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Adaptation by stealth: climate information use in the Great Lakes region across scales

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Abstract While there has been considerable focus on understanding barriers to climate information use associated with the character of climate knowledge, individuals' negative perception of its usability and constraints of decision-contexts, less attention has been paid to understanding how different scales of decision-making influence information use. In this study, we explore how water and resource managers' scales of decision-making and scope of decision responsibilities influence climate information use in two Great Lakes watersheds. We find that despite availability of tailored climate information, actual use of information remains low. Reasons include (a) lack of willingness to place climate on agendas because local managers perceive climate change as politically risky, (b) lack of formal mandate or authority at the city and county scale to translate climate information into on-the-ground action, (c) problems with the information itself, and (d) perceived lack of demand for climate information by those managers who have the mandate and authority to use (or help others use) climate information. Our findings suggest that (1) scientists and information brokers should produce information that meets a range of decision needs and reserve intensive tailoring efforts for decision makers who have willingness and authority to use climate information; (2) without support from higher levels of decision-making (e.g., state), it is unlikely that climate information use will accelerate significantly; and (3) the trend towards characterizing climate specific actions within a broader concept of sustainability practices, or "adaptation by stealth," should be supported as a component of the climate adaptation repertoire.

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1 Introduction

Worldwide, climate change poses an emerging threat with potential devastating impacts on ecosystems and livelihoods. Impacts from climate change are already being felt across the world and in the Great Lakes region of the USA as a result of both gradual changes in temperature and precipitation as well as more frequent and severe extreme events (IPCC 2014; NCA 2014). Scholars and policymakers point to the need for scientific information, especially climate information, to support adaptation actions in the water sector (Jiménez Cisneros et al. 2014; Rayner et al. 2005; Moss et al. 2013). However, while expectations that scientific knowledge would do much to support action, concrete evidence of application and effect has been mixed (Lemos 2015; Kirchhoff et al. 2013). Scholars examining this lack of use of climate science in decision-making point to challenges in how decision makers perceive the salience, credibility, and legitimacy of knowledge (Cash et al. 2003); how new knowledge fits and interplays with existing practices and knowledge (Lemos et al. 2012); how challenges to climate information use may arise if scales of knowledge creation and use are mismatched (Gordon et al. 2016); and how limited understanding of decision spaces and of the opportunities and constraints they represent may impede uptake (Dilling et al. 2014). Other scholars attribute lack of use of climate information to challenges with how decision makers perceive climate change as an issue fraught with political tensions and its impacts as too far off in the future to be relevant for local decisions (Phadke et al. 2015; Weber 2006). However, the politics and distinct nature of climate change may also create the conditions for climate action "by stealth" (Lach et al. 2003; Rabe 2007). In this study, rather than a political move (Rabe 2007) or a strategy to insulate the pursuit of innovation (Lach et al. 2003), we conceptualize adaptation by stealth as the fostering of adaptation action under a broader umbrella of sustainability, perhaps as a means (consciously or unconsciously) for decision makers to seek a less contested pathway of climate change action. Finally, scholars aiming to help overcome these challenges suggest that increasing climate information use requires (a) improving interactions between producers and users of climate information; (b) employing boundary organizations to convene, transfer, and translate information to motivated users; and (c) better tailoring of information for particular decisions (Gordon et al. 2016). Whereas this body of research has advanced our understanding of factors that impede or promote climate information use, the vast majority of these insights focus on improving the information itself and the process of information production (or co-production) while leaving the specific question about how the scale of decision-making influences information uptake relatively unexplored.

To fill this gap, this paper explores how the scale at which decisions are made (e.g., at a small community scale vs. a large city or a state agency scale); the authority associated with that scale; or the characteristics of particular decisions influence information use. In particular, we aim to tease out why climate information still go unused despite circumstances that favor information uptake such as when tailored climate information is available. Specifically related to scales, our objectives are to understand (1) whether and how climate information is brokered across different scales of decision-making; (2) how the availability of tailored climate information facilitates (or not) information use at any scale; (3) how agendas, authorities, and perceived information needs vary across scales of decision-making and how these factors influence climate information use; and 4) what types of decisions made at different scales are more (or less) conducive to using climate information. To accomplish these objectives, we use qualitative data collected from 46 in-depth interviews with water and resource managers operating at different scales of decision-making with different agendas and responsibilities in two Great Lakes freshwater watersheds.

