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Adapting to Climate Change in the Upper Mississippi River Basin: Exploring Stakeholder Perspectives on River System Management and Flood Risk Reduction

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ABSTRACT: In the Midwestern United States (US), river flooding is a climate change-related hazard that poses a significant threat to health, well-being and economic stability. The 2019 Midwest floods led to major flooding at every monitoring site along the Mississippi River, set record water levels at 42 sites, and resulted in an estimated $6.2 billion in infrastructure damage and recovery costs. Although the risks associated with increasing flooding in the Midwestern US have been well recognized, less is known about the adaptation challenges and opportunities in the region, particularly in the Upper Mississippi River Basin. This exploratory study examined stakeholder perspectives on river system management, flood risk reduction, and adaptation planning in the Upper Mississippi River Basin. We conducted in-depth interviews with flood management stakeholders between August and October 2019. Interview data were analyzed using thematic analysis. Five themes emerged from the interviews: (1) River flooding in the Midwestern US is a different experience than US coastal flooding; (2) River flooding in the Midwestern US is a regional experience that requires a regional response; (3) Local actors face constrained resources for flood risk protection and recovery; (4) Differentiated responsibility across levels of governments makes recovery and response difficult to navigate; and (5) Competing stakeholder goals challenge cooperative flood hazard management. Overall, these results suggest that locally focused adaptation efforts, while perhaps appropriate for coastal communities or more urban contexts, are suboptimal strategies for communities in the flood-prone river basins of the Midwestern US. Instead, structures and support for regional collaboration should be considered and pursued.

KEYWORDS: Climate change, adaptation, flood, river, planning, Midwestern United States

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Introduction

Human activity has caused an estimated 1°C rise in average global temperature since the pre-industrial era, an amount expected to rise to 1.5°C between 2030 and 2052 if significant and immediate changes are not made.[1] These changes to the global climate system are likely to produce increasingly severe and more frequent extreme weather events posing a direct threat to human life, property and welfare.[1] While international and domestic policies about climate change have emphasized both mitigation (reducing emissions of greenhouse gases, the main drivers of human-caused climate change) and adaptation (strengthening human responses to the impacts of climate change), mitigation has traditionally received more attention and a greater sense of immediacy in policy implementation.[2,3] However, given the potential of even more severe temperature increases if mitigation targets are not met by mid-century, there has been an increasing focus on adaptation as well as mitigation.[3,4] In recent years, climate change adaptation has become a more prominent issue at the international level[5,6] and is emerging as a distinct field of practice in the United States (US).[7,8]

The emerging literature on best practices in climate change mitigation and adaptation strategies emphasizes that, while mitigation is best addressed at the highest geospatial and policy scales of national and international governance, adaptation is best addressed locally.[9-14] "Adaptation is local" has become a mantra of its own within the field.[15] In a quantitative content analysis on this framing, Nalau, Preston and Maloney found that adaptation responses at the local level were prominent in the literature, with 59% of the analyzed articles endorsing a local approach, 33% staying neutral, and only 8% critiquing adaptation as a locally optimized strategy.[15] In their comprehensive review of climate adaptation efforts in the US, Bierbaum and colleagues reported that, while all levels of government should be engaged to some degree in climate adaptation work and planning, federal level planning focuses more on capacity building, funding mechanisms and technical information sharing – all work promoting adaptation efforts at lower levels of government.[16] In the US, while several federal agencies may be engaged in comprehensive planning within their specific sectors, adaptation at the federal level prioritizes funding that supports local-level planning and action.[16] Even at the state level, Bierbaum and colleagues found that climate-related

* Authors contributed equally to the work

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policy efforts tend to "incentivize or inhibit adaptation at other governance scales," and that most adaptation efforts to date are centered at the lowest local level.[16]

Climate change will have wide ranging effects on both the natural and built environments, and adaptation work has to be prepared for a variety of potential impacts, including increasing and more severe heat and cold spells, droughts, wildfires and tornados. Meanwhile, in the Midwestern US, one of the biggest risk concerns for future weather events is the impact of severe flooding. According to the US National Oceanic and Atmospheric Administration (NOAA), for example, increased rainfall in the US from July 2018 through June 2019 averaged 37.86 inches nationally, resulting in the highest 12-month rainfall period on record, with extensive flooding along the interior river basins.[17]

