt. Transitioning to materials and construction techniques that have a smaller carbon footprint will help communities reduce (**mitigate**) their impact on climate change.

These adaptation and mitigation concerns prompted Rob Montgomery to organize practitioners in 2020 and launch the Infrastructure Working Group (IWG) as part of the Wisconsin Initiative on Climate Change Impacts (WICCI). The IWG co-chairs include the UW-Madison civil engineering faculty, Daniel Wright and Bu Wang, and Maria Hart, an emerita transportation researcher.

Adaptation versus Mitigation

Climate Change Adaptation is the process of adjusting to new (climate) conditions in order to reduce risks to valued assets. Adaptation can be physical, as in raising a road or behavioral, as in using less water in times of drought.

Climate Change Mitigation are actions that can reduce the amount and speed of future climate change by reducing emissions of heat-trapping gases or removing them from the atmosphere. Examples of activities range from clean energy projects to carbon capture technologies.

U.S. Climate Resilience Toolkit
https://toolkit.climate.gov/content/glossary

Survey of the State of Practice

As one of its first activities, the IWG conducted a survey of public infrastructure managers, planners, consultants, and elected officials. The goal was to hear from practitioners on the priorities the IWG should focus on as well as to determine the state of practice of resilience planning. "We made a big push to reach a broad group of practitioners early so that we could get input in the development of products from the get-go," Montgomery said. "We spoke to public works directors, consultants, researchers, city engineers, public water utilities, and city administrators. They all came together. Our goal is to provide information that will be valuable to the design engineer, the infrastructure manager, and the construction industry."

"We now have a baseline and understand where issues are ranked. For example, we know that the top two concerns are aging infrastructure and pavement deterioration," said Maria Hart, the IWG co-chair who led the survey.

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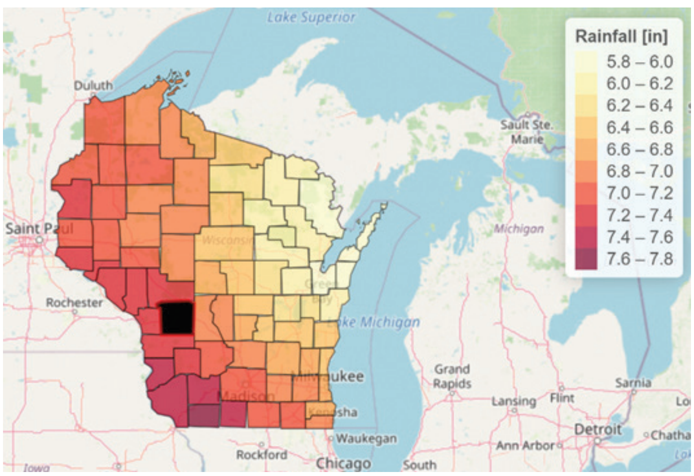
1. The carbon footprint measures the total greenhouse gas emissions caused directly and indirectly by a person, organization, event or product. Carbon Footprint Fact Sheet https://css.umich.edu/factsheets/carbon-footprint-factsheet

The survey confirmed the need for updated rainfall data and new design approaches. Other priorities include the need for information on the use of nature-based solutions, such as green infrastructure, and training on climate change/adaptation/ mitigation procedures for municipal employees.

The Wisconsin Rainfall Project

The objective of the Wisconsin Rainfall Project is to provide up-to-date rainfall statistics – often referred to as design storms[2] – that take into account the extreme rainfalls we've seen in recent decades. Additionally, the project offers projections of rainfall statistics for time horizons to the end of the 21st century using the results of climate models. Daniel Wright, who leads the UW-Madison Hydroclimate Extremes Research Group, has led this effort.



The Wisconsin Rainfall Project website portal allows users to view current and future rainfall statistics for any county in Wisconsin. This new rainfall data is often significantly different than existing statistical references that are required to be used in many codes and ordinances. Best practices for using results from the Rainfall Project need to be worked out collaboratively with designers and regulators. Discussions on the use of updated and future rainfall statistics will begin in the fall of 2021, with presentations at conferences and IWG discussions in the IWG. https://her.cee.wisc.edu/the-wisconsin-rainfall-project/

Reducing Embodied Greenhouse Gas Emissions in Construction Materials

Many Wisconsin municipalities have embarked on Climate Action Plans, looking for ways to mitigate greenhouse gas emissions to diminish our carbon footprint. Some actions include switching to solar or other renewables and upgrading fleets to hybrid or electric. These plans could also include goals to reduce the carbon footprint of infrastructure.

