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Using Serious Games to Facilitate Collaborative Water Management Planning Under Climate Extremes

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Abstract: Sustainable management is a complex process that involves balancing the competing interests of the human, plant, and animal communities that depend on watershed resources. It involves developing and implementing plans, programs, and projects that sustain and enhance watershed functions while taking into account the natural, social, political, economic, and institutional factors operating within the watershed and other relevant regions. Examples of such factors include crosscutting mandates by different levels of government, conflicting objectives across sectors, and the constraints and uncertainty of the availability and accessibility of the resources within the watershed. One way to address these complexities is with public participation processes designed to share knowledge among disciplinary experts, policy-makers, and local stakeholders and provide outcomes, which inform the creation of sustainable watershed management plans. Serious games (i.e., games played for purposes other than pure entertainment) are an example of such processes. Here, we present a case study of how a serious game, called the multi-hazard tournament, was used to facilitate watershed management by promoting social learning, cross-sectoral dialogue, and stakeholder participation in the planning process.

Keywords: *water resources, drought, public participation, systems thinking, social learning*

Games are becoming increasingly popular as an alternative education and training tool, as businesses, organizations, and government entities look for innovative ways to engage individuals, train staff, and address societal challenges (Galvão et al. 2000; Michael and Chen 2006). Applications of games include the military, business, higher education, medical training, urban development, policy, natural resource management, and countless others (Cohen and Rhenman 1961; Burton 1994; Wachowicz et al. 2003; Mayer et al. 2005; Bots and Van Daalen 2007; Royse and Newton 2007; Mayer 2009; Breuer and Bente 2010; Hummel et al. 2011). The U.S. Department of Homeland Security (DHAS) promotes the use of games when managing risk and considers them to play a key role in disaster management (FEMA 2016). For instance, serious games can identify vulnerabilities and solutions for mitigation; increase preparedness by training participants, clarify roles and responsibilities, and improve interagency coordination; identify needs and capabilities during a response to a disaster; and assess the resources needed for recovery.

Games have numerous benefits that translate to water management. For example, participation in a game, as a fun activity, may make the learning process more enjoyable or may bring people to the table who would otherwise not participate (Burby 2003). Games provide a safe environment for players to learn and experiment with decisions by seeing the direct impact of those decisions through feedback mechanisms (Mayer 2009). Games can also prepare players for the real situation to which the game refers (Peters and Vissers 2004) and provide a suitable environment for improving negotiation skills, consensus building, and changing players' beliefs and attitudes (Garris et al. 2002; Rusca et al.

2012). These benefits become especially important with the fact that adults have a greater motivation to learn if the learning process is interactive (Falk 2001) and when they know the new knowledge will effectively incorporate with their real-life problems and responsibilities (Arndt and LaDue 2008).

In this paper, we use a case study of how a game, called the multi-hazard tournament (Muste et al. 2017), was used in the Cedar River Watershed in eastern Iowa to increase stakeholder participation in the planning process, foster cross-sector collaboration, build knowledge of the complexities of water management planning, and influence attitudes toward policy.

Serious Games

Games that have a designed purpose other than entertainment are called serious games (Abt 1987). Serious games focus on the transfer of game features like competition, co-operation, participants, and rules to user-centric contexts and goals. In other words, they try to help users understand a situation by thinking of it as a game rather than a real-world challenge and as players rather than competing stakeholders (Schmidt et al. 2015).

The Invitational Drought Tournament (IDT) is an example of a serious game used within the context of water management. The IDT, developed by Agriculture and Agri-food Canada (Hill et al. 2014), is a goal-oriented game designed to educate and train participants in decision-making skills around drought and water management. Part workshop and part competition, the tournament engages participants in the use of environmental data to stimulate conversations about drought in the context of a changing climate. Players work in interdisciplinary teams to develop comprehensive management strategies for minimizing environmental, social, and economic impacts of drought.

In early iterations of the tournament (AMEC 2012; Lapp 2012; AMEC 2014), teams were guided through scenarios set in a fictitious watershed that had features and characteristics similar to those that would be found in the region where the tournament was taking place. The fictional setting helped keep the game as politically and geographically neutral as possible so that players could engage in open discussion in a safe forum. Scenarios included drought characteristics (e.g., temperature, precipitation, soil moisture, etc.) as well as impacts of drought (e.g., decreased agricultural yields, increased household stress, reduced tourism, etc.).

More recently, the IDT has evolved in complexity to include multiple hazards (e.g., flood, drought, water quality) and the use of a model-based interactive decision-support system designed to support community problem-solving in selecting a watershed adaptation strategy (Muste et al. 2017). This iteration of the tournament was tested in the Cedar River Basin in eastern Iowa to assess its effectiveness in meeting objectives falling within the context of three theoretical frameworks.

Theoretical Background

The frameworks used in this case study include: public participation theory, systems thinking theory, and gaming theory.

Public Participation Theory

Public participation is the process by which public concerns, needs, and values are incorporated into the decision-making processes of governments, organizations, and corporations (Creighton 2005). The International Association for Public Participation (IAP2) defines a set of core values for making better decisions and reflecting the interests and concerns of the affected parties (IAP2 n.d.). These core values state the following:

1. The public has a right to be involved in decisions that affect their lives.
2. The public's contribution will influence the decision.
3. The public participation process will communicate the needs and interests of all participants, including the decision-makers.
4. The public participation process will seek out and facilitates the involvement of those potentially affected by a decision.
5. The public participation process will seek input from participants in designing how they will participate.
6. The public participation process will provide participants with the information they need to participate in a meaningful way.