In the Midwestern US, river flooding poses a significant threat to safety, well-being and economic stability. For example, the Great Flood of 1993, occurring across 9 Midwestern states in two basins (Upper Mississippi River Basin and Missouri River Basin) and comprising approximately 320,000 square miles, resulted in $12 to $16 billion in monetary damages and unquantifiable costs to the health and wellbeing of residents.[18,19] Over half of the damage sustained by these states in 1993 was caused during single flood events – meaning that this region has been susceptible to rare, but severely damaging floods.[19] With respect to climate change, the Midwestern US will be especially vulnerable as changes are predicted to manifest as recurrent severe flooding of the Upper Mississippi and Missouri River basins. This flooding will threaten existing infrastructure and pose severe challenges to future and ongoing agricultural production and output.[20-23]

Given the potential human health and economic risks that severe flood events pose to the region, it is vital to expand knowledge and identify key gaps and priorities regarding flood risk reduction and climate adaptation in the Upper Mississippi basin region. Several forms of social capital, such as the presence of community trust, reciprocity, and cooperation, have been found to influence the implementation of adaptation measures.[24-27] Further, given the multi-state geographic spread of US river basins, examining the issue regionally (i.e. between local and national) seems critical. Prior regional studies conducted in the US have focused on Western river systems such as snow-fed systems in California and Nevada,[28] cooperative management of water allocation in the Rio Grande/Bravo basins,[29] the San Francisco Bay area with three distinct systems draining into an estuary,[30] New York's freshwater supply system in the Catskills,[31] and the Sacramento River basin covering much of northern California.[32] Other examples of cooperative regional planning exist at the state level, but it is important to note that state-level plans,[33,34] while having a geographic focus larger than the local, also have the benefit of a central organizer and planning apparatus. In comparison, rivers systems that cross many local, county and state borders face much larger challenges in regards to cooperative planning and decision-making efforts. Despite these promising examples studying regional responses to climate change, a study of 43 local adaptation plans in the US found that only 25% referenced the need to work toward regional advocacy and action, on any climate-related issue, not just flood-related – underlining the tendency to focus on the smallest scale as primary when considering adaptation planning.[35]

Over the decades, a number of social, economic and structural tools have emerged to mitigate risk and hazard from severe flooding along the Upper Mississippi, including buyout programs, flood insurance, levee construction and improvement, retaining basins, wetlands restoration, and flood-resistant infrastructures or building materials.[30,36-39] Though many of these tools require some stakeholder cooperation between scales (buyout programs may involve federal, state and local scale actors, for example), the majority of these tools are implemented and maintained at the local scale.[7,9,12,37] The purpose of this exploratory study was to examine the current state of flood risk response on the Upper Mississippi River Basin from the perspective of stakeholders involved in flood planning and management, and to draw out the key themes and challenges for flood risk reduction and adaptation planning in the region, presuming the likely increase of severe flooding events in the years to come. The study examines the following research questions:

(1) What are the unique features of flood risk reduction and adaptation planning in the Upper Mississippi River Basin?
(2) Are locally-centered planning approaches the best practice for flood adaptation in the Upper Mississippi River Basin?
(3) What are the specific social, economic, or political barriers threatening effective flood risk reduction and adaptation planning in the Upper Mississippi River Basin?

Materials and Methods

Study context

The Upper Mississippi River Basin extends from northern Minnesota to the southern tip of Illinois and includes large parts of Illinois and Missouri. The basin drains approximately 189,000 square miles, and over 60% of the basin is farmland.[36] Approximately 30 million people live in the basin, with 80% residing in urban areas such as Chicago, Illinois and St. Louis, Missouri.[36]

With a January to May period that was the wettest on record in the US, the spring and summer seasons of 2019 saw severe flooding throughout the Upper Mississippi River Basin. There were federal disaster declarations in Illinois, Missouri, South Dakota, and Iowa, and an estimated 14 million people were directly impacted.[40] Severe flooding began in early March 2019, following higher than average rainfall and snow melt,

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Table 1. Characteristics of river basin management stakeholders.

STAKEHOLDER	STAKEHOLDER GROUP(S)	YEARS OF MANAGEMENT EXPERIENCE
1	Federal, Army Corps of Engineers	15+
2	State Level Governance, Federal Level Governance	5-10
3	State Level Governance, Resource Management	15+
4	Nonprofit Environmental Advocacy	5-10
5	Agricultural Operators, Local Governance	15+
6	State Level Governance	15+
7	State Level Governance	15+
8	Local Leadership, Agricultural Interests	15+

Some stakeholders represent more than 1 group.

