Working Paper Series No. 8

Loss and damage in a changing climate

Games for learning and dialogue that link HFA and UNFCCC

Some 12,000 Ghanaian children reportedly die each year from diseases that could be prevented by hand-washing with soap. Many of these illnesses, such as cholera and other diarrhoeal diseases, are likely to worsen with a changing climate. A UNICEF workshop in Akosombo, southern Ghana, Facilitated by the Climate Centre in collaboration with the Engagement Lab at Emerson College, laid foundations for a new game that will help children to learn about hand-washing and take action to reduce the risk of disease. (Photo: Wade Kimbrough/Climate Centre)

By Pablo Suarez, Friederike E. L. Otto, Nidhi Kalra, Carina Bachofen, Eric Gordon and Wisford Mudenda

Red Cross/Red Crescent Climate Centre

P.O. Box 28120
2502 KC The Hague
The Netherlands

+31 (0)70 4455666
climatecentre@redcross.nl
www.climatecentre.org

RED CROSS/RED CRESCENT CLIMATE CENTRE

International Federation of Red Cross and Red Crescent Societies

The Netherlands Red Cross

1. Introduction

As both the Hyogo Framework for Action (HFA) and the United Nations Framework Convention on Climate Change (UNFCCC) approach critical thresholds in the year 2015, we collectively face the opportunity to examine the relationships between the HFA+ and an increasingly important mechanism under the UNFCCC: the Warsaw International Mechanism for *Loss and Damage* under the Cancun Adaptation Framework. Addressing loss and damage (L&D) in a changing climate requires learning and dialogue among very diverse stakeholders, who often lack a shared understanding of complex concepts such as weather, climate, extreme events, probability, uncertainty, and attribution. Similarly, the post 2015 HFA framework will require increased understanding of the synergies between climate variability, climate change and the links between disaster risk reduction (DRR) strategies and climate change adaptation. Conventional communication approaches often fail to convey these core concepts to key stakeholders (CRED 2009), including from policy makers and planners at the global level to the local communities most directly impacted by climate-related disasters. As a result, the prospect of engaging very different stakeholders in learning and dialogue using unconventional participatory tools merits further consideration; some of these tools, such as serious games, can accelerate the effectiveness and efficiency of decision-making processes, and along the way enable discovery of what works for stimulating learning, accelerating uptake and shaping global agreements.

The purpose of this manuscript is to examine the role of games for improving communication, spurring learning, and improving decision-making capacity about climate risk management amongst diverse stakeholders. This paper is organized as follows: Section 2 presents the challenges associated with communicating the concept of loss and damage and the implications of this for the HFA+ and the UNFCCC. Section 3 introduces participatory games as a promising approach to convey key elements and relationships involved in climate and disasters. Section 4 briefly outlines four case studies of game-enabled processes for learning and dialogue on climate risk management: one on value and use of science based forecasts, a second on the importance of deep uncertainty for investment decisions, a third on engaging at-risk populations in shaping flood warning systems in the Zambezi river, and a fourth used to enable learning and dialogue on L&D at the 2013 UNFCCC Conference of the Parties (COP) in Warsaw. Section 5 discusses some of the limitations of game-enabled processes, and reflects why landmark instruments such as the HFA+ and the Warsaw Mechanism for Loss & Damage should consider serious games as enablers of meaningful communication for accelerating risk management and sustainable development.

2. Communication challenges for loss and damage and HFA

2.1 Understanding the science and politics of loss and damage

Warming of the climate system is unequivocal, and it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century (IPCC 2013). Basic physics implies that an increase in global mean temperature will lead to rising sea levels and thus threaten coastal areas. Hence it can be relatively straightforward to attribute the increase of loss and damage associated with such slow-onset events to anthropogenic climate change. On the other hand, rapid onset extreme weather events cause arguably the majority of loss and damage, though the science that causally links changes in the risk of these types of events is only just emerging (IPCC SREX 2012).

With temperatures rising on a global scale, fundamental thermodynamics implies an increase in global precipitation, which might lead to an increase in extreme events in general but depend on the feedbacks of the climate system (see e.g., Liu and Allan, 2013). However, the chaotic nature of the system and inherent feedbacks do not allow for conclusions on local and regional scales to be drawn from these findings and therefore, many people are of the impression that it is impossible to attribute extreme and rare weather events to past anthropogenic greenhouse gas emissions. This constitutes a communication challenge at the interface between science and policy.

The emerging science of probabilistic event attribution (PEA, Allen, 2003) increasingly allows evaluating the extent to which human-induced climate change is affecting localised weather events (e.g. Stott et al., 2004; Stone and Allen, 2005; Pall et al., 2011; Otto et al., 2012). While it is impossible to say for a single event that it would not have occurred in the absence of anthropogenic climate change, it is possible to analyse how the probability of an extreme event occurring has changed in a changing climate.

Conceptually it is straightforward to perform theses attribution studies of changes in extreme weather events, but the only way this is technically possible is by employing large ensembles of climate model simulations. From the perspective of policymakers, the science appears to be highly technical and not very accessible from the published scientific literature alone. Nonetheless, it is important that decision makers and negotiators are aware of the scientific evidence and their limitations for the attribution of changes in the occurrence probability and magnitude of extreme weather events—especially with respect to the UNFCCC's Warsaw Mechanism on Loss and Damage as it explicitly recognises loss and damage due to extreme weather events.

While loss and damage arising from the impacts of climate change have been the norm for a long time, only in recent years has the concept come to the fore of the global climate change agenda. Loss and damage is considered to be intrinsically linked to mitigation and adaptation and can be characterized as *avoided* (through mitigation and adaptation), *unavoided* (through inadequate mitigation and adaptation efforts) or *unavoidable* which is the case when loss and damage results from climate change impacts that cannot be adapted to such as sea level rise or ocean acidification (Verheyen 2012).

As a result "Loss and Damage" has emerged as a dominant theme in UNFCCC negotiations and was a particularly contentious topic during UNFCCC COP19 in Warsaw where most developing countries—led by the small island developing states and least developed countries—aimed to seek compensation from developed countries to address loss and damage, whereas developed countries refused to discuss approaches that would assign liability and suggest a responsibility for compensation.

The resulting Warsaw Mechanism on Loss and Damage has been tasked to, *inter alia*: enhancing knowledge and understanding of comprehensive risk management approaches; strengthening dialogue, coordination, coherence and synergies among relevant stakeholders; and enhancing action and support, including finance, technology and capacity-building (UNFCCC 2013). This constitutes a remarkable communication challenge, especially considering the technical nature and political relevance of the issue of attribution of slow-onset and extreme weather events to external climate drivers like greenhouse gas emissions.

Clearly, the science and politics related to loss and damage are complex Conventional, unidirectional approaches used to communicate these core concepts are usually unable to properly convey feedbacks, thresholds, trade-offs, and other important emergent properties of climate-sensitive systems—in particular the probabilistic nature of attribution analysis, the uncertainties involved from a climatological aspect as well as the impacts of extreme events and the sensitivity of scientific results (Otto et al., 2014). The latter highlights the importance of *dialogue* instead of dissemination of scientific evidence, as the questions scientists provide answers for are often not the questions to which stakeholders and negotiators need answers. On the other hand, the formal format of UNFCCC negotiations is dominated by unidirectional presentations followed by discussions structured in such a way that make it difficult to explore creative approaches and solutions for resolving differences in opinion. As such the unidirectional way of sharing information does not create an environment conducive to learning and uptake of unfamiliar concepts. Hence, two key questions arise: how can learning and dialogue on loss and damage be supported in such a way that the scientific complexities as well as the political contentiousness of the topic is recognized? Can parallel processes such as development of the post 2015 HFA benefit from similar learning and dialogue support tools that enhance communication and understanding of fundamental key concepts?

