Water Resilient Cities

Climate Change, Infrastructure, Economies, and Governance in the Great Lakes Basin

April 21 & 22, 2016

Executive Summary of Conference Proceedings

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1.0 Introduction

1.1 Purpose of the Conference

Cities and their metropolitan regions around the globe are now the habitat for the majority of people on the planet and are the locus of most of the economic production and consumption. As such, cities will profoundly influence water management over this century (Whitler and Warner, 2014; The City Upstream and Down, 2015). One of the most significant advancements in our thinking about water in the early 21st century is the recognition of two important conditions. First, much of the world will face water stresses during this century, either because of inherent limits, such as in arid regions, or because of increasing population, and/or increasing income levels and economic development, both of which may increase demand for water and generate higher levels of pollution without technological improvements. Secondly, professionals who manage water and researchers who seek to understand and support that management increasingly recognize that the challenges of water stresses need to be addressed through adoption of more integrated policy and management frameworks implemented through cross-disciplinary and cross-sector collaboration.

The Water Resilient Cities conference that took place in April 2016 focused on the Great Lakes ecosystem and the cities in the basin, where we have an abundance of water, but as we have learned, protecting the quality of the water and managing its use is critical to ensuring a secure supply of water, now and into the future (Michigan Land Use Institute, 2003; Gregg et al., 2012). Our cities are often labeled legacy cities to recognize the history of manufacturing and pollution and aging infrastructures built for many more people (The American Assembly, 2011). Revitalization efforts here will require reinvestment in aging public infrastructure, including water and wastewater. These realities gave inspiration to the purpose and organization of the Water Resilient Cities Conference, which was to explore how cities can manage water collaboratively to become resilient to the disruptions of climate change as these affect water-dependent ecosystem services and water security for urban populations.

More practically, the objectives were to:

1) convene a broad range of people in water and land management professions together as participants;

2) engage the conference attendees in using resilience as a framework to think about managing water resources;

3) foster formal and informal conversations to share best practices and identify industry and research needs; and

4) provide access to water related scientific and technical information to the general public and the broader community of professionals and researchers across the Great Lakes basin.

More than 140 people attended the conference as registered participants, including professionals from the fields of city and regional planning, drinking and waste water operations, storm water management, watershed management, water technology development, economic

development, port operations, and coastal management, and a range of local government associations, regional government entities, and elected local officials. Participants came from across the Great Lakes basin, preponderantly from northeast Ohio, but from all but one Great Lakes state. Several attendees were from Washington DC and states outside the basin. Faculty researchers and students from across the Great Lakes basin attended as well, and a cadre of CSU students assisted in note taking at sessions throughout the two days.

1.2 Conference Agenda Overview

The conference was organized as a series of keynote and panel presentations, attendee participant presentations (chosen through an abstract solicitation process), and facilitated workshop sessions to foster conversations and knowledge sharing. (See Appendix 1, Conference Summary Report, for the conference schedule). Post-conference reporting includes a web page, twitter, linked in, and emails announcing the distribution of conference materials. The presentations are all available as power points and as recordings on the post-conference web page https://www.csuohio.edu/urban/events/Water-Resilient-Cities-Conference. The best practices and research session power points are also available on the site. The full conference report is also available on the Water Resilient Cities post-conference web site.

2.0 Water Resilient Cities: Conference Framework

2.1 Water and Great Lakes Cities

Climate scientists have been researching the effect of climate change on the Great Lakes for decades. Plausible scenarios for the next 50 to 100 years indicate an overall decrease in water levels in the Great Lakes due to increased evaporation and less frequent ice coverage, with more frequent extreme storm events, generating increased flooding and stormwater volumes exceeding current infrastructure capacities (Kahl and Stirratt, n.d.; Kling et al., 2003). Redesign of the water systems needs to include greater flexibility to respond to changing conditions. Changing lake levels may adversely affect transportation, commercial shipping, recreational uses, and water intake infrastructure (Kahl and Stirratt, n.d.). Governance and the participation across the basin are and will continue to be critical to ensure stewardship and sustainable use of water resources (NOAA's Next Generation Strategic Plan, 2010; Simonsen et al., 2014). Revitalization of Great Lakes cities depends upon continued sustainable governance of the lakes systems and of the waterways that flow into them (Manno and Krantzberg, n.d.).

