RAND CORPORATION

Research Report

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Climate Futures and South Asia 2042

Hazard Card Climate Game

Climate change is a worsening challenge that will affect the entire world, generating such hazards as heat waves, droughts, and flooding. While there is an immense amount of uncertainty surrounding future climate change and its associated impacts, it is abundantly clear that changes to the climate are occurring and will continue to occur, such that these hazards will increase in frequency and severity as the Earth continues to warm.[1]

As climate change alters the physical landscape, it will affect the geopolitical and national security landscape as well. Sea level rise (SLR) will displace millions from their homes, droughts will wreak havoc on crop yields, and heat waves will induce blackouts. The impacts of climate hazards can be devastating depending on the affected population's level of resilience. All these factors can contribute to rising unrest and ultimately culminate in conflict in the absence of mitigating factors, such as a stable government.[2] In addition, when tensions already exist between states, climate events may change the local balance of power or create situations in which one state might see opportunity to make gains at the expense of the other.[3] Climate change could also drive new tensions between states, such as competition for control over increasingly scarce common-pool resources.[4] Thus, the impacts of climate change must be considered when policymakers and defense planners look toward the future.

KEY FINDINGS

- The magnitude of hazards resulting from climate change and their associated impacts are deeply uncertain. Scenario-based planning and analytic gaming are therefore useful methods for exploring the flexibility in assumptions required when considering climate change and its impacts.
- A scenario-based climate hazard card game as a stand-alone event provides an opportunity for communication and learning about climate change and its existing and potential future impacts.
- A scenario-based climate hazard card game conducted as part of a traditional wargame provides a useful vehicle for updating players on the evolving physical hazards that influence gameplay.
- In the future, developing a gaming community repository of climate data and associated hazards will help expand access to credible ways of including more-specific climate and weather information in games.

Abbreviations

DoD	U.S. Department of Defense
IPCC	Intergovernmental Panel on Climate Change
J-8	Force Structure, Resources, and Assessment Directorate
RCP	representative concentration pathway
SLR	sea level rise
SSP	shared socioeconomic pathway

This report outlines the methodology for a scenario-based climate planning game to be played by itself or incorporated into other analytic games, commonly referred to as *wargames* in the defense community. Wargaming serves as a valuable research method for exploring complex questions across the national security space by helping participants frame, understand, and react to uncertain problems. In addition, wargames provide space for participants to learn experientially about the complexities of a particular problem to ultimately support decision-making. While gaming cannot be the only research method applied to a research problem—nor should it be—it provides an in-depth means of exploring the interactions and interstakeholder dynamics of a problem in a way that other methods frequently cannot.

The U.S. Department of Defense (DoD) Joint Staff Force Structure, Resources, and Assessment Directorate (J-8) employs wargames to support resource and force structure analysis. In 2022–2023, J-8, along with U.S. Central Command (USCENTCOM), sponsored a series of RAND Corporation–led wargames examining conflict in South Asia in the 2040 time frame, with a focus on climate and weather-related hazards. The overarching project was designed to explore the acute and chronic climate change hazards and impacts on the region, including the effects of climate change on people, infrastructure, and military operations. Future security risks from climate change are especially notable in South Asia, which is known to be one of the regions of the world most at risk from climate change.[5] This report outlines the design of a "hazard card" climate game, which was used to understand the nature of future India-Pakistan conflicts in scenarios influenced by climate change. It served both as the first game in this series and as a building block for subsequent games conducted in the series. Climate change has been incorporated into wargames previously; the first major climate wargame occurred in 2008,[6] and the first major DoD exercise, Elliptic Thunder, occurred in 2021. Since then, the Army, Navy, and Coast Guard have conducted wargame exercises involving climate change. The recent releases of climate strategy documents[7] are likely to induce more demand for climate change–focused wargames in the future.

How Was the Hazard Card Climate Game Developed?

Event Cards

The central research product of the game was a deck of event cards representing climate hazards that could strike the South Asia region, with a specific focus on India and Pakistan. Event card–based games are relatively common in both hobby and analytical gaming and are particularly useful in areas in which there is a desire to represent and explore a wide spectrum of possible scenarios in a short time frame. They are also useful in that the design team can shape the level of stochasticity of play through the distribution of cards in the deck, while the facilitation team can decide on the random or nonrandom way in which cards are drawn. This structure is well-suited to communicate both the overall trend in worsening hazards and the inherent uncertainty in the spatial distribution, frequency, and severity of climate hazards.

To construct each of the event cards, we developed combinations of the following factors: (1) the climate hazard, (2) the level of severity, (3) the general geographic area affected, and (4) the environmental and human-system impacts. Each card was unique in its combination of these four factors, leading to 31 scenarios that could build on one another as the game progressed (see Appendix B). Thus, this game introduced a way to explicitly consider climate change in the context of wargaming.