7. The public participation process will communicate to participants how their input affected the decision.

The complexity of water resource planning and management makes it essential to bring together the right group of people and to provide them with the necessary data for making fair, efficient, and informed decisions for managing the risks caused by climate extremes. Stakeholders involved in the process should represent several aspects of social, economic, and environmental perspectives to expand options, address the most concerns possible, and create mutual understanding. Any gaps in information or perspective could lead to results that fall short of planning goals (Wall and Hayes 2016).

Public participation includes five levels of engagement (Figure 1) designed to inform, consult, involve, collaborate with, and empower the public (IAP2 n.d.; Creighton 2005). Each level includes greater engagement with the public and, correspondingly, has a greater impact. The inform stage, which has the lowest level of public impact, is a one-way flow of information designed to provide the public with the necessary background to fully understand a project or decision. In the consult stage, two-way communication begins and the public is provided an opportunity to express their views. The involve stage includes an interactive exchange of ideas throughout the project or decision-making process, though final decisions remain out of the public's hands. In the collaborate stage, the public takes an active role in the decision-making process in an effort to reach a consensus and mutually resolve issues. The highest level of public impact occurs with empowerment, which places final decision-making in the hands of the public. The higher levels of engagement also include aspects of the lower levels. For example,

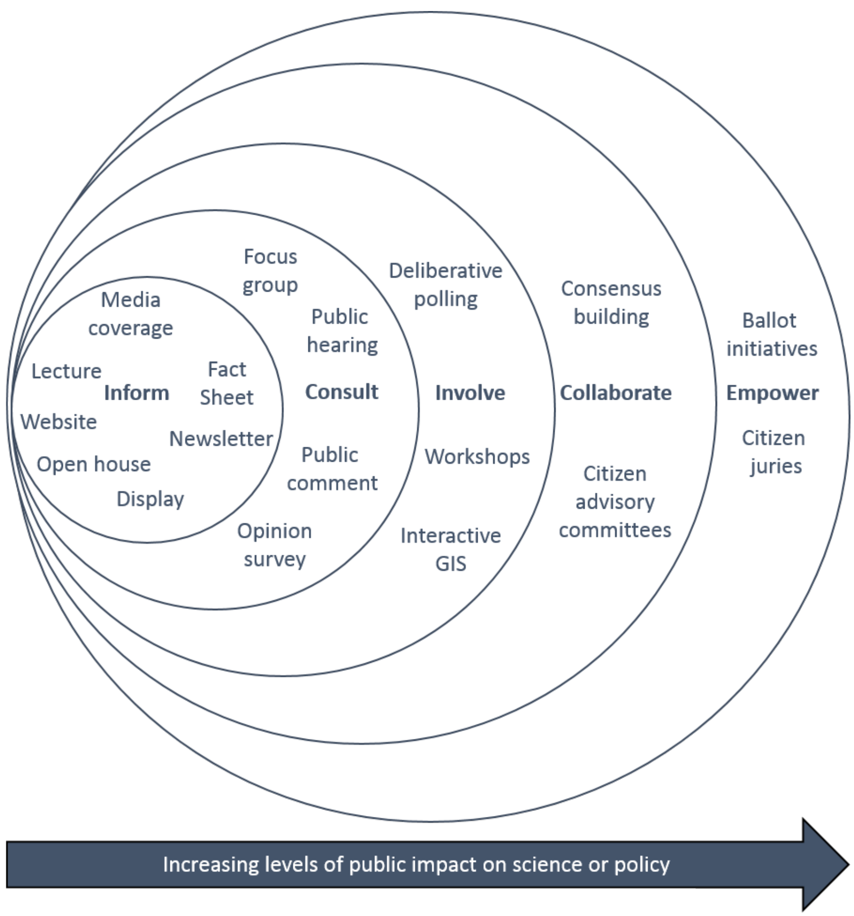

Figure 1. Levels of public participation (IAP2 n.d.; Miskowiak 2004).

the public must be informed to actively participate in collaborations or to make knowledgeable decisions. Public participation programs may include multiple levels of public participation, because of differing needs at different stages of the process and because different stakeholders will choose to engage in different ways.

Serious games such as the multi-hazard tournament meet a variety of goals in the public participation spectrum. For example, the multi-hazard tournament informs participants by providing them with an entertaining method for digesting scientific information and creates opportunities for collaboration by providing an environment in which participants can experiment with decisions under the constraints of economic, policy, and political frameworks (Hill et al. 2014). Part of the public participation process includes designing meaningful objectives and goals and providing information that can be communicated in a meaningful way. In doing so, stakeholders can see how they are affected by outcomes and organizers can assess whether or not the information and process made a significant impact in a stakeholder's decision-making.

Systems Thinking Theory

Systems thinking is a holistic approach to problem-solving that focuses on the interconnectedness and interdependencies among the different parts of a system (Behl and Ferriera 2014). It can be thought of as the ability to see the "big picture" or to recognize that "the whole is more than the sum of its parts." This approach provides opportunities to incorporate multiple perspectives, understand complex system behavior, work on problems with "fuzzy" boundaries or scopes, and to predict the impact of changes to the system (Arnold and Wade 2015).

Key components to systems thinking (Stave and Hopper 2007; Behl and Ferriera 2014; Arnold and Wade 2015) include the ability to: 1) perceive the system as a whole rather than individual parts; 2) recognize and understand feedbacks within the system; 3) understand how the behavior of the system is a function of internal structure and interactions; 4) use conceptual models to explain system behavior; and 5) understand systems at different scales.

A systems thinking approach is particularly suited to water management as managers today are expected to cope with increasing complexity and uncertainty. For instance, water managers need to account for diversity in water use, consider differing stakeholder viewpoints, understand the interconnected relationships within and between the environment and society, and discern how changes in policy affect water quantity and quality, and impact communities and ecosystems (Halbe et al. 2013; Behl and Ferriera 2014).