2.2 Urban Resilience

Every city in the Great Lakes basin is part of a complex social-ecological system (SES), constituted by the natural aspects of the Great Lakes basin, the built form of urban center itself, and the social systems that operate across them. These social systems include government, private entities, our economy, and civil society. In an SES, natural and human systems exist in a reciprocal, interdependent relationship (Walker and Salt, 2006), and disturbances fast or slow, large or small, in any of the subsystems can precipitate change across the entire system (Resilience Alliance, 2010; Walker and Salt, 2006). The complex nature of these SESs and their relationships imply uncertainty and non-linear change. It is uncertainty that is the hallmark of

climate change scenarios, and it is under conditions of uncertainty that public responses to climate change will occur (Resilience Alliance, 2010; Simonsen et al., 2014).

The Kresge Foundation (2013), in its report *Bounce Forward: Urban Resilience in the Era of Climate Change*, defines resilience as "the capacity of a community to anticipate, plan for, and mitigate the risks—and seize the opportunities—associated with environmental and social change" (p. 11). Knowledge of the mechanisms that will sustain cities includes the interconnected systems of metabolic flows, the built environment, social dynamics and governance networks. In short, resilience and adaptability of these systems together constitutes the "how to" of urban sustainability (Backus et al., 2012; The Kresge Foundation, 2013).

Overall an approach that embodies resilience implies *efforts to reduce exposure to hazards*, thereby reducing risk to human populations and the economy. It may also imply rethinking the *utility of reliance on hard infrastructure* with a 50-year project life span when conditions may change more rapidly than in the past. It also implies *anticipatory management* that adjusts over time as uncertain states become known. It also implies a *more flexible governance system* that can adapt more readily and find innovative solutions.

2.4 Integrated Water Resources Management through Integrated Knowledge

Integrated water management is an approach to coordinate across the entire system of management agencies and entities that influence water resources, as well as with land use and other systems in urban environments. IWRM is a widely accepted approach today in many countries. The United Nations Environment Program defined IWRM as "a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems' (UNEP-DHI, 2009). The basis for this approach is that water is a finite resource, and it connects to virtually all aspects of human society. The interdependencies of drinking water, waste water, agriculture, industry and ecosystem services requires systemic thinking that bridges sectors and requires bottom up collaborative management arrangements.

Given this background, some of the key questions that this conference focused on were: What are current practices in the United States and in the Great Lakes basin? Are city and regional government agencies making plans across the various water sectors? Is the best research from academic institutions and public agencies being used to guide decision making across the public and private sectors? Are researchers taking the ongoing and likely future needs of decision makers into their research portfolios? Are researchers and policy practitioners using the best metrics to frame their understanding and decision-making?

3.0 Conference Presentations Summaries

3.1. Plenary Speakers

To begin the conference, Dr. Wendy Kellogg, Professor Urban Planning and Environmental Studies at the Levin College, and conference chair and organizer, reviewed the conference themes related to resilience and water (Kellogg: Resilience Framework).

Ms. Elizabeth Gibbons, Director of the Climate Center at the University of Michigan, addressed issues of what scientists know with some certainty, what is not known, or is only known at a relatively low level of certainty and to identify the biochemical changes that are anticipated and how these may play out (Resilient Waters, Resilient Cities).

Mr. John Austin, Director of the Michigan Economic Center and a non-resident Senior Fellow at the Brookings Institution, spoke about the major economic benefits of this Great Lakes system and how continued stewardship of the lakes provides benefits to our economies Water is Our Past-Water is Our Future).

Ms. Carol Howe, director of ForEvaSolutions, spoke about the benefits from integrated water management that cities in the Great Lakes might find helpful in addressing climate change (Transitioning to Integrated Water Management).