The climate change hazards (a) and their associated impacts (d) in the event card deck were chosen from a literature review of climate change and its current and projected impacts in South Asia. We began the review with the latest Intergovernmental Panel on Climate Change (IPCC) assessment reports of the physical science basis of climate change and impacts, adaptation, and vulnerability in the region caused by climate change.[8] These reports, along with the World Bank Climate Change Action Plan,[9] indicated that aridification, glacial retreat, SLR, heat waves, extreme precipitation (monsoon and tropical storms), and drought are the main climate hazards affecting human systems in the region. Appendix A provides further information about the trajectory of each of these hazards in South Asia.

While the kinds of climate hazards that regions may experience and their worsening trends[10] are generally agreed upon (see Appendix A for further discussion on each hazard in the region), the magnitudes and frequency of these hazards are uncertain. This uncertainty is due in part to the complex and nonlinear nature of the climate system and the unknown thresholds of tipping points, where small changes in system inputs (e.g., emissions or temperature) give rise to disproportionate impacts (e.g., a shutdown of the thermohaline circulation of the ocean). The climate modeling community represents this uncertainty through different structural assumptions (i.e., relationships between variables) in climate models. In the near to middle term, this structural uncertainty in the climate system yields far greater variability in impacts than uncertainty in emissions pathways (which is represented by the representative concentration pathways [RCPs], as discussed in the next section). Thus, since the game is set in 2040, levels of severity are determined by the magnitudes and frequency of hazards across climate models.[11]

We created four categories of scenarios: events that reflect chronic trends in climate change that are expected to persist as the new normal; extreme events that represent the more severe end of model projections; low-likelihood, high-impact catastrophic events, which are plausible only under certain conditions but would have particularly disastrous effects; and events that are plausible but outside the general consensus in the literature and modeled results (i.e., off-normal events) (see Appendix A). Importantly, the levels of severity for each hazard depend on the hazard in question. For example, the chronic hazards aridity and glacial retreat are present only at the new normal level of severity. This is to communicate that these hazards are to be expected on a year-to-year basis, unlike the acute hazards included in the other cards. Figure 1 shows the range of severity across a sample of cards.

The cards also represent the projected first-order impacts of each hazard. Within the deck, the impact categories included food insecurity, flooding, heat effects, human migration, and infrastructure. Each scenario included at least one impact, and additional context for each event (e.g., mechanism, geographic extent, magnitude) was provided to help participants better understand each event.

Game Play

Once the scenarios are established, the game itself is simple to play. A schematic of the stages of the game is given in Figure 2. Prior to playing the game, players are provided helpful information, such as the boundaries of major watersheds, maps of crop production, and other relevant background information on the region of interest. The game consists of ten turns, each representing a single year, and one event card is pulled from the deck during each turn. Guided by the facilitation team, players consider which effects of the climatic event on the region were of greatest concern. This includes ecological and human impacts (e.g., food insecurity), as well as political, military, and strategic concerns both within and between countries (e.g., domestic political unrest and competition for scarce resources between states). Players then evaluate the stability of the region given these concerns.

To enrich the discussion, the participants imagine futures of varying levels of adaptive capacity when assessing the implications of each scenario. These levels are based on shared socioeconomic pathways (SSPs). The basic assumptions of each SSP are presented in a qualitative fashion to the game participants before the game starts. The SSPs contain assumptions regarding how population growth, gross domestic product (GDP), technological change, and energy and dietary preferences will unfold until