The multi-hazard tournament applies many of the aspects of a systems thinking approach to water management (Muste et. al. 2017). For example, interdisciplinary teams can promote social learning and help participants understand multiple perspectives for water resource management. A conceptual model of the river basin simplifies the complexity of the system to help increase understanding and a computer-based decision support system offers a way for participants to examine how feedbacks within the system relate to differing adaptation options. Finally, input from local, state, and federal entities help stakeholders understand the system at different scales. By providing players with opportunities to test potential adaptation strategies to reduce risk from extreme climate events while, at the same time, accounting for water quality issues, tournament organizers hope to move people toward a systems thinking approach (Hill et al. 2014).

Complexity and Game Theory

Game theory is the process of modeling the "conflict and cooperation between intelligent, rational decision-makers" (Myerson 2013). While this theory may have begun under the hypothesis that decision-making is well thought out and strategic, it has since evolved with the hypothesis that decision-making is, rather, "chaotic and messy" (Mayer 2009), and that straightforward programmable solutions do not always exist.

Problems in decision-making can be defined by both technical-physical and social-political complexity (Mayer 2009). Technical-physical complexity refers to complexity that arises as a result of the physical and technical entities within the system or quantifiable factors such as economics and demographics. Social-political complexity results from competing values, needs, norms, and beliefs of stakeholders affecting and affected by policy outcomes. For example, natural resources management is frequently hampered by conflicting uses and priorities driving management decision.

Serious games now have the potential to help address and integrate technical-physical and social-political complexity (Medema et al. 2016). For example, a game can use conceptual models to simplify the complex interactions within a water management system and provide opportunities for players to test and gain insight into different adaptation strategies (Bots and van Daalen 2007; Ewen and Siebert 2016). When a game incorporates multiple players it has additional benefits of allowing players to interact, experience social learning (i.e., adjust their understanding by "walking in another's shoes"), negotiate conflict, and engage in collaborative decision-making (Bots and van Daalen 2007; Ewen and Siebert 2016; Medema et al. 2016). These types of games may provide benefits to natural resources management by creating shared knowledge, increasing understanding of the system, and leading to more effective collaborative planning (Innes and Booher 1999; Barreteau et al. 2007).

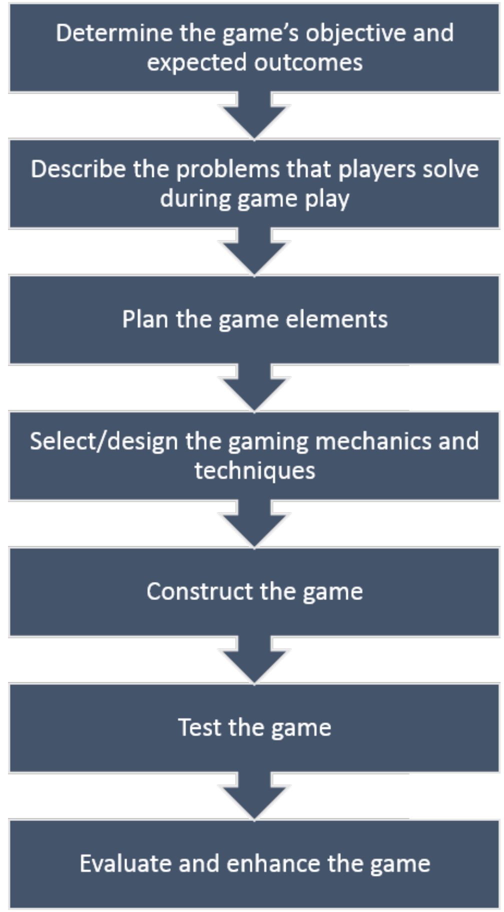

Figure 2. Basic steps to game design (Duke 1980; Smith et al. 2017).

Assessment Plan

Setting clear goals during the planning stages of a serious game (Figure 2) is essential for assessing its effectiveness within the contexts of public participation, systems thinking, and complexity and gaming theories. In the game, process outcomes can include *knowledge into action*, where the goal is to learn and apply knowledge; *action into knowledge*, where the goal is to generate new knowledge through participation in the game; or an *integration of action and knowledge*, where the goal is to make connections between the two (Koestler 2009).

In the case of the first (knowledge into action), organizers can assess whether an action, or even perceptions of an action, change before and after learning new knowledge. In the case of the second (action into knowledge), assessment includes determining whether participants changed their understanding of a topic through participation in the game. The goals of a serious game may integrate both knowledge-into-action and action-into-knowledge, where the expectation is that participants bring diverse knowledge and learn to apply their knowledge to a problem *and* generate understanding, skills, and knowledge from the experience.

A multiplayer game such as the multi-hazard tournament, adds elements of social learning which include learning new knowledge from one another, generating new knowledge from the act of working collaboratively, and working collectively to apply knowledge to a problem. In this instance, assessment may be based upon the following outcomes:

Action-to-Knowledge

- Did the players learn anything regarding the problem, information resources, or strategies?

- Did players learn or generate knowledge about strengths and weakness in existing plans, policies, or decision-making processes?
- Did players get the information that they needed to make change?

Knowledge-to-Action

- Will the players incorporate new tools or skills into future activities?
- Did or will it improve communication and coordination among player agencies and sectors? Did any new collaborations emerge?
- Do players intend to change plans, policies, or decision-making processes based on information obtained from the tournament?

Table 1 maps these outcomes to the theoretical frameworks discussed previously.

Case Study

Cedar River Watershed Overview

The multi-hazard tournament described in this case study focused on the Middle Cedar Watershed, a watershed or drainage basin that starts at the beginning of the Cedar River near Austin, Minnesota and extends southward into the city of Cedar Rapids, Iowa. The watershed spans parts of 10 counties in eastern Iowa (Figure 3) and covers approximately 1.5 million acres (University of Iowa 2017). The watershed serves multiple communities including the cities of Cedar Rapids (pop. 126,326), Waterloo (pop. 68,406), and Cedar Falls (39,260) (U.S. Census Bureau 2016). It also supports intensive agriculture, with over 73 percent of the land dedicated to row crop and seed corn production (University of Iowa 2017), and industrial uses.

