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Climate Security in South Asia

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Climate Security Roundtable

Board on Atmospheric Sciences and Climate

Division on Earth and Life Studies

Intelligence Community Studies Board

Division on Engineering and Physical Sciences

Board on Environmental Change and Society

Division of Behavioral and Social Sciences and Education

Proceedings of a Workshop

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We thank the following individuals for their review of this proceedings:

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Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the content of the proceedings nor did they see the final draft before its release. The review of this proceedings was overseen by **BILAL AYYUB,** University of Maryland, who was responsible for making certain that an independent examination of this proceedings was carried out in accordance with standards of the National Academies and that all review comments were carefully considered. Responsibility for the final content rests entirely with the rapporteurs and the National Academies.

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Acronyms

CSRT	Climate Security Roundtable
GHG	greenhouse gas
HADR	humanitarian assistance and disaster relief
HKH	Hindu Kush Himalaya
IC	U.S. Intelligence Community
ICCCAD	International Centre for Climate Change and Development
IOM	International Organization for Migration
IPCC	Intergovernmental Panel on Climate Change
MSD	multisectoral dynamics
NIC	National Intelligence Council
NIE	National Intelligence Estimate
ODNI	Office of the Director of National Intelligence

Workshop Overview

The impacts of climate change overseas pose a significant and cross-cutting threat to the security of the United States (USGCRP, 2018; NASEM, 2021; NIC, 2021a, 2021b). The South Asia region, in particular, presents a confluence of major climate impacts and key security challenges (IPCC, 2022; Shaw et al., 2022). From a weather and climate standpoint, the region experiences a wide range of hazards, such as the recent heatwaves, droughts, storms, and floods that have upended the lives and livelihoods of millions of people. From a demographic and socioeconomic standpoint, the region is experiencing rapid transformations and progress, even as fundamental challenges such as poverty and inequality persist. From a security standpoint, the region is the setting for a range of social and political dynamics that impact U.S. interests, including conflict at national and subnational levels; regional rivalries; and the imprint of global geopolitics.

On October 26–27, 2022, the National Academies of Sciences, Engineering, and Medicine (National Academies) convened a workshop to explore "Climate Security in South Asia."[1] The workshop was the first held under the auspices of the National Academies Climate Security Roundtable. Over two days, workshop participants considered some of the underlying climate, development, and geopolitical dynamics at play in the South Asia region; they explored a set of historical case studies and future scenarios for climate change and security in South Asia; and they considered the available tools for analyzing and forecasting climate-related risks.

The South Asia climate security landscape encompasses a broad range of topics and issues, and the workshop case studies and scenarios initially focused on security challenges related to storms and water cycle extremes in the countries of Bangladesh, India, and Pakistan. In plenary and breakout sessions, participants broadened the discussion to consider how these specific examples might illuminate some of the more general aspects of climate change and security in the region. Participants identified some key elements of "systems thinking"[2] for climate-related security risks; they discussed the particular climate-related security threats that are most pressing in South Asia; and they identified some basic analytic capabilities and capacities that could be helpful to effectively analyze and anticipate those threats moving forward.

At the outset of the workshop, participants were also introduced to a conceptual framework, previously developed by the National Academies Climate Security Roundtable, that comprises two key sets of factors that shape the evolution of climate-related security risk in a given setting: *external influences and stressors* that act from outside of the setting and the *internal network interactions* between the interconnected and interdependent systems and sectors within the setting (see Chapter 6 for detailed examples).

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[1] This proceedings has been prepared by the workshop rapporteurs as a factual summary of what occurred at the workshop. The planning committee's role was limited to planning and convening the workshop. The views contained in the proceedings are those of individual workshop participants and do not necessarily represent the views of all workshop participants, the planning committee, or the National Academies.

[2] The term "systems thinking" does not currently have a precise, agreed-upon definition. In the context of climate change, however, systems thinking generally recognizes that the complex and unpredictable nature of climate outcomes arises from the deep interconnections and interdependencies that exist both within and between the natural and societal components of the world, at all scales. Specifically, a systems approach to climate-related risks would consider the dynamic interactions and feedbacks among social, economic, political, and environmental factors that create the potential of harm to people and nature.