FIGURE 1

A Sample of Climate Futures Hazard Cards

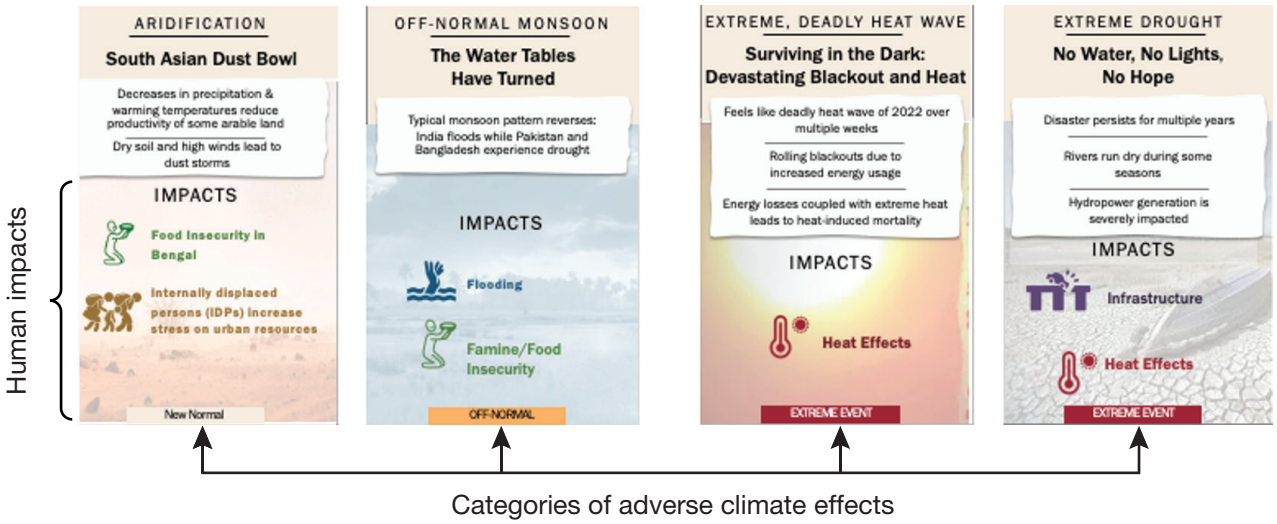
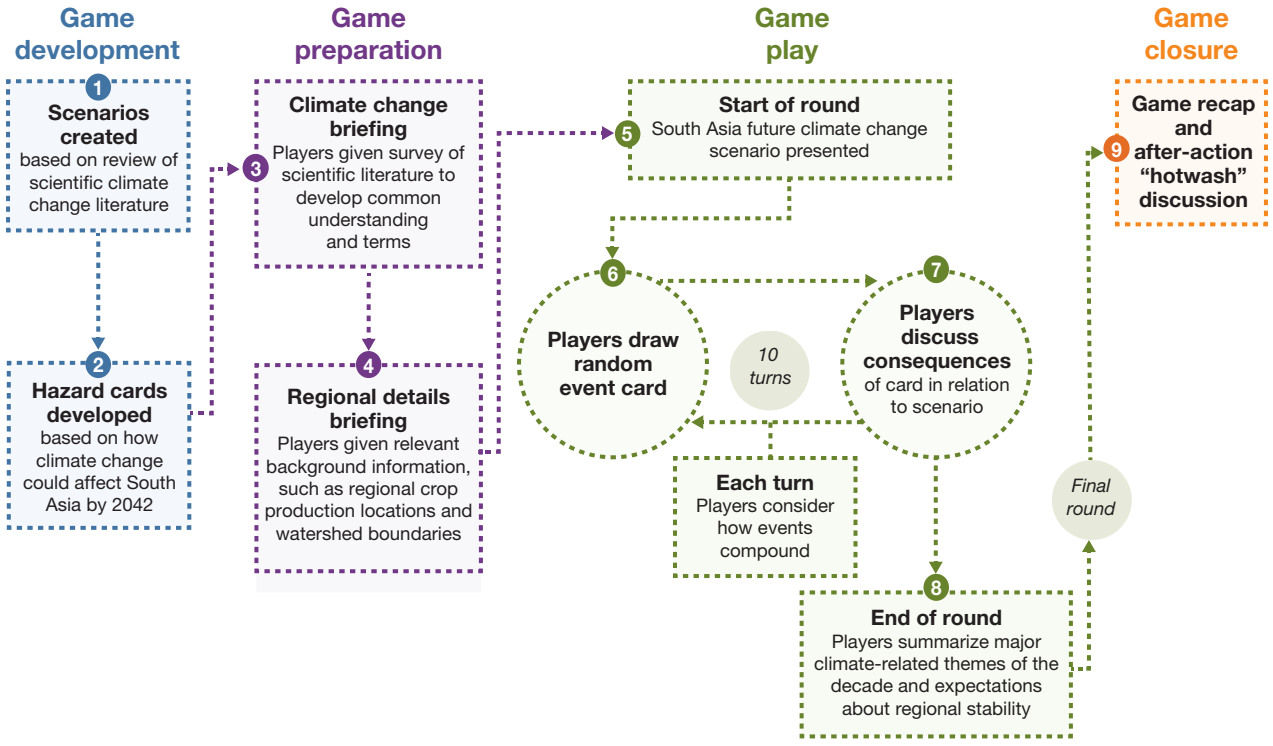


FIGURE 2

Stages of Game Design, Play, and Discussion



the end of the century (see Appendix C).[12] These scenarios lead to a low (SSP 1), medium (SSP 2), and high (SSP 5) challenge scenario for the participants to consider when assessing impacts. Many different climate futures are possible with each SSP, but some outcomes are inconsistent with certain socioeconomic assumptions. The matching of possible socioeconomic and climate outcomes is traditionally done

using the RCPs.[13] The game participants react to scenarios given the baseline SSP assumptions that are paired with certain RCPs (i.e., SSP 1 RCP 2.6, SSP 2 RCP 4.5, and SSP 5 RCP 8.5). The RCPs noticeably differ from one another only after mid-century, so, while the scenarios were consistent across challenge levels,[14] the participants consider possible actions knowing that they could be on a specific RCP (i.e., participants consider actions knowing that hazards and impacts may be much more severe in the future).

After the discussion has ended, another card is pulled from the deck. Each additional card adds to the discussed impacts from the previous card. For example, a heat wave event card could be pulled after a drought event card, which would compound the effects being discussed. Alternatively, an extreme precipitation card could be pulled after a drought card. This has the possibility of mitigating previous impacts or compounding them (i.e., soil that is hardened may not take in moisture, leading to intense deluges).