2 Climate information in a multi-scaled decision environment

2.1 Barriers and drivers of climate information use

User's perception of climate change as a problem influences whether or not climate information is integrated in decision-making. For example, the perception of climate change as a global problem dominates the way knowledge is produced and consumed (Hulme 2007). Yet, recently, the push for adaptation actions to address climate change impacts is shifting attention to local scales where the emergence of place-based action (Reid and Huq 2014) is increasing the demand for better fitting information (Archie et al. 2014). In turn, this demand drives the enduring focus on producing "downscaled" climate information to meet users' needs (Mearns 2010; Weaver et al. 2013). This focus on downscaled climate information (i.e., output from numerical climate models that has been dynamically or statistically adjusted to provide information at a regional scale (Briley et al. 2015)) perpetuates the assumption that for climate information to be useful at local scales, it must also be provided at finer spatial scales (Dessai et al. 2009).

Focusing mostly on the "usability gap," considerable scholarship has explored how factors characterizing climate information and those who use it influence climate information uptake. Users are more likely to employ climate information in decision-making if they perceive the information to fit with their decision-making needs (Lemos et al. 2012). Also, users are more likely to use information if they find it to be timely, accurate, credible, salient, and aligned with their decision-scale (Lemos and Morehouse 2005). A persistent issue affecting climate information use involves mismatches between the scale of the available information and the scale at which the decisions are being made (Cash et al. 2006; Gordon et al. 2016; Kalafatis et al. 2015). For example, large-scale climate information (i.e., regional or global climate models) might have relevance for national decision makers but little relevance to subnational or local decision makers (Brown et al. 2012; Darela Filho et al. 2016). Conversely, assessments that focus solely on local-scale impacts and help inform local decisions might not be useful to policy-makers at higher scales who are more interested in aggregate impacts of climate change (Cash and Moser 2000). Better aligning information with the scale and nature of decision-making helps increase the relevance and use of climate information for adaptation decisions (Dow et al. 2009).

How new knowledge interplays with other kinds of knowledge and existing decision practices employed by users and decision makers' past experiences also affects information use (Marx et al. 2007). On the one hand, new knowledge can complement and create positive synergies with existing knowledge. On the other hand, existing established decision routines may also create path dependencies that make using new information more troublesome (Lemos et al. 2012; Rayner et al. 2005).

Finally, how users obtain information and participate in its production affects use. Empirical evidence from in-depth case studies has, for example, shown how two-way communication is important to usability (Kirchhoff 2013; Roncoli et al. 2009). Rather than operating independently, Lemos et al. (2012) argue that information fit, interplay, and how users obtain information interrelate to constrain or increase usability of climate information.

2.2 A better focus across scales and ways to improve information uptake

While the issue of scale has received considerable attention in relation of multi-level and polycentric governance of natural resources (O'Brien et al. 2004; Ostrom 2001), less effort has been spent in understanding how scale might shape climate information use. Cash et al. (2006) define scale as the spatial, temporal, or analytical dimensions used to study any phenomenon, whereas levels are the units of analysis that are located at different positions on a scale. When scholars implicitly consider climate information and its use in decision-making, they tend to focus empirical work on just one decision-making scale or level, thereby missing a thorough understanding of interactions within and across scales and levels (Lopez et al. 2009; Poff et al. 2016). More than a decade ago, Cash and Moser (2000) highlighted the need to consider cross-scale and multi-level dynamics in climate adaptation. Yet much of the scholarly literature has focused on understanding how management and/or policy decisions implemented at certain spatial, jurisdictional, and temporal scales influence the ability of decision makers at other scales to make management decisions (Eakin et al. 2014; Eriksen et al. 2011).