Perspectives from Panel Discussion[3]

One perspective expressed throughout workshop discussions is that *climate security in South Asia is integrated with every other dimension of security* in the region and maps directly onto economic security, political stability, border security, and regional peace and conflict.

With respect to climate and security linkages: Climate–security crises in South Asia arise primarily from the compounding and cascading interactions between climate impacts and existing societal challenges.

- These challenges can include existing vulnerabilities in poor and underdeveloped communities, poor infrastructure, poor governance and management capacity at national and local levels, and lack of public faith in institutions and the government. At the interstate level, opportunities to resolve disputes and contestation are severely constrained by the lack of regional cooperation or solutions mechanisms.
- Conversely, resilience to climate impacts rests on the presence of strong civic institutions; strong capacity to act; and strong social cohesion, at subnational, national, and international levels.

With respect to climate and security pathways in the region: Overall, South Asia is characterized by a high degree of both vulnerability and exposure to climate hazards, due largely to its high population density, relatively low level of adaptive capacity, and relatively high number of climate hazards.

- Climatic and socioeconomic conditions are both highly variable across South Asia. Security in the region is critically influenced by interactions between these two sources of natural and societal heterogeneity. The uncertainties in their future variability constrain analysts' and policymakers' ability to anticipate future security risk. Looking ahead, however, it is likely that South Asia will continue to be characterized by a high degree of climate vulnerability and exposure.
- Risk pathways involving the impacts of climate hazards on livelihoods and community structures are particularly relevant to security analysis. In particular, the cascading impacts from humanitarian disasters are a concern, since they can push vulnerable people into "problematic pathways" involving isolation, alienation, radicalization, and/or mental illness.
- Security discussions often focus on the relationship between climate change, migration, and conflict, but the evidence indicates that the linkages are indirect and somewhat context dependent. The clearest linkage between climate, migration, and security in South Asia is through the risks posed by climate to poorer and disadvantaged communities, who would be disproportionately mobilized by those risks.

With respect to the external influences and stressors that are most relevant to climate-related security risk in South Asian contexts, workshop participants highlighted climate-related stressors such as extreme heat, drought, extreme precipitation, floods, and sea-level rise. Participants also highlighted non-environmental influences, such as international economic and geopolitical processes, as well as underlying demographic and socioeconomic conditions—for example, rapid population growth and urbanization.

With respect to the key network interactions within the South Asia region, workshop participants highlighted the complex interdependencies between infrastructure, governance, and socioeconomic systems, as well as between specific societal sectors in the region—particularly the food, water, and energy sectors. Participants also discussed aggregating, compounding, and cascading

[3] This list is the rapporteurs' summary of some general perspectives expressed during the two days of workshop discussion. The statements do not represent a consensus view of the participants, and they have not been endorsed or verified by the National Academies of Sciences, Engineering, and Medicine.

interactions between individual climate-related risks that can further increase the overall risk to society from climate change.

Finally, participants considered various potential security risk pathways in the region. Many participants focused attention on the risks stemming from societal transitions occurring in response to climate change—for example, the potential security challenges created by specific climate mitigation policy actions. Many participants also focused attention on the security implications of risk pathways involving the impacts of climate hazards on livelihoods and community structures—for example, the cascading humanitarian disasters that can push vulnerable people into "problematic pathways" involving isolation, alienation, radicalization, and/or mental illness.

1
Introduction

The impacts of climate change overseas pose a significant and cross-cutting threat to the security of the United States (USGCRP, 2018; NASEM, 2021; NIC, 2021a, 2021b). Collectively, these impacts threaten critical natural and societal systems; undermine human health and well-being; and produce risks that compound and cascade across societal sectors and borders (IPCC, 2022; O'Neill et al., 2022). Climate change increasingly drives food and water insecurity, illness and premature death, and involuntary migration and displacement, and it is amplifying existing socioeconomic, political, and cultural drivers of conflict and contestation (Cissé et al., 2022; IPCC, 2022). These impacts affect the security interests of the United States and its allies and partners by disrupting economic and trade linkages, undermining international development investments, and exacerbating geopolitical flashpoints (USGCRP, 2018; NIC, 2021b).