The challenge level of the game with its underlying socioeconomic and climate scenario (i.e., SSP and RCP combination) also shapes the way that players respond to the events. Under the high-emissions future, players may attribute higher impacts to a drought than in the lower-emissions scenario, in which they expect a higher likelihood of a return to normalcy. This reflects the importance of considering different plausible futures in decisionmaking contexts. Players do not know the contents of the event cards, the included climate hazards, or the frequency of extreme versus baseline (i.e., new normal) cards and therefore cannot plan around that distribution. However, players can form expectations about the future according to the given resiliency of each scenario.

At the end of each ten-year round, players give a summary of the major climate themes of the decade, as well as their expectations about regional stability moving out of the 2040s. After all individual rounds are completed, the participants join together for a recap and hotwash (debriefing) after-action discussion with the RAND team.

The challenge level of the game with its underlying socioeconomic and climate scenario shapes the way that players respond to the events.

Why Is a Hazard-Style Card Game an Appealing Format for Exploring Climate Change Implications?

Climate change is a seminal example of what are known as *wicked* problems, meaning complex problems with dependencies between multiple interacting systems, possibly irreversible decisions, and no well-defined problem formulation or objective.[15] While the reality of climate change and its worsening trend is unequivocal,[16] the severity, frequency, and location of impacts are difficult to plan for given the deeply uncertain nature of the climate system. Experts do not agree on the correct way to represent relationships within the system (e.g., the role of clouds in exacerbating or mitigating the greenhouse effect), or on the possible range or probability of critical system inputs (e.g., how much temperature increases per doubling of CO_2 concentration, also known as the *climate sensitivity*). This discord is further complicated when considering the impacts of climate change in the human system, in which impacts are dependent on a population's current technological, socioeconomic, political, and geographic characteristics, along with its capacity to adapt to change.

Games are a useful vehicle to communicate these complexities because of their flexibility and participatory nature. This is especially true of games

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that incorporate scenario-based planning. Scenarios outline plausible futures and are helpful to use in uncertain, complex environments to overcome the limitations involved with linear extrapolation of historic trends. Additionally, planners can alter key inputs in the scenario to explore the uncertainty space in the problem context. Scenarios as an aid for military planning began being used systematically by DoD in the 1950s and continue to be used by military planners to contend with a dynamic and unpredictable geostrategic environment.[17] The climate change research community also relies heavily on a consistent set of scenarios to help communicate uncertainties, differences between models, and plausible outcomes.[18] It is therefore both an attainable and a necessary step to develop climate change scenarios for military planning.

This game is a first step toward accomplishing this integration. Of the many ways scenarios could be incorporated into game design, this game uses a *hazard card* style, in which participants draw cards from a deck randomly during each turn. The scenarios in each card build on one another to form an emerging future. This style of game is effective because of its simplicity, modularity, and engaging nature. To fully explore a space with deep uncertainty, it is especially important that the participants have the creative freedom to consider the climate events and craft their own narrative, depending on their respective objectives in the game, rather than be constrained by overly rigid rules. In other words, the simplicity of the game leaves the players free to devote their cognitive power toward thinking about plausible strategic responses to each scenario instead of the rules of the game. The game is inherently modular in that it can be played individually or by a group, as part of a discussion or in addition to another wargame, or by concentrating on a specific set of hazards within the deck. Finally, the game is engaging because the participants do not know the distribution of hazards and their severity within the deck and therefore must confront—and live with the consequences of—a potentially surprising world as it unfolds. This uncertainty is necessary to simulate the deep uncertainty of climate change in reality.

This design based on scenario exploration serves both educational and analytic purposes. First, the event cards teach participants about how the climate could change in South Asia by the 2040s and what impacts these changes could have on infrastructure, agriculture, human health, and migration, among other factors. The range of the severity of hazards in the deck conveys the high amount of uncertainty at hand when assessing climate hazards and impacts in the medium to long term. Finally, the cards stimulate discussion of the potential impacts of each event. The climate system hazards (e.g., drought, extreme heat) are specified on each card, but the exact magnitude and geographic extent of these hazards are left to the participants to explore to identify important thresholds and locations of importance.[19]

What Are Other Ways of Using a Hazard Card Climate Game?

The design of the climate hazard game lends itself well to possible extensions and other uses. Its modular nature generates opportunities for using it as a stand-alone game or as an aspect of a broader game. A stand-alone climate hazard card game can also be used as an educational tool in a hazards-focused workshop. The game described in the previous section included both educational and analytic elements. However, it could have also simply focused solely on the educational aspects such that the nature of discussion could become very tactical in terms of how to respond to particular events.

Another approach for using a climate hazard card game would be in the development of a *road*

to war, or narrative that describes the lead-up to the scenario that the players will confront, to be used in a broader wargame context. Climate hazard cards are also ready-made to serve as additions or crisis events in a broader game. Facilitators can simply pull (or have participants pull) cards from a deck to inform a "hazard update" at the start of a move or disrupt move planning as it proceeds. This would help adjudicators determine which hazards might enable or prevent players from conducting a move as intended.