The tournament focused on the watershed level because it includes groundwater, lakes, streams, reservoirs, and wetlands and allows for a holistic approach to water management. Water management concerns within the watershed include nutrient loading, flooding, and drought.

Water Management Regulatory Issues

The following items are example regulations within the Cedar Rapids Watershed that contribute to the complexity of water management in the basin (U.S. Army Corps of Engineers, 2016).

Ownership and Permitting. Surface and groundwater are public goods of the state; however nearly all of bed and banks of Iowa's rivers and streams are privately owned. Permitting for withdrawals and storage depends upon the quantity of water being diverted. Users must preserve minimum flow values in the river and not interfere with the course of drainage to the extent that it damages others' property.

Water Quality. Agricultural producers are exempt from liability resulting from nitrate or pesticide contamination of groundwater as long as fertilizers and pesticides are applied in accordance with soil test results and applicable regulations. Permits are required for the discharge of anything into underground water bodies and for discharge into surface water. Drinking water facilities must be regulated in accordance with federal standards.

Water Quantity. Water uses are subject to the control of the State and must be for a recognized "beneficial use." The Governor can prohibit various activities and uses to protect life, health, property, or public peace for ten days.

Tournament Description

Participants were organized into teams charged with integrated management of the Cedar River Watershed to create the best solutions for reducing flood, drought, and water quality impacts under climate scenarios affecting the basin (USACE IWR 2016; Muste et al. 2017). Each team worked collaboratively using their knowledge and expertise to select appropriate adaptation options for the scenarios under the constraints of time, budgets, state and municipal regulations, and technical aspects (Table 2).

In addition to team players, the tournament included other roles (USACE IWR 2016). Referees served as content experts for providing insight and feedback into the feasibility of innovative adaptation options and participated in the scoring process for assessing each team's management plan (Figure 4). Team facilitators kept discussions flowing, ensured all team members were respected and heard, tracked the time and budget, and submitted the team's final decisions and peer scores. Fans observed the tournament, participated in the scoring process, and

Table 1. Assessment outcomes matched to the underlying theoretical frameworks.

	Assessed outcome	Applicable theoretical framework(s)
Action to Knowledge	Did the players learn anything regarding the problem, information resources, or strategies?	*Public Participation:* Players were informed about decisions that would affect their lives. *Systems Thinking:* Players' ability to perceive the system as a whole increased as a result of their participation in the tournament. *Complexity and Game Theory:* Players experienced social learning.
	Did players learn or generate knowledge about strengths and weakness in existing strategies for mitigation?	*Systems Thinking:* Players recognized and understood feedbacks within the management system.
	Could players evaluate the investments needed to drive change?	*Systems thinking:* Players understood the behavior of the system. *Complexity and Game Theory:* The game adequately simplified complex interactions within the system.
Knowledge to Action	Will the players incorporate new tools or skills into future activities?	*Public Participation:* Players were empowered to use new information and skills
	Did/Will it improve communication and coordination among player agencies and sectors? Did any new collaborations emerge?	*Public Participation:* Players' experience increased partnerships in the planning process. *Complexity and Game Theory:* Game interactions led to more collaborative planning.
	Do players intend to change plans, policies, decision-making processes based on information obtained from the tournament?	*Public Participation:* Players were empowered to use new information and skills.

Figure 3. Cedar River Basin upstream of the city of Cedar Rapids (University of Iowa 2016).

Figure 4. A team consults with a referee regarding a technical question or innovation.

provided feedback on the tournament process. An announcer presented the scenarios and provided overall facilitation for the event.

Sixty participants, representing entities ranging from federal, state, and local governments to non-governmental organizations, farmers, and academia, attended the tournament. They were sorted into seven teams. Each team was given the same budget and a list of adaptation options to address when working through four scenarios. The format for the day (Figure 5) consisted of four rounds which included a presentation of the scenario, facilitated discussion of the scenarios, adaptation option selection, team report-outs (in the form of a press release, to justify the choices made), and scoring.

In the first scenario each team was given a $1.6 billion budget for adopting water management strategies for a 20 year planning period. This amount was based on a real-world estimate, which included anticipated funding for the region over the next 20 years. The first round was considered a long-term planning round and did not include hazards. In rounds two and three, the planning range was reduced to one year and team budgets dropped to $62 million, including the maintenance and operating costs from round one. Round two emphasized flood, which caused the teams to reconsider previous management choices and consider future flood precautions. Round three focused on drought causing the teams' mindsets to shift from too much water and immediate damage

Table 2. Summary of the Iowa Multi-hazard Tournament design by game element (adapted from Duke 1980).

