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A Perspective-Based Simulation Game to Explore Future Pathways of a Water-Society System Under Climate Change

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Abstract

In this article, the authors address the challenge of including societal responses, society-environment interactions, discontinuity, and surprise in environmental scenario analysis. They do so through developing and testing a perspective-based simulation game for a typical Dutch river stretch. Concepts deriving from Cultural Theory, the Advocacy Coalition Framework, and Transition Theory provide the input for the game design. Players take on the role of water managers, responding to events and developments in the water-society system under specific realizations of a climate scenario. Responses include the choice for specific river management options, changing coalition perspectives, and changes in advocacy coalition membership. A pilot case study shows that the simulation game is a useful tool to explore possible future river management dynamics. It generates relevant insights in the water management strategies that may be chosen under future conditions, the possible drivers underlying future societal perspective change, and the way advocacy coalitions may interact. As such, the simulation game offers great potential for developing and assessing policy relevant climate adaptation pathways, in which water-society interaction, discontinuity, and surprise is taken explicitly into account. The main challenges for future research

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include reducing game complexity, better representing changes in the advocacy coalitions' strengths, and exploring more fundamental societal perspective shifts.

Keywords

climate adaptation, discontinuity, environmental scenario analysis, integrated assessment, perspective-based simulation game, perspectives, scenario analysis, surprise, transitions, uncertainty, water-society interaction, water management

Climate adaptation refers to the process of taking action to minimize adverse social, environmental, and economic impacts of climate change (Hulme & Neufeldt, 2009). In the Netherlands, climate adaptation is considered necessary to cope with expected increases in the risks of both flooding and drought (Ministry of Housing, Spatial Planning and the Environment, 2007). Climate adaptation, however, is a particularly difficult task because of the large uncertainty involved. Relevant uncertainties include global climate change, its regional implications, the natural variability of the discharge pattern, various socioeconomic developments, and land use change, to name but a few. Taking into account such uncertainties in water management is necessary to develop management strategies that are robust (i.e., relatively desirable under multiple possible futures) and flexible (i.e., allowing for strategy change) (see Offermans, Haasnoot, & Valkering, 2011; Valkering, Van der Brugge, Offermans, & Rijkens-Klomp, 2011).

To support climate adaptation in this uncertain context, environmental scenario analysis can help. Environmental scenario analysis is concerned with exploring the future of coupled environment-society systems (Alcamo, 2008). A variety of scenario analysis approaches exists, including quantitative and qualitative approaches, forecasting and back-casting studies, descriptive and normative scenario types, and combinations of those, each with their own strengths and weaknesses (see Alcamo, 2008; Bishop, Hines, & Collins, 2007; Swart, Raskin, & Robinson, 2004; Van Notten, 2005, for overviews).

One limitation in current environmental scenario practice, however, is the lack of methods to include discontinuity and surprise that typically emerge from complex interactions within the environment-society system (Alcamo, 2008; Van Asselt, Rotmans, & Rothman, 2005; Van Drunen et al., 2011; Van Notten, 2005). Notably, scenarios underrepresent ways in which societies may respond to events and developments in the environmental system. They tend to ignore the way water managers and the public at large begin to think and act differently as the future unfolds. Given main uncertainty sources like behavioral variability and societal randomness (Van Asselt, 2000), it is impossible to predict how such societal responses will unfold. However, we know that future trajectories will depend on societal responses, making this an indispensable and necessary aspect to explore in scenario analysis.

Exploring societal responses and water-society interactions in scenario analysis may benefit from simulation gaming. Simulation games can be defined as

> experi(m)ent(i)al, rule-based, interactive environments, where players learn by taking actions and by experiencing their effects through feedback-mechanisms that are deliberately built into and around the game. (Mayer, 2009, p. 825)

Simulation games can serve various functions as clarified through the metaphors of Bots and Van Daalen (2007). They can serve both as an analytical tool to gain insight into complex issues (gaming as a "laboratory") as well as a learning tool for participants offering various forms of support.[1] Following the gaming as a laboratory metaphor, simulation games may lend themselves to the development of scenarios in which societal responses—and hence, environment-society interactions, discontinuity, and surprise—are better represented.

The concrete method presented here entails what we call a *perspective-based simulation game* to develop scenario storylines for a case of Dutch river management. The game's design closely follows theoretical concepts of Cultural Theory (Thompson, Ellis, & Wildavsky, 1990), Advocacy Coalition Framework (ACF) Theory (Sabatier & Jenkins-Smith, 1993), and societal transitions (Rotmans, 2005; Van der Brugge, 2009) presenting complementary views on the dynamics of the societal response. These concepts are translated into a simulation game format in which players take up the role of water managers of a river stretch within a delta being confronted with climate change. This results in integrated storylines, or adaptation pathways, in which climate change and the water system on the one hand, and dominant worldviews and water management strategies on the other, develop in a coherent—and possibly discontinuous and surprising—way.

In this article, we describe the conceptual framework underlying the game design, the concrete setup of the simulation game, and the results of playing the game for a pilot case study. This aims to show the relevance of the approach for representing the societal response, and thereby water-society interaction, discontinuity, and surprise. Moreover, it aims to draw methodological lessons for improving the simulation game. For a more extensive discussion on various parts of the project, we refer to previous articles, dealing with the conceptual underpinning of the gaming approach (Valkering, Tàbara, Wallman, & Offermans, 2009), the mapping of shifts in societal perspective change in scenario analysis (Offermans et al., 2011; Valkering et al., 2011), and the use and development of a water simulation model in the simulation game (Haasnoot, Middelkoop, Van Beek, & Van Deursen, 2011).

Exploring Water-Society Systems Through a Simulation Game

We understand water management as dealing with a social-ecological (Norgaard, 1994), human-environment (Scholz & Binder, 2003), natural-human (Bossel, 1999), or—in this article—water-society system. The society system encompasses human actors and institutions, including their actions and belief systems, regulations, and the like. The water system encompasses water channels, biodiversity, infrastructure, and so on. These two systems are so much interwoven that they are said to coevolve. The societal system continually responds to the water system. It alters the water system through water management measures or changing water use. This, in turn, triggers new interventions and so on. Therefore, the developmental trajectory of either system cannot be understood without taking into account the other (Norgaard, 1994).

The coupled water-society system may exhibit different types of dynamics. Continuation of historical trends is one of them. However, one may also encounter nonlinear dynamics that may be responsible for discontinuous and surprising pathways. Discontinuity, in this context, can be characterized as an intrinsic difference with established trends, dominant patterns, or paradigms that may emerge both abruptly and more gradually, often involving complex interactions between short-term events and long-term developments, and between physical and immaterial processes (Van Notten, 2005). Surprise is a similar, yet more subjective concept as it depends on the perception of an observer of what is expected and what not.[2] Discontinuity and surprise may result from the interaction between the water and society systems. The typology of Toth (2008) distinguishes isolated surprise (unforeseen events in one subsystem without a significant impact on the other), interactive surprise (involving an event in one of the subsystems and a surprising reaction of the other subsystem), and propagating surprise (involving a sequence of responses between the society and water subsystems).