and by the end of the summer produced some of the worst flooding of the decade, with new record water levels set in 42 locations, and major flooding at every monitoring site along the Mississippi River.[17,41] By March 2019, satellite data showed that over 1 million acres of cropland had already been devastated by flooding, resulting in heavy economic impacts for residents.[42] While final costs for the 2019 floods have not been finalized, it is estimated that the final costs for response and infrastructure repair will top $2 billion.[40] The 2019 flood was distinctive for being a "total system flood", meaning every subsection of the Mississippi River Basin experienced flooding.[43]

Study design and sample

A convenience, snowball sampling approach was used to recruit stakeholders engaged in Upper Mississippi river basin and flood management policy. We sought participants with high levels (⩾ 5 years) of management experience in flood response or planning. We used snowball sampling because we anticipated that only a small number of highly specialized people would be engaged in Upper Mississippi basin decision-making. Recruitment was conducted by email or phone call after the stakeholder was identified as someone with a high level of demonstrated personal knowledge or experience with flood response or planning of the Upper Mississippi. At the conclusion of each interview, the interviewer asked the participant to identify other knowledgeable individuals for potential study participation. Interviews with eight stakeholders were conducted between August and October 2019. Interviews lasted approximately 90 minutes, and we ceased recruiting after eight participants because no new information was emerging.[44] Study participants represented a range of perspectives (Table 1). All stakeholders were residents of the Upper Mississippi River Basin, with management experience in upstream and downstream locations throughout Illinois and Missouri.

Data collection

Individual, in-depth, semi-structured interviews were conducted by the first author. An interview guide was utilized to ensure that all participants were asked a set of core questions covering: (1) the participant's flood risk reduction background and work roles, (2) the role of the participant's organization in flood risk reduction, (3) conflicts of goals or interests between regional stakeholders regarding flood risk reduction, and (4) beliefs and concerns with respect to effective flood risk reduction over the next decade.

All interviews were audio recorded with participant knowledge and verbal consent, with the assurance that the recording was voluntary, could be stopped at any time, and that the participant had the right to refuse to answer any question or prompt. All participants were informed that their participation and responses would be de-identified and anonymous. Each interview lasted between 1 and 3 hours, largely determined by the desire of the participant to continue sharing their knowledge or opinion about the topic with the interviewer. Study methods were approved by the Human Research Protection Office at Washington University in St Louis (#201905214).

Data analysis

We used Braun and Clarke's framework for theoretical thematic analysis to identify emerging themes and patterns from interview transcripts.[45] Data analysis was conducted by two investigators (TR and CE) to identify emerging themes. Each transcript was read multiple times and reviewed to generate initial codes, which were then arranged into themes. Representative quotes were identified from each of the interviews, highlighting the primary findings. We achieved substantial interrater-reliability,[46] with kappa agreement values ranging from 0.75 to 0.88 across the five themes.

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Results

Five key themes emerged for the context of the Midwestern US experience of severe river flooding: (1) River flooding in the Midwestern US is a different experience than US coastal flooding; (2) River flooding in the Midwestern US is a regional experience that requires a regional response; (3) Local actors face constrained resources for flood risk protection and recovery; (4) Differentiated responsibility across levels of governments makes response and recovery difficult to navigate; and (5) Competing stakeholder goals challenge cooperative flood hazard management.

River flooding in the Midwestern US is a different experience than US coastal flooding

Study participants described the nature of river flooding; specifically, that river basin floods are slow onset, long-lasting, and impact more than one locality at a time. There was an emphasis on the extent of agricultural land impacted by floods in this region, and the challenges faced by agricultural communities during flood response and recovery. As one state level government official described:

> *There are these FEMA [Federal Emergency Management Agency] mitigation programs, funding, to do buyouts, but they're really targeted at urban neighborhoods, urban houses, buying out those houses. One of the problems we had with that in the Midwest is our economy is very much driven by agriculture. We have a lot of agriculture in the flood plain. These buyout programs, mitigation programs, they don't do anything to address issues on the rural landscape, which is troubling because as we move into this area of having these big mega storms, we need more than few city blocks to convey the flood water.*

Because it often takes a long time for rain and river flooding to qualify as a federally declared emergency, many residents and counties are locked out of access to aid. This is in contrast to coastal flood events, which are often declared federal emergencies immediately following significant storms. One of the participants working in funding and programs for local preparation noted:

> *It's been tough watching what's going on in Illinois. I know they actually got turned down on their appeal for individual assistance for all the flooding. I think a lot of people in the public don't know, when it comes to disaster relief money, is it has to exceed the ability of the community and state to handle the emergency. Well, that's done on an individual county basis. If it's all farmland and you have 800 families, it's almost impossible for you to reach that threshold of what the state can't help you with. . ..It's very easy on the East Coast where there are a lot of people, a lot of buildings.*