2.2. Forging links between the HFA2, the UNFCCC, and the loss and damage discussions

Links between the HFA and UNFCCC frameworks and their connection to the issue of Loss and Damage are complex and nuanced. For a complete examination of fundamental differences in the objectives, terminology, approach, source of financing, legal nature and—importantly—responsibility under the UNFCCC and the Hyogo Framework, see Mace and Schaeffer (2013)[1].

Despite the irrefutable connection between climate change and DRR, the UNFCCC and the Hyogo Framework for Action have remained largely parallel processes (Schipper 2009). HFA focuses squarely on reducing disaster risks, and explicitly address post-disaster recovery and rehabilitation. The UNFCCC concept of 'Loss and Damage' is thus directly related to HFA, both in terms of avoiding L&D through DRR, and in addressing L&D through mechanisms for financing disaster risk recovery and rehabilitation.

Managing disaster risks in a changing climate requires new kinds of decision-making, in familiar contexts under unfamiliar circumstances. Solutions often involve a trial and error process that simply cannot easily materialize with conventional approaches to learning and dialogue. Decision science has shown that experience, because of the emotional pathways it triggers, is a much better teacher than mere exposure to information (Stefani et al. 2000). Games can help people to "inhabit" the complexity of climate risk management decisions, allowing us to explore, then test a range of plausible futures.

3. Games for experiencing the future of climate-related disaster risks

A set of dice from ancient Sumer, dated about 5000 B.C., may be one of the most enduring objects in our culture, remarkably resembling the common 6-sided dice we still use today to embody what scientists call a "probability distribution function", i.e. a representation of the range of possible outcomes including the chance of occurrence of each outcome (such as rolling a double six). Games are intrinsic to human culture across time and geographies (Huizinga 1955), expressing many of the same ideas they did 5,000 or more years ago—yet continually diversifying in form and type—from sports and board games to military simulations and massively multiplayer online games. Through their simple form, common dice invite us to take them in our hands and roll them - inspiring insights on the randomness and inevitability of unusual phenomena in the world (Mendler de Suarez et al, 2012). We are living in a world of systems and information, and games are *the* cultural form of systems Games are, nowadays, the cultural form of systems (Zimmerman 2011).

Participatory games can help us "inhabit" the complexity of climate risk management decisions, allowing us through system dynamics modeling to explore, then test a range of plausible futures. Albert Einstein once said that "Games are the most elevated form of investigation" (McGonigal 2011). Abt (1970) portrayed Serious Games as combining the analytic and questioning concentration of the scientific viewpoint with the intuitive freedom and rewards of imaginative, artistic acts. Serious games have an explicit purpose. They are not intended to be played primarily for amusement - although this does not mean that serious games are not, or should not be, captivating and fun.

[2] The authors conclude that "discussions of loss and damage under the UNFCCC and under the HFA are linked, but distinct. The objectives, contexts and legal obligations of the two frameworks in which these discussions take place are fundamentally different: the HFA strives to place responsibility for managing the risk of loss and damage from all kinds of disasters squarely on national and local stakeholders, with only a voluntary international support system; the UNFCCC explicitly recognizes the obligations of those most responsible for greenhouse gas emissions to address the adverse effects of these emissions, in particular for vulnerable developing country Parties. Accordingly, the Convention provides that developed country Parties should take the lead in combating the adverse effects of climate change."

The remainder of this section introduces key features of games as playable system dynamic models that can embody attributes of climate risk, and then offers a very brief overview of recent experiences involving participatory games for climate risk management.

3.1. How games can capture essential attributes of systems involving climate risks

(i) Linking information, decisions and consequences through emergent complexity

In their seminal work titled *Rules of Play: Game Design Fundamentals*, Salen and Zimmerman (2003) define games as "systems in which players engage in an artificial conflict, defined by rules, that result in a quantifiable outcome". Well-designed games, like real-world climate risk management decisions, involve decisions with consequences.

For the purposes of learning and dialogue to improve climate risk management, useful games involve emergent systems: they generate, from a simple set of rules, patterns of complexity that are unpredictable or surprising. In games, the limited set of elements that constitute the system can yield a vast array of plausible combinations and outcomes - what game designers call the *space of possibility* (i.e. all possible future actions and meanings that can emerge in the course of a game). Thus, a participant can start a gameplay experience with no awareness of specific causal relationships, and then after the gameplay experience reveals a large range of outcomes, see a particular pattern of causality as exquisitely obvious.

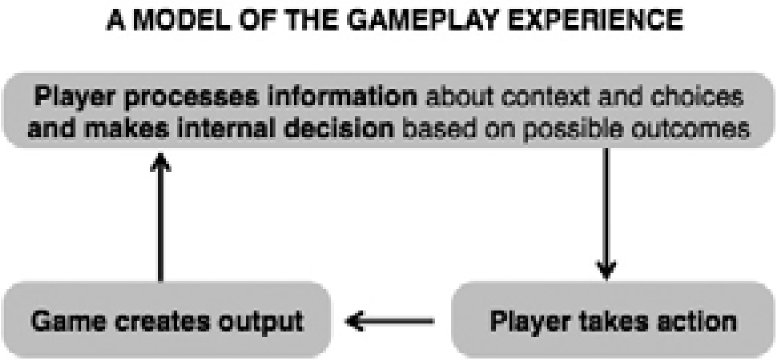

Figure 1: A distillation of the experience of gameplay, based on Salen and ZImmerman (2003). When a player takes action, the game system creates output by applying rules. Such output becomes information about context and choices shaping subsequent decisions—or determines a win/loss state.

Games can take many forms, but are contained within an experiential system described in the iterative model shown in Figure 1. At the core is what Salen and Zimmerman call a set of "choice molecules": *action → outcome*; an interaction unit that links a possible choice with its corresponding consequence within a designed system. These choice molecules constitute the units with which game designers create larger, organic structures of designed interaction. These organic, playful structures tend can do a very good job at embodying two of the most important tradeoffs involved in climate risk: on the one hand, the "now versus later" tradeoff (better outcomes for the longer-range future may require sacrifices in the short term), and on the other hand the "me versus us" tradeoff (selfish decisions often lead to more dependable good outcomes, whereas collective decisions, although potentially risky due to dependence on others, can lead to economies of scale and other reasons for achieving better collective outcomes). When both tradeoffs are present, games offer a platform that is singularly conducive to learning and dialogue on disaster risk management, allowing for the exploration of plausible futures.

In the context of climate risk management, the core of the choice molecule can be boiled down to the following four possible outcomes depending on whether the player acts for disaster risk reduction and whether the disaster materializes:

worthy action: decide to act, then event materializes and losses are avoided
worthy inaction: decide to not act, then event does not materialize
fail to act: decide to not act, then event materializes - leading to avoidable losses
act in vain: decide to act, then event does not materialize - often resulting in perceived waste of resources and loss of trust.

The decision of whether or not to act will necessarily be a subjective call, and should be based on the *probability* of the event's occurrence, and an analysis and comparison of the four possible outcomes of the choice molecule (Suarez and Tall 2010).