The U.S. Intelligence Community (IC) is responsible for providing policymakers with analyses and assessments that can illuminate threats to U.S. security. In its most recent Global Trends report, the National Intelligence Council (NIC) framed climate change as a "shared global challenge" and one that is "likely to exacerbate food and water insecurity for poor countries, increase migration, precipitate new health challenges, and contribute to biodiversity losses" (NIC, 2021a). The most recent National Intelligence Estimate (NIE) states that climate change "will increasingly exacerbate risks to US national security interests" (NIC, 2021b).

For more than a decade, the National Academies of Sciences, Engineering, and Medicine (National Academies) have convened activities to explore the climate and security nexus. One such activity is the National Academies Climate Security Roundtable (CSRT or Roundtable), which was established by the U.S. Congress in 2021 as a partnership between the National Academies and the Office of the Director of National Intelligence (ODNI). The Roundtable leverages the unique convening power of the National Academies to create a platform for federal officials to engage experts from academia, the private sector, and civil society on a wide range of climate and national security issues (see Appendix A for more detail on the Roundtable and its work).

The "Climate Security in South Asia" workshop (hereafter, workshop) summarized in this proceedings was convened under the auspices of the CSRT. The workshop's overarching goal was to advance an integrative "systems" understanding of climate security risk in South Asia and the basic capacities and capabilities that could support a more integrative analysis of climate security in the region. This introductory chapter explains the motivation behind the selection of South Asia as the regional focus, presents some relevant perspectives on climate security analysis from the Roundtable's previous discussions, and describes the basic organization of the workshop and this proceedings.

CLIMATE AND SECURITY IN SOUTH ASIA—MOTIVATION FOR THE WORKSHOP

In the workshop's opening session, a representative from ODNI[1] explained the reasoning behind the Roundtable's choice of South Asia as the topic for the workshop. The representative

[1] This workshop included participants from members of the IC. To abide by legal requirements to protect the identities of IC officers, wherever a specific attribution other than "workshop participant" is needed, this proceedings will use "member of the IC" or "representative of Agency X."

noted that the region—comprising Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka (see map in Figure 1-1)—presents a unique confluence of major climate hazards and key U.S. security concerns:

- *From a weather and climate standpoint:* South Asia experiences a wide range of hazards (Box 1-1). These include extreme events such as the recent heatwaves, droughts, storms, and floods that have upended the lives and livelihoods of millions of people, as well as longer-term trends of warming temperature, increased and more variable precipitation, and sea-level rise that will increasingly expose people and society to adverse effects.
- *From a demographic and socioeconomic standpoint:* South Asia is experiencing rapid transformations and progress, even as fundamental challenges persist (Box 1-2). The region has seen strong economic growth in recent years, while also suffering from persistent poverty and inequality, poor physical and social infrastructure, and poor health and educational outcomes. Ongoing demographic trends, particularly rapid population growth[2] and urbanization[3], are expected to aggravate existing problems.
- *From a security standpoint:* South Asia is the setting for a range of social and political dynamics that impact U.S. interests (Box 1-3). Among these are a history of conflict at national and subnational levels, long-simmering regional rivalries, and the imprint of global geopolitics. South Asian states are becoming key U.S. trading partners, as well as targets for Chinese and Russian influence. In addition, Pakistan and India, both nuclear powers, as well as Bangladesh were identified in the most recent U.S. National Intelligence Estimate as countries whose vulnerability to climate impacts is particularly consequential to U.S. security interests (NIC, 2021b).