How Can These Games Be Supported in the Future?

Hazard card–based games are just one method of many that researchers and practitioners may use to incorporate climate change into wargames. For example, a game could be set in a specific scenario induced by climate change, such as the shutdown of thermohaline circulation or melting of Arctic sea ice. Although climate change–based wargames help enable both climate education and strategic planning, there are nontrivial challenges in constructing these games. One of the main barriers to entry of using climate data is their innately vast scope. If the data are intended for use for local planning purposes, the level of spatial and temporal resolution must be high enough to support those use cases. Even in a local context, climate change is a long-term global phenomenon, in which events from around the world will affect other regions through teleconnections in the climate system. In turn, these events will propagate to markets and influence the global supply chain. Additionally, the uncertainty space is vast, encompassing both different scenarios of future climate change and different climate models. These models produce several hydroclimatic variables that can be used to form many different metrics of future hazards. Thus, it is necessary to help refine the slate of climate data so that it is most useful for the DoD wargaming community.[20]

In doing so, it would be helpful to codify the approaches to including climate change in games so that the associated hazards are more accessible to designers of future games. This work could build upon the existing Joint Staff guidance on the use of climate models. Specifically, the guidance could include a list of top climate hazards for different regions of interest around the world, as well as instructions on how to develop helpful scenarios given the main hazards and the recommended data sources. Because of the rapid pace of advancements in climate science, DoD should conduct regular discussions on best practices for incorporating climate science into wargames.

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APPENDIX A

South Asia Climate Summary

Hazards

Aridification

Aridity is defined as the ratio of precipitation to *potential evapotranspiration* (i.e., the moisture demanded by the atmosphere). This ratio gives an indication of how much of that moisture demand is being supplied (i.e., how dry the area is). A region can become more arid if total precipitation declines and also if potential evapotranspiration demand rises through increases in temperature. Research indicates that, while central India is projected to become more dry, other areas, such as Bhutan, are likely to become wetter.[21] The extent and magnitude of the changes in aridity vary widely across climate scenarios and models. Aridification will affect agricultural production, which may lead to farmers being displaced from their homes.

Glacial Retreat

The South Asian basins rely on snow and glacial melt to varying extents. The Indus basin relies heavily on meltwater, with snow and glacial melt contributing 151 percent more discharge than runoff generated from other sources while contributing only 27 percent of the total discharge in the Ganges basin.[22] In the Ganges and Indus basins, around 40 percent of the meltwater comes from glaciers. Thus, glacial retreat caused by rising temperatures will decrease the supply of surface water in these basins over time. Estimates of glacial ablation in the future are often specific to glaciers. For example, one study estimates that, by 2040, ice volume in the Chandra subbasin in the Indus basin will decrease by 22 percent and 35 percent in RCP 4.5 and RCP 8.5, respectively.[23] The melting of glaciers can lead to flooding if a wall of a glacial lake bursts.

Sea Level Rise

By the 2040s, the sea level is projected to rise between 0.1 and 0.2 meters around the world.[24] Most of the magnitude of SLR comes from ocean thermal expansion and mass loss from glaciers.[25] Because of the high degree of uncertainty in future SLR, the latest IPCC assessment report included a low-confidence 95th-percentile scenario of projected SLR to show what extreme outcomes are possible. Under this high-end scenario, SLR could be as much as 0.4 meters by 2042.[26] In a 2020 article, Abadie et al. estimated that Mumbai will be one of the top cities most affected by SLR in the world, with an estimated $112 billion in expected damages in RCP 8.5 in 2050 and $162 billion in expected damages in the high-end 95th-percentile scenario in 2050.[27] SLR can cause damage to coastal infrastructure and saltwater intrusion into coastal aquifers and lead to the displacement of coastal communities. Bangladesh is especially at risk of SLR because of its low-lying topography and densely populated coastal areas. By using population projections and topographic maps in 2018, Davis et al. found that as many as 900,000 people could be affected by SLR and forced to migrate by 2050.[28] A migration of this size would have massive implications for the rest of the region.

Heat Wave

Heat waves can affect agricultural yields, energy demand, and morbidity and mortality. Especially when coupled with humid conditions, extreme heat can be deadly if proper precautions are not taken. The regions that are most vulnerable to these effects are the densely populated and low-lying agricultural regions of the Indus and Ganges basins, since much of the population must work outside.[29] Studies have shown that wet bulb temperatures are increasing to dangerous levels, especially in the Choto Nagpur Plateau, northeastern India, and Bangladesh.[30] Other work has shown that the rise in temperature and humidity can lead to a decline of 30 percent to 40 percent in work performance throughout India by the end of the century.[31] Heat waves are known to cause losses in agricultural yields, heat-induced mortality and morbidity, and increased water demand.