(ii) Representing probabilities and uncertainty

In the world of climate risk management, probabilities are everywhere. A disaster is, by definition, a rather improbable event. Yet, in the words of Aristotle: "it is in the very nature of probabilty that improbable things will happen". Behavioral economists have demonstrated that people tend to make systematic errors in estimating probabilities, leading to internal inconsistencies and unwanted outcomes (Tversky and Kahneman 1974). These decision biases can manifest very strongly in the face of probabilistic forecasts involving climate risks (Suarez and Patt 2004).

Games offer a most suitable platform for embodying probabilities in risky decisions, thus enabling researchers and practitioners to better understand the role of randomness in climate risk management. Random inputs, both in real life and in games, provides a sense of drama that is generally absent from other approaches to risk communication. Costikyan (2013) argues that capturing randomness is a key strength of games as they provide simulation value: there is a moment of tension when the dice are rolled, or the player otherwise commits to a course of action the outcome of which is luck dependent.

Diverse game materials have been used successfully in a wide range of settings. Patt (2001) utilized a set of games with a simple spinning wheel with two colors (red and green, in varying proportions), and different payout structures, to test assumptions by climate forecast communicators in southern Africa that vulnerable populations lack the capacity to learn how to use probabilistic information—an assumption that led to seasonal precipitation forecasts based on El Niño to be announced by radio as if they were deterministic, i.e. announcing the certainty of imminent drought (an approach that of course is certain to backfire when sooner or later the predicted event doesn't materialize). Gameplay data from rural Zimbabwe demonstrated that subsistence farmers respond to probabilistic information by adopting strategies that are reasonably successful, and responsive to changing probabilities—thus supporting the case for participatory forecast communication processes that fully disclose the true nature of science-based predictions.

There are numerous other simple ways to represent changing probabilities, such as drawing colored marbles from bags or drawing from evolving decks of cards, in ways that allow players to estimate probabilities, as illustrated in the more than eight games reported by Patt et al (2009) to communicate index insurance for climate risk management among farmers in Brazil, Ethiopia, India, Kenya, Malawi and Peru. Other approaches, such as changing the number of faces of a dice (see section 4.1 below) or digital randomizers (Harteveld 2010), can also construct any probability distribution function.

Game elements that capture randommness can be applied not just to natural hazards, but also to human-dependent aspects of reality affecting the outcomes of our decisions. For example, the game "Paying for Predictions" described in section 4.1 uses a bidding process to show how one's decisions are affected by other people's choices. The game "Humans versus Mosquitoes" uses a mechanic similar to rock-paper-scissors to illustrate how outcomes emerge from the interdependence of players' decisions (Suarez et al. 2014), and the game "Ready!" uses randomization to define how long it takes a person to implement a disaster preparedness action before an imminent shock strikes (Macklin 2014).

Games can also tap on mechanics that lead to changed probabilities that are not so easy to understand. A project by Patt et al. (2006) examined strategies for communicating expert advice utilizing the three-door Monty Hall game, whereby a subject is offered to choose between three seemingly identical doors, one of which hides a prize. Once the participant had made an initial selection, the experimenter opened a different door that he knew was empty, and then gave the participant the choice of whether to stay with the original door already selected or to switch to the remaining closed door. Once the participant indicated which door the experimenter should open, the experimenter opened that door and revealed whether the participant had won the prize. As argued by the authors, the math behind the three-door game is simple yet deceptive. There is a one-third chance that the participant's initial selection is the winning door, and therefore if they switch to the one remaining door after the hint, they win with probability two-thirds. The three-door game is a well-established choice anomaly (across different cultures, fewer than 20% of participants switch doors the first time they play the game, and only after many rounds does the percentage of people switching rise past fifty (Granberg, 1999). This is analogous to people's reaction to much disaster risk management advice: individuals often disregard expert information about enhanced probability of certain outcomes, and games offer, through a sustained learning experience that compresses time, one suitable approach to enabling them to understand the validity of the counterintuitive nature of some probabilistic forecasts and their implications.

The concept of probability implies knowledge of all possible outcomes, and an understanding of how many of those outcomes fulfill a certain condition. Thus in a roll of a six-sided die there is a 1/6 probability of rolling a one (which could represent about 16% chance of drought on any given year). However, in the world of disaster risks, there are many cases where we simply cannot describe the chances of occurrence of certain outcomes in clear quantitative terms. Instead of known probabilities, we have uncertainty.

Games can be extremely good at conveying the nature of uncertainty and its implications. For example, the game "Decisions for the Decade" described in section 4.2 below swaps a six-sided die with a truncated cone with a geometry that simply doesn't lend itself to evidently calculable probabilities of whether rolling the object will lead to 'drought', 'flood' or 'no disaster'. A game on geoengineering uses opaque bags containing unknown quantities of unknown objects to depict the uncertainties associated with solar radiation management (i.e. the deliberate manipulation of the global climate by adding sulfuric particles to the upper atmosphere in order to bounce off sunlight), leading to a rich discussion on implications for humanitarian work. Costikyan (2013) lists eleven sources of uncertainty in games that are apoplicable to risk management, ranging from *hidden information* (not knowing what others know) to *semiotic uncertainty* (not knowing the cultural meaning of an outcome).

3.2. Participatory games for climate risk management: brief overview of the literature

Games can capture the essence of how information leads to individual decisions that have collective, often surprising consequences, as illustrated by Shelling (1978) in numerous counterintuitive aggregate patterns resulting from simple individual behavior. Past decades have seen remarkable growth in the use of games as a medium to research of issues pertaining to disaster risks. From the pioneering work of Tverky and Kahneman (1974) on behavioral science and risk preferences and biases among experimental subjects in developed countries that led to the Nobel Prize in economics, to the evidence that subsistence farmers can quickly learn through games the role of El Niño in changing probabilities of droughts in Zimbabwe (Patt 2001), games have proven their value for analytically rigorous examination of how people process and use information about risks.

Over the last decade, various humanitarian and development organizations have embraced the idea of using participatory games for real-world work. Mendler de Suarez et al (2012) and Suarez and Bachofen (2013) document dozens of game-enabled initiatives developed by the Red Cross / Red Crescent Climate Centre, the World Bank, the UN World Food Programme, UNFCCC, IPCC, the Tanzanian Government, the Zambian Red Cross and many other entities—addressing a very wide range of issues encompassing food security, supply chain logistics in humanitarian relief, interpreting and acting on climate information, climate-resilient coastal development, disaster preparedness and response and more. Hundreds of game sessions on climate risks have engaged thousands of participants from Nairobi shantytowns to UNFCCC COP to the White House.

These “inhabitable games” are playable dynamic models that meaningfully engage people in experiencing complex systems that involve real-world tensions: long-term versus short-term, individual versus collective, local versus national, and other trade-offs that simply cannot be captured vividly in written texts or unidirectional presentations. These games explicitly embed elusive concepts such as changing probability distribution functions, risk sharing mechanisms, hidden causal loops, dynamic forces affecting hazards and vulnerabilities, residual risks that cannot be addressed through mitigation or adaptation measures, and other fundamental elements and relationships shaping how we can collectively avoid and address loss and damage associated with climate change impacts. Analytically rigorous research of games that explicitly involve climate-related losses and damages (e.g. Juhola et al 2013, Patt et al 2009) shows the positive impact of games on players, helping them to better understand their current or potential role in transforming the systems they inhabit—in a way that is serious, and fun.