Given that adaptation decisions will have to account for scale issues, a concerted effort to elucidate the role of scale in managing climate risk is overdue. For example, in the USA, water management is devolved from the federal to the state scale and from the state across multiple interlinking centers of authority and jurisdictions (e.g., clearly bounded and organized political units) such as a community, county, or city. Because spatial, jurisdictional, and hydrological scales are conflated in water management, we do not refer to these centers as levels. Rather, we use the term "decision scales" to denote the multiscale and multilevel nature of water management, meaning that managers at each scale make decisions across different authorities and responsibilities. While climate information could be integrated within and across these scales of decisions, we do not yet fully understand how the scale at which decisions are made, the authority associated with a particular scale, or the characteristics of decisions influence information use.

Of the range of strategies to improve information uptake, co-production models employed in the context of boundary organizations have been promoted as particular effective (Briley et al. 2015; Meadow et al. 2015). Boundary organizations facilitate ongoing communication which helps to overcome barriers to information use associated with decision-contexts, institutions, and individuals' negative perceptions of the information (Dilling and Berggren 2014; Soares and Dessai 2015). Moreover, co-production helps overcome scalar mismatches through collaboration and convening, transfer, and translation functions with motivated users (Gordon et al. 2016; Kirchhoff et al. 2013; Lemos et al. 2014). Yet, other issues of scale (e.g., cross-scale dynamics and issues with insufficient authority) or particular types of decisions may defy our best efforts to improve climate information use.

3 Methodology

We analyzed qualitative data obtained through interviews conducted from December 2013 to August 2014. We specifically targeted two Great Lakes watersheds: the Huron River in Michigan and the Maumee River in Ohio. In each of the watersheds, we carried out in-depth qualitative interviews with staff at a watershed scale organization—i.e., the Huron River Watershed Council (HRWC) in Michigan and the Partners for Clean Streams (PCS) in Ohio—and water and natural resource managers they partner with in their respective watersheds.

HRWC and PCS collaborate with federal, state, watershed, county, city, and community water managers and provide resources including climate information (see S1 for more detail). Interviews with HRWC and PCS watershed scale managers helped to understand whether and how climate information is brokered across scales of decision-making. We identified our initial sample from those water managers who had a relationship with each of the two organizations; from this initial group, we snowballed to build a larger sample of respondents. Interviews with managers enabled an examination of (1) how the availability of tailored climate information facilitated (or not) information use, (2) how agendas and authorities vary across different scales of decision-making, and (3) how the decision space influences climate information use and what types of decisions are more (or less) conducive to using climate information. In total, 46 semi-structured interviews were conducted representing the federal ($n = 1$), state ($n = 9$), watershed ($n = 11$), county ($n = 7$), city ($n = 9$), and small community ($n = 9$) scales. Federal water managers make decisions about reservoir operations and dam management, state government water managers set and enforce water allocation amounts and regulate community water systems, county water managers manage drainage systems while city managers usually manage stormwater and floodplains, urban forestry, and water supply, and finally, municipal water officials manage local water supplies and floodplains (Feldman and Ingram 2009; Kirchhoff and Dilling 2016).

During interviews, similar questions were asked at all scales. Firstly, the interviews enabled an exploration of interviewees' access to and use of climate information. Since we were particularly interested in the information flow across scales, we asked individuals whether, and if so how, HRWC or PCS helped them gather climate information to address water management problems. By doing so, we attempted to gauge how climate information flows across agencies. Secondly, attention was devoted to the ways in which climate information was used in decision-making (or not, and in this case, why). Thirdly, interviews helped to illuminate existing decision contexts and how decision contexts within and across scales influenced climate information use. Each interview was recorded and transcribed.

To analyze interview data, we created a detailed codebook with codes corresponding to information flows across scales, different categories of use, and different mechanisms that helped or hindered use. For example, codes such as *ClimateInfoUse* were used to flag when climate information was used (or not) while codes like *InfoUse_D2D* and *InfoUse_PrioritySetting* were used to help distinguish how the information was used (e.g., for day-to-day decisions or priority setting). Finally, different codes such as *ClimateInfoUse_constrain* were used to flag potential barriers to climate information use. Transcripts were analyzed using NVivo (QSR International software 10.0).