Monsoon

The summer Indian monsoon occurs from June through September and accounts for approximately 80 percent of the region's total annual rainfall.[32] The monsoon begins on the west coast of India on the Arabian Sea, then traverses to the Bay of Bengal to return to the east coast and finally travel to the north. As global temperatures increase, the air is able to hold more moisture. Thus, the length of dry spells will increase, but precipitation will be more intense when it does occur. Overall, the monsoon is expected to be more erratic in the future, with more extreme precipitation events.[33]

Tropical Storm

Because of the same physical mechanisms underlying the increase in variability of the monsoon, precipitation during tropical cyclones is expected to intensify. Additionally, research has found that tropical cyclones are expected to have lower translation speeds in the future, meaning that they will stay over the ocean for longer periods and thus gather more energy and intensity before making landfall.[34] Cyclones will increase more rapidly on the west coast of India as the Arabian Sea experiences a faster rate of warming than the rest of the world.[35] Overall, extreme precipitation events (including those experi-

enced during the monsoon) can cause flooding and damage to infrastructure.

Drought

Assessing the future frequency and severity of droughts in South Asia necessitates an accurate portrayal of monsoonal dynamics. While the latest advances in climate models have improved on their ability to model the monsoon, many models in the Coupled Model Intercomparison Project (CMIP6) ensemble do a poor job of modeling summer precipitation and project an unrealistic increase in precipitation caused by warming.[36] A recent study considered only climate models that could realistically portray monsoonal dynamics in its analysis of future drought in South Asia and found that, contrary to studies that examined all CMIP6 models in its analysis, the frequency and severity of drought would increase in South Asia because of climate change.[37] Subsequent research found that the severity of the worst drought in recorded history in South Asia, which occurred in 2002 and affected 65 percent of the region, would increase in frequency by 150 percent in the future.[38]

Severity

To help planners respond to climate change hazards, it is necessary to communicate their severity. For example, *meteorological drought* is simply defined by a region receiving a below-average amount of precipitation. The severity of the drought will inform its impacts on agriculture, energy production, sanitation, and overall well-being.

New Normal

The new normal event cards were developed to represent the chronic trends in climate change in the future. These chronic hazards include aridification, SLR, glacial retreat, heat waves, and monsoon, as discussed above. These cards show the overall consensus across climate models and scenarios. Notably, events that may seem extreme in 2023 may also be characterized as new normal events in the game due to expected trends in climate hazards in the future.

Off-Normal

Off-normal event cards were designed to show the range of uncertainty in the estimates. These cards were not designed as extreme events but rather to show the range of plausible outcomes, representing events that could cut against the consensus trends but may nevertheless occur across a sufficient time step. This was especially necessary in the case of precipitation-based hazards, such as the monsoon, because of the high amount of variability in the future projections.

Extreme

The extreme event cards can be thought of as events at the level of severity that would be expected to occur only "once in ten years" at the historical baseline. The number of extreme event cards per hazard indicates the increasing frequency of "ten-year" events caused by climate change. However, because the events are in different geographic locations, the specific number of cards given in an individual deck should not be interpreted as a representation of the projected likely frequency of occurrence of these events in the 2040s.

Catastrophic

The catastrophic event cards reflect the deep uncertainty inherent in the climate system, representing a much larger scale of event than previous categories. These are events that are plausible but rare and do not have a specific probability associated with them. These event cards can be thought of in the same way as the high-impact storyline of SLR in the sixth IPCC assessment report.[39] The catastrophic event cards were included only in the high-emission scenario game. Future game facilitators may also consider using the catastrophic cards to indicate that a tipping point has been passed and ask participants to discuss the consequences of such an event.

APPENDIX B

Full Complement of Climate Hazard Cards for the South Asia Wargame

Table 1 lists and describes the attributes of the event cards in the game deck.

TABLE 1

Event Cards Deck

Hazard	Severity	Name	Impacts
Aridification	New normal	South Asian Dust Bowl	• Food insecurity in Bengal • IDPs increase stress on urban resources
Aridification	New normal	Water Woes in South Asia	• Food insecurity in Bengal • IDPs increase stress on urban resources
Aridification	New normal	Reclaiming the Desert	• Decreased food insecurity in Pakistan
Glacial retreat	New normal	The Last of the Glaciers, First of the Floods	• Flooding and associated casualties
Glacial retreat	New normal	Glacial Lake Outbursts: Rare but Deadly	• Flooding and associated casualties • Infrastructure strain
Glacial retreat	New normal	South Asian Reefs Face Freshwater Devastation	• Food insecurity in coastal regions
Sea level rise	New normal	The Venice of South Asia	• IDPs increase stress on urban resources • Infrastructure strain
Sea level rise	New normal	Salted Earth: Aquifers Deadly to Crops	• Food insecurity in India
Sea level rise	New normal	Rice Crops: Lowest Yield Ever	• Food insecurity across the region • IDPs increase stress on urban resources
Heat wave	New normal	Scorched Earth	• Wildfires in northern India and eastern Pakistan • IDPs increase stress on urban resources
Heat wave	New normal	Boiling to Death: Realities of Indus River Workers	• Heat-related deaths skyrocket in the agriculture sector
Heat wave	New normal	Farmers Protest: No Regulation on Irrigation Days	• Irrigation demand skyrockets as crops dry out • Famine/food insecurity
Monsoon	New normal	Feast or Famine: Neither Wins	• Food insecurity in India • IDPs increase stress on urban resources
Monsoon	New normal	Terrifying Deluges	• Flooding
Monsoon	New normal	Our Wells Run Dry	• Famine/food insecurity
Monsoon	Off-normal	The Water Tables Have Turned	• Flooding • Famine/food insecurity
Monsoon	Off-normal	Water Systems in South Asia: A New Normal	• Flooding • Famine/food insecurity
Monsoon	Off-normal	Floating Cities: Adapting to Longer Monsoon Seasons	• Flooding • Infrastructure strain
Tropical storm	Off-normal	“Are We Prepared?” Bangladesh Storm Slam	• Flooding
Tropical storm	Off-normal	Diwali Devastation: Landslides Destroy Villages	• Flooding • Infrastructure strain
Drought	Off-normal	The Wells Run Dry—for Millions	• Famine/food insecurity • Heat effects
Drought	Off-normal	Skyrocketing Energy Use in South Asia	• Infrastructure strain • Heat effects
Drought	Off-normal	Crops Wither, Prices Soar	• Famine/food insecurity