3.2 Eaton Corporation Water Innovation Keynote Address

Ms. Hillary Brown, Professor of Architecture at the Spitzer School of Architecture, City College of New York, spoke about how we can change the design and implementation of infrastructure systems to better respond to climate change and make these systems more resilient by . understanding "infrastructure ecologies" (Future-proofing Infrastructure for the Anthropocene).

4.0 Variations on Conference Themes

This session offered five presentations that conference organizers felt best exemplified and illustrated the themes of resilience: systems, feedback and adaptive capacity. (These presentations are videoed and available on the post-conference web site.)

Katy Lackey of the Water Environmental Research Foundation presented case studies of how water and waste water utilities were addressing extreme events brought on by climate change. Tom Denbow of Biohabitats spoke about regenerative design as a framework to encourage adaptability and biomimetic systems to address stormwater. Dr. Derek Kauneckis and Jacqueline Kloepfer of the Voinovich School at Ohio University presented research on the range of approaches to water policy being used by cities in the Great Lakes basin. Bryan Stubbs, director of the Cleveland Water Alliance, spoke about the value of water for economic development, particularly the potential of water as an industrial attraction strategy for northeast Ohio. Dr. Sanda Kaufman of the Levin College of Urban Affairs described the use of scenarios for planning robust watershed decisions under conditions of high uncertainty.

5.0 Best Practices and Research Presentations (by Resilience Themes)

The conference featured two sessions in each of three tracks that were organized according to

three themes inherent in resilience-based planning and management:

- Systems—Cross Sector, Scale and Time: systems and how they function across sectors, scales and time frames;
- Decision Support & Feedback Loops: the need for continually renewed information and knowledge generation needed to find the most appropriate interventions such as policies and management practices; and
- Adaptive Capacity: the ability of the human management systems to adapt practices over time and reorganize efforts in response to new knowledge and to ongoing changes to the natural world resulting from climate change.

Each session contained four or five presentations by water-related professionals and academic researchers. The purpose of each session was to share practices and research were being carried out across the Great Lakes that illustrated the theme of the session. After the presentations, participants were asked to identify emergent practices, challenges, assets that were being used to resolve these challenges, and what the participants considered to be the most significant points or concepts in the presentations. Table 1 summarizes the outcomes of the session.

Table 1. Summary of Sessions on Systems

Emergent Themes and Assets	Emergent Challenges (System stressors)
• increased community access to projects and building community connections • connecting private and public sectors to leverage funding • connecting physical infrastructure with the social fabric of communities through key policy drivers such as zoning codes, and collaborative planning and management. • availability of scientific data - needs to be made accessible and well presented for wider public use • senior citizens and faith communities could be potential assets in community organizing around water	• aging infrastructure • sustenance and longevity of projects • identification of right roles for planning and management • lack of maintenance of newer projects (could be a potential area of cross-sector collaboration) • uncertainty related to climate change induced impacts and resultant limitations in strategies • lack of collaboration between cities and other political jurisdictions

5.2 Decision Support & Feedback Loops Session Summary

"Decision support" is any data-focused mechanism or process that assists decision makers to make better decisions. Since scales (geographic, governance, markets, etc.) are interconnected in SESs, there exists 'feedback loops' among different parts or components of a system. Feedback loops could either be reinforcing (positive) or dampening (negative). Managing feedback is crucial to keep the system functioning in a manner that it provides adequate

ecosystem services, and identification of critical thresholds, which might flip the system to a desirable or undesirable state. Feedbacks are critical because it is through these that systems respond to change, self-organize, emerge into new configurations, and adapt to change. Chief among feedbacks is knowledge, analysis and monitoring information – incorporating decision support tools – to avoid changes in system state that is detrimental, and establishing governance structures that can facilitate more informed decision making (The Kresge Foundation, 2013; Resilience Alliance, 2010; Simonsen et al., 2014). Much of the presenter information in this session focused on technological tools used to not only better capture climate-related data, but also disperse that data to relevant actors and geographies, and make it available where it is needed. Table 2. Summarizes the outcomes of the session.