Representing such nonlinear dynamics of the water-society system in environmental scenario analysis can be a real challenge (Alcamo, 2008; Van Asselt et al., 2005; Van Notten, 2005). To address that challenge, we propose a perspective-based simulation game. The format of the simulation game is presented in Figure 1. It represents water-society interaction as the interaction between a *water system* (e.g., the river stretch considered) and a *societal response* (e.g., the actions undertaken by Dutch water management). This interaction is driven by an external *context*, including Social, Technological, Economic, Environmental, and Political (STEEP) developments, with a special focus on climate change.

This format is implemented as follows:

Water model. The water system is modeled with a so-called *Integrated Assessment Meta Model* (IAMM; Haasnoot et al., 2011) that describes the cause-effect relations within the water system. This metamodel is based on results of more complex hydrological and impact models previously applied. It allows for a rapid calculation of the effects of climate change and river management measures on river hydrology (e.g., water levels) and river functions (housing, agriculture, nature, and shipping) typically related to flooding and drought. During a gaming session, the IAMM is operated by a member of the research team to assess the implications of adopted water management measures and the climate change scenario, which are then presented to the game players.

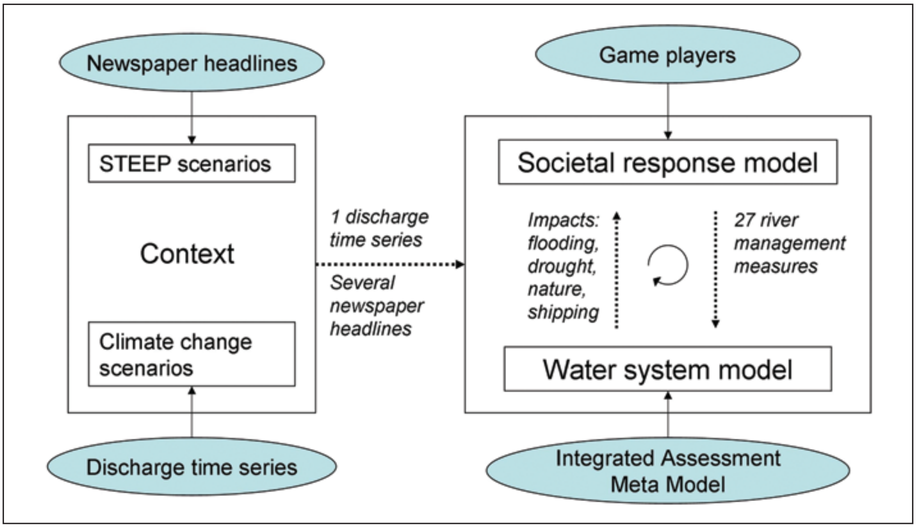

Figure 1. Game format representing water-society interaction.
Note: STEEP = Social, Technological, Economic, Environmental, and Political.

Headlines. General contextual developments are presented in the form of *newspaper headlines*. These update game players on, for example, water quality issues or technological breakthroughs in neighboring countries.

Discharge. Climate conditions are expressed through a set of possible future *discharge time series*, including both yearly peak discharges as well as the yearly duration discharge falls below critical levels. These data are based on simulations with a rainfall generator (Buishand & Brandsma, 1996) coupled to a hydrological model for the Rhine (Te Linde, 2007). They reflect so-called transient climate scenarios in which the 2006 climate scenarios of the Royal Netherlands Meteorological Institute (2006) are incorporated as a linear change up to 2100. For each game session, specific discharge time series were selected on the basis of the timing and frequency of discharge peaks, the extent of underlying climate change, and the type of responses the project-team aimed to assess. For the pilot runs described in this article, time series were used from scenarios with large climate change (scenario "Wplus") and without climate change (see Figure 2).

Society. The *societal response*, finally, is represented through the actions of the game players. The game (described in detail in the section "The Perspective-Based Simulation Game") involves a number of rounds in which game players implement consecutive river management measures as events and developments in climate, the water system, and context unfold. In addition, the game monitors changes in the perspectives that players have on water management and changes in advocacy coalitions of game players holding similar views. The next section deals with the conceptual model underlying the game's design.

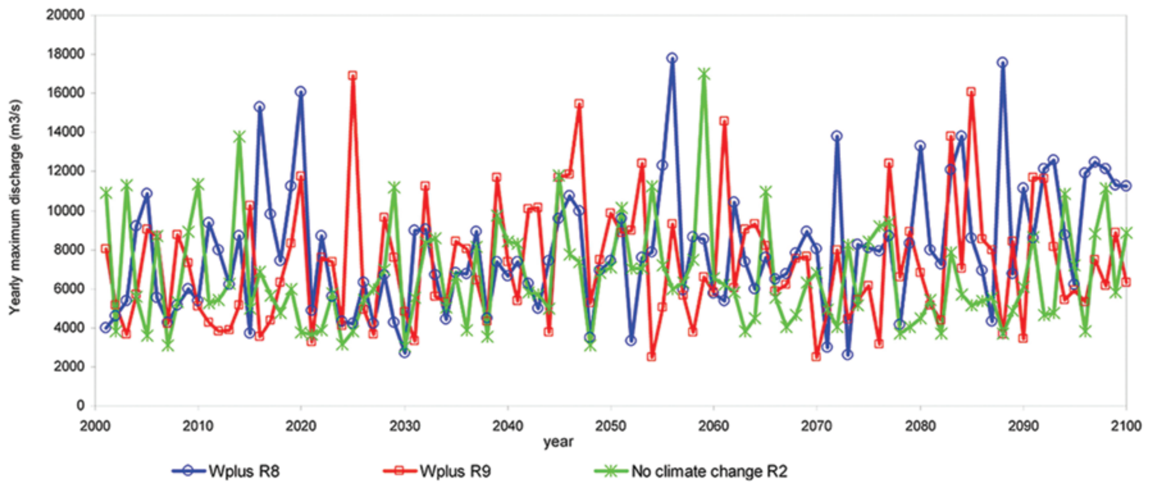

Figure 2. Scenario time series of yearly peak discharges applied in the simulation game.
Note: The figure shows two realizations (R2, R8) corresponding to the so-called Wplus scenario of the Royal Netherlands Meteorological Institute (2006), and one realization (R2) of the case without climate change.