For agricultural stakeholders, there was a need to be recognized for the value they bring not only to their local communities but to the US as a whole:

> *. . . but we have to be careful on what we want because almost a third of the ground in the United States that is farmed is in the river bottoms, so if you ask us to take out all that production out of the bottoms, you're taking a third of the [food] production of the United States out of production.*

The challenge of managing a diverse patchwork of levees was a prominent topic within the interviews, with many interviewees concerned about the ability of the levees their towns depend on to hold over time. A number of interviewees expressed concern about the age of the existent infrastructure, as the majority of US levees have been built to standards set over a century ago, and that may not be adequate for increasing high water from severe weather, or even just from the increased pressure put on older levees from newer, improved ones further upstream. As one levee district representative noted:

> *Our flood-control system was designed in the Civil War. It's not adequate for today and it's certainly not adequate for the future with climate change.*

Lastly, compared to coastal water management, river floodplain management relies heavily on levees to move and control water across vast geographies. However, participants note that many current, local levees are in need of on-going shoring up or repair, which is not always an immediate budget concern for a local taxation district. Maintenance might include dredging of levees and redisposition of the material, repairing base board at the top, or repairing ground level pressure points. These weaknesses show up unpredictably under pressure, and can cause significant flood damage from otherwise relatively minor water pressure events:

> *The water's moving. It comes out. Water comes out, which in and of itself isn't bad – it's relieving pressure – but when silt comes out with it, it's coming from somewhere and, more than likely, underneath the levee. Now you're developing a hole.*

River flooding in the Midwestern US is a regional experience that requires a regional response

Because river plain management relies heavily on levee systems to manage flood risk, downriver communities are directly impacted by the protective measures undertaken by communities upriver. An emerging topic that was brought up repeatedly during interviews is that, as development of waterfronts becomes a major economic development in better resourced towns, those towns are able to independently invest in improving their local levee system. This has become especially appealing with incentives from federal level actors, such as FEMA. For example, a town that improves its levee to FEMA's 500-year flood certification can significantly decrease the insurance premiums paid by its businesses and residents. However, these locally based improvements increase the physical risk and flood damage for communities downriver, by increasing the speed and volume of water flow during flood events.

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This unintended impact was prominent and recurrent in participant interviews and was emphasized by every participant. Stakeholders almost universally expressed that local management of individual levees has the potential to create harm for others, and that the solution to this problem is a more collectively managed system, or at least some way to seek redress. A city manager described the concerns of downriver communities:

> *I guess my main takeaway is that unless the up-river communities stop pushing the water downstream, the rest of us are going to be in pretty bad shape before too long.*

A state-level official mentioned the lack of collaboration between Upper Mississippi communities:

> *On the Lower Mississippi, because you have this comprehensive federal system, during a flood event, no one is allowed to add height on top of that levee. You're not allowed to put up sandbags to add to your level of protection because everything was modeled based on a certain level of protection. On the Missouri and Upper Mississippi, when we get a flood, people are allowed to flood fight. They're allowed to add free board on top their levees, so it's kind of, from my perspective, it's the wild west. There's no ability – when you hear a community say, 'We have a certain level of protection,' do they really? It all depends on what is being added to the top of other levees. We don't have any kind of overarching comprehensive approach.*

A levee engineer also highlighted the need for regional collaboration:

> *I think we're headed for disaster if we continue. . .operating as independent communities doing what's best for them, because what they're doing is probably best for them, but not best for the system. . ..If you get nothing else out of this: we are doomed to failure as the Upper Miss[issippi] if we don't develop a plan that we can all agree on. . ..You can't have all these individual decisions being made because they impact other people.*

Local actors face constrained resources for flood risk protection and recovery

In addition to the widespread concerns about how some communities are improving their levees at the cost of other communities' protection, a challenge frequently faced by river communities trying to mitigate flood risk or adapt to future flood events is a lack of resources or civic capacity available for their current infrastructure construction, repair and upkeep: As one participant noted:

> *It's centralized to the local needs and also the ability to get grant money to mitigate it. FEMA absolutely takes into account cost-benefit analysis. That is in the localized sense. FEMA won't pay for a levee unless it benefits them.*

A state level emergency manager described the burden of Midwestern states:

> *It's definitely a concern, I think, if we continue to see really severe weather events. The amount of money that has to go in year over year on recovery and that kind of thing–it's not sustainable, from the state's perspective.*