Game element	Description	Iowa Multi-hazard Tournament
Scenario	Story line and sequence of drought-related events that challenge players	Teams worked collaboratively to address water management issues in the Cedar River Basin under extreme climate events
Sequence	Order in which the game unfolds	Game consisted of four rounds: (1) initial set up of the team's water management strategy and the selection of management options for a (2) flood, (3) drought, and (4) climate change
Steps of play	Progression of the phases in a turn	Introduction of the scenario, facilitated team discussion, selection of adaptation options using a web-based decision-support tool, presentation of a press release, and scoring
Rules	Regulations governing game play	A playbook outlined the game rules. Players worked under time and budget constraints to select pre-determined adaptation options or devise innovative solutions deemed feasible by the referees
Roles	Characters assigned to game participants	Team players, team facilitators, referees, fans, and an announcer
Scoring	Basis for awarding points	Scoring was based on how well team adaptation options performed in the economic, social, and environmental evaluation metrics within the decision-support tool and by how well other participants rated the appropriateness of their options
Game materials	Objects necessary for game play, highly dependent upon game complexity	Playbook, score sheets, decision-support tools, laptops, monitors, and flip charts

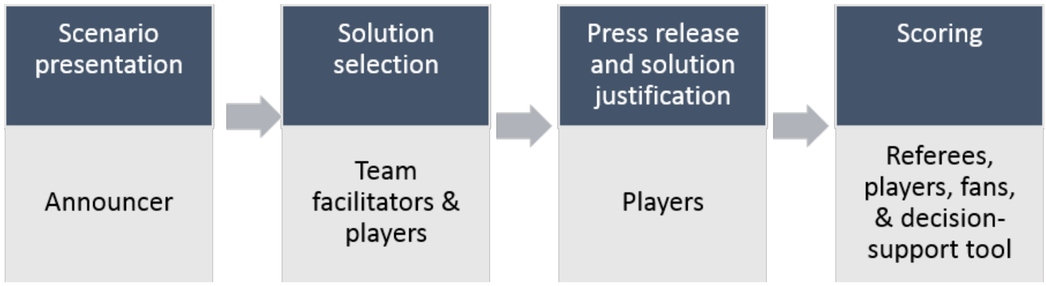

Figure 5. The process for each round of the multi-hazard tournament (Muste et al. 2017).

to a slow moving disaster that involved water shortages and broader impacts. The final round consisted of a climate change scenario with more frequent and extreme flooding and drought events. This round had a $1.6 billion budget and allowed teams to reset their strategies based on the lessons they learned from the other three turns (Muste et al. 2017). In each round, teams could invest in policy, structural adaptation options, or non-structural adaptation options, and they were tasked with identifying an overall management strategy that considered tradeoffs and would minimize social, economic, and environmental impacts.

In each of the scenario rounds, teams brainstormed, discussed, and agreed upon management strategies for the watershed based on the projected climate conditions. A list of management options was included in the team's playbook and incorporated into the decision support tool. Some of the management options included: restoring or adding wetland spaces, reclaiming property, installing deep-water wells, installing nitrate removal equipment, raising houses out of flood zones, infrastructure improvements, and reinforcing levees. A computer based decision support system, designed specifically for the tournament by engineers and hydrologists at the University of Iowa (Muste et al. 2017) was available for each team to evaluate their choices and the impact these would have on public and private property, water quality, and aquifers, among others.

Teams had to justify their strategies to the other teams, judges, and fans by completing and presenting a press release at the conclusion of each round. Competing teams, referees, and fans scored each team's overall management plans based on the appropriateness of the adaptation options; consideration of impacts and trade-offs to society, ecosystems, and the economy; and innovation. In addition, the decision-support tool also calculated a score based on predefined library of simulations. At the end of the day, the team with the highest final score was selected as the winner (U.S Army Corps of Engineers 2016; Muste et al. 2017).

Partners in the event were the Rock Island District, the Institute for Water Resources, and Portland District, all with the U.S. Army Corps of Engineers; Sandia National Laboratories; Iowa Institute of Hydraulic Research (University of Iowa); the city of Cedar Rapids; the National Drought Mitigation Center at University of Nebraska-Lincoln; the Natural Resources Conservation Service; U.S. Geological Survey; the National Integrated Drought Information System; and Iowa State University.

Assessment Methods and Results

To evaluate the action-to-knowledge and knowledge-to-action outcomes of the tournament, we asked participants to complete knowledge and perception assessments prior to participation in the tournament, immediately following the tournament event, and three months after the tournament event. The surveys were administered online to tournament participants using Qualtrics survey software.

Survey questions were developed by tournament organizers following the framework described above. In both the pre-tournament survey and the post-tournament survey, we asked participants to self-assess their familiarity with hazard planning and with using climate information, as well as their familiarity with a variety of water quality, flood control, and drought mitigation strategies. We also asked participants, pre- and post- tournament, to rate the effectiveness of each strategy, state preferences for implementing each strategy, and estimate the cost of reducing water quality, flood, and drought damages over the next 20 years. Specific questions are listed along with the results below.

We measured collaborations and other actions in the post-tournament survey as well as the three-month follow-up survey, by asking participants whether they had met new people, discussed/pursued potential collaborations or identified opportunities to coordinate efforts, communicated with others, or considered changes to policies or decision-making processes. We also asked how they used new knowledge in decision-making; what plans, policies, or decision-making processes in the Cedar Rapids region that they thought needed to be changed; and what impact they thought the tournament might have on water quality, flood, and drought decisions in the region.

The pre-tournament survey was emailed one week prior to the tournament event (with one reminder) to 36 registered participants (including team members, facilitators, fans, and leaders), with 27 participants (75%) responding. The post-tournament survey was administered the day of the tournament event (with one reminder five days later) to 35 participants with 23 participants (66%) responding. Eighteen of the tournament team members participated in both the pre-tournament and post-tournament survey; we used this group to analyze changes in familiarity with processes and strategies, as well as changes in perceptions. The three-month follow up survey was administered three months after tournament event (with two reminders) to 35 participants, with 11 participants (31%) responding.

Action-to-Knowledge Outcomes

Did the players learn anything regarding the problem, information resources, or strategies?