KEY PERSPECTIVES FROM THE CLIMATE SECURITY ROUNDTABLE

A central aim of the CSRT's work has been to advance an integrative understanding of climate-related security risk—one that considers the diverse interactions between nature and society and illuminates the pathways along which climate-related security risks can evolve. To help participants organize their discussions at the South Asia workshop, the co-chairs and staff of the Roundtable summarized some of the key themes that have emerged from its previous discussions, including perspectives on systems approaches to climate security, conceptualization of complex risks, and the human dimensions of security[4]:

[2] An important feature of population growth in the South Asia region is a "youth bulge", which is a demographic pattern in which a high proportion of the population consists of young adults and children, increasing the number of working age individuals. If they can be fully engaged in society and employed, then the youth bulge will produce a demographic dividend. If not, then the youth bulge could produce a demographic bomb, with large numbers of young people frustrated by the lack of socioeconomic opportunity and potentially becoming a source of social and political instability (Hafeez and Safeeh, 2018).

[3] The urban population in South Asian countries increased by 130 million in the first decade of the 2000's. This growth is associated with rising GDP and lower rates of extreme poverty. However, urbanization in South Asia is also characterized by a relatively high degree of poor and pressures on land, housing, infrastructure, basic services, and the environment. (Ellis and Roberts, 2016).

[4] This summary presents some key themes from previous discussions between CSRT members. It does not provide a comprehensive summary of these discussions and does not necessarily reflect a consensus view of the Roundtable or of the National Academies.

- *The importance of a systems approach:* A systems framework for climate security analysis considers the particular human and natural geographic setting for the analysis, as well as the influencing factors acting from outside the setting and the network interactions within the analytic setting (Figure 1-4). This approach is influenced by a multisectoral dynamics (MSD) perspective, which provides a useful approach to the various interactions and feedbacks between nature and society that produce security risks. MSD considers nature and society as systems of systems that are interconnected, interdependent, and co-evolving in relation to a set of dynamic influences and stressors (Reed et al., 2022).
- *Conceptualizing complex risk:* A useful conceptualization of risk is that it emerges from the dynamic interplay of several determining factors: hazards, exposure, and vulnerability, as well as the human responses that can modulate them (see Figure 1-5). The complex behavior of climate-related risks arises from interactions at multiple scales: the interplay of factors within a single risk determinant; the overlap between different determinants; and the aggregating, compounding, or cascading interactions between separate risks (Reisinger et al., 2020; Simpson et al., 2021). Risk applies to both impacts of and responses to climate change.