A Conceptual Model of the Societal Response

The societal response refers to the response of a society as a whole, including a web of actors with different roles (water managers, farmers, residents, boaters, conservationists), operating at different scale levels (individual, household, community, regional, country), and with different beliefs, water management preferences, and power. Given this complexity, we derived three starting points to describe and analyze the societal response. Our first starting point is that actors interpret the world according to their perspectives, guiding their strategy for water management. A second starting point is that groups of actors with similar perspectives group together in coalitions. The third starting point is that—within a society—shifts with regard to the most popular, dominant perspective may occur. These starting points are derived from three complementary theories: Cultural Theory (Thompson et al., 1990), ACF Theory (Sabatier & Jenkins-Smith, 1993), and Transition Theory (Rotmans, 2005; Van der Brugge, 2009). We will shortly outline these three theories and point out in which way we have used them.

Cultural Theory: Perspectives and Perspective Change

Cultural Theory (Douglas, 1970) was developed to classify, analyze, and interpret communities' behavior according to their (religious) rituals (Douglas, 1970). It delivers a typology of stereotypical perspectives that has been used, among others, to analyze different views on nature and resources (Thompson et al., 1990), climate change (Pendergraft, 1998), uncertainty and risk (Van Asselt, 2000), and water management (Hoekstra, 1998; Middelkoop et al., 2004; Van Asselt et al., 2001). Regarding water management, three so-called "active" perspectives are thought to be relevant: hierarchist, egalitarian, and individualist. The hierarchist believes in control, regulation, and safety, emphasizing government responsibility, research, and expert knowledge. Water is seen as a threat if not managed well. Egalitarians, however, prioritize ecological recovery and participatory decision-making processes. Humans should adapt to the natural water system. Individualists, finally, perceive water primarily as an asset that can be used to increase prosperity. They adhere to optimism regarding market opportunities; innovative, technological solutions; and individual responsibility.

These stereotypical perspectives are useful as a typology to monitor perspectives that players have on river management. In reality, however, no actor perspective is of a pure type. Actors generally endorse beliefs of various stereotypical perspectives (Douglas, 1970; Thompson et al., 1990; Verweij & Thompson, 2006). Consequently, perspectives are made operational on the so-called perspectives map (Offermans et al., 2011; Valkering et al., 2011; see Table 1). This map includes a set of salient beliefs on Dutch river management (first column). For each belief, the hierarchist, individualist, and egalitarian position is given (columns 2-4). To map a perspective, one decides for each belief which position is supported (having the possibility to mark none, one, two, or three positions per belief). The total number of supported positions for

Table 1. The Perspectives Map for Dutch River Management.

Salient belief	Position 1	Position 2	Position 3
Water function priority	Nature and space	Discharge of water	Prosperity
Trust in technology	Positive but reserved	Great trust	Low
Climate change	Minimal trend	Extreme trend	Average trend
Economic context	Average trend	Weak growth	Strong growth
Safety	Adaptation and innovation	Avoiding flood prone areas	Flood prevention
Principle of spatial planning	Water follows	Water steers	Water offers opportunities
Responsibility	Society	Government	Private
Decision-making process	Norms and expert knowledge	Market and privatization	Participatory

Note: The perspectives map consists of a set of salient beliefs regarding river management (first column). For each belief, the hierarchist, individualist, and egalitarian positions are given (columns 2-4, in random order). The current map shows the perspective of a coalition during one of the simulation runs.

each stereotypical perspective constitutes a three-dimensional vector representing the average perspective. This vector is normalized and plotted in so-called barycentric coordinates as a point in the perspectives triangle of Figure 3. The corners of this triangle correspond to the extreme, stereotypical positions; the other positions on the triangle correspond to other combinations of endorsed beliefs (see Offermans et al., 2011; Valkering et al., 2011).

Regarding perspective change, Cultural Theory highlights two opposing driving forces (Thompson et al., 1990). On the one hand, perspectives may change due to "surprise": events or developments that indicate a mismatch between expectation (perspective) and reality. On the other hand, perspectives are resistant to change. People tend to ignore surprises or explain them in such a way that they still accord one's expectations. However, reality can only be denied up to a certain extent, and an accumulation of surprises will inevitably lead to perspective change (Thompson et al., 1990). In the game, relevant surprises may include various unexpected impacts—for example associated with a flood or a drought—and various unanticipated contextual developments and events. Linking those events and developments with the development of perspectives monitored on the perspectives map thus provides a tool to explore possible drivers behind future perspective change.

The ACF: Perspective-Based Coalitions

The ACF (Sabatier & Jenkins-Smith, 1993) was developed to explain the dynamics of policy development. The ACF explains these dynamics at the level of the policy

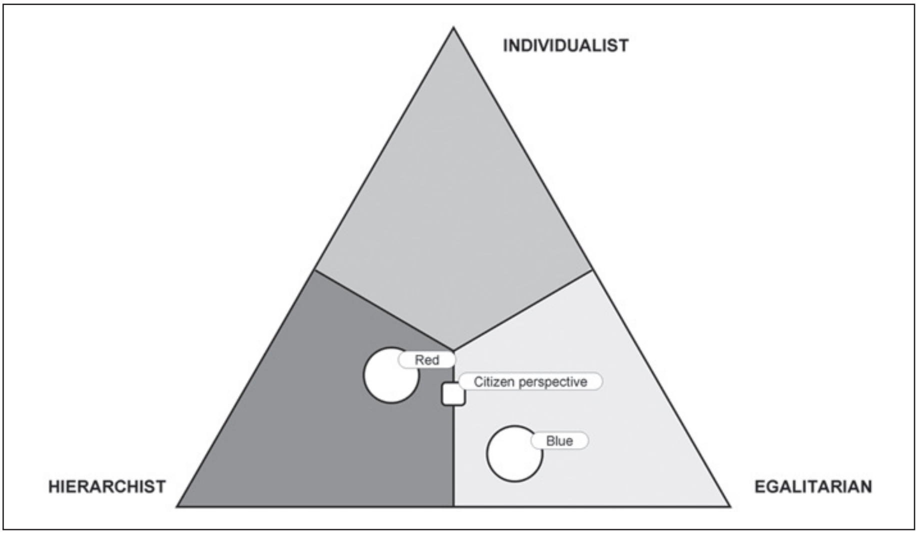

Figure 3. Societal perspective change on river management.
Note: Societal perspective change on river management is seen as a coevolution of multiple perspective-based coalitions (circles labeled red and blue) and a citizen perspective (square) representing public opinion. The coalitions are characterized by their position on the perspectives triangle, and their size, representing coalition strength. The perspectives shown reflect the starting positions of the coalitions and citizen perspective during one of the simulation runs.

subsystem, defined as the set of actors dealing with a particular policy problem. These actors—referred to as policy elites—may hold various positions, such as public official, interest group leader, or researcher. In a way similar to Cultural Theory, their political beliefs are assumed to determine the desired direction of a policy.[3] Moreover, ACF describes how policy actors that share a particular set of beliefs form coalitions that advocate diverging policy strategies. The policy process, then, is interpreted as a competition among the different advocacy coalitions, with fundamental policy change usually being the result of changing advocacy coalition strengths. This process is strongly driven by factors external to the policy subsystem, including socioeconomic conditions and public opinion (Sabatier & Jenkins-Smith, 1993).