Players inhabit games differently than users inhabit non-game systems. Games provide opportunity to play within a given system, experiment and draw conclusions about how it functions, while significantly lowering the stakes of failure. It is in fact a player’s ability to fail safely that differentiates play from work, creating opportunity for people to understand how systems function without risking undesirable practical or social outcomes of using systems incorrectly (Bogost 2010, Malaby 2007).

4. Case studies: Three game-based initiatives

4.1. Assessing the value and use of forecasts: the “Paying for Predictions” game

Given the obstacles confronted by disaster management practitioners in terms of accessing, understanding, trusting and using science-based precipitation forecasts, the game “Paying for Predictions” (P4P) was designed with the following objectives: (i) illustrate the potential value and limitations of forecasts for the humanitarian sector; (ii) convey the idea that it takes investment of time and resources for organizations to access and understand those forecasts; (iii) communicate that climate change and other trends are augmenting the risk of floods, and as a result forecasts become progressively more valuable to reduce losses; and (iv) facilitate a dialogue process between forecasters, humanitarian workers, government agents, donors and people at risk.

The game described in this section is presented in more detail in Suarez et al (forthcoming). It consists of ten consecutive rounds; each round represents one year. Players are divided into teams of 3; each team represents a “region” and each player assumes the role of a Red Cross worker in a sub-regional district, starting the game with a budget of ten beans as well as one white six-sided die representing local rainfall conditions. Each team also receives one colored six-sided die for regional rainfall, with one opaque cup in which to “roll” the regional die (the value of the regional rainfall die is concealed under the cup each turn). The player with the most beans after ten rounds of gameplay wins a small prize. The team that collectively ends up with the most beans after ten rounds of gameplay is given a bigger prize. This establishes a trade-off between collaboration and competition, which enriches the discussion and adds emotional depth to the gameplay experience.

Whether or not a flood occurs in any district depends on the roll of the dice: if the sum of the regional and local “rainfall” equals ten or more, a flood materializes. If a flood strikes a player’s district and people are left homeless, that player is in charge of delivering volunteers and tents. The cost of humanitarian action depends on *when* action is taken: *Pay one bean* to take “early action”, such as prepositioning volunteers and tents before the floods begin (it is not clear whether or not the investment will be needed), or *Pay four beans* if action must be taken after a flood has materialized (i.e. tents are transported in flooded terrain, the cost is higher.

After a couple of practice rounds to familiarize players with the game mechanics, the game officially begins with a surprise: players may choose to engage in a bidding process to access an early warning system (EWS) for the region—represented by replacing the opaque cup with a transparent cup. Each player discusses with team members, and then secretly puts into the regional cup as many beans as desired (between zero and ten—representing how much of their budget they are willing to invest in accessing and utilizing the seasonal prediction). By the end of the bidding countdown, each team's cup is brought to the front. For all ten rounds of gameplay, half of the teams—the highest bidders—will be able to "see" the level of regional rains before making the decision of whether or not to preposition tents. The other half of the teams recover their bidding beans, and won't be able to see their regional die before deciding whether or not to take early action.

The game proceeds according to this sequence for each year (round):

- Teams roll their regional rainfall die under the cup (those with EWS can see the value)
- The facilitator gives each team one or two minutes to discuss strategy
- By the countdown, each player is either standing (early action, pay 1 bean), or sitting
- Each player rolls the local die, and adds its value to the regional die to see whether a flood occurs (i.e. combined roll of ten or more).
- Those who didn't take early action and get a flood must pay 4 beans for response. If not enough beans to pay, they suffer a 'humanitarian crisis' and get a red stone.
- Next round begins.

Each round, players record on a form their decisions, and the outcome of the dice. By the seventh round another surprise is added: climate change. The facilitator secretly replaces the regional die with an eight-sided die (values ranging from 1 to 8), and rolls this die under the cup. This increases flood risk and is used in all remaining rounds. The game ends after the tenth round. A few survey questions on individual gamesheets elicit information about game insights, to jumpstart a facilitated discussion on the gameplay experience and implications for forecast-based humanitarian decisions.

Gameplay data was collected from mid 2012 until March 2013. Figure 2 shows the distribution of 581 player bids and the total number of crises they experienced during gameplay. The horizontal axis shows the range of beans that were invested in the bid. The bars represent the number of players for each bid value (quantified in the vertical axis on the left). As can be seen, the most frequent player bids are between 2 and 4 beans (69% of the players). About 20% of the players were skeptical of the early warning and bid nothing or only 1 bean. People bidding 6 or more beans (placing perhaps inordinately high value on early warning) represent only 3% of the total.

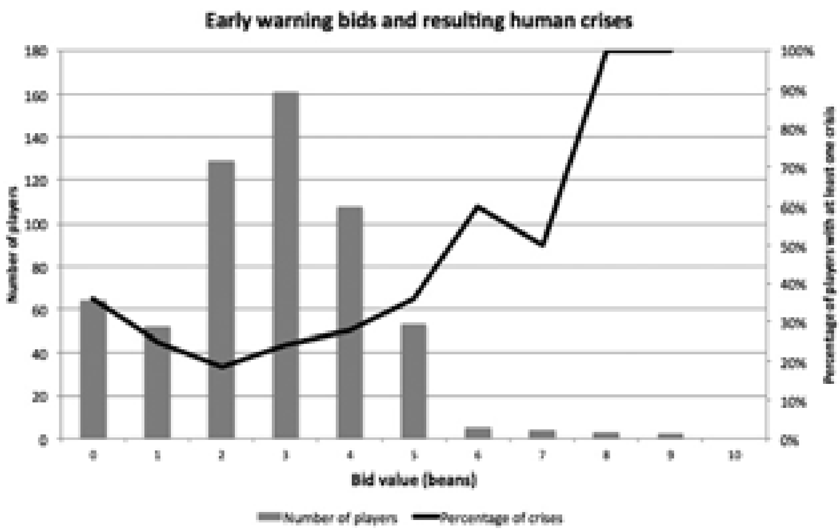

Figure 2: Distribution of bidding values and associated percentage of players with humanitarian crises.

After the game session, players were asked to document (in survey questions) how many beans they would bid if they were to start the game again. Figure 3 shows the distribution of those bids.

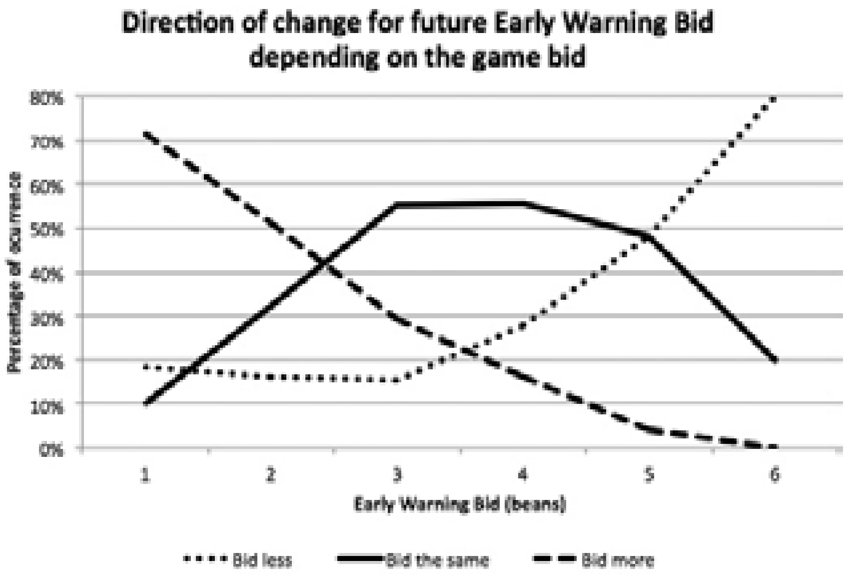

Figure 3: Many participants adjusted their bidding behavior based on learning

Analyzing the direction of this change after the game shows that people grasp the real value of the early warning. Figure 3 shows the percentage of players that change their bid up, down, or remain the same depending on their original bid. Only bids between 1 and 6 are shown in this plot (those who bid 0 can only go higher; and those who bid more than 6 are very few making the statistics not representative). A majority of people that bid 3 or 4 beans tend to stick to their bid (which, according to observed and modeled gameplay, leads to better outcomes). On the other hand, those who bid too much or too little are most likely to change their bid: Most players with lower bids recorded intention to bid higher (dashed line), whereas players that paid too much for early warning tend to bid lower in the futre (dotted line). This constitutes evidence that gameplay helped participants reexamine their choices and apply what they learned in ways likely to improve their future performance.