Table 2. Summary of Sessions on Decision Support and Feedback

Emergent Themes and Assets (Strengthening feedback)	Emergent Challenges (System stressors)
• *smart water quality monitoring projects and scenario modeling* • *innovative and "locally intelligible" use of scientific data and innovation* • *focus on emergent management practices such as "watershed trusts"* • *regulatory practices to account for externalities, including land-use in water management funding* • *smart growth analysis* • *developing a standard practice of benchmarking for sustainable infrastructure projects* • *costs of implementing changes and related recordkeeping for different programs (to increase efficiencies)* • *accounting for connections and feedbacks in system for policy and public finance tools* • *National Climate Assessment toolkit*	• *creation of a facilitative compliance environment at the local level* • *matching models and modeling tools with compliance options* • *leap-frogging optimization to new technologies (for monitoring, controlling, and looking at feedback) should be accounted for by regulatory agencies* • *paradigm shift to the thinking (in planning and management by agencies and municipalities) that includes accounting for externalities* • *no standard practice of benchmarking for infrastructure for sustainable/resilience projects* • *public education and outreach with a built in adaptation component to climate and environmental changes (with specific focus on health)*

5.3 Adaptive Capacity

Adaptive capacity is the ability of the human management systems to adapt practices over time and reorganize efforts in response to new knowledge and to ongoing changes to the natural world resulting from climate change. Critical for building adaptive capacity is learning by doing with an explicit focus on sharing of knowledge between actors, boosting learning through knowledge sharing across organizational and institutional scale, and collaborative processes and broader participation that stimulates learning among different groups (Resilience Alliance, 2010).

Presenter topics in this session focused on themes of restoration and community resilience, as well as equitable distribution of programs and tools, or tools that helped measure the specific vulnerability of different areas in order to allocate resources efficiently. Table 3 summarizes the outcomes of the session.

Table 3. Summary of Sessions on Adaptive Capacity

Emergent Themes and Assets	Emergent Challenges
• *restoration and community resilience* • *equitable distribution of programs and tools* • *efficient allocation of resources (based on vulnerability assessment tools)* • *development of institutional tools that improve knowledge and collaboration and dissemination of information collected through the tools* • *ideas of vulnerability shifting design challenges to management and maintenance* • *community collaboration to gain knowledge about infrastructure development*	• *challenges and roadblocks in resilience planning and management - scale issues, lack of leadership, education, compliance with regulation, etc.* • *challenges of the time needed to create zoning codes and the enforcement of zoning codes* • *not enough cross-sector collaboration* • *engineers risk averse with design decisions* • *community decision makers/leadership not up to speed on issues; small communities lack decision makers making change*

6.0 Working Sessions

6.1. Break out Sessions Organized by Communities of Practice

After two sessions of presentations from conference attendees on day one and the morning of day two of the conference, attendees split into three break-out workshops. The topics for these workshops were designed to encourage discussion among professionals and academics in three different communities of practice: *economic aspects of water resilience; physical/landscape aspects; and governance*. Each session was designed to encourage responses to the following questions:

- What are the issues of concern related to vulnerabilities from climate change in your field or practice;
- What is the current state of adaptive capacity to respond to these issues; and
- What strategies are you using, did you hear about at the conference thus far or from others in your profession that can address the issues and build adaptive capacity?

6.2 Strategies for Research and Practice

For this final session, each breakout group from the sessions summarized their work to the entire conference attendees, and posed strategies for moving forward.