Following ACF Theory, game players are grouped into two[4] coalitions of players holding similar perspectives on water management. The coalitions are visualized as circles in the perspectives triangle of Figure 3. The position of a circle reflects the common, or average, perspective of the coalition as a whole, as assessed on the perspectives map. The size of a circle is proportional to the number of members the coalition has, also referred to as the coalition's strength. During the game, each coalition is allowed to present and motivate their water management plans. Yet, they have to compete—for example, through negotiation—as none of the coalitions has full control over the water system. Moreover, the coalitions have to reckon with an external "citizen perspective" representing public opinion. The citizen perspective is played by a project-team member and visualized as a square in Figure 3. It forms an influential factor that may block the implementation of certain measures proposed by the coalitions due to a lack of societal support.

During the course of the game, the coalitions' perspectives are assumed continuously subject to change. Moreover, players are allowed to change coalitions, for example, when their individual and coalition perspectives no longer match. The coalitions are thus said to coevolve, involving both a change of the coalitions' and citizen perspectives (visualized as changing position on the perspectives triangle) as well as a change of the coalitions' strengths (visualized as a growing or shrinking of the coalitions' size), see Figure 3.

Transitions: Dominant Perspectives and Undercurrents

Transition Theory describes and explains the dynamics of how societal systems may change fundamentally (Rotmans, 2005; Van der Brugge, 2009). This generally entails the characterization of the dominant actors, processes, and structures in a societal system—which is called the regime—and how they change over time and why. The main driving forces are slow macrotrends, external events (calamities), internal adaptation, and emerging innovative niches (Van der Brugge, 2009).

Following Offermans and Cörvers (2012) and Van der Brugge et al. (2005), transitions can be described in terms of large shifts in dominant perspectives in a societal system. For example, since the 1960s, the Dutch water management style shifted from a more hierarchist toward a more egalitarian approach, with—since the turn of the century—the individualist perspective emerging as well. These shifts between dominant and less dominant perspectives, called undercurrents, correspond to transitions in which new water management strategies can come to the fore.

Combining the notion of dominant perspectives and undercurrents with the ACF, the dominant perspective is understood as a relatively large coalition. In contrast, the undercurrent is seen as a relatively small coalition, representing a small, but distinguishable societal movement advocating a different perspective than the dominant one. Undercurrents may exist for a long time while hardly being noticed. However, large-scale trends, nagging problems (that will not be solved), calamities, and innovations may form the breeding ground to stimulate the growth of the undercurrent to eventually replace the dominant perspective.

Figure 4 shows a two-dimensional plane that helps to interpret the observed dynamics between the two coalitions in the game in terms of possible transition pathways, and the development of dominant coalitions and undercurrents. The first dimension is *dominance*,[5] which represents the extent to which one of the two coalitions is dominant over the other. High dominance implies that one perspective is clearly larger than, and hence rather independent from, the other. Low dominance indicates a situation in which different perspective-based coalitions are of equal size, implying that they are mutually dependent and have to negotiate about water management policies. The

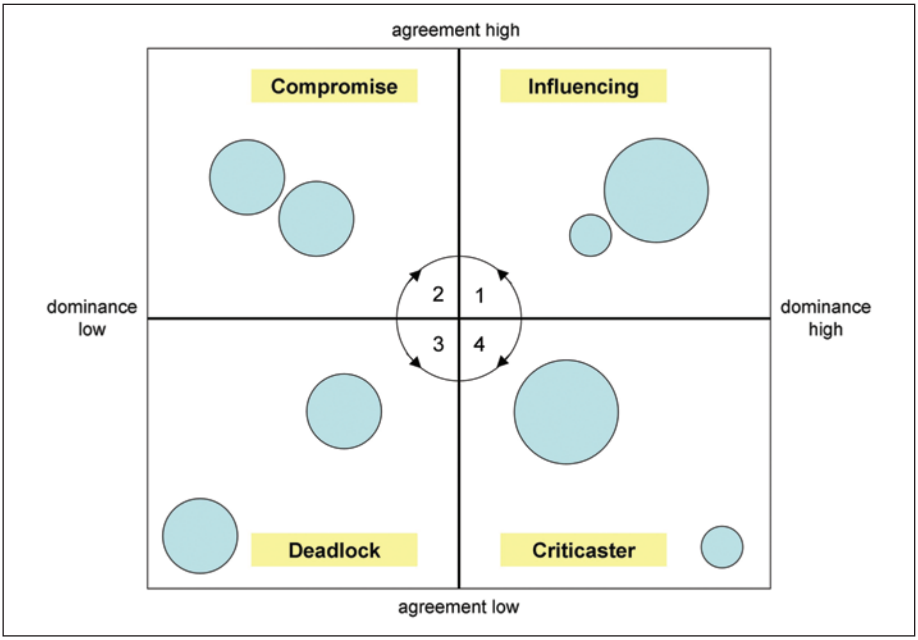

Figure 4. The codevelopment of two coalitions is mapped as pathways in a plane generated by the dimensions of *dominance* and *agreement*.

second dimension is *agreement*,[6] which represents the extent to which the coalition perspectives overlap. High agreement means that the coalitions are rather "close" to each other and probably willing to cooperate. Disagreement means that they will be further apart in a rather conflictive relation.

The two dimensions dominance and agreement generate four distinguishable system states (see Figure 4). The upper right quadrant (agreement high-dominance high) is referred to as "influence." This state constitutes a large and a small coalition that show only a small difference in viewpoints. It is assumed that the smaller coalition will aim to influence the larger one on minor accounts, without any radical points of critique. The upper left quadrant (agreement high-dominance low) is referred to as "compromise." This state reflects strong similarity and equal dominance among the coalitions. It is assumed that coalitions will easily find common ground to implement a mutually supported river management plan. The lower left quadrant (agreement low-dominance low) is referred to as "deadlock." In this state, two coalitions with diverging ideas are balanced in power. It is assumed that it will be problematic for the coalitions to find common ground and a mutually supported strategy. The lower right quadrant (agreement low-dominance high) is referred to as "criticaster." This state constitutes a large and a small coalition with a large difference in viewpoints. It is assumed that the larger coalition can implement its view independently. The smaller coalition, however, will (very) critically reflect on their position. The larger coalition is free to take this critique into account or not.