4 Climate information uptake across scales of decision-making

4.1 Sources and flows of climate information

The HRWC in Michigan and the PCS in Ohio work primarily at the watershed scale—the eco-hydrological scale theorized as the most appropriate scale to tackle water management challenges. HRWC and PCS work across smaller (e.g., community, city) and larger scales (e.g., county, multi-county, state).

While HRWC and PCS do not produce climate information themselves, they acquire knowledge of local climate change and trends from different organizations and, in the case of the HRWC, customized climate information (e.g., watershed narrative descriptions of anticipated climate change impacts) from the Great Lakes Integrated Sciences and Assessments Center (GLISA), a boundary organization funded by the National Oceanic and Atmospheric Administration Regional Integrated Sciences and Assessments program (Briley et al. 2015; Kirchhoff et al. 2015). HRWC's relationship with GLISA has been not only advantageous for obtaining tailored climate information but also for advancing HRWC staff's climate information brokering capabilities. With these additional capabilities, HRWC staff broker climate science to water and resource managers within their existing networks. However, interview data suggests that it remains difficult to get climate change on local agendas—i.e., eight out of nine local interviewees did not put climate on their agendas. Also, as expressed by one HRWC watershed manager: "Most of the water managers are really slow to open their eyes to climate change impacts."

Because it is difficult to get climate change on local agendas, HRWC engages in a range of climate information brokering activities aimed at both specific information uptake and more general awareness building efforts. For example, HRWC uses factsheets, on observed and expected changes in e.g., heavy precipitation events and average precipitation, to help cities integrate past storm trends into planning (e.g., http://glisa.umich.edu/media/files/AnnArborMI_Climatology.pdf). Beyond specific information uptake efforts, HRWC partners with GLISA on the Climate Resilience Communities Project (for a detailed summary of the project, see Kirchhoff et al. 2015). Finally, HRWC raises awareness through disseminating climate information via a newsletter to their members (e.g., http://www.hrwc.org/2016/). Yet efforts to raise awareness can also be challenging as illustrated by the following quote from a watershed-scale manager: "Sometimes we try not to talk about climate change and what causes it but just talk about how to deal with it. There is a bit of a subtext about how worried we should be about our wording about climate change [when we talk with communities]…. or should we just move on and work with communities on how to deal with it. We do not want to alienate communities."

In contrast to HRWC's efforts to disseminate climate information, PCS staff consider the brokering of climate information as outside of their mandate. Rather than provide climate information, PCS focuses on producing and disseminating water quality data to aid in ecosystem and water resources management.

4.2 Climate change as a distant problem vs. local demand for climate information

For managers operating at fine spatial scales, a persistent issue forestalling climate information use is the mismatch between managers' perception of the scale of climate change—perceived to be a distant and intangible problem—and the hyper-local scale of their water or resource management problems. For example, one water manager operating at the community scale noted "…climate change seems to be far more national than regional or local," while another expressed "I don't think we really are much affected by climate change." According to these managers, there is little connection between global climate change and specific decisions and actions undertaken at the local level. Managers at the local level appear most concerned with finer scale and shorter-term weather information such as improved tornado warnings and 8–14-day precipitation forecasts (Table 1). In addition, they are concerned about extreme precipitation, specifically local rainfall events of more than 1 in. in 24 h. Water managers interviewed at this scale do not associate extreme events with climate change. And, for managers in the Huron River watershed in particular, despite the availability of locally tailored climate science through

Table 1 Examples of climate and weather information used by water managers operating at different scales (applied by >10% of managers at the scale in question) in two Great Lakes watersheds ($n = 46$ water managers)

	Types of information used by water managers	Community ($n = 9$)	City ($n = 9$)	County ($n = 7$)	Watershed ($n = 11$)	State ($n = 9$)	Federal ($n = 1$)
Climate information	Design storms		X	X	X		
	Precipitation time series (current and past trends)		X	X		X	
	Temperature time series (current and past trends)		X				
	Precipitation projections		X	X		X	
	Seasonal forecast		X				
Weather information	NOAA Storm predictions (4–8 days outlook, aggregated to a 9–10 county region)	X	X	X			
	Precipitation forecasts (8–14 days outlook)	X	X	X			
	Tornado warnings	X	X	X			
	Lake-effect snow forecasts						X
Climate-linked information	# of days exceeding thresholds (e.g., growing degree days, growing season length) (USGS Downscaled Climate Projection Portal[a])					X	
Weather-linked information	USGS real-time river flow		X		X	X	
	NOAA flood levels				X		