While many levees in the Midwestern river basins are federally managed, the majority are not, and instead rely on individual levee districts for funding and maintenance. Smaller levee districts use an array of local taxation and budget methods to make their budgets. However, without additional access to federal funds, levee districts relying on local government tax options often find it challenging to pay to maintain and repair levees in years like 2019, where there has been heavy and sustained flooding of the river basins. This constraint can be especially burdensome to smaller towns with smaller tax bases and smaller budgets. As one local levee district representative noted:

> *Because, the way they're formed, every levee district is on its own, and they didn't think they could fund the kinds of things that would have to be done, because it was extensive. A lot of the–this is an issue of flood plain management. The people that live in the flood plain that's protected by the levee have to pay for that levee.*

While some grant funding might be available at the state or federal level, interview participants found a lack of local civic capacity, low knowledge and small population size were hurdles in applying for and receiving grants and funding above the local municipal level. This point often related back to the second theme (flooding requires a regional response) because working together with other local municipalities was seen as one avenue for gaining access to higher level funding for infrastructure construction and repair. From a state level planner:

> *There was no support on the upper level. For one thing, we had–I think they probably turned back a million dollars in help, management costs, and they wouldn't let us hire anybody. We had several big disasters in a row. We had $120 million to spend, and there's two of us working on it. The planner quit–or took another position. It was just two of us working on all of this stuff. Then they wanted to fire a couple of people that were in a different section, so we got to do their job, too.*

According to a local levee district representative:

> *When you take the three counties, they really have taken it upon themselves to pay for that themselves. . . Now that is where our region got together. They didn't try and fix just one system. They fixed five systems in that. The solution can't be just one area – one system. It's gotta be a unit of several to make the project almost a – big enough to fund so it has capabilities of creating enough revenue to fix – to have a solution.*

Differentiated responsibility across levels of governments makes response and recovery difficult to navigate

Several participants mentioned that having different agencies or levels of government responsible for different parts of flood response was inefficient, and presented challenges to local action. As described by a participant who coordinates regional planning and response:

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Any entity that wants to apply for hazard mitigation money has to adopt a plan. Here, in [state omitted for anonymity] and, actually, everywhere, because it's FEMA, but it's administered by the State's Emergency Management Agency, so SEMA. It can be counties, cities, school districts, and special districts. . .For our region, if we counted everybody, we'd be almost up to 300 partners. As it is, we focus on the 187 that we have a handle on.

This challenge was noted by a federal level representative:

The people that have to [coordinate a plan] are these independent government agencies that are the states. The federal government can help but we can't dictate. We can't tell Missouri what their policy is on raising levees. We can't tell Illinois, and they're completely different.

Another state level official explained that, even between different agencies within the same state, there is often confusion and disconnect over who is responsible for what in response and recovery:

The one big difference between here versus [the state level emergency management agency; omitted for anonymity] is we have a much narrower focus where, because they're bond funds, we cannot do elevations, and then there are other people who handle the structural projects. The funds that I'm in charge of, we can strictly do buyouts with.

The most commonly mentioned actors for this theme were FEMA, state level emergency management associations, local levee districts, and the Army Corps of Engineers. At times, this disconnect was experienced even at the local levee level, when responsibility for different parts of infrastructure by different districts slowed response time or reduced the options available to local level actors:

What I've started doing is I get the - I started with my levee commissioners, because each levee system has three - in Illinois, we have three commissioners for each levee district, and in [my] county we have, let's see, one, two, three, four - we have six different districts in [omitted for anonymity] county. In those six districts, there's three levee commissioners. . . As you go up and down the system, there's actually 143 different levee districts in Illinois, I believe - actually in Missouri, Illinois and Iowa there, I believe there's 143 different districts, and they all have different ways of, they've all kind of created their own way of revenue, so it's not one rate for everybody. Everybody creates their own.

Competing stakeholder goals challenge cooperative flood hazard management

Across interviews, the reason most often cited for poor flood response and management was the divergence of stakeholder priorities. The most frequently identified stakeholder groups described by participants were the Army Corps of Engineers, Agriculture, Conservationists and Environmentalists, Recreationalists, and Residents (Table 2).

Army Corps of Engineers. Tasked with overseeing much of the infrastructure directing the US's interior waterways, the Corp's primary directive, and their goal in river management, is maintaining the navigability of the river. Counterintuitively to many stakeholders in flood zones, this means making sure there is *enough* water in the levee system, rather than diverting water away. This can lead to tension with state and local level leaders, who need water diversion away from their towns during high water years. As described by a state level representative:

You had a lot of controversy in the states on how the Corps managed and where they put material that they would dredge out of the river and communities that would get upset when the Corps was placing that dredge material in areas around their communities without any kind of coordination.