Before the tournament and after, participants were asked to self-assess their level of familiarity with 15 options associated with water quality, flood control, and drought mitigation on a three-point scale (not at all familiar - very familiar). Six "upstream"-related options included building small agricultural ponds, planting cover crops, installing on-farm denitrifying bioreactors, managing agricultural nutrients to minimize runoff, changing land cover from row crops to grass, and changing land cover from row crops to wetlands. Nine "downstream"-related options included installing municipal nitrate removal equipment, raising municipal well intakes, installing new or upgrading existing municipal wells, building or enhancing levees, elevating structure through planning and zoning processes, improving municipal water system efficiency, lessening municipal water demand through conservation campaigns, and building large dams or reservoirs. Participants were asked the same question after the tournament. As shown in Table 3, participants brought varying levels of technical familiarity with them to the tournament. In the pre-post comparison (n=18), we found that those who were the least familiar with each option before the tournament tended to report higher levels of familiarity after the tournament.

Did players learn or generate knowledge about strengths and weakness in existing plans, policies, or decision-making processes?

Before the tournament and after, participants were asked to select what they believed were the three most cost-effective strategies (each) to "protect and enhance water quality", to "limit flood damages", and to "limit drought damages" for the Cedar Rapids area, using the same list of options described above. They were then asked to imagine that they were responsible for simultaneously protecting and enhancing water quality, minimizing flood damages, and minimizing drought damages in the Cedar Rapids area, and to choose their top three strategies for meeting all three goals.

We found that, in the process of the tournament game, participants changed their judgement of the strengths and weaknesses for some of the options. For example, the percent of survey respondents (n=18) who saw planting cover crops as a cost-effective strategy to protect water quality increased from 54% pre-tournament to 86% post-tournament. At the same time, the percent of respondents who would choose to invest in planting cover crops as a strategy to simultaneously protect and enhance water quality, minimize flood damages, and minimize drought damages increased from 42% pre-tournament to 62% post-tournament. Pre- and

Table 3. Percent of respondents who said they were not familiar/somewhat familiar/very familiar with options pre-tournament (and whether their familiarity increased, didn't change, or decreased post-tournament).

"Tournament Options Associated with Water Quality"	Not familiar pre-tournament	Somewhat familiar pre-tournament	Very familiar pre-tournament
Installing municipal nitrate removal equipment	20% (increase)	75% (no change)	5% (no change)
Raising municipal well intakes	30% (increase)	55% (increase)	15% (no change)
Installing new, or upgrading existing, municipal wells	15% (increase)	65% (increase)	20% (decrease)
Building or enhancing levees	10% (no change)	65% (no change)	25% (no change)
Elevating structures through planning and zoning processes	5% (no change)	55% (no change)	40% (no change)
Relocating structures through planning and zoning processes	15% (increase)	50% (increase)	35% (no change)
Building large dams or reservoir	45% (increase)	35% (no change)	20% (no change)
Improving municipal water system efficiency, including leak detection	35% (increase)	60% (no change)	5% (decrease)
Lessening municipal water demand through conservation campaigns	10% (no change)	80% (increase)	10% (no change)
Building small agricultural ponds	25% (increase)	50% (no change)	25% (no change)
Planting cover crops	15% (increase)	50% (no change)	35% (no change)
Managing agricultural nutrients to minimize runoff	20% (increase)	45% (no change)	35% (no change)
Installing on-farm denitrifying bioreactors	30% (increase)	55% (no change)	15% (decrease)
Changing land cover from row crops to grass	10% (increase)	65% (increase)	25% (no change)
Changing land cover from row crops to wetland	5% (increase)	75% (no change)	20% (no change)

post-tournament prioritization of all options is shown in Figure 6.

In line with the focus of the tournament on agriculture and urban stakeholders, many participants said they had learned more about opportunities and challenges for balancing needs and responsibilities. Comments included:

"*How modest changes in farming practices can lead to cost-effective strategies to mitigate drought, flood and water quality issues. Highlights the importance of including local farmers and associations in mitigation decisions, especially for agricultural-based communities.*"

"*Some farmers think in-field practices should not be compensated since they make good business sense, but edge-of-field practices should be because they do not return anything to the farm business. Community planners and stakeholders have very different ways of thinking about how to plan/organize a watershed or community. Planners manage risk. Many stakeholders described their process as balanced or watershed-based.*"

"The necessity of balancing input from all stakeholders regardless of rural or urban orientation."

Three months after the tournament, three participants reported they had reflected on plans, policies, or decision-making processes in the Cedar Rapids region that they think need to be changed. Suggestions included empowerment of the Watershed Management Authorities, more "respect of the floodplains and more restrictive floodplain development rules," and continued development of nutrient credit trading programs.