[a] USGS projections are available for the following time periods: 2011–2039, 2040–2069, and 2070–2099. For further information, see http://cida.usgs.gov/climate/derivative/

HRWC, individual's perceptions of climate change as a distant problem create a barrier that limits its application to fine-grained local- or community-scale decisions. At the small community scale ($n = 9$), only one of the interviewees expressed interest in climate information, specifically past trends in precipitation time series. According to this interviewee, citizens act on past experiences with rainfall events rather than future climate projections.

At the city ($n = 9$) and county scale ($n = 7$), the majority of managers (six and four, respectively) revealed a greater use of climate information such as estimation of design storms (rainfall events above a specified size and return frequency, e.g., 50 years), precipitation time series; and seasonal forecasts (Table 1). For example, city water managers concerned with future water supplies consider how local water supply and global climate dynamics intersect and interact. Likewise, floodplain managers operating at the city and county scale consider how changing precipitation patterns may impact drainage design and flood proofing efforts.

One might expect less of a mismatch at larger spatial scales and a greater interest in climate information at these scales. Yet, this was not the case. Rather, among interviewees at the state scale, we found limited use of and interest in climate information. Only three of the nine interviewees at state agencies expressed interest in climate and climate information. For the state agencies, the limited attention given to climate change and climate information is a function of perceived limited local demand for climate information. One state water manager explained their rationale for not engaging with climate in this way: "Watershed planning is locally driven. When the issue [climate change] is pushed locally, we lend technical support." In other words, state agency interest in climate change hinged on local demand for climate information. Yet, when demands for addressing climate change drove incorporation of climate information, such as applying climate formally in a watershed management plan, state support was lacking and issues arose as explained by one watershed-scale manager: "There were some issues with the last watershed management plan. One of the partners threatened not to sign off on it if the part about climate change was kept in the plan…" In such cases, from a watershed manager perspective, having state leadership that promoted incorporating climate change into watershed planning might make climate-informed watershed planning easier. For both the state- and watershed-scale managers, climate change is perceived as a "hot-button issue," which makes incorporating climate information and taking action to mitigate climate change impacts difficult as expressed by a watershed manager: "I was at the Watershed Management Plan meeting and there was a local stakeholder that challenged the concept of global warming and its inclusion in the plan. I questioned its inclusion as well."

4.3 Mandate/authority of decision makers as a driver/barrier of climate information uptake

The variation across spatial scales in the uptake of climate information is also related to the mandate and authority of water and resource managers. At the state scale, water managers view climate as a separate agenda item that does not fit with their regulatory-driven mandate for protecting the quality of air, land, and water resources. In the words of a state manager, "We focus mainly on water quality issues. We are not unaware of climate data. We have some basic information but we don't focus on providing that data." Despite having authority to put climate on the agenda such as establishing new climate-informed stormwater design standards—which do have water quality implications, other state water managers likewise indicated that climate change is simply a lower priority issue than other issues already on their full agendas. Also, without perceived strong local demand for climate information and the lack of one specific person or department in charge of climate change, many state water managers perceive climate change as "an undercurrent theme" rather than a distinct issue requiring immediate attention as expressed by staff from one state agency: "We haven't had formal conversations [about climate change]; they are sidebar conversations."

At the watershed scale, there is little decision-making authority; so while HRWC and to a lesser extent PCS advance efforts to improve climate resilience in the watershed, they lack authority to compel water managers to incorporate climate information or to take adaptation decisions. Rather, watershed managers work collaboratively with managers operating at different scales to facilitate integration of climate information if there is willingness and interest to do so.

City and county managers' actions must be in compliance with state regulations such as those for floodplain management and water supply planning; they experience challenges when actions run up against the limit of their jurisdictional authority. That is, within their jurisdictional authority, managers may incorporate climate information and make adaptation decisions but managers have little power to impose distinct climate agendas and norms on managers operating at other scales. For example, despite interest in changing precipitation patterns to inform more stringent local standards for stormwater system design, city and county water managers expressed frustration at not being able to do so because such standard setting falls within the purview of the state water management agency. In the words of a county-scale water manager explaining the lack of attention to climate in everyday decisions, "We are waiting to see what state and local policies might do and how we fit."