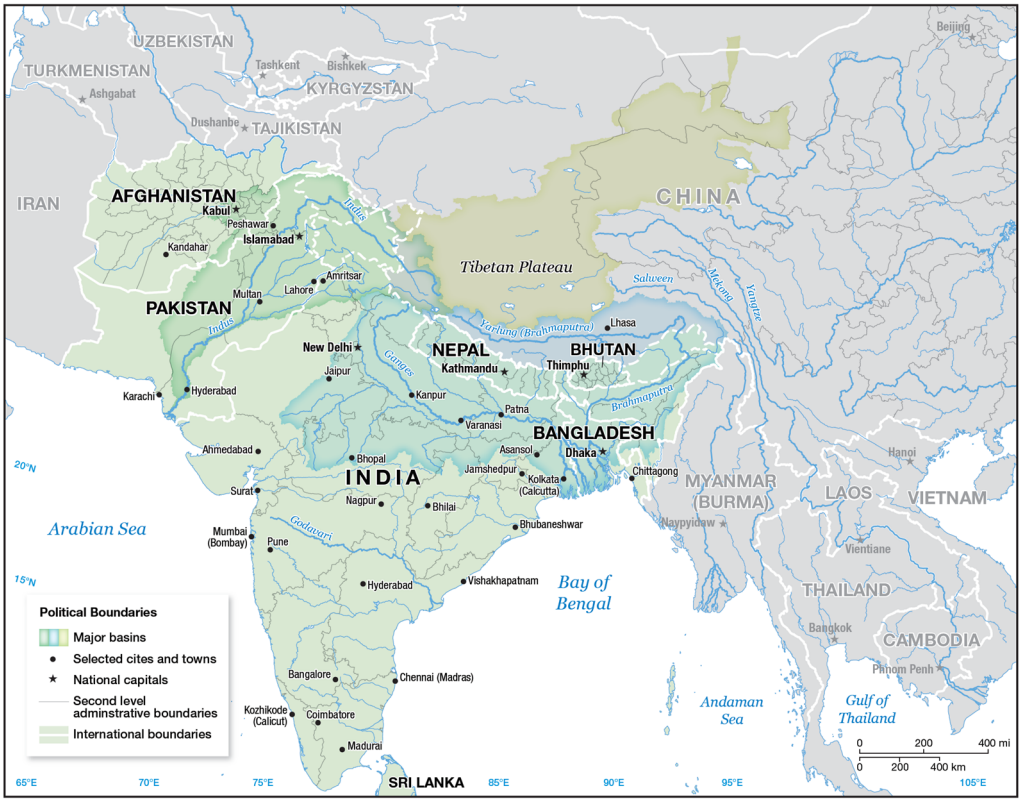

FIGURE 1-1. Map of South Asia region. SOURCE: Modified from NRC, 2012.

- *Incorporating the human dimensions of security:* Security is not simply the absence of conflict and instability; it is fundamentally founded on the health and well-being of individuals, communities, and societies. The national security implications of climate change thus largely rest on the dynamic interactions and feedbacks between climate and society. Understanding climate–society interactions requires a deep exploration of human motivations and behavior across scales.

BOX 1-1
Climate Change in South Asia

Workshop panel sessions and participant discussions highlighted some of the key projected climate trends that will impact the region:

- *Increasing temperatures:* Warming will lead to increased likelihood of extreme heat events in both urban and rural settings, as well as melting of mountain glaciers that are water resources for hundreds of millions of people. Heatwaves are expected to increase in their frequency, areal extent, duration, and the number of people exposed.
- *Increased and more variable precipitation:* While average rainfall is expected to increase, it will likely be more variable and involve more frequent intense rain events, including massive rain events related to tropical cyclones. The seasonal South Asian monsoon rainfall is also expected to increase but with greater variability in its intensity, duration, and timing. An important anticipated consequence would be increased flood frequency in monsoon regions. River flooding is expected to increase, in relation to increases in precipitation, which will come mostly in the form of extreme events rather than uniformly distributed rainfall across the season.
- *Sea-level rise:* Higher sea levels will lead to increased likelihood of flooding and damage in coastal cities and regions due to storm surges and high ocean waves, particularly related to tropical cyclones.

Workshop panel sessions and participant discussions highlighted some of the key areas where climate change has impacted human systems (see also Figure 1-2):

- *Impacts on human health and well-being:* Climate change has increased the incidence of water-borne and vector-borne diseases, increased heat-related morbidity and mortality, impacted mental health, and increased displacement of people by climate- and weather-scale extremes.
- *Impacts on food and water security:* Climate change has decreased overall water availability and has acted to decrease agricultural and crop production. In addition, it has contributed to nutritional deficiencies.
- *Impacts on physical and societal infrastructure:* Climate change has increased flood and storm damages to infrastructure and key economic sectors, such as agriculture, manufacturing, and technology.

SOURCE: Shaw et al., 2022; Also includes the rapporteurs' summary of the points made during plenary discussion.