Shifts in the dominant perspective are thought to follow certain pathways through the dominance-agreement plane. Such pathways may include sequences of "state transitions" in which the system moves from one state, or quadrant, to another. This conceptualization of possible transition pathways may provide better insight in the societal dynamics underlying societal perspective change, hence supporting the future exploration of societal responses.

The Perspective-Based Simulation Game

The game revolves around a virtual river stretch called the Waas, representative of many low-lying river stretches in the Rhine delta of the Netherlands. The river and its floodplains are schematized, but have realistic characteristics. The river is bounded by embankments and the floodplains are divided into five dike rings. A large city is situated on higher grounds. Smaller villages exist in the remaining area, including also greenhouses, industry, nature, and pastures.

The game is generally played with 10 to 20 players—typically water managers and/or academics—and takes about 2 to 4 hours to play. Players are given the role of water managers. Before or at the start of the session, players fill in the perspectives map. This information is used to form two coalitions (referred to as teams) of players with a relatively large agreement among their perspectives. Each team appoints a team captain, a reporter, and a recruiter. The latter has the explicit aim to convince members of the other coalition to join theirs.

The citizen perspective is played by a project-team member. This person may interactively engage with the game—shifting perspective in response to the various developments and events—but the development of the citizen perspective may also be prepared beforehand in relation to the discharge time series and newspaper headlines that enter in the game.

After an introduction (explaining rules and objective of the game), the game starts with a story of the present, emphasizing that living and working along the Waas is not without risk. Over the past 25 years, two major flood events have occurred, causing significant damage for the various functions. On average, only 92% of the time, the river was navigable. It is projected that, in the future, climate change and socioeconomic developments may increase both the probability of floods and drought as well as potential flood damage in the floodplains. From this point forward, the managers of the River Waas are challenged to manage their river in a sustainable way. The game then follows three to four cycles of the following steps (see Figure 5):

- *White papers*. Each coalition formulates a "white paper" including a concrete proposal for a water management strategy and the underlying motivation. They select two concrete river management measures from a deck of 27 measures cards.

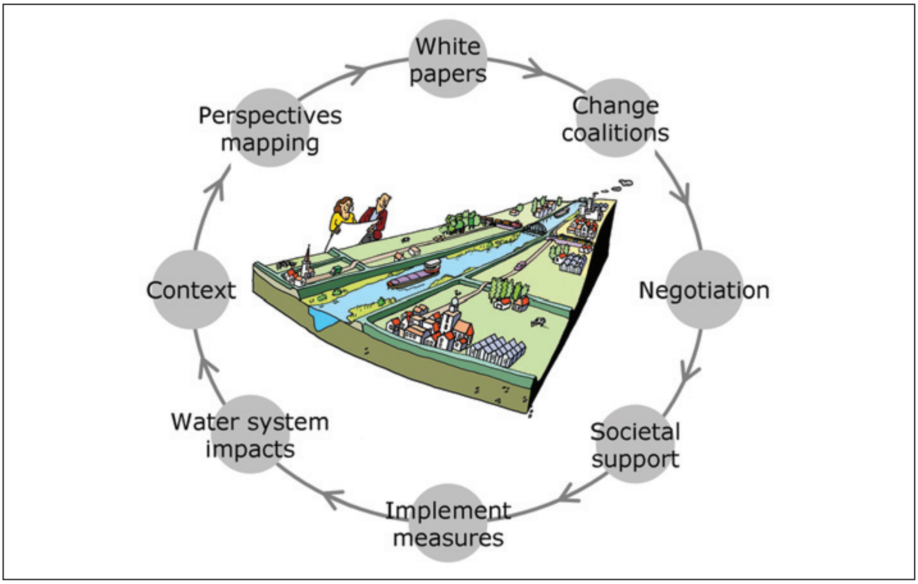

Figure 5. Overview of the game process.
Note: The game typically follows three to four cycles of the denoted steps, starting with the formulation of "white papers."

- *Change coalition.* Players are encouraged to reflect on their team membership. They can decide to stay in their team, or to shift to the other one.
- *Negotiation.* In case none of the coalitions is dominant[7] ("deadlock" or "cooperation"), the two teams must agree on a common water management strategy consisting of a maximum of two measures. In this case, representatives of each team engage in a short[8] negotiation process. In case one coalition is dominant ("influencing" or "criticaster"), negotiation is skipped; the dominant coalition may implement its preferred strategy.
- *Societal support.* The project-team decides whether the envisioned measures are in line with the citizen perspective.[9] Possibly, one or both measures are rejected.
- *Implement measures*. The selected measures are implemented in the water system model (IAMM). Results are calculated for a time period of typically 10 to 20 years.
- *Water system impacts*. The main impacts on flooding, drought, nature development, and shipping are presented by the project-team. They are briefly discussed with the players.
- *Context*. Possible contextual events and developments are presented in the form of newspaper headlines.

- *Perspectives mapping.* Mapping perspective changes of the coalitions was carried out in two different ways. In early sessions, it was carried out through observation of the discussions within and between coalitions, notably regarding the motivations underlying their respective white papers. These statements were analyzed and depicted on a perspectives map by a project-team member during the game. In later sessions, participants were asked to reflect explicitly on the perspectives map themselves.

After each gaming session, the session is briefly recapitulated by showing the simulated pathways on the perspectives triangle. A debriefing session follows to evaluate the game. The debriefing takes the form of an open, plenary discussion. Typically, the following questions are addressed:

- What did you like about the game and what not?
- Was the game clear and understandable?
- How did you perceive the game dynamics? Did your perspective change during the game? Why, or why not?
- Were you tempted to change coalitions? Why, or why not?
- What did you learn from the game?
- What lessons for water management can we draw?

Playing the Game: Results of the Waas Pilot

The aim of the Waas pilot was to test the gaming approach. To this end, a number of gaming sessions were organized with different groups of players. Here, we report on three pilot sessions: with a group of *water managers* of the Dutch Water Service, with *academics* dealing with issues of water management and uncertainty at the Dutch University of Twente, and with a *mixed group* of scientists and water managers participating at an international conference on deltas in times of climate change.[10] Each gaming session resulted in an adaptation pathway in which water system, external context, societal perspectives, and adopted river management strategies develop in an integrated way (see Figure 6). Here, we describe the types of insights that can be derived from these prototypical storylines.