At the local or small community scale, some, but not all managers, have jurisdictional authority to put climate on local agendas such as in taking action to manage stormwater or localized flooding or through community planning. However, the willingness to do so is often lacking owing to difficulties with translating climate information into on-the-ground climate action and projects. For example, one manager pointed out "The community is cognizant of the past. There is a mindset that there is a history to preserve. This is a unique community. We like the narrow roads. We want to preserve that uniqueness. We are in some ways stuck in the past. We have always done it that way so, why do it differently?" And when asked about whether they discuss climate change and use climate information in community meetings, a community supervisor said "….not in the board room. We have people that think it is a hoax. I wouldn't mention it in the room because it wouldn't be productive."

4.4 Adaptation by stealth: putting climate on the agenda with or without climate information

Only managers at the county and city scale actually use climate information to address climate change impacts rationalizing these actions by emphasizing that current practices are not apt for future conditions: "We are trying to revise the rules of the Water Resource Commissioner [Those revisions relate to procedures and design criteria for stormwater management systems]. We are looking at the precipitation data -what are the numbers? Are we constructing our infrastructure and projects for the future precipitation conditions or not?" In addition to incorporating precipitation time series and projections, city and county managers consider estimates of the frequency and intensity of future design storms vital for stormwater management. As indicated in Table 2, climate information bears directly on city and county infrastructure planning such as the construction of stormwater storage facilities and the design of storm drains and ditches as well as for cities managing water supplies, urban canopies, and for broader planning efforts.

However, not all decisions that city and county managers make benefit from using climate information directly. Rather, some decisions are influenced by climate information because the information plays a role in agenda setting. For example, precipitation time series and projections showing a trend towards more frequent and intense storms fueled an increased interest by water managers at the city scale to incentivize homeowners to replace impervious surfaces on their properties with permeable surfaces that better absorb stormwater. Rather than using climate information directly or taking actions to respond to anticipated climate changes, these managers use prior experience as a means to place climate more firmly on decision agendas. As expressed by a city manager, "…the last 5–10 years we have had a few 100-year [flood] events. The theme of climate change is inherent in that conversation. But we don't look at projecting that forward. We see it as a way to talk to citizens' about problems…" Other examples, likewise at the city scale, include cities' move towards more "climate-friendly" management such as urban forestry plans and "green streets" policies. The green street policies entail that every time a city street is constructed or reconstructed, the construction should address improved stormwater management such as having rock beds underneath streets. Such climate-friendly management decisions are, among other factors, influenced by climate information, but the actual design of individual urban forestry projects and green streets do not factor in, for example, detailed precipitation projections. A reason for not using climate

Table 2 Examples of decisions involving use of climate information at the city or county scale

Examples of climate information adopted	Decisions involving climate information
Design storms	Stormwater management • Design of storm sewers • Extension of sewage system • Water treatment plans
Precipitation time series	Stormwater management • Design of storm sewers • Extension of sewage system • Water treatment plans • Pipe size and ditch widening
Temperature time series	General planning • Budgeting based on previous droughts
Precipitation projections	Stormwater management • Urban forestry management plan • Green infrastructure on public lands • Green infrastructure on private lands Flood management • Flood control • Outline of flood hazard zones
Seasonal forecast	Management of water supply and demand • When/if to shift to different water sources • Budgeting for water demand and chemical use • Possibly issue water use restrictions (if river flows are very low)
# of days that exceed certain thresholds	Ecosystem management • Which ecosystems to protect now as compared to in 50 years • Move away from protecting species that require an unbroken canopy • Restoration General planning • Best management practices

information directly relates to information fit. In the words of a city manager, "With the [climate] information coming out it is hard to use it in a specific way, but more broadly we are thinking about extreme events and warming trends." This played out during a city planning department group exercise where the employees were asked to plan for infrastructure maintenance near a floodplain. When the group finished the initial exercise, they were asked to re-do the planning *considering* climate change. Attention was thereby devoted to whether or not climate change will happen and to developing a set of climate-related actions rather than needing more specific climate information about the extent of anticipated climate changes. In the words of a city manager, "Our whole mindset is changing and that new mindset fits right in with climate change. It won't matter what climate change does (e.g. if the trends change or do not change)…" The inclination to make climate decisions without depending on tailored climate information was likewise expressed by a county manager: "The information we are using is just a gut feel for long-term planning. We are using the same old assumptions to identify the problem areas but all this stuff is changing."