4.2. Understanding deep uncertainty through the game "Decisions for the Decade"

When it comes to disaster risk management in a changing climate, deep uncertainty is pervasive, challenging decision makers around the world. Yet, such uncertainty is difficult to acknowledge, understand, and manage. We are more comfortable facing risks we can quantify and solving problems for which we have familiar, well-honed tools. This creates a blind spot: As stated by Silver (2012), "The most calamitous failures of prediction usually have a lot in common. We focus on those signals that tell a story about the world as we would like it to be, not how it really is. We ignore the risks that are hardest to measure, even when they pose the greatest threats...We abhor uncertainty even when it is an irreducible part of the problem we are trying to solve." Sociopolitical expectations compound the problem: Analysts and decision makers routinely face pressures to demonstrate that a decision is risk-free. Political and cultural expediency press them to ignore rather than acknowledge uncertainty and present their decision as advantageous and certain (Bonzanigo and Kalra 2014). Under such pressures, robust decisions can be elusive. It is rare for decision makers to seek out and promote robust decisions, even though in practice it may be easier to build consensus around them.

As the world's largest development lending institution, the World Bank grapples with these challenges daily. The Office of the Chief Economist of the Sustainable Development Network seeks to shine a spotlight on the issue of deep uncertainty, which refers to a situation in which analysts do not know or cannot agree on (i) models that relate key forces that shape the future, (ii) probability distributions of key variables and parameters in these models, and/or (iii) the value of alternative outcomesas (Hallegatte et al 2012). It also seeks to hone methods of managing deep uncertainty, to apply these methods in World Bank projects, and to train decision makers and analysts in making robust decisions.

In the past, the climate change community has relied largely on lectures and presentations to communicate to decision makers both the problem of deep uncertainty and robustness as a way to manage it. This format has the shortcomings of most unidirectional forms of engagement. Unfortunately, the cost of failing to successfully reach the target audience is high. Governments and institutions around the world spend billions of dollars annually in long-term investments for which managing deep uncertainty is essential. Climate change looms large as a new kind of threat that cannot be managed with institutions' traditional approaches to risk management based on well-understood probabilities and projections.

In the past year, the Office of the Chief Economist has turned to serious games as a way to enable its stakeholders to experience these challenges first hand. In collaboration with the Red Cross Red Crescent Climate Centre, it has developed "Decisions for the Decade," a game in which participants must make long-term investment decisions that are at risk from uncertain and often surprising disasters. Central to this experience is that participants do not initially recognize the likelihood of disasters as deeply uncertain and, like many decision makers in the real world, plan for the most likely disaster regimes rather than for extreme events that bring devastating outcomes.

In this game, each participant is a provincial governor and four participants together make up the governing body of a nation. All participants begin the game with a budget of ten beans (for a ten-year cycle), and seek to maximize the prosperity of their province and country by investing a portion of their budget in long-term development. However, floods and droughts threaten this investment. The threat of extreme events is depicted by a six-sided die, introduced to players as the probability distribution function of precipitation based on the past record (a 1 represents a drought, a 6 a flood). Governors may choose to allocate a portion of their budget to disaster protection to avoid humanitarian crises—each bean offers protection against one extreme event. If all extreme events that occur after ten rolls of the dice are matched by a corresponding protection investment, their development investment leads to prosperity, or accrue *prosperity points*. If they incur a crisis (for example more floods occur than flood protection beans allocated) their development investment is diverted to crisis management, and they do not increase their prosperity.

After three ten-year cycles, the winning provinces are the ones that accrued the most prosperity points while simultaneously avoided crises. Importantly, unknown to the players, the object representing the rainfall is changed at the beginning of each cycle: first by an eigh-sided die (a flood occurs if the roll is 6 or more: probability of 3/8, or more than double the original probability of one in six); and then by a truncated cone that is near-impossible to understand in terms of the chancess of falling on the big base (representing floods) or the small base (representing droughts). As with the climate projections for much of the world, different players formulate very different interpretations of whether future conditions are likely to become wetter or drier, and as a team they have a chance to reflect on how to manage the emergent deep uncertainty.

The game offers participants robust options, which are insensitive to the probabilities of disasters, but which also have a lower payout than would an optimized investment if these probabilities were known. In other words, the robust options work well no matter what the disaster regime, but they may not be the best in any single predicted regime. The game further invites urgency, as scientific information changes during game play, and conflict, as certain decisions require consensus in the face of diverging beliefs about the scientific information.

“Decisions for the Decade” has been played with several audiences. In December 2013 it was used to launch a collaboration with stakeholders in Peru on using Robust Decision Making to ensure long-term water security. Participants included technical staff from diverse backgrounds and interests, including technical staff from the water utility, officials from the National Water Authority, leaders at the private hydropower company, and representatives from local NGOs. In January 2014, it was used at a kickoff workshop in Colombo, Sri Lanka for a master planning effort on flood risk and wetland management—as well as at a meeting of lead coordinating authors of the Integovernmental Panel on Climate Change (IPCC), where a modified version of the game integrated the actual graphs of the IPCC summary for policy makers to integrate risk and uncertainty considerations in investment decisions.

Feedback from the game sessions reveals that this intensely interactive approach whets participants’ appetites—intellectually and emotionally—for an in-depth presentation and discussion on deep uncertainties and how to manage them in real world settings. The game primes participants to think about the unknown, to challenge each other on assumptions about the future, and to explore how different types of analyses—those that focus on robustness—can help address the changing challenges they face.

As one example, a participant in one gameplay session remarked, “At first I thought it was very unfair to change the probabilities of the disasters, but afterwards, I realized that this happens in the real world all the time. We have to plan for surprises.” At another event, a participant noted, “Without the game, we don’t get a feeling of uncertainty. We always make decisions based on the past. This is not the correct approach,” and, in reference to their mission of flood risk management, added, “We need to know what the robust flood risk actions are for us!”

4.3. Engaging subsistence farmers in flood warnings: Zambia’s “UpRiver” game

Rainfall upstream means river flow downstream, and more water there now translates into more water here later. This simple fact can be translated into fairly reliable quantitative simulations of hydrological behavior in river basins, turning intensity of precipitation into volume of water flow per unit time, leading to an estimation of corresponding river level for any specific time and location, which in turn can be linnked to flooded households, allowing for an estimation of related losses and damages. Rainfall forecasts combined with predictive hydrological models can, in theory, feed into early warning systems that trigger early action to prevent or reduce avoidable losses. Yet people living in floodplains continue to suffer and die due to floods, despite their entirely predictable nature—especially for large, often transboundary river basins like the Zambezi in southern Africa.