Water Management Strategies

First, the game allows for insight in the types of water management strategies chosen in possible future situations and the motivations underlying those choices. In the pilot runs, the water management strategies were typically reactive in response to flood events. Measures aimed at flood prevention, such as dike broadening, dike elevation, river widening, and upstream cooperation (to reduce peak discharges), were most popular. In contrast, measures aimed at flood adaptation (e.g., improvements in the flood alarm system and flood resistant building) and measures to reduce

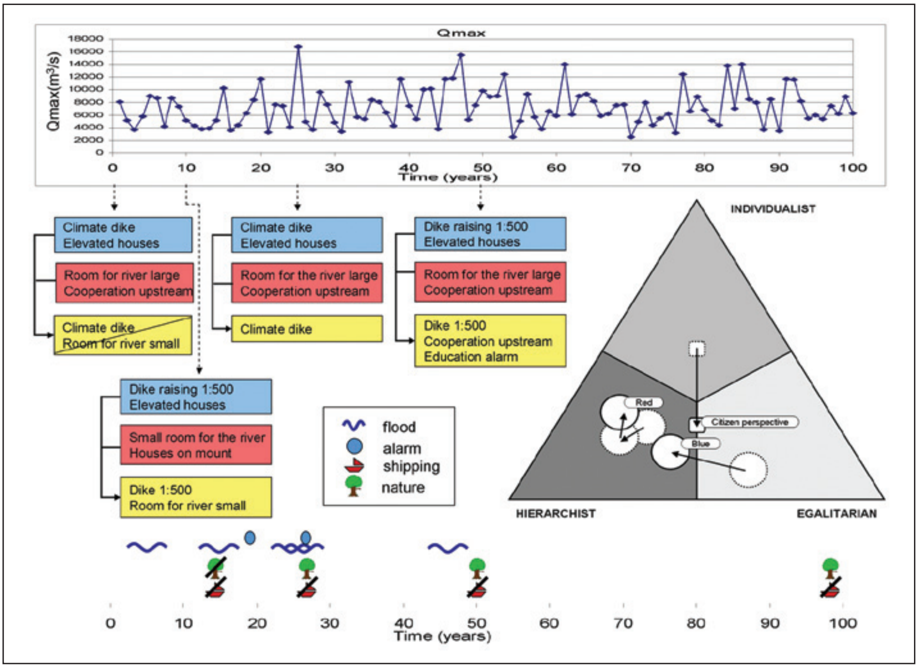

Figure 6. Overview of the adaptation pathway developed at the Dutch water service.
Note: The top of the figure shows the discharge time series the players were confronted with (Wplus, R9; see also Figure 2). It also indicates the river management measures proposed in each time step by a blue and red coalition (top two boxes), and the measures that emerged from the coalitions' negotiation (bottom box). The latter are struck out if rejected by the citizen (for example, at time = 0). The bottom of the figure indicates the associated water system impacts, for example, concerning flooding (flood damage, flood alarm), shipping (nonnavigable time), and nature (area and diversity). Finally, the development of the perspectives during the game of the two coalitions and the citizens are mapped on the perspectives triangle.

drought-related problems (e.g., investing in smaller ships) were chosen less. These preferences are in line with the overall development of the coalition perspectives that—for all pilot runs—remained within the hierarchist and egalitarian domains. In the session with the *water managers*, for example, the blue coalition reflected a rather egalitarian perspective characterized by a high appreciation of nature, concern about climate change, limited trust on technology, and the belief that flood risk can only be reduced by avoiding flood prone areas. Consequently, they considered throughout the game typical egalitarian measures—like room for the river, upstream cooperation, collaboration with upstream areas, and building on artificial mounts.

In some cases, however, the relation between perspectives and preferred strategies was less intuitive. In the same *water managers*' session, for example, the red coalition

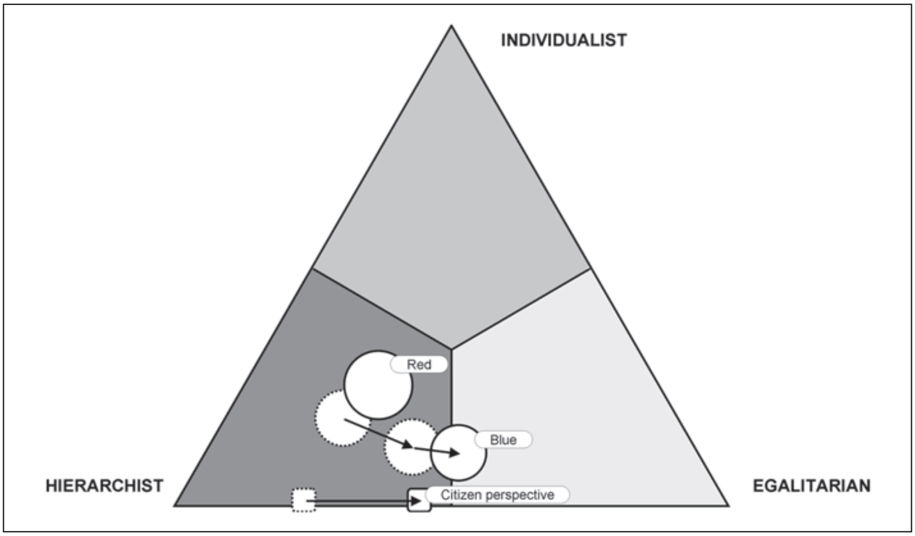

Figure 7. Codevelopment of two coalitions and citizen perspective mapped on the perspectives landscape.
Note: This particular storyline—taken from the *mixed group* session—shows the red and blue coalition initially in agreement, with the blue coalition and citizen perspective gradually shifting toward egalitarianism.

consistently supported flood resistant building as a complementary measure to a dike-building strategy. This specific measure fits well with an individualist perspective, but is difficult to explain from their predominantly hierarchist view of flood prevention and control. Another interesting observation is the lack of a clear individualist perspective in all of the pilot runs. A possible reason is that the current dominant perspective on Dutch water management indeed shows hierarchist and egalitarian beliefs, rather than individualist ones.

Perspective Change

Figure 7 illustrates the perspective change trajectory of the *mixed group* pilot run. This particular storyline shows that the red and blue coalitions are initially in agreement, but that the blue coalition and citizen perspective gradually shift toward egalitarianism. This allows for a second type of analysis, which relates to the conditions under which perspective change may occur. Zooming in on perspective changes during the various game sessions, a number of observations can be made:

Regarding the extent of perspective change, we observe minor shifts of perspective, but not complete transitions from one perspective to another. The perspective shift of Figure 7, for example, occurs because the coalition's belief on climate change gradually shifts from expecting an average trend to an extreme trend of climate change (see Table 1) as a result of regular floods. However, other beliefs on the perspectives map remained the same. This suggests that certain beliefs are more stable than others. In general, we found that beliefs concerning the economic context, water management responsibility, and decision-making process changed less frequently than beliefs about water function priority, flood safety, and the principle of water in spatial planning.

Regarding the drivers of perspective change, the game includes triggers from the water system (e.g., floods and droughts), the society system (citizen perspective), and context (contextual events). In the pilot sessions, the most important trigger was flooding. Besides changing the perception of climate change (as in the example of the *mixed group* session above), flooding might also change the perception of what constitutes the most adequate flood management approach (e.g., from flood prevention to flood adaptation) and of the water management responsibility (from government to individual and market responsibility) as the session with the *academics* shows.