While many city and county managers have begun thinking differently about planning because of prior experience with altered climate, some managers are also thinking about broader sustainability actions not tied to specific types of climate information. A county-scale manager expressed their sustainability efforts this way: “We are looking to see where we can put more tree canopy. Climate change also motivates our efforts to use natural light better.” These examples suggest that decision makers rarely focus on climate alone because climate is considered as one of a number of stresses driving decisions. Faced with a multitude of other sustainability challenges, neglecting climate concerns appears, in many cases, an easier solution. That prior experiences with climate rather than specific types of climate information trigger water managers to think differently is related to an increasing emphasis on creating resiliency and sustainability. And in this process, specific climate information ends up having a weak traction or being ignored.

5 A climate decision spectrum for understanding variation across scales

In reviewing how information is used across scales, our findings suggest that whether climate information ultimately gets integrated in decision-making depends on factors beyond the information itself. Firstly, we find a distinct variation in the extent to which water and resource managers operating at various spatial scales frame climate. Whereas local managers regard climate as a distant issue with which they do not need to concern themselves until there is a state or federal mandate, state agencies view climate as a more local issue that will only get on the agenda if there is a demand from local managers. The finding that local managers perceive climate change as distant from everyday practices aligns with previous studies indicating that such perceptions are a barrier to information uptake (Jones et al. 2015; Phadke et al. 2015; Wolf and Moser 2011). It also challenges the prevailing view in the climate science community that increasing the spatial resolution of climate models is sufficient to ensure information usability (Dessai et al. 2009).

Consistent with previous work on barriers and drivers of information uptake (Kirchhoff et al. 2013; Lemos and Morehouse 2005), we find that information characteristics and fit do influence whether climate information is being integrated in decision-making. But as an important additional factor, we find that management frameworks and existing agendas matter for whether and how climate information is integrated at various scales. Our results show that it is primarily at the city and county scale that existing agendas exert influence on the interest in climate information. Our findings also emphasize that climate change is perceived as a “political hot potato,” which may, on the one hand, impede water managers’ use of climate information and adaptation actions across scales. On the other hand, the very framing and political controversy surrounding climate change may also motivate less visible climate driven (e.g., as sustainability initiatives) adaptation by stealth actions.

Finally, we find that the mandate and authority of managers ultimately influence whether climate information is being integrated into decision-making. In line with the findings of Kirchhoff and Dilling (2016), our results show that there is a need for states to take more leadership on the integration of climate information to ensure that risks from climate change are managed across all decision scales. Importantly, it is primarily at the city and county scale that climate information is being integrated into decision-making—and only among those managers willing to put climate on the agenda since limited state mandate exists to compel action. Even if state or county managers were required to put climate on the agenda through, e.g. an adaptation plan, further actions beyond the adaptation plan may be limited (Woodruff and Stults 2016).