The carbon footprint of infrastructure from materials and construction is surprisingly large – concrete and steel alone account for more than 20% of global greenhouse gas emissions.[3] These emissions are produced during mining, manufacturing, and transportation of materials, and the construction process itself. "The first step in reducing this impact is to quantify the emissions embodied by materials like concrete, steel, and asphalt. It is a complex process, and will involve collaboration between owners, designers, contractors, and material suppliers. The IWG has developed a roadmap to help owners and contractors get started," said Bu Wang, the IWG lead on this project. "As we quantify embodied emissions, we can develop the policies for design and construction to reduce or offset these emissions."

Planning for Infrastructure Resilience

Many communities in Wisconsin have begun climate change resiliency planning, while others have developed and are refining plans to identify the risks posed by future conditions and to determine what changes need to be made to maintain public health and safety.

Currently there are no regulatory requirements that specify what future climate issues should be considered in infrastructure design and resiliency planning. Individual oraginizations must decide what policies and approaches to utilize. Professional associations like the American Society of Civil Engineers are working on developing technical and policy approaches. The Institute for Sustainable Infrastructure, among others, specifically includes climate change issues in their project rating system, and the US Climate Resilience Toolkit provides an excellent framework for resilience analysis and decision-making. https://toolkit.climate.gov/topics/built-environment/community-resilience

Municipalities may want to look to other parts of the country for examples of how to move forward, including collaborative approaches. For example, in southeast Florida, a compact of several counties have agreed to use a unified set of sea level projections and will build to that standard. Another example is the just-issued 2021 Climate Action Plan for the Chicago Region, developed by the 275-member Metropolitan Mayors Caucus.

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2. Depending on the risk posed by failure and related regulations, design storms can range from 5-year or 10-year events for storm sewers to as large as a 500-year storm for a dam's spillway. For example, a "5-year" event has a 1-in-5, or 20% probability of occurring in any particular year.

3. "Accelerating to Zero by 2040!," https://architecture2030.org/accelerating-to-zero-by-2040/, Architecture 2030, Published October 2019.

One of the first steps in planning is to understand the impacts of the changing climate on transportation, water supply/treatment, and community infrastructure. After the physical impacts of climate are identified, the next step is to conduct a vulnerability assessment, which looks at both physical assets and human assets (such as locations where seniors live) and assess risk. For example, a recently designed senior facility may have low risk, but the road providing critical services to the facility may be at high risk.

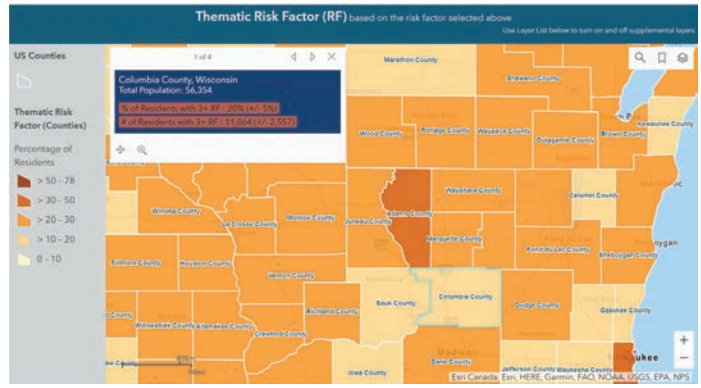
With the vulnerabilities identified, communities can determine solutions and priorities. More frequent road maintenance may be a first step with the goal of changing to fossil-free materials. Additional issues to consider are climate migration[4] and determining whether infrastructure will adequately serve a changing population.

Adaptation Returns $4 for Every $1 Invested

In response to the IWG survey 49% of respondents said that "*adapting to climate change is too expensive.*"

Twenty-three years of data from the Federal Emergency Management Agency shows that there is at least a $4 return on every dollar invested in adaptation. If adaptation involves changes in administrative codes, such as building codes, subdivision ordinances, construction standards, and building design standards, the return can be as high as $7. It is clear that well-planned adaptation can save money.