Part of the problem is that there aren’t sufficiently reliable hydrological models for many such river basins due to a combination of lack of data about observed river level over time (no incentives for people to collect and convey precise data, or no funding for installing and maintaining automated stations), as well as no allocation of expert time to develop the quantitative tools for understanding and anticipating river flow downstream based on observable data upstream. Additionally, even when somewhat accurate flood predictions exist, vulnerable people can have difficulty accessing, understanding or trusting the early warning, or turning it into timely early action (for example by taking family and valuables to higher ground and securing shelter, water, sanitation and other basic needs—perhaps with support from early action by humanitarian organizations).

The Zambia Red Cross, with support from the Disaster Relief Emergency Fund managed by the International Federation of Red Cross and Red Crescent Societies (IFRC), has been assisting communities along the Zambezi floodplain after a disaster has occurred (see for example IFRC 2008 for the DREF operation report from 2006 disaster in the district of Kazungula). While some level of investment in disaster response is of course inevitable, much could be done ahead of the flood after an early warning of imminent threat but before the flood, if a forecast of likely floods were available and acted upon. The fact that hydrological models do not exist shouldn't necessarily translate into absence of early action: as long as unusual conditions can be noticed upstream and the message can travel faster than water, a rudimentary early warning system can be set in place, and help improve lives and livelihoods through early action. Yet as of now, the villagers of Kazungula report having no reliable knowledge about expected flood levels: they just see the river go up or down—in real time.

It should be noted that the closest river gauge station has a standard operating procedure whereby the human operator measures river level once a day, takes note of the value in a form and then every three months sends the form with about 90 days of data to the experts in the capital city. The purpose is to collect data—not to inform action. Given the cost of paying operators to measure and convey river levels, there are very few gauging stations along the river and its tributaries. In the absence of imminent deployment of early warning systems, new ways to create and internalize this knowledge are urgently needed.

To address the flood problem, the Zambia Red Cross Society, together with the Engagement Game Lab and the Red Cross / Red Crescent Climate Centre, is engaging subsistence farmers in an innovative approach to support vulnerable communities in understanding and predicting river levels along flood-prone areas of the Zambezi. "UpRiver" is a two-part early warning / early action game. The first part is a participatory game to be played in community workshops to help convey the mechanics of how river levels change through space and time, and the importance of upstream-downstream communication to manage disaster risks. The second part, and SMS-based game played on cell phones, aims to further these concepts by simultaneously putting in place and actual communication network for relaying upstream information, and crowdsourcing river level data to help calibrate science-based hydrological models—thus accelerating more reliable flood predictions.

UpRiver challenges players to predict what the water level will be at a river gauge near them at a future date. In the analog game, players siimulate water levels along the river by standing in a line with cups filled with different amounts of water. Rainfall and evaporation are represented as sponges of different size that add or substract water from the cups (based on somewhat predictable yet random process involving special cards and dice). The contents of the cups change due to rainfall as they travel from upstream to downstream. Players are asked to predict the final river level, and need to take early action if they anticipate that a flood will occur (i.e. water overflowing the cup). The default condition is that each player can only see what is going on in her own location. A game mechanic allows them to invest fictional points in accessing information from upstream to try to improve their prediction.

Players can earn more points by correctly anticipating future river levels: more lead time and more accurate their prediciton lead to larger rewards. In the digital version, UpRiver is played via text message, with multiple players in various communities along the river—a web platform processes game inputs, manages flow of information from and to players, and allows to record and visualize crowdsourced data along the river. Predictions need to be submitted via SMS at scheduled deadlines chosen to match the periods of expected dynamism in river levels (for example based on six-day weather forecasts for extreme rains combined with high soil saturation in the upper basin, or strong seasonal rainfall forecasts indicating unusually high risk of a very wet season).

In both the digital and analog versions, players earn game currency by reporting water level about their local area (this can be expanded to include observed daily rainfall and other real-time observations). Participants learn about the cost, value and limitations of upstream data. Those who outperform others in figuring out the river system win a small prize. Players who can anticipate exceptionally high river levels coming from upstream are more likely to trust the flood forecast, alert their neighbors, and act to reduce losses.

Importantly, the game design team envisions a future stage where, if a sufficiently reliable hydrological model is developed for the Zambezi river basin, the model itself would join the game as a fictional participant, competing against human players (who would receive a text message with the models' prediction right after the submission deadline): players who outperform the model get extra points (something fairly likely during periods of relatively normal rivel level conditions, but much more difficult when extreme conditions are expected). This approach can enhance familiarity and trust in predictive flood models, while helping scientists improve them. Importantly, the game-enabled participatory process can help vulnerable people as well as government agencies and humanitarian organizations to trigger early action based on early warnings, both to reduce losses and to manage the unavoidable damages through faster and better disaster response and reconstruction.

UpRiver embodies the principles of what Gordon et al (2014) refer to as "engagement games": a new type of interface for real-world processes that use game mechanics to scaffold play onto the environment that participants live in, so that real and action occurs while playing the game. In engagement games, the game is in part or in whole the official process (for example, for data collection on river levels); game actions are actions in the real world (for example, acquiring information about river levels upstream). Engagement games can result in better action, more trust, and civic learning.

4.4. Innovative learning and dialogue on L&D: the CAULDRON Game

Recognizing that communication challenges surrounding Loss & Damage would be prominent on the negotiating agenda of the UNFCCC COP 19 in Warsaw (December 2013), and that and the emerging science to link extreme events and climate change, probabilistic event attribution, would not be understood as a resource of evidence, a partnership between ACE-Africa (Oxford University, University of Reading, Oxfam Great Britain and UK Met Office), the International Institute for Environment and Development (IIED), and the Red Cross / Red Crescent Climate Centre, led to an intensely interactive, game-based approach to address L&D in the Development and Climate Days at COP 19 (ENB 2013).

The CAULDRON game (Climate Attribution Under Loss and Damage: Risking, Observing, Negotiating) was specifically designed for COP19 to promote discussion and learning around attribution of weather and climate-related events to external climate drivers (Bachofen et al, forthcoming). This game explicitly embeds what a changing probability distribution means for the odds of an event to occur, how some risks can be reduced, and which are residual risks. Playing the game, participants grapple with fundamental relationships that shape whether and how loss and damage associated with climate change impacts can be collectively avoided and addressed in the real world. During the game, players are assembled in small groups of four to eight players with each group representing a region and each player representing a country within that region. These regions and countries are not intended to match regions in the real world. Each player sequentially takes on three very different roles: farmers, scientists and UNFCCC negotiators.

First, *Farmers* can be from either developed or developing countries, each with the option of planting low-yield or high-yield crops. Rainfall is determined by the roll of a normal die ("rainmaker"), with one of the faces representing a drought. When the rains were good, farmers from developed countries 'harvest' higher yields than farmers from developing countries. During 'drought', all farmers would experience crop failure (with more dramatic consequences for poor farmers). Individual risk preferences, combined with the known one-in-six probability of crop loss, informed players' crop choice. After a few rounds, global climate change is introduced as an unnoticeably loaded die. However, not all dice are replaced by a loaded die so farmers remain uncertain as to whether or not a changing global climate is affecting their specific region. Similar to reality, the extent to which changes in climate affect their harvests is not inferable from the observed record of rain and drought the players have created by recording the outcomes of their actions and the rainmaker results each round.