Table 1—Continued

Hazard	Severity	Name	Impacts
Heat wave	Extreme	Surviving in the Dark: Devastating Blackout and Heat	• Heat effects
Tropical storm	Extreme	Record Breaking: More Frequent, Stronger Storms	• Flooding
Drought	Extreme	Farewell, Ganges: River Dries, Leaves Millions Thirsty	• Famine/food insecurity • Heat effects
Drought	Extreme	No Water, No Lights, No Hope	• Infrastructure strain • Heat effects
Heat wave	Catastrophic	No Water, No Lights, No Hope	• Famine/food insecurity • Human migration • Heat effects
Drought	Catastrophic	Now That the Rivers Have Run Dry	• Famine/food insecurity • Heat effects
Sea level rise	Catastrophic	Mumbai: A City Lost at Sea	• Infrastructure strain • Flooding

NOTE: IDPs = internally displaced persons.

APPENDIX C

Shared Socioeconomic Pathways

The SSPs are plausible pathways of how the future will unfold to the end of the century that have been developed by the climate science community and quantified using integrated assessment models.[40] The SSPs are based on the combinations of challenges to adaptation and mitigation of climate change. SSP 1 envisions low challenges to adaptation and mitigation of climate change with a relatively small population that uses renewable sources of energy. SSP 2 is the middle of the road scenario that extrapolates historical trends to produce a world with medium challenges to both adaptation and mitigation. SSP 3 is characterized by high challenges to both adaptation and mitigation of climate change and features, of all the scenarios, the largest population that is relatively poor. SSP 4 envisions a fractionated world in which the rich get richer, the poor become poorer, and technology does not get shared across borders. Finally, SSP 5 is characterized by high challenges to mitigation of climate change because of a high amount of emissions from a world dependent on fossil fuels. SSP 5 also experiences low challenges to adaptation since the growth powered by fossil fuels leads to a wealthy population.

Notes

[1] Arias et al., *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change; Technical Summary.*

[2] Hsiang, Burke, and Miguel, "Quantifying the Influence of Climate on Human Conflict"; Jones, Mattiacci, and Braumoeller, "Food Scarcity and State Vulnerability: Unpacking the Link Between Climate Variability and Violent Unrest."

[3] Wirth, "Climate Chaos."

[4] Klare, "Climate Change, Water Scarcity, and the Potential for Interstate Conflict in South Asia."

[5] Hirji, Nicol, and Davis, *South Asia Climate Change Risks in Water Management*.

[6] Tollefson, "Climate War Games."

[7] Department of the Army, Office of the Assistant Secretary of the Army for Installations, Energy and Environment, *United States Army Climate Strategy*; Department of the Navy, Office of the Assistant Secretary of the Navy for Energy, Installations, and Environment, *Department of the Navy Climate Action 2030*.

[8] Masson-Delmotte et al., "Climate Change 2021: The Physical Science Basis"; Pörtner et al., *Climate Change 2022: Impacts, Adaptation and Vulnerability.*

[9] World Bank Group, *Climate Change Action Plan 2021–2025: Supporting Green, Resilient, and Inclusive Development.*

[10] Change depends on the region in question, although, according to the latest IPCC Assessment Report (IPCC, *Climate Change 2023*), almost all regions in the world will experience an increase in extreme heat, and more regions will see increases in heavy precipitation and drought than decreases.

[11] We used the modeled output in the IPCC Working Group I Interactive Atlas (IPCC, "IPCC WGI Interactive Atlas: Regional Information [Advanced]").

[12] O'Neill et al., "The Roads Ahead: Narratives for Shared Socioeconomic Pathways Describing World Futures in the 21st Century."