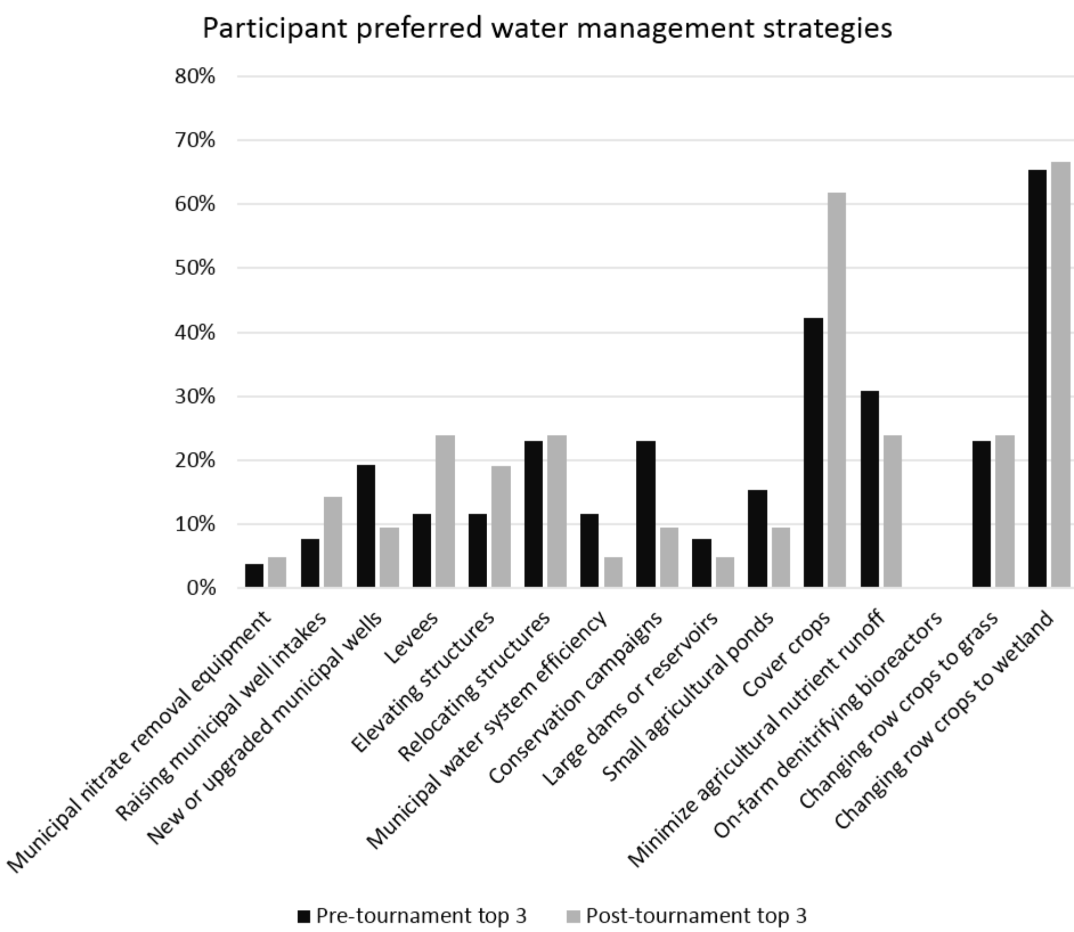

Figure 6. Percent of respondents selecting each option as one of their top three priorities to simultaneously protect and enhance water quality, minimize flood damages, and minimize drought damages in the Cedar Rapids area.

Others said they didn't know, or their opinions had not changed, or did not answer the question.

Could players evaluate the investments needed to drive change?

Prior to the tournament, and after, participants were asked their opinion on two questions related to financial investments needed to drive change: 1) how much of a total financial investment might be required to make an appreciable reduction over the next 20 years in water quality, flood, and drought damages for the Cedar Rapids area; and 2) with an investment of $60 million per year for the next 20 years, what percentage change in water quality, flood, and drought damage reduction might you expect to see in the Cedar Rapids area. Both were open-ended questions with an "I don't know" option.

Through the process of the tournament, some survey respondents (n=18) developed more concrete estimates of the financial investment that would be required to reduce water quality, flood, and drought damages for the Cedar Rapids area. Pre-tournament, 54% of respondents said they did not know how much of a financial investment might be required to reduce damages, and 30% said they did not know the amount of damage reduction possible in the region with an investment of $60 million per year for the next 20 years. Post-tournament, the percentage of "I don't know" decreased to 30% and 15%, respectively. On average, respondents estimated a higher total financial investment required to reduce damages after the tournament than before, but did not change the percent reduction in damages that they thought could be achieved. One participant said they "learned more about the capitol costs of localized and infrastructure related adaption practices. Learned about the different effectiveness of wetlands, this might influence the wetlands [our organization] targets to restore."

Dissenting views on learning objectives:

A few participants were critical of use of this method to meet learning objectives. One participant commented, "I would rather hear from experts on the aforementioned techniques and experiences tacticians to educate me on flood/drought/water supply… Reducing everyone's collectively knowledge and trying to fit into a crafty game with artificial parameters and limits and clunky rules could not have created a greater travesty."

Knowledge to Action Outcomes

Did/Will it improve communication and coordination among player agencies and sectors? Did any new collaborations emerge?

Directly after the tournament, participants were asked whether they had: met a person they didn't know before who could be a beneficial contact in the future; discussed potential projects or collaborations; learned about another person's interests with regard to water quality, flood, and drought mitigation that will be useful to them professionally; or identified potential opportunities to coordinate efforts.

After the tournament 95% of participants (n=20) said they met someone that they didn't know before who could be a beneficial contact in the future; 85% said they had learned about another person's interests that would be useful professionally; 75% said they had discussed potential projects or collaborations; and 63% said they had identified potential opportunities to coordinate efforts (Figure 7a). One participant commented, "I thought the tournament was a great way to get people from many different disciplines in one room to discuss these hazards as they WILL impact the area sometime in the near future."

Three months after the tournament, participants were asked whether they had pursued potential projects or collaborations with someone they hadn't worked with before, or identified synergies or opportunities to coordinate efforts with another agency. Sixty-two percent of respondents (n=8) said they had begun to pursue new projects or collaborations, and 75% said they had identified synergies or opportunities to coordinate efforts with another agency (Figure 7b).

Will the players incorporate new tools or skills into future activities?

Three months after the tournament, participants were asked whether they had learned more about another aspect of water quality, flood, and drought mitigation, or sought additional training based on questions that arose during the tournament. Eighty-nine percent of respondents (n=9) said they had learned more about another aspect of water quality, flood, and drought mitigation, and 22% said they had sought additional training based on questions that arose during the tournament (Figure 7b).

Do players intend to change plans, policies, or decision-making processes based on information obtained from the tournament?