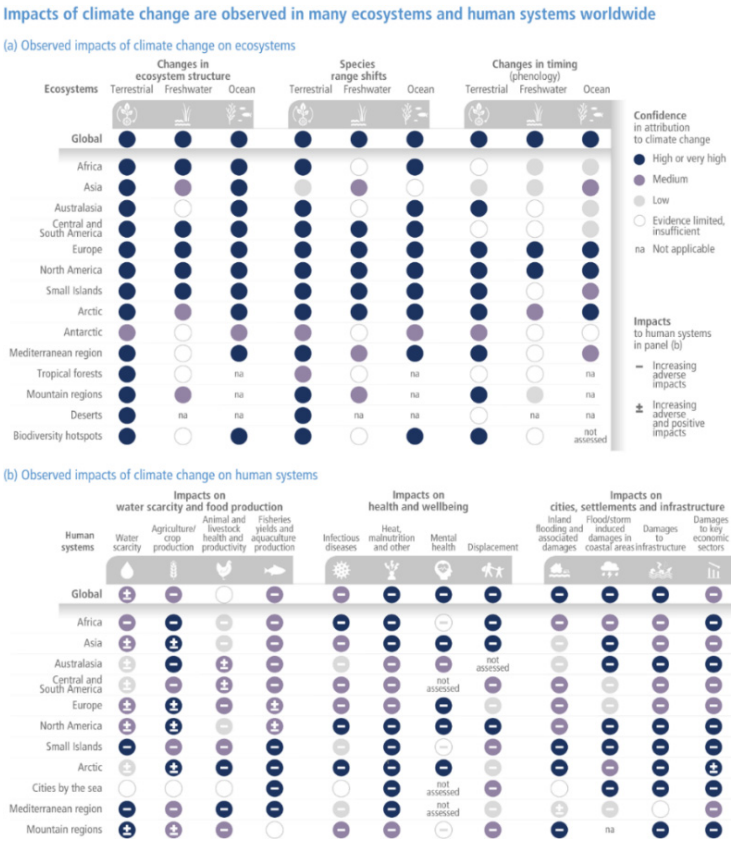

FIGURE 1-2. Observed impacts on (a) ecosystems and (b) human systems due to climate change. Climate change has already had diverse adverse impacts on human systems, including on water scarcity and food production; health and well-being; and cities, settlements, and infrastructure. The colors indicate confidence levels reflecting uncertainty in attribution of the observed impact to climate change. The + and – symbols indicate the direction of observed impacts, with a – denoting an increasing adverse impact and a ± denoting that, within a region or globally, both adverse and positive impacts have been observed. SOURCE: IPCC, 2022.

ORGANIZATION OF THE WORKSHOP AND PROCEEDINGS

The National Academies hosted the "Climate Security in South Asia" workshop on October 26–27, 2022, at the National Academy of Sciences building in Washington, D.C., and virtually. The workshop was the first held under the auspices of the Climate Security Roundtable and was organized by an informal planning committee of Roundtable members and external experts tasked with designing the agenda and identifying speakers (Box 1-4).[5] Over the course of two days,

[5] This proceedings has been prepared by the workshop rapporteurs as a factual summary of what occurred at the workshop. The planning committee's role was limited to planning and convening the workshop. The views contained in the proceedings are those of individual workshop participants and do not necessarily represent the views of all workshop participants, the planning committee, or the National Academies.

participants engaged with invited speakers in panel sessions and with each other in plenary and small group discussions to explore the climate security landscape in South Asia, examine historical cases and future scenarios, consider analytical needs for assessing and anticipating climate security risk, and reflect on the climate security issues in the region.[6]

BOX 1-2
Demographic and Socioeconomic Dynamics in South Asia

During the opening session and in discussions over two days, workshop participants noted that South Asia is experiencing rapid transformations and progress, even as fundamental development challenges persist:

- *Economic development:* South Asia has seen strong economic growth in recent years, particularly in India, which has emerged as a critical information technology and services hub, and Bangladesh, which has become a major global textile exporter. At the same time, the region is poorly integrated, with relatively low levels of interstate trade and economic cooperation.
- *Social development:* While economic development has lifted millions of people into the middle class, South Asia still suffers from persistent poverty and inequality, poor physical and social infrastructure, and poor health and educational outcomes. Overall, the region is characterized by a high degree of both vulnerability and exposure to climate hazards, due largely to its high population density, relatively low level of adaptive capacity, and relatively high number of climate hazards (see Figure 1-3).
- *Demographic trends:* Ongoing demographic trends, particularly rapid population growth and urbanization, as well as urban area expansion, will likely exacerbate existing problems.