However, there is often contention when it comes to levee planning and funding, where local actors may expect more support from the Corps than they were receiving. These decisions are often made from the point of view of what is best for the whole system, or what is the best use of Corps funding. Those decisions do not always serve to protect smaller and less economically vital river communities. As one participant explained:

Part of it is when people say the Corps won't improve [our levee], a lot of people want those levees paid for by the federal government. . ..I don't know what the current cost share is, but the majority is the federal government. The other part is local. In order to do that, there would be a study, and. . .then they would look at the benefits. A lot of these local [needs] don't show a positive benefit-cost ratio, from the Corps' point of view.

Agriculture. Much of the most at-risk and flood prone land along the river basin is used for agricultural production. These stakeholders can be some of the most severely impacted from long term or severe flooding, since basin flooding threatens both their homes and their livelihoods. It was clear from interviews that citizens with an agricultural interest can feel maligned by others – particularly environmental and conservation stakeholders – and are eager to emphasize the value they bring to their communities and the positive role they can play

Table 2. Stakeholder groups and goals.

STAKEHOLDER GROUP	GOALS
Army Corps of Engineers	Maintaining the navigability of rivers
Agriculture	Promoting and maintaining economic growth and stability; discouraging environmental regulation of operations
Conservationism	Maintaining environmental and water quality; restoring and protecting wetlands
Recreation	Maintaining water level in reservoirs
Residents	Avoiding widespread buyout programs; maintaining place-based social capital; improving and maintaining flood resilience infrastructures

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in flood risk mitigation (e.g. through pond water retention, or as ditch and culvert redirections):

> *So often the opposition does not wanna hear why we are there and the reasons we are there. Nobody wants to have a livestock operation right next to them up in the hills [laughter]. They all wanna say it stinks. Well, okay. I see it completely different. I look at it as a revenue source for the school districts or municipalities to help fund your EMS, that kinda thing—all on what a business does. Businesses—many times, folks don't look at farms as businesses, and that's exactly what we are. . ..When I sit down in a conversation like we did at the meeting up there the UMRBA had, I sit here and I listen to the opposition. When the opposition tells me that we are destroying—or we are hurting the land. That is so far from the truth. It's bringing facts to the table so that we can discuss them. So often, the opposition does not bring facts to the table.*

Conservationists and Environmentalists. Focused on the water quality and health of the river, these stakeholders are often interested in creating easements or protecting river watersheds publicly via wetlands protection areas. They encourage "making room for the river" initiatives that are meant to restore land to the river flow and decrease waterfront development, arguing that doing so is one of the most economically sound ways to reduce flood damage costs. Reflecting conflict points that recur frequently, participants in this group were careful to emphasize they are not entirely opposed to agricultural or recreational uses of the river, but seek ways to work together to protect Midwestern waterways environmentally as well:

> *Then, on the flipside of that, where you see a lot of the dispute is from folks who are on the more environmental-conservation side, who are looking at things in a bigger picture, that are saying, 'Okay, in order for us to be economically sustainable into the future with climate change, we need to try to reverse some of our past decisions to develop floodplains in various ways.'*

Recreationalists. This stakeholder group is influenced by policy decisions around reservoirs and lakes that are used to retain excessive water, or to increase flow into the rivers by the Army Corps of Engineers as part of their navigability mandate. These goals can come into conflict when the reservoirs are lowered, forcing the decrease of recreational use. Communities that rely on the recreation revenue of these resources can be defensive about plans or policy actions that change river flow into or out of the reservoirs:

> *That was the fight in the 80's, is the lakes started to go low, so recreation was being impacted. Your dock was a mile that way and not connected. Then they [recreationalists] said, 'We're important, too. It's not just about navigation. We don't wanna get a release water for navigation. We're important, too.'*

Residents. Communities that have existed for a long time in the floodplain can be in opposition to state or federal level plans to use buyouts and disinvestment as a means to remove residents and businesses from flood-prone waterfronts. According to one long-term resident:

> *When it floods, you get all these people talking about buyouts and moving people, and what have you. Especially, I think for IEMA [Illinois Emergency Management Agency] and FEMA, it's 'Let's just go move everyone, and then we won't have to deal with them anymore.' Well, this town's been here a long time. And these people have been here a long time. And maybe what's best for IEMA and FEMA isn't the best for everybody else.*

Or, as an elected city government leader of a flooded community explained:

> *After the last buyouts–because we have businesses, ok? Mostly it's businesses now, in downtown. But when they move the people, we start losing revenue. I have an elementary school up on the hill, we almost had to close it after the last big buyout, in 2011. . ..we lose residents, and then we can't fund the school. Now you tell me, how am I supposed to attract young families here, if we lose our elementary school?*

Overall, stakeholders understood other groups' needs and concerns for the river as well as their own, and they would loop this theme back into the second theme of needing to coordinate the river as a whole region system – not just for protection, but to make room for competing stakeholder goals. From a regional response coordinator:

> *My concern is instead of realizing we're not all going to get everything we want, it's impossible, we've got to sit down and create enough trust and a forum to discuss compromise in how we manage the resource or else nobody's going to have their needs met, because there's going to be this constant whipsaw of whether it's different administrations' approaches or congressional that will tailor their actions to the subset of stakeholders, and so we tend not to get a lot done because we're not willing to compromise.*

Discussion

This study examined, from an experienced stakeholder perspective, river system management, flood risk reduction, and adaptation planning in the Upper Mississippi River Basin of the Midwestern US. Despite the continuing recommendation to prioritize local adaptation within both the literature and the practice of climate adaptation planning, using "adaptation is local" as a one-size-fits all policy prescription may not be appropriate for flood mitigation and response planning in the Midwestern US. This is consistent with findings from other studies of river system flooding and adaptation in other parts of the US.[28,30] Our results indicate that locally driven planning may even be considered maladaptive, as independent local improvements push risk exposure downstream onto other communities. Evidence for this increased risk exposure has been previously developed through examinations of the 'levee effect', where hard-scape improvements in one location increase risk for down-river communities.[47] In addition to the risks for communities who do not or can not improve their own infrastructures to keep pace with their upstream neighbors, communities may unintentionally be exposing their own residents to increased future flood risk by focusing on locally based improvements. For instance, there is evidence that increasing

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flood protections for economically valuable areas provides incentives for increased development in those areas – meaning more risk for expensive loss of structures and displacement of residents in the event of catastrophic future flooding.[48-50] This and other themes that emerged during this study have planning implications for managers charged with optimizing resilience and response to future severe weather events and flooding in the Midwestern US.

There are several factors contributing to the disadvantages of using locally focused adaptation strategies for these communities. The first challenge is that federal grant mechanisms emphasizing local planning generally distribute money to local governments using state agencies as intermediaries. This can be problematic in the river basins because (1) smaller communities may not have the internal civic capacity to navigate application processes successfully, and (2) the nature of river flooding's slow onset and long duration mean that municipalities get locked outside the official declaration period, or are left out when their local community does not break the damage cost threshold necessary for federal aid.[51,52] The challenge stems from the unfortunate reality that, outside of urban resources and economies, local levels of government often have the least capacity and the fewest resources to plan for long-term adaptation, let alone to implement those plans.[12,15] Smaller communities feel the strain of resource limitations acutely, as they may not meet the cost-benefit value necessary for broader infrastructure investment or protection from state and federal government policies. Additionally, they often lack the civic capacity for increasing their local funding streams to meet the cost-sharing requirements of necessary grants, let alone the civic or professional expertise necessary for grant writing, effective adaptation, or resilience planning.[15,53]

Individual home and landowners often must navigate a maze of local, state and federal agencies in order to access aid and support, and they must do so in specific timeframes. In rural communities, residents may not always be as informed or have access to the information they need to access these opportunities in a timely manner, as well as not knowing where to go to find that information. In local news reports from the 2019 flood, many rural residents from areas suffering from widespread and long-lasting damage found that they either did not qualify for access to state or federal aid because the declaration came weeks after their home was damaged, or experienced great difficulty in navigating the complex process of applying for loans, buyouts or relief.[54] There were efforts made to provide resources to help local residents, such as resource centers where they could come and get advice or ask questions about flood insurance, small business loans, USDA farm assistance, FEMA applications or state aid programs.[55] However, one of this study's participants who works with an agency managing state-level buyout programs noted that no one from his agency had ever been invited to one – illustrating the difficulties in ensuring that individual citizens know which agency, at what level of government, is responsible for providing assistance for their situation.