Change of citizen perspective was another trigger for perspective change in the game. In some cases, the game players chose to follow the citizen perspective, as this presumably offers less resistance toward their proposed strategies. An example is the run with the *academics*, in which both coalitions abolish their dike-building strategy in response to an emerging negative public attitude toward dikes. Game players may, however, also resist the public opinion. An example is the run with the *water managers* in which the citizen perspective is countered with ongoing focus on flood prevention and active attempts to change the public's view.

Coalition Dynamics

A third type of insight relates to the role of coalition dynamics. Figure 8 shows that dominance between coalitions remained constant for each pilot run. Individual players were hesitant to shift coalitions once they felt loyal to their team and thus the strengths of the coalitions did not change. Hence, the dynamics between emergent undercurrents replacing the dominant perspectives—as postulated in our conceptual societal response model—did not take place in the game. However, we do observe (minor) changes in agreement over time.

The negotiation outcomes could most often be characterized as a compromise. A typical example of compromise is the *water managers*' run, where in practically each negotiation round, one (hierarchical) dike-building measure of one coalition and one (more egalitarian) river widening measure of the other coalition were agreed upon. This observation is in line with their pathways on the dominance-agreement plane covering the compromise state.

In some cases, however, the relation between the coalitions' agreement and their negotiation outcome is less intuitive. For example, although having a relatively high score on agreement (indicating compromise) in the *mixed group* run, only the measure

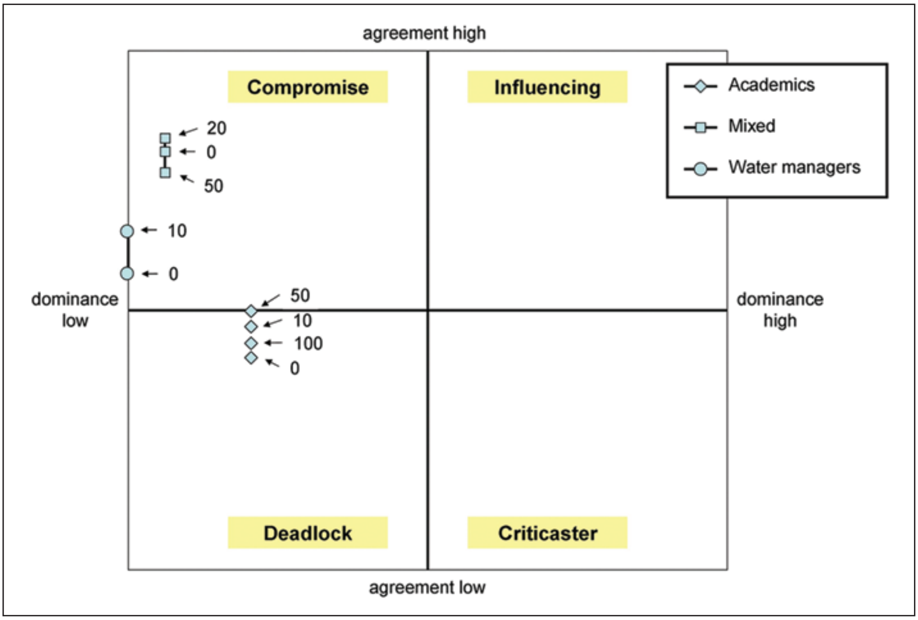

Figure 8. Codevelopment of two coalitions mapped on the dominance-agreement phase space.
Note: The figure shows the three pilot sessions described in this article. The numbers indicate the time step to which the points correspond.

of upstream cooperation was agreed upon. This type of negotiation outcome would be rather expected in a deadlock stage. In addition, new types of negotiation outcomes were observed that were not yet explicitly listed in the quadrants of Figure 8. An example is *alternative*: a new measure emerges from the negotiation that was previously not considered in the respective white papers.

Discussion

In this section, we reflect on the extent to which the game generates insights in the two challenges of environmental scenario analysis described in the introduction: water-society interaction, and discontinuity and surprise. In addition, it presents our main methodological lessons.

Representing Water-Society Interaction

The game captures water-society interaction as a typical action-reaction feedback loop. Players formulate water management strategies, which are instantaneously implemented in the water model. The participants are confronted with the results of their choices and consequently reformulate a next set of strategies. In each gaming session, an adaptation pathway is thus developed, which can be further evaluated in terms of its underlying dynamics (what happened and why?), societal impacts and associated costs (see Haasnoot, Middelkoop, Offermans, Van Beek, & Van Deursen, 2012).

In the debriefings, game players emphasized that exploring water-society interaction is a main virtue of the approach. Their experience indicated that long-term water management involves actions and reactions and that water management strategies that seem suitable now, may need to be adapted in the future, due to (possibly unforeseen) developments and events. They experienced how adopting certain river management strategies now may restrict river management options in the future. Consequently, exploring no-regret (and regret!) options were mentioned as benefits of the gaming approach.

Further clustering and analysis of the developed adaptation pathways may reveal insight in patterns of water-society interaction that may dominate future water management. It may reveal generic responses to certain events—for example, flood events being generally followed by flood prevention (rather than flood adaptation) measures—which raises the question of whether these responses are indeed most effective and robust. In addition, it may serve to compare patterns of reactive (as observed mostly during the pilot sessions) and patterns of more proactive responses.

Representing Discontinuity and Surprise

Although observed discontinuities are not considered extreme (see also below), the game captures a number of discontinuous elements. Surprises in the water management context were introduced through the newspaper headlines—portraying generally unforeseen yet plausible contextual events—and through the unpredictable occurrence of extremely high or low discharges. These surprises typically propagate through to the societal and water systems, causing discontinuity. In the *academics session*, for example, ongoing flooding led to changes in dominant perception (e.g., flood prevention toward flood adaptation), led to changes in water management strategies (e.g., dike building toward improving flood alarm), which led to changes in the water system.

Such storylines illustrate that discontinuities arise not as the result on one single event in a single system, but emerge from the interactions between water system, society system, and external context. Again, further clustering and analysis of individual pathways is necessary to explore which types of discontinuity may be anticipated upon in future water management, and the types of interaction patterns through which these may arise. Here, the typology of Toth (2008) on surprises may prove useful to classify observed discontinuities into isolated, interactive, or propagating surprise.

Methodological Lessons

Most of the game participants considered the game to be an enjoyable and interesting experience. Nonetheless, the pilot sessions indicated various ways in which the game could be improved:

A first lesson relates to the complexity of the game. In its current form, the game encompasses different types of dynamics: *water-society interaction*, the dynamics of *perspective change* in response to developments and events, and *coalition dynamics* representing how advocacy coalitions may rise and fall. The virtue of this approach is that it allows for a rich representation of societal change and an understanding of how these different types of dynamics are related. The drawback, however, is that it makes the game rather complex and sometimes difficult to understand for the game players. Managing this complexity—whether by streamlining the game or by developing more focused subversions of the game—is a main challenge in future work.