Information on community composition is available in the 2020 US Census Community Resilience Estimates Dashboard. The dashboard provides data on the following risk factors: Income to Poverty Ratio, Single or Zero Caregiver Household Crowding, Communication Barrier, Unemployment, Disability, No Health Insurance, Age 65+, Heart Disease, Diabetes, and Respiratory Disease. On average, a quarter of Wisconsin's population have three or more risk factors, making a case for proactive, resilience planning.



Thematic Risk Factors Source: US Census

Decisions

For the infrastructure community, adapting to new climate realities means reviewing all our processes and methodologies to see if they hold up to the risks that climate change could produce. We will need to decide what risks we can accept, and what infrastructure actions we should take to keep our communities safe.

To learn more or join this effort, visit https://wicci.wisc.edu/infrastructure-working-group/about/ Follow WICCI Infrastructure Working Group on Twitter @IWGWICCI.

About the Co-Authors/IWG Leadership:

Maria Hart is a climate change adaptation planning consultant and founder of Embed Climate, a social impact venture focused on climate literacy. She is an active member of the American Society of Adaptation Professionals. Maria conducted research in UW-Madison's Department of Civil and Environmental Engineering, focused on freight planning, livability, and transportation workforce development. Contact Maria at maria.hart@nomadplanners.com

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4. According to the International Organization for Migration, "Environmental migrants are persons or groups of persons who, predominantly for reasons of sudden or progressive change in the environment that adversely affects their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad."

Rob Montgomery, P.E., is a Principal Engineer at Emmons & Olivier Resources and serves as the chair of the WICCI Infrastructure Working Group. He also serves as an adjunct faculty member of the UW-Madison Department of Civil and Environmental Engineering. Rob has worked on a wide range of water resources, coastal and civil engineering projects as a consulting engineer. Contact Rob at rmontgomery2@wisc.edu

Dr. Bu Wang is an Assistant Professor in the Department of Civil and Environmental Engineering at UW-Madison. Dr. Wang teaches courses on civil engineering materials and sustainability in construction at UW-Madison. His research focuses on sustainability issues related to construction materials, waste material utilization, and carbon mitigation technologies such as carbon capture and utilization. He is serving on the Academic Committee of the Institute for Sustainable Infrastructure and Envision. He joined the WICCI Infrastructure Working Group in 2020. Contact Bu at bu.wang@wisc.edu

Dr. Daniel Wright joined the Civil and Environmental Engineering Department at UW-Madison as an assistant professor in 2016, where his research, teaching, and outreach focuses on floods and how they are influenced by meteorology, urbanization, and climate change. Dan leads the Wisconsin Rainfall Project and is a member of NASA's Precipitation Measurement Mission Science Team. He is a co-chair of the Infrastructure Working Group and is a member of the WICCI Science Advisory Board. Dan received UW-Madison's Exceptional Service Award in 2020 for his climate and infrastructure-related outreach. Contact Dan at danielb.wright@wisc.edu

A United States Geological Survey (USGS) hydrologist documents a flooded street near the Sugar River in Verona, Wisconsin, after the area received near-record rainfall on August 20, 2018. Photo credit: USGS Upper Midwest Water Science Center.

Wisconsin Initiative on Climate Change Impacts

The Wisconsin Initiative on Climate Change Impacts (WICCI) has generated a wealth of information on how climate change impacts Wisconsin's environment, livelihoods, and industries. The initiative started in 2007 as a partnership between UW-Madison and state government and issued its first report in 2012. A major update, the 2021 Assessment Report, will be released in Fall 2021.

"One of the unique things about WICCI is the participation of many working groups that focus on particular resource issues or industries in Wisconsin that are affected by climate change. The working groups gather practitioners and stakeholders to collaborate with university researchers." said Steve Vavrus, a climate scientist and a WICCI co-director. "Members represent many organizations across the state and bring differing perspectives and skills to the table." Current working groups include agriculture, climate, coastal resilience, fisheries, forestry, geospatial, great lakes, water resources, human health, infrastructure, plants and natural communities, tourism and outdoor recreation, and wildlife.

For example, Toni Herkert, the League of Wisconsin Municipalities Government Affairs Director, is a Community Sustainability Working Group member, a newer group focused on planning issues. "As a first step, we'll be surveying municipalities to understand issues and priorities," said Herkert.