SOURCE: Shaw et al., 2022.

The South Asia climate security landscape contains a broad range of topics and issues, and the workshop case studies and scenarios initially focused on security challenges related to storms and water cycle extremes in the countries of Bangladesh, India, and Pakistan. In plenary and breakout sessions, participants broadened the discussion to consider how these specific examples might illuminate some of the more general aspects of climate change and security in the region. Participants identified some key elements of a "systems" framing for climate-related security risks; they discussed the particular climate-related security threats that are most pressing in South Asia; and they identified some basic analytic capabilities and capacities that could be used to analyze and anticipate those threats moving forward.

This proceedings summarizes the discussions at the workshop and is organized to reflect the major themes explored over the two days. Following the Introduction, Chapter 2 sets the stage by describing some underlying climate, development, and security challenges in South Asia. Chapter 3 explores historical case studies where climate change and response needs precipitated a security issue. Chapter 4 considers potential futures for climate change and how the response to it could precipitate a security issue. Chapter 5 considers the current tools for analyzing and forecasting climate-related risks. Finally, Chapter 6 reflects on some key systems elements, risk pathways, and examples of analytic needs.

[6] A detailed workshop agenda is available in Appendix B. Short biographies of workshop planning committee members and workshop speakers are in Appendixes C and D, respectively.

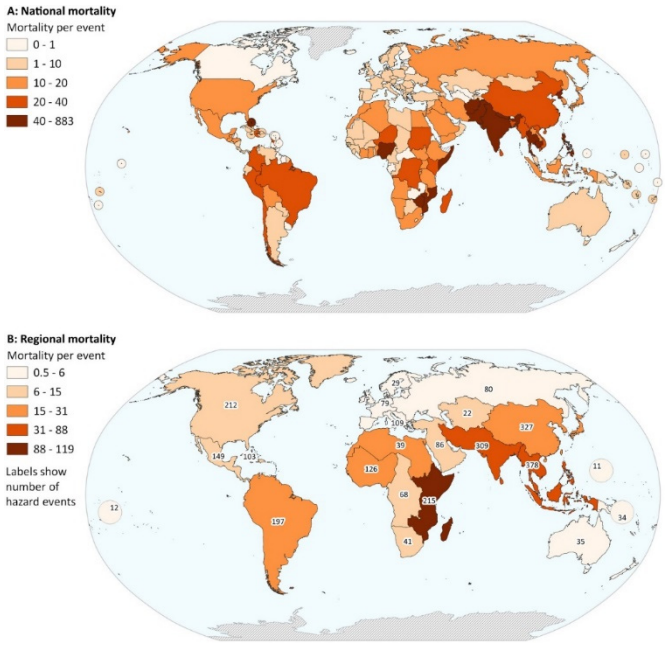

FIGURE 1-3. (a) National and (b) regional mortality per climate-related hazard event (floods, storms, and droughts) between 2010 and 2019 at the national level. Maps are based on national-scale data from the Emergency Events Database—EM-DAT (https://www.emdat.be/database) for storms, floods, and drought hazards. SOURCE: Birkmann et al., 2022.