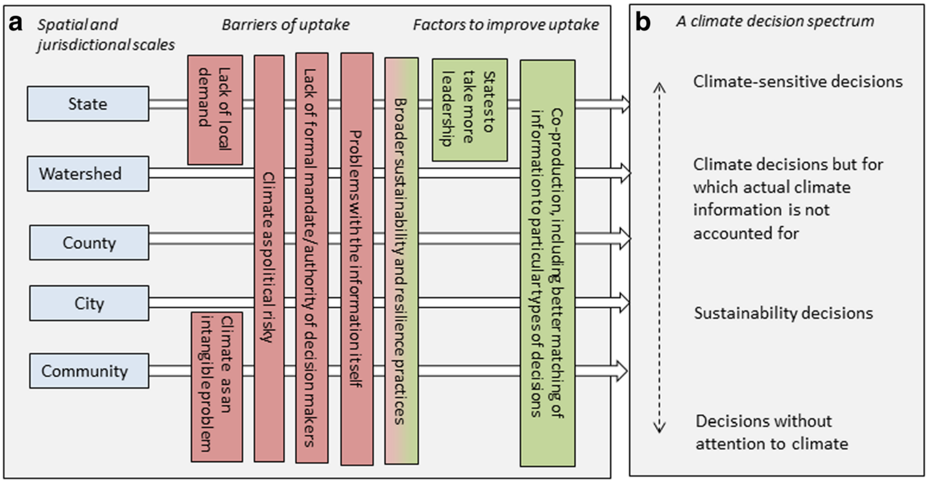

Fig. 1 Schematic diagram that shows how water and resource managers' scales of decision-making influence the use of climate information (**a**) in decisions located along a spectrum from climate sensitive decisions to decisions without attention to climate (**b**)

Our results suggest that the mainstreaming of climate information and the interaction between existing knowledge and new information make it a challenge to strictly separate "climate adaptation decisions" from decisions informed by—but not necessarily dependent on—climate information that can be characterized more broadly. Thus, in our conceptualization of adaptation by stealth, rather than one or the other, we regard climate information use within a decision spectrum. On the one end of the decision spectrum, climate information is directly integrated into climate sensitive decisions (e.g., stormwater system design) while on the other end, decisions are made without attention to climate. In between are decisions informed by climate change risks but where the specific climate information is virtually ignored (e.g., when managers think broadly about precipitation patterns or temperature trends) and broader sustainability decisions. Such adaptation strategies should be considered an important component of the adaptation repertoire and may suggest a need for climate information brokering to attend to different kinds of information uses and needs beyond highly customized information. Figure 1 summarizes the scale-specific and more general factors that constrain and drive climate information use in different types of decisions.

6 Conclusions

Our Great Lakes-focused study, while limited in scope and generalizability, provides empirical evidence of how the scale and context of decision-making influence uptake of climate information. For example, despite both having usable climate information available and the potential utility of climate information to inform risk management efforts, we find that climate information is not always used by water and resource managers operating at different scales of decision-making. The sweet spot for climate information use appears to be at the city and county scale where climate change impacts are perceived to be locally relevant and the availability of locally tailored climate information helps to inform climate-impacted decisions. At other scales of decision-making, problems with the information itself persist to impede information use. In addition, information is not used because managers are not willing or are unable to place climate firmly on their agendas. For example, at hyper local scales despite having climate information available, managers avoid putting climate on their agenda because climate change is perceived both a political hot potato and a distant and intangible issue. By contrast, water managers at state agencies regard climate change as a local issue that will only get on state agendas if driven by local manager interests. Other impediments to information use stem from constraints imposed by existing mandates/authorities such as limits to city and county water managers' ability to translate climate information into revised stormwater infrastructure design standards, a state regulatory authority. With impediments to information use stemming from restrictive agendas and mandates, our findings demonstrate that challenges to climate information use extend beyond having tailored climate information available. In particular, our findings suggest that states should take more leadership on the integration of climate information to facilitate adaptation across scales.

Our results also suggest that to improve climate information uptake and decision-making in the context of climate change, we need to better match particular types of climate information to particular types of decisions. That is, climate scientists and information brokers should aim at producing information that meets a range of decision needs and reserve more intensive tailoring efforts for decision makers who have both the authority and willingness to use climate information.

Finally, we must rethink the ways in which climate information gets integrated into decision-making across scales to better reflect that decision makers are moving towards broader sustainability and resilience practices that take other considerations into account instead of narrower, climate-only focused actions. On the one hand, given the persistent politicization of climate as an issue, these "mainstreaming" choices allow for adaptation while calling it something else. On the other hand, this "adaptation by stealth" may create the conditions for climate information uptake. Given this shift, scientists, practitioners, and policy-makers should acknowledge and support (e.g., with relevant information and policies) those broad strategies as an important component of the climate adaptation repertoire.

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Compliance with ethical standards

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