In the second phase of the game players are *scientists* tasked with formulating hypotheses about whether their country had been experiencing climate change based on their recorded data in phase one, to inform UNFCCC negotiators. To obtain a better statistical record than is possible from the players' observations of their distribution of droughts in the first phase of the game, players are given a 'climate model'. This climate model appears very similar to the rainmaker and the scientists are allowed to shake them several times to generate a record of model data. As in the real world, the scientists are aware of the fact that model data contain more imperfections than observed data and can thus not be taken as identical evidence. Nonetheless, by the end of this phase, the scientists have to "publish" how confident they were in whether or not more dangerous rainfall patterns could be attributed to climate change, using IPCC language (bidding four beans meant "virtually certain"; bidding one bean meant "more likely than not"). By the end of the game the dice can be seen, distinguishing loaded from unloaded ones. Players whose hypothesis was correct double the beans they invested in representing confidence; those who get it wrong lose their beans.

Finally, players become *negotiators*, each representing the country for which they have already played the role of farmer and scientist. Negotiators at each table have to come up with an agreed text to address the loss and damage that they encountered in their roles as farmers. It is up to the negotiators whether they consider the scientific evidence on the extreme events allegedly due to climate change. Under overwhelming time pressure, the text agreement needs to be consistent and signed by all players to be valid. It is negotiators' task to decide whether or not climate science should be relevant for the various aspects of the loss and damage negotiations. Thus the game's design highlights the fact that there are no expectations about the actual content of the agreement: the purpose is to let the participants explore if and how the potential of scientific evidence for the attribution of extreme weather events can shape negotiations on reallocation of resources in light of loss and damage. After the deadline, the negotiation texts from each table are discussed in plenary.

This 90-minute game was played on 16th November 2013 in Warsaw as part of the Development and Climate Days at COP19. About 70 participants from very different backgrounds engaged in animated, rich discussions about extreme events, challenges in attributing their changing frequency or intensity to climate change, and the very limited but potentially crucial role of climate science in shaping negotiations. Importantly, during the gameplay interactions and post-game discussions, participants indicated that they confronted through their individual experiences many of the challenges that influence progress or lack of progress in the UNFCCC deliberations, such as:

- Grappling with the inevitability of some level of residual risk that manifests itself as loss and damage
- Contending with the fact that extreme events are rare and thus scarce observations of such events alone, during a relatively short period of time, do not allow for the unquestionable detection of a change in the probability of extremes.
- The emergence of entrenched positions, questionable allegations of causality, and questionable dissociations from responsibility.

Participants also found value in the game platform in helping to see and take ownership on positions from other stakeholders, enabling a meaningful conversation about how to avoid and address loss and damage associated with climate change impacts.

The success of this session has motivated participants to organize more sessions featuring the CAULDRON game in events to understand the L&D issue, from academic settings to meetings hosted by national government agencies.

5. Conclusion

Substantial challenges in communicating technically precise concepts to key stakeholders persist; and fostering a fruitful atmosphere of learning and dialogue becomes more challenging as lack of information or poorly communicated information lead to entrenched positions. From illiterate subsistence farmers to senior government negotiators in UNFCCC events, these challenges can be addressed with the aid of intensely interactive tools, like serious games, that enable an experiential approach to learning about the complexity of disaster risk reduction and residual risk in a changing climate. Importantly, as argued by Gordon and Baldwin-Philippi (2014), games can help participants to cultivate a kind of procedural literacy, increasing their awareness of systems and how they can act within them.

As a deeply participatory process, this somewhat unconventional “full immersion” approach to dialogue and learning does require some risk-taking and some time to take hold. Clearly, there must be room to make mistakes, to engage in an iterative process, and to discuss the limitations of any game before and during deployment. Recognizing that time is valuable, not everyone will be immediately willing to experiment with such an innovative approach; skeptics or even saboteurs are likely to emerge. Questions may arise concerning the justification for allocating human, time, and financial resources to games. Some may relate games with child’s play and be reluctant to carve out time in busy schedules, or even see gameplay propositions as patronizing. To be taken seriously, those in power may need to experience games to discover their value as a serious approach to learning—for all ages (Mendler de Suarez et al 2012).

Indeed, issues of power structure and agency must be adequately addressed, particularly given the highly political processes underpinning the Warsaw Mechanism for L&D and HFA+. Participation does not automatically translate into empowerment (White 1996, Few et al. 2007). Pre-existing power relations can impose serious limitations to the meaningful participation of individuals. While games can in theory be great equalizers, in practice they may even provide a platform on which existing unjust power dynamics are replicated or further entrenched. Experienced facilitators aware of the potential pitfalls can be better prepared to manage these, leading to fair and reflective deliberations.

As illustrated in the case studies, games offer a serious approach to meaningful and sound communication for many different stakeholders—indeed thought leaders and policy makers from some of the world's most influential and far-reaching organizations have embraced games as a promising approach to bridge communication divide faced in an array of contexts. If risk management is addressed in an incoherent manner, it will offer little scope for accelerating sustainable development. While instruments such as the Warsaw Mechanism for L&D and HFA+ are tasked with guiding and regulating aspects of climate-smart disaster risk management from the local to the global levels, managing risk and opportunities in a realistic and reasonable manner needs to remain a common feature. The mechanics, dynamics and aesthetics of participatory games can support these instruments as they create spaces for learning and dialogue that can address the critical issues. As critical milestones for both the UNFCCC and the Hyogo Framework for Action approach, stakeholders may find in participatory games a suitable modality for accelerating the integration of knowledge into climate-smart action.

ACKNOWLEDGEMENTS

This paper was developed with support from the Japanese International Cooperation Agency (JICA) in the context of the "Development and Climate Days at COP19" grant to the Red Cross / Red Crescent Climate Centre. Additional support for fieldwork and analysis was provided by the Norwegian Research Council through the project "Courting Catastrophe? Humanitarian policy and practice in a changing climate". This work builds on research and practice on participatory games made possible by numerous partners, including the African Union, the American Red Cross, CDKN, PETLab/Parsons the New School for Design, the UN World Food Programme, and the World Bank. The authors are grateful to the many people and organziations that have supported game design, facilitation and analysis, in particular Janot Mendler de Suarez, Patricia Fay and Ricardo Petroni for "Paying for Predictions", Ankur Shah, Janot Mendler de Suarez, Laura Bonzanigo, Michael Chaitkin and Stephane Hallegatte for "Decisions for the Decade", Stephen Walter and Wade Kimbrough for "UpRiver", and Hannah Ruth Parker, Rosalind Cornforth, Rachel James, Peter Walton, and Myles Allen for CAULDRON. We also thank Patricia Fay for research support and literature review.

REFERENCES

Abt, C. (1970). Serious Games. New York: Viking Press.

Allen (2003) Liability for climate change. Nature, 421:891-892.

Bachofen, C., Sunstrom, R., Iqbal, F.Y. and Suarez, P. (forthcoming). Participation, learning and innovation in adaptation to climate change: the 2013 Development & Climate Days. In review at *Climate and Development*.

Bogost, I. (2010). Persuasive Games: The Expressive Power of Video Games. Cambridge, MA: MIT Press

Bonzanigo, L., and Kalra, N. (2014). *Making Informed Investment Decisions in an Uncertain World: A Short Demonstration*. Policy Research Working Paper. World Bank.

Costikyan, G. (2013). Uncertainty in games. Cambridge MA: MIT Press.