Three months after the tournament, participants were asked whether they had considered or enacted changes to policies or decision-making processes related to water quality, flood, or drought. Sixty-two percent of respondents (n=8) said they had considered changes to policies or decision-making processes related to water quality, flood, or drought, and one individual had enacted changes to relevant policies or processes (Figure 7b). One participant said, "We are in the process of updating our State Hazard Mitigation Plan. Also, we review submissions local mitigation plans. We are trying to figure out how to change our plan, as well as provide guidance on local plans, to include some of the information and processes discussed in the tournament." Most participants did not feel that the tournament would directly impact water quality, flood, and drought related decisions in

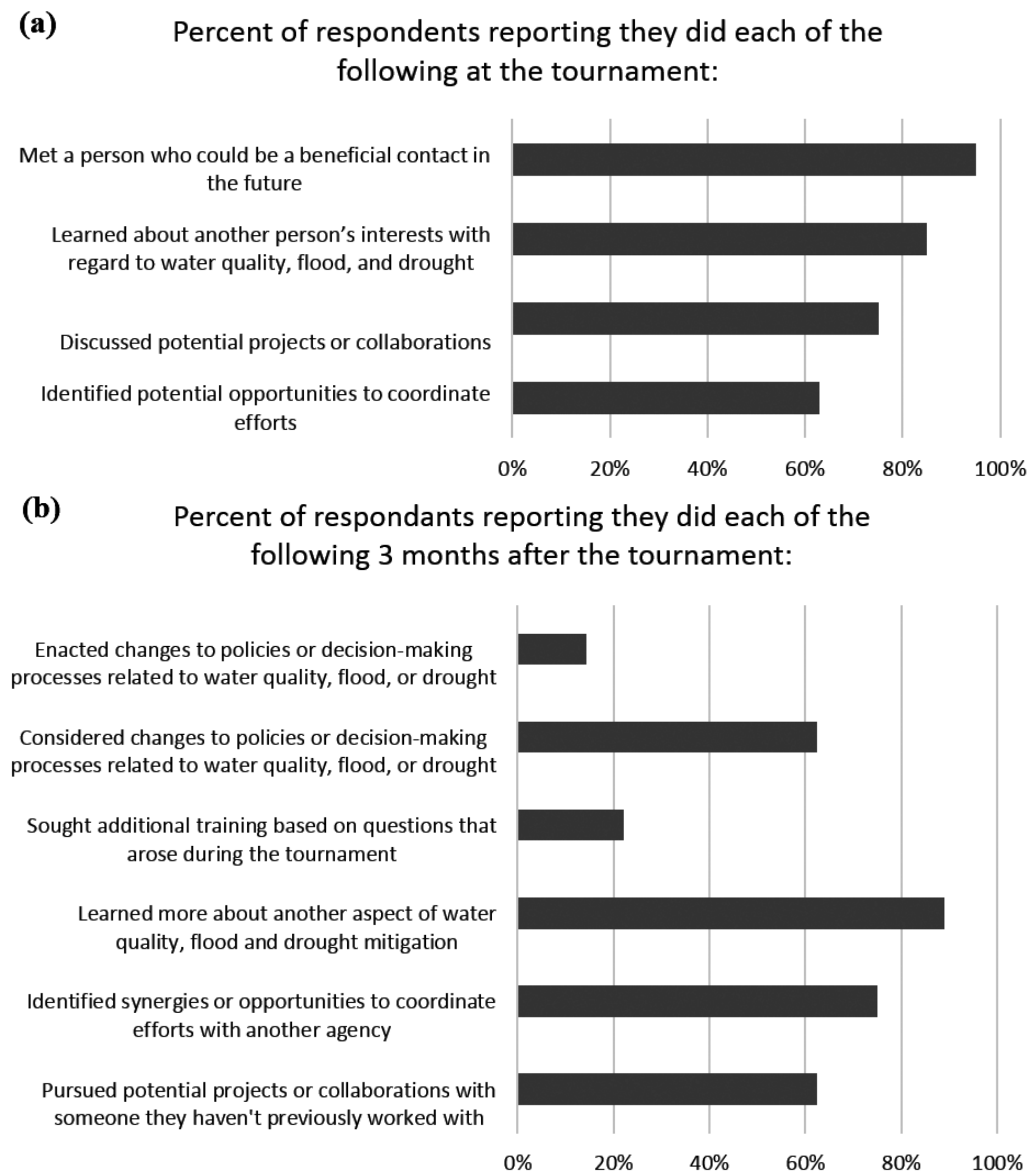

Figure 7. Assessment results (a) immediately following the tournament and (b) three months after the tournament.

the Cedar Rapids area. However, two participants again pointed out the benefit of the tournament; by educating and bringing groups together in collaboration, the tournament was a step toward improving decision-making.

Other Outcomes

After the tournament, participants were asked to agree or disagree with a number of statements about the tournament itself, including whether the tournament was the right mix of information and engagement, and whether the hazard scenarios provided a realistic context for decision-making. Eighty-five percent of participants (n=21) agreed that the tournament was the right mix of information and engagement. About 64% agreed the hazard scenarios used in the tournament provided a realistic context for decision-making.

Conclusion

We found the Iowa multi-hazard tournament to be a successful mechanism for testing the public policy, systems thinking, and complexity and gaming theories. Supporting the public participation theory, players said they gained new knowledge on aspects of water quality, flood, and drought mitigation. Additionally, players felt empowered to use new information and skills, as evidenced by the way they used the information to make decisions. The tournament appeared to be particularly effective for meeting objectives for facilitating new collaboration opportunities and communication across sectors as evidenced by the relatively high percentage of participants who had either identified or pursued new opportunities for collaboration. In support of systems thinking theory, we found that players gained knowledge about water management options and the ability to evaluate them critically in light of the broader systems that affect water quality under flood and drought events. Players also increased their understanding of the financial investments needed to drive change. With regards to the complexity and gaming theory, players experienced social learning social learning as they engaged with new individuals across sectors and worked collaboratively through the scenarios. Finally, the game successfully presented complex information in a way that enabled the participants to interact with and learn from the scenario.

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