Water Economy

This group had discussed facets of water quality, including chemical, physical, ecological facets as well as the relationship of these to climate change. This group chose to focus strategies on issues related to the chemical aspects of water quality:

- tackle nonpoint source pollution by reducing "Total Maximum Daily Load" (TMDL) goals at major industry of chemical prescriptions, factory chemicals, and phosphorous. To reach this goal, it was noted that partnerships with farmers and the farm industry, legislators, and community members would need to be established. It was also noted that this would be difficult to undertake as a long-term goal, and that education would need to be involved in some respect. Another strategy posed was creating a watershed utility, which would streamline multiple issues into one entity.
- differentiate between natural and human impacts and adaptability. Human components and their multiple systems and layer—nonprofits, economics, local businesses, state partnerships—complicate nature's natural adaptive capacity, which, on its own, is very high. However, using all of these human facets across silos—namely the economic and nonprofit sector—can be very effective. All sectors need to be involved to find any solution.

Waterscapes and the Physical City

This group discussed strategies for adapting Great Lakes cities to climate change. The group discussed the challenges of dealing with "meta issues" first, and also the "chronic vs. crisis" aspect of many problems facing the region. Another problem was mentioned was the link between water quality and health, and a final issue was the barriers to large infrastructure and ways around these barriers. An example given to illustrate the "chronic vs. crisis" nature was the events of water contamination in Flint, MI, and how this was dealt with when the crisis arose, rather than as a long-term problem that builds over time.

A major theme the group identified was cross-sector collaboration. They discussed the steps of research, cross-institutional work, and communicating this to the public. They also mentioned the importance of public-private partnerships, and the general discussion of climate change, with suggested strategies to include.

- biomimicry, and anything that "gets us to adapt green infrastructure to particular places…more on the human side than the technology side;"
- monitoring water quality up and downstream. A question posed to the group by Dr. Kellogg was where and when to monitor water quality, and whether to do so before or after weather events. In addition, early warning systems for water quality detection (connections of human fecal matter to where overflow occurs) could work well in terms of cross-sector collaboration, so strategies for this topic should be discussed further.
- Determining what health data to use if the data first identified as necessary for a problem cannot be collected. A suggestion made was that sharing this health data—rather than reinventing the wheel—would be a way around the time, cost and logistics

of collecting new data. Interagency groups that share and access data have a lot of data content that could be discussed and disseminated.

- how can communities adapt legal structures to enable more reliable monitoring? What, in terms of water quality, is being monitored, that the process of monitoring is too costly. Areas that have better long-term control plans with green infrastructure have stronger systems. In some places, regulations for storm water retrofitting do not exist, and this is another obstacle.

Governance

The following issues were brought forward by this group:

- dredging, and its consequential erosion and sedimentation. The corresponding strategy is to change dredging practices, restore stream bank, and create land banks with existing sediment and bedload interceptors. These schemes could be achieved through cross-sector collaboration of agencies and businesses;
- algal blooms. Suggested strategies were more research, use of biomimicry, sustainable agriculture practices, and steps to phosphorus runoff reduction. Mentioned here was collaboration with farming agencies, increased education and public outreach.
- urban infrastructure and how inter-organizational communication about utilities can increase resilience. This can be assisted by government incentivizing as well as education, and streamlined infrastructure.
- regional flooding problems. The strategy suggested to tackle flooding would involve land-use planning, at a watershed scale, as well as incentivizing and better disaster management.

7.0 Outcomes and Next Steps

7.1 Key Comments and Recommendations Emerging from Conference

The recommendations and suggestions emerging from the best practices and research sessions and the post conference survey have been summarized and organized into Table 4 below. Conference participants provided their views and ideas through their presentations and discussions. The following table outlines the key resilience themes and ideas that emerged conceptually throughout the sessions and the emergent variables/measures that could be used to track the key themes associated with the broader resilience dimensions.