A second lesson relates to the coalition dynamics. We assumed that individual players would be triggered to change coalition when they found that the other coalition better corresponded with their own beliefs. In reality, however, individual players were loyal to their initial coalition, considering changing coalitions as a way of losing the game. Hence, this calls for a different form of implementing coalition dynamics in which commitment to a coalition is less strong. Possibly, the goal of the game should be formulated such that individual players are triggered to change coalitions as a strategy to win the game.

A third lesson relates to the extremes of the discontinuities observed. Although discontinuities emerge naturally in the storylines, they generally do not constitute full-scale societal transitions as perceived by Rotmans (2005) and Van der Brugge (2009). This is illustrated by the relatively small extent of societal perspective shifts that occurred in the gaming sessions. From the viewpoint of surprise and discontinuity, this seems to be a drawback. However, it may simply support our assumption that perspectives are generally resistant to change. One can imagine different ways in which the extent of discontinuity might be enlarged, for example, through the application of a more discontinuous context scenario. This may allow for exploring more radical societal transitions between hierarchical, egalitarian, or individual worlds.

A fourth lesson relates to the citizen perspective. It is a relatively influential role, played by a member of the project-team. The citizen perspective aims to represent a complex and multifaceted concept as public opinion, encompassing a multitude of diverging societal perspectives, into a single aggregated perspective. Although this might seem simplistic, we believe it to be the most useful level of detail to explore the implications of public opinion development. It would be interesting to invite real-life citizens to play the citizen perspectives, for example, inhabitants of a village behind the dikes. Allowing for better insights in the nature of their responses, this might also contribute to the complexity of the game. How to deal with this is left for future research.

A final issue relates to the applicability of the game approach to other social-cultural and water management contexts. In principle, the use of Cultural Theory allows for mapping a broad range of possible water management cultures. Whereas Dutch water management appears to play out notably in the hierarchist corner of the perspectives triangle, in other cases, the egalitarian or individualist domain may be dominant. The conceptual response model, representing river management through the advocacy coalition-based approach, is more context dependent. Nonetheless, even considering its bias toward pluralistic political systems, successful applications of ACF Theory worldwide do suggest broad applicability (Sabatier & Weible, 2007). A cross-comparison of game applicability between different contexts would be an interesting avenue for further research.

Outlook

In the near future, the game will be tailored to the Rhine Delta in the Netherlands. This implies a number of further developments, including the application of stakeholder roles and operating at a higher geographical scale level.

In this context, a main further step is to aggregate observations from individual gaming sessions—as well as from historical analysis—to generic insights on water-society interaction and societal change. This will involve a clustering and analysis of storylines that show similar dynamical patterns. The challenge, then, is to find generic circumstances under which certain patterns do—or do not—occur. It will also involve hypothesis testing to assess more specifically possible patterns within the water-society system under specific conditions. This approach thus relies on a careful formulation of hypotheses and a targeted selection and application of the context scenarios. Eventually, insight into the game dynamics may be translated into generic *response rules,* reflecting societal responses to given events and developments. This would allow running and analyzing statistical ensembles of water-society interaction, which would further enhance insights into possible discontinuous water management futures and promising adaptation pathways (see also Haasnoot et al., 2011).

Conclusion

In this article, we have proposed the method of perspective-based simulation gaming as a way to deal with water-society interaction, discontinuity, and surprise regarding climate adaptation. The game allows for a rich representation of future societal responses in the case of surprising events. To this end, we developed a conceptual model of the societal response, combining aspects from Cultural Theory, Advocacy Coalition Theory, and Transition Theory. We translated this model into a simulation game, which we tested in a number of cases. Preliminary insights include that responses were rather reactive, that societal perspectives tended to remain within the egalitarian and hierarchist domains, and that societal perspective change was largely driven by floods.

The overall conclusion is that the simulation game generates relevant insights into possible future societal responses, in terms of chosen water management strategies, societal perspective changes, and the way advocacy coalitions may interact. This, in turn, allows generating and assessing climate adaptation pathways, including water-society interaction, discontinuity, and surprise. With the set of adaptation pathways resulting from these analyses, it is possible to identify opportunities, no-regret strategies, dead ends, and timing of a strategy, all of which can be used by policy makers to develop water management roadmaps into the future. Moreover, exploring the implications of societal perspective change may enhance awareness that the river management strategies that "work" now may not be adequate in future situations, supporting policy makers in the development of robust and flexible climate adaptation paths.

Many challenges still exist for translating the concept into a working, useful, and enjoyable game. These include incorporating different types of dynamics into a manageable game format, better representing changes in the advocacy coalitions' strengths, exploring more fundamental societal perspective shifts, and aggregating observations from individual gaming sessions to generic insights on water-society interaction and discontinuous societal change. To this end, clustering storylines, hypothesis testing, and developing response rules to allow for model-based simulation of water-society interaction are considered fruitful directions of future research.

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Notes

1. Game as a design studio, practice ring, negotiation table, consultative forum, or parliament.
2. In the scenario literature, surprises are also referred to as "unexpected discrete events", "discontinuities in long-term trends", and "the sudden emergence of new information" (Van Notten, 2005).
3. The so-called core policy beliefs of Advocacy Coalition Framework (ACF) correspond to the salient beliefs on water management as defined on the perspectives map.
4. In principle, a larger number of coalitions is possible: ACF analyses (Sabatier & Jenkins-Smith, 1993) usually distinguish two to three advocacy coalitions. Restricting the number of coalitions in the game was done to keep the complexity of the game within margins.
5. Dominance is proportional to the size of the largest coalition relative to the total number of game players, measured on a scale of 0 to 1. With equal distribution of players among the two coalitions, dominance = 0; with all players in one coalitions, dominance = 1.
6. Agreement is proportional to the average distance between the coalitions' perspectives for each salient belief on the perspectives map, also measured on a scale of 0 to 1. When the interpretation of each salient belief on the perspectives map is identical, agreement = 1; when the interpretations are opposing for each salient belief, agreement = 0.

7. As determined by the number of the coalitions' members.
8. If the coalitions do not succeed in agreeing on measures within a specified time period, then no measures are implemented over the upcoming planning period.
9. To this end, a formal procedure was designed that lists for each belief on the perspectives-map, measures that will not be supported if the citizen endorses that belief. For example, if the citizen has low trust in technological measures, implementation of floating houses will not be supported.
10. Deltas in Times of Climate Change, Rotterdam, The Netherlands, September 29 to October 1, 2010.

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