[13] Van Vuuren et al., "The Representative Concentration Pathways: An Overview." These pathways quantified the changes that would result from levels of emissions through the end of the century. The scenarios are named RCP 2.6, 4.5, 6.0, and 8.5 after the difference in radiative forcing entering and leaving the atmosphere at the end of the century.

[14] Meaning the low, medium, and high adaptive capacity assumptions corresponding to SSPs 1, 2, and 5, respectively. This is true with the exception of the catastrophic event cards, which were made available only in the high challenge scenario (SSP 5 RCP 8.5).

[15] Levin et al., "Overcoming the Tragedy of Super Wicked Problems: Constraining Our Future Selves to Ameliorate Global Climate Change"; Rittel and Webber, "Dilemmas in a General Theory of Planning."

[16] Masson-Delmotte et al., "Climate Change 2021: The Physical Science Basis"; Pörtner et al., *Climate Change 2022: Impacts, Adaptation and Vulnerability.*

[17] Amer, Daim, and Jetter, "A Review of Scenario Planning"; Mazarr et al., *The U.S. Department of Defense's Planning Process: Components and Challenges.*

[18] Moss et al., "The Next Generation of Scenarios for Climate Change Research and Assessment."

[19] Note that the cards contained levels of severity and approximate geographic extent, as discussed in the next section. However, these were not quantified.

[20] The issue of climate literacy, which the game hopes to address, might remain significant even when data are used appropriately.

[21] Aadhar and Mishra, "A Substantial Rise in the Area and Population Affected by Dryness in South Asia Under 1.5 °C, 2.0 °C and 2.5 °C Warmer Worlds."

[22] Immerzeel, Van Beek, and Bierkens, "Climate Change Will Affect the Asian Water Towers."

[23] Tawde, Kulkarni, and Bala, "An Assessment of Climate Change Impacts on Glacier Mass Balance and Geometry in the Chandra Basin, Western Himalaya for the 21st Century."

[24] Masson-Delmotte et al., "Climate Change 2021: The Physical Science Basis"; Pörtner et al., *Climate Change 2022: Impacts, Adaptation and Vulnerability.*

[25] Fox-Kemper, "Ocean, Cryosphere and Sea Level Change."

[26] Fox-Kemper, "Ocean, Cryosphere and Sea Level Change."

[27] Abadie et al., "Comparing Urban Coastal Flood Risk in 136 Cities Under Two Alternative Sea-Level Projections: RCP 8.5 and an Expert Opinion-Based High-End Scenario."

[28] Davis et al., "A Universal Model for Predicting Human Migration Under Climate Change: Examining Future Sea Level Rise in Bangladesh."

[29] Im, Pal, and Eltahir, "Deadly Heat Waves Projected in the Densely Populated Agricultural Regions of South Asia."

[30] *Wet bulb temperature* is the temperature at which the air is completely saturated. Thus, it combines temperature with relative humidity (Im, Pal, and Eltahir, "Deadly Heat Waves Projected in the Densely Populated Agricultural Regions of South Asia").

[31] Koteswara Rao et al., "Projections of Heat Stress and Associated Work Performance over India in Response to Global Warming."

[32] The term *monsoon* indicates the seasonal change in prevailing winds. Therefore, there is a dry winter Indian monsoon and a wet summer Indian monsoon. If not specified, this discussion refers to the wet summer monsoon. Mitra, "A Comparative Study on the Skill of CMIP6 Models to Preserve Daily Spatial Patterns of Monsoon Rainfall over India."

[33] Katzenberger et al., "Robust Increase of Indian Monsoon Rainfall and Its Variability Under Future Warming in CMIP6 Models."

[34] Jyoteeshkumar Reddy et al., "Impact of Climate Change on Intense Bay of Bengal Tropical Cyclones of the Post-Monsoon Season: A Pseudo Global Warming Approach."

[35] Murakami, Vecchi, and Underwood, "Increasing Frequency of Extremely Severe Cyclonic Storms over the Arabian Sea."

[36] Ashfaq et al., "Sources of Errors in the Simulation of South Asian Summer Monsoon in the CMIP5 GCMs."

[37] Aadhar and Mishra, "On the Projected Decline in Droughts over South Asia in CMIP6 Multimodel Ensemble."

[38] Aadhar and Mishra, "On the Occurrence of the Worst Drought in South Asia in the Observed and Future Climate."

[39] Fox-Kemper, "Ocean, Cryosphere and Sea Level Change."

[40] O'Neill et al., "The Roads Ahead: Narratives for Shared Socioeconomic Pathways Describing World Futures in the 21st Century."

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About This Report

This report describes the methodology and utility behind a "hazard card" climate game that can be played by itself or incorporated as a module into other wargames. The game is based on a deck of event cards that portray a range of climate change hazards at varying levels of severity. Participants draw a card representing the major climate hazard for each year of the game and discuss the associated impacts of that hazard from political, military, and economic perspectives. This type of game is well-suited to complement a variety of other wargames and discussion-based workshops because it is simple to understand, engaging, and forces players to grapple with the uncertainty inherent to climate change hazards.

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