CRED - Center for Research on Environmental Decisions. (2009). The Psychology of Climate Change Communication: A Guide for Scientists, Journalists, Educators, Political Aides, and the Interested Public. New York.

ENB - Environmental Negotiations Bullettin (2013). Development and Climate Days (D&C Days) 2013 - "Innovative approaches, incisive dialogue for climate-smart development". Available online at http://www.iisd.ca/climate/cop19/dcd/

Few, R., Brown, K., and Tompkins, E.L. (2007) Public Participation and Climate Change Adaptation: Avoiding the Illusion of Inclusion. *Climate Policy* 7 (1): 46-59.

Gordon, E. and Baldwin-Philippi, J. (2014). Playful Civic Learning: Enabling Reflection and Lateral Trust in Game-based Public Participation. International Journal of Communication 8: 759–786.

Gordon, E., Walter, S. and Suarez, P. (2014). Engagement Games: A case for designing games to facilitate real-world action. Boston: EGL. Available online at http://engagementgamelab.org/pdfs/engagement-game-guide.pdf

Granberg, D. (1999). Cross-cultural comparison of responses to the Monte Hall dilemma. *Social Behavior and Personality*, 27(4), 431-438.

Hallegatte, S., Shah, A., Lempert, R., Brown, C. and Gill, S. (2012). Investment Decision Making under Deep Uncertainty - Application to Climate Change. Policy Research Working Paper. World Bank.

Harteveld, C. (2010). Triadic game design: Balancing reality, meaning, and play. New York: Springer.

Huizinga, J. (1955). Homo ludens; a study of the play-element in culture. Boston: Beacon Press.

IFRC - International Federation of Red Cross and Red Crescent Societies (2008). DREF operation final report - Zambia: Kazungula Floods. DREF operation n° MDRZW002. 9 May 2008. Available online at http://www.ifrc.org/docs/appeals/06/MDRZM002%20Final.pdf

IPCC, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Juhola, S., Driscoll, P., Mendler de Suarez, J. and Suarez, P. (2013). Social strategy games in communicating trade-offs between mitigation and adaptation in cities. *Urban Climate* 4:102-116.

Liu, C. and R. P. Allan 2013 *Environ. Res. Lett*. 8 034002 doi:10.1088/1748-9326/8/3/034002

Mace, M.J. and Schaeffer, M. (2013). Loss and Damage under the UNFCCC: What relationship to the Hyogo Framework. Report prepared by Climate Analytics. Available online at http://www.lossanddamage.net/download/7248.pdf

Macklin, C. (2014). Ready! Lessons in the design of humanitarian games. The Hague: Red Cross / Red Cerscent Cliamte Centre Working Paper Series No. 3

Malaby, T. M. (2007). Beyond Play: A New Approach to Games. Games and Culture, 2(2), 95–113.

McGonigal, J. (2011). Reality Is Broken: Why Games Make Us Better and How They Can Change the World. New York: Penguin Group.

Mendler de Suarez, J., Suarez, P., Bachofen, C., Fortugno, N., Goentzel, J., Gonçalves, P., Grist, N., Macklin, C., Pfeifer, K., Schweizer, S., Van Aalst, M., and Virji, H. (2012). Games for a New Climate: Experiencing the Complexity of Future Risks. Pardee Center Task Force Report. Boston: The Frederick S. Pardee Center for the Study of the Longer-Range Future, Boston University.

Otto, F.E.L., N. Massey, G.J. van Oldenborgh, R. G. Jones, and M. R. Allen (2012) Reconciling two approaches to attribution of the 2010 Russian heat wave. *Geophys. Res. Lett*, 39, L04702.

Otto, F.E.L., Boyd, E., Cornforth, R.J., James, R., Parker, H.R. and Allen, M.R. (forthcoming). Attribution of extreme weather events in Africa: A preliminary exploration of the science and policy implications. Submitted to *Global Environmental Change*.

Pall, P., T. Aina, D.A. Stone et al. (2011), Anthropogenic greenhouse gas contribution to flood risk in England and Wales in autumn 2000, *Nature*, 470, 382-385.

Patt, A. G. (2001). Understanding uncertainty: forecasting seasonal climate for farmers in Zimbabwe. Risk, Decision and Policy 6 (2):105-119.

Patt, A.G., Bowles, H.R. and Cash, D.W. (2006). Mechanisms for enhancing the credibility of an adviser: Prepayment and aligned incentives. Journal of Behavioral Decision Making 19 (4): 347-359.

Patt, A.G., Peterson, N, Carter. M, Velez, M., Hess, U. and Suarez, P. (2009). Making index insurance attractive to farmers. *Mitigation and Adaptation Strategies for Global Change* 14: 737-757.

Roberts E., Huq, S., Hasemann, A., Roddick, S. (2012) Early Lessons from the Process to Enhance Understanding of Loss and Damage in Bangladesh Advanced Version. International Centre for Climate Change and Development (ICCCAD).

Salen, K. and Zimmerman, E. (2003). Rules of Play: Game Design Fundamentals. Cambridge (USA): MIT Press

Schelling, T.C. (1978) Micromotives and macrobehavior. Toronto: Norton.

Schipper, E. L. F. (2009). Meeting at the crossroads?: Exploring the linkages between climate change adaptation and disaster risk reduction. *Climate and Development* 1 (1) 16-30.

Silver, Nate. *The Signal and the Noise: Why so Many Predictions Fail - but Some Don't.* New York: Penguin Press, 2012.

Stefani, L.A.J., Clarke, J. and Littlejohn, A.H., (2000). Developing a Student-Centred Approach to Reflective Learning. *Innovations in Education and Training International* 37:163-171.

Stone DA & Allen MR (2005), The end-to-end attribution problem: From emissions to impacts. *Climatic Change*, 71, 303-318.

Stott, P.A., D.A. Stone and M.R. Allen (2004), Human contribution to the European heatwave of 2003, *Nature*, 432, 610-614, doi:10.1038/nature03089.

Suarez, P., Mendler de Suarez, J., Koelle, B. and Boykoff, M. (2014). Serious Fun: Scaling Up Community Based Adaptation through experiential learning. In: Schipper, E. L., Ayers, J., Reid, H., Huq, S., and Rahman, A. (eds.) Community-based adaptation to climate change: Scaling it up. London, Routledge.

Suarez, P., Mendler de Suarez, J., Petroni, R. and Ghosh, S. (Forthcoming) “Paying for Predictions”: Game-enabled exploration of forecasts for mainstreaming adaptation. In review at *Climate and Development.*

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: heuristics and biases. *Science*, 211, 1124-1131.

Verheyen, R. (2012). Bonn: Germanwatch. Tackling Loss and Damage: A new role for the climate regime? Bonn: Germanwatch.

White, S. C. (1996). Depoliticizing Development: The Uses and Abuses of Participation. *Development in Practice* 6 (1): 6-15.

Zimmerman, E. (2011). Quoted in the “Name that Game” blog entry by Steven Heller, available online at http://www.printmag.com/imprint/name-that-game/

Citation: Pablo Suarez, Friederike E. L. Otto, Nidhi Kalra, Carina Bachofen, Eric Gordon and Wisford Mudenda. *Loss and damage in a changing climate, Games for learning and dialogue that link HFA and UNFCCC*. The Hague: Red Cross Red Crescent Climate Centre, Working Paper Series No. 8. Commissioned as an input paper for the United Nations Office for Disaster Risk Reduction (UNISDR), *Global Assessment Report on Disaster Risk Reduction* 2015.