Table 4. Summary of Key Resilience Dimensions		
Resilience Dimensions	Key Ideas/Themes	Emergent Variables/Measures
Systems: Cross Sector, Scale and Time	Connection between systems and hierarchy of nested systems	understanding key connections; collaborations across institutions to remove planning, organizational, and knowledge barriers; multi-jurisdictional water management efforts; consolidation/simplification of teams and programs; systems thinking and scalable frameworks across professional disciplines
	Identification of disturbances and critical variables	identifying links between ecosystem functions (eg. climate change and health); municipal management of stormwater and climate change; water management perspectives from targeted end users; multi-disciplinary collaborations
Decision Support and Feedback Loops	Knowledge, learning, and monitoring related decision support tools to inform policies and management practices	bridging gap between climate science and climate adaptation strategies and communities; opportunities in workforce development in climate resilience planning; multidisciplinary inputs to water resource management; invasive species management; linking cities to ecosystem processes through regenerative design; interdisciplinary approach for crisis management; matching emerging technologies with infrastructural issues; estimates such as future precipitation frequency
	Governance and institutional structures to either manage or avoid regime shifts	building institutional capacity and integration for regional planning and management; implementation of climate change adaptation at local level; urban planning as potential focal point of multi-disciplinary teams; lessons from local governments plans and programs; evaluation of present policies and plans (helping or hindering); orchestration of initiatives at an agency or institutional level; greater integration of water infrastructure in the urban area; building capacity for outreach/education in climate resiliency
Adaptive Capacity	Adapting practices including learning, organizational, and collaboration	integration of climate information in planning and design; cities building capacity to export blue economy solutions; cities taking an adaptive approach to climate change; public engagement and education; need for collaboration; sharing and education about successful projects using IWRM; regional efforts to build adaptive capacity

Additionally, following are some key recommendations that emerged from the conference that could be used both for integrated management of water resources and using

resilience as a framework for building capacity for adaptive governance (research, planning and policy, and practice):

- There is gap between climate science and the practitioners that need to use the science to bring about change in the built environment. Currently these two groups are speaking completely different languages. Most city infrastructure designed by engineers hasn't adapted to alter its guidelines based on the changing climate (e.g. increased precipitation, increased heat, etc.). There should be more focus on this aspect.
- Need for supportive legislation and funding sources at all levels of government
- Although climate change is viewed by many as a negative, its impact on the region may be a benefit in terms of economic development, as long as it is addressed carefully considering the impact of possible population growth, environmental consequences and proper infrastructure planning. Public awareness and education programs should be pursued.
- How can new businesses be attracted to water abundant regions? Learning more about the concept of 'regenerative design' and how even smaller cities could practically implement this design could be useful.
- Water resilience depends on not only infrastructure but also optimal operation of current facilities. Broadening topics for optimal operations (management) of facilities (structures) in watersheds could be useful.
- The economic risks/opportunities is an area that needs to be explored further.
- Distinctions between drinking water, storm water and waste water: do they need different approaches for resiliency?
- Bringing educators – from higher ed. and K-12 – into the dialogue to talk about ways to create water resilience - literate audience.
- Community design responses to water resiliency including more case studies on what communities are doing in order to continue the conversation on how Great Lakes communities are responding.
- Established funding sources for research related to water/climate resiliency.

7.2 Next Steps for Water Resilient Cities Program

The Levin College has established a Program on Water Resilient Cities that is within the Urban Centers unit of the college. Dr. Kellogg is directing that program. This program will coordinate across campus and into the community to continue the focus on water resilient cities.

Next steps for the WRC program include distribution of this report to the conference participants and to a wider group of professionals and researchers associated with water and land management. The conference outreach will target university students and the general public in the future. We also anticipate working with water professional organizations in

Northern Ohio in organizing smaller local/regional workshops/briefings to local utilities, city planners and managers, and water professionals following the conference to broaden the distribution of the results and to gather additional information on best practices using an integrated water management approach.

Our partners and sponsors (http://www.csuohio.edu/urban/events/Water-Resilient-Cities-Conference) will assist in dissemination of the materials produced through their networks much as they have done for the advertising of the conference. This summary report, and other smaller items generated from it, will be disseminated on the Levin College web site, and will be shared electronically through the networks of conference sponsors and partners (more than a dozen with access to thousands).

The participants of the conference will be connected through the Water Resilient Cities Network (facilitated through a professional Linkedin group and through Twitter) to connect, network, and share research and best practices and to take forward and/or collaborate on the various ideas generated through the conference.

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