The large amount of agricultural land impacted by river flooding is disadvantaged by the structure of federal and state emergency response funding mechanisms. Agricultural operations are seen as businesses, and homeowners living on farmland may not be included in federal or state aid packages or buyout programs – leaving farmers and ranchers to rely on small business loans or USDA loans to cope with heavy flood damage losses.[56] FEMA disaster funds and buyout policies are not written with large farmland properties in mind, making it difficult for local leaders to adapt federal standards and mandates to fit their specific communities' needs and contexts.[56,57] Interview participants familiar with the process of translating federal funds into local impact brought up the disconnects they encountered between rules from FEMA and the local realities of agricultural communities. For instance, in an example given during interviews, a state level buyout program was not able to buyout damaged property owners because FEMA insisted that the entire acreage must be purchased, instead of allowing states to buyout the residents for the acreage and value of their homes, but leave the remaining land in agricultural production. In another example, FEMA requirements requiring complete inclusion of mineral rights for deed transfers posed serious hurdles to accessing buyout funding for large acreage deeds. Agricultural needs are such an important aspect for regionally focused flood response that the Missouri Governor's Flood Advisory Task Force included mention of agriculture in several of their key findings, including the very first recommendation of the report: "The state of Missouri should develop a resource guide for state and federal flood recovery assistance for flood protection infrastructure and agriculture," clearly placing agricultural stakeholders and their economic value on the same level of state priority as flood protection infrastructure itself.[58] These types of policy directives make the most sense at scales of governance beyond the local level.

As participants emphasized throughout, the stress placed on local implementation actively increases the risk exposure of smaller and less resourced communities to flooding damage. Especially because FEMA's national flood insurance policies become more favorable with improvements to locally controlled levees, there is a distinct incentive for communities that can afford it to improve their own town's protections.[59] Wealthier communities upstream that are able to secure grants or other funding to improve their local infrastructures are, in turn, increasing the pressure on local dams and protections of downstream communities – endangering fail safes that may have been adequate for decades but are quickly being overrun by the amount of water entering the system along increasingly common record-level floods.

This unintended consequence is of such concern that it was a major focal point of state-level policy analysis following the 2019 spring and summer floods. For example, a flood response

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task force convened by the state of Missouri recommended regionally focused coordination with Iowa, Kansas, and Nebraska, as well as the "ongoing coordination, led by the Upper Mississippi River Basin Association, to improve management of flooding, sediment, and drought."[58] However, there is also a recommendation that the Governor and congressional delegations of Missouri should "support the development of a systematic approach to levee design on the upper Mississippi River to ensure balanced protection," highlighting concerns that the current patchwork of locally driven improvements creates inequitable risk distribution when considering the river system as a whole.[58]

While the current best practice recommendations for severe weather adaptation emphasizes local response planning and resources, the infrastructure needs of river management require federal level budgets. Federal level grants often use cost sharing schemes between the federal government, the state and the local municipality. This may not pose an insurmountable challenge in more population dense contexts, with large personal and property tax bases to tap into, but some river basin communities can struggle to access the funding necessary to rebuild.[9,60-62] This can be due to a myriad of factors, including state restrictions on what types or amounts of taxes can be levied at the local level, the more limited property values and population concentrations of rural towns, or because of the cost-benefit decision making processes used by federal agencies to prioritize funding do not often produce support for smaller municipalities.[9,60]

Strengths and Limitations

The main strength of this study was the participation of key stakeholders with extensive high-level experience in issues related to river management and flood response policy in the Midwestern US. The participant pool was also notable for including representatives from a diverse set of stakeholder groups (local, state, and federal government officials; leaders of community-based organizations; agricultural operators; and local residents). However, our study included a relatively small sample of participants and it is unknown whether these findings are representative of other stakeholders' view in the region or would be generalizable beyond flood management in the Upper Mississippi River Basin. Despite these limitations, we were able to capture rich data from a variety of perspectives, and our findings have implications for planning and research as study results can inform future flood planning efforts as well as future large-scale investigations of climate adaptation strategies in the Midwestern US.

Conclusion

Existing work in climate adaptation research and policy has produced widespread recommendations for locally-driven and locally-centered planning as the best practice for flood and severe weather adaptation in the US. However, those locally-centered adaptation frameworks are not well-suited to the regional management needed for Midwestern US river water systems. The unique features of river flooding in the Midwestern US create distinct challenges at the municipal and regional level, and response and adaptation planning will need to be tailored to meet those demands. There are steps that actors at all levels of governance and decision-making can take to reduce individual community flood risk. State-level actors, for example, can incentivize cooperative action by providing funding and professional capacity to smaller river communities for planning and resource development, and both federal- and state-level actors can consider liability models that protect downstream communities from the unilateral changes to the river system created by upstream communities. Given the probable increase of significant, multi-state flood events in the future, leaders and policymakers at all levels of governance will benefit from working collaboratively to develop regional, multi-state planning for the Upper Mississippi River Basin.

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