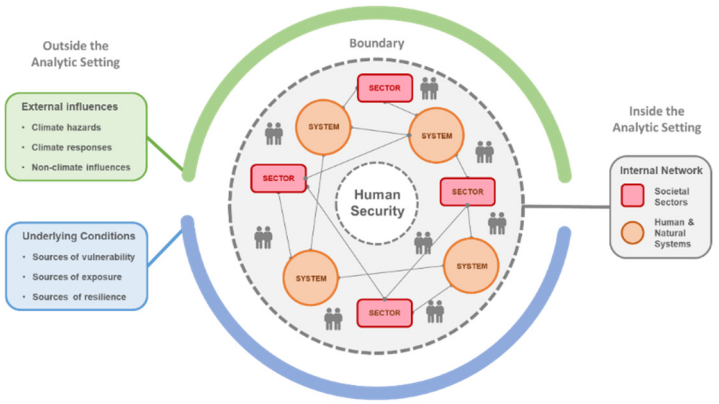

FIGURE 1-4. A systems conceptual framework for climate security analysis. The framework comprises three main conceptual domains: (1) *Analytic setting*: Climate security analyses focus on places or spaces that are characterized by a particular set of natural and human attributes. In order to be tractable, the analysis would need to define the boundaries of that setting, as well as spatial and temporal scales that are appropriate for the questions being asked. (2) *External influences and stressors*: Factors that act on the setting from outside, although they may be coupled with dynamics inside it. These may include climate and nonclimate stressors, as well as the natural and societal teleconnections that link the analytic setting to the wider world. They may also include underlying processes or conditions that can determine the response of the setting to those stressors. (3) *Network interactions*: The network of dynamically interacting natural and societal systems within the problem setting. Assessment of security risk entails an understanding of the critical interconnections and interdependencies between these systems.

BOX 1-3
Security Dynamics in South Asia

The workshop opening session and plenary discussions over two days highlighted three levels of security dynamics in South Asia that are relevant to U.S. security interests:

- *Conflict and instability at the national and subnational levels:* South Asian countries are characterized by relatively high levels of political instability. This can take the form of coups, irregular power transitions, or mass violence. The drivers of this instability include community tensions, structural issues, and, more recently, crises such as the COVID-19 pandemic and the Russian invasion of Ukraine. The major stressor related to the war in Ukraine has been spiking prices of food, fuel, and other commodities.
- *Conflicts and rivalries within the region:* These include border conflicts and spillover of violence across national borders. India is involved in two entrenched border disputes with neighboring Pakistan and China. In Afghanistan and Pakistan, the risk of terrorism spillover from Afghanistan is an increasing concern for Pakistan, where the potential influx of Afghan refugees would add to millions that are already there. Disputes over shared river resources have been one important driver of interstate tension and conflict.
- *Great power rivalries playing out in the region:* China has increased its economic and security influence in the South Asia region. In addition to being the top trading partner and top international creditor for many South Asian countries, China has made massive infrastructure investments in the region and is looking for opportunities to establish a military presence—for example, in Sri Lanka. Russia is also seeking to establish strategic partnerships in the region, and countries in the region are looking to Russia to expand its alliances.

SOURCES: NIC, 2021a, 2021b; rapporteurs' summary of the points made by ODNI representative in the opening session.

BOX 1-4
Workshop Statement of Task

The National Academies of Sciences, Engineering, and Medicine will organize a workshop to explore climate security risks in the South Asia region. The overall goal of the workshop will be to inform the U.S. Intelligence Community's understanding of, and ability to anticipate, the impacts of climate change on U.S. national security interests in the region.

The workshop will apply a systems-oriented conceptual framework that has been developed by the Climate Security Roundtable to organize and drive its climate security analyses across a range of regional and topical contexts. This South Asia regional workshop, specifically, will identify and examine:

- The key climate security questions in the region, and the appropriate bounds (in terms of geographic borders, societal sectors, spatial/temporal scales, etc.) for analysis in each case;
- The important underlying conditions and processes, external influences, and teleconnections that shape climate security issues in the region;
- The key internal systems, entities, and linkages that determine the evolution of climate security risk within the region, with a focus on cascading and compounding risk, as well as how key risks outside of South Asia can impact the region;

continued

BOX 1-4 *continued*

- The critical analytic capacity and capabilities (e.g., data and information systems, tools and methodologies, collaborative relationships, fundamental research, etc.) needed to effectively characterize climate security risk in the region; and
- The critical tools needed to effectively reduce climate security risks in the region (e.g., adaptation best practices, ways to build resilience, key points of intervention as a climate crisis unfolds).

Workshop activities would include examination of case studies of historical climate security risks that have materialized in the region, as well as scenario development to understand how future climate security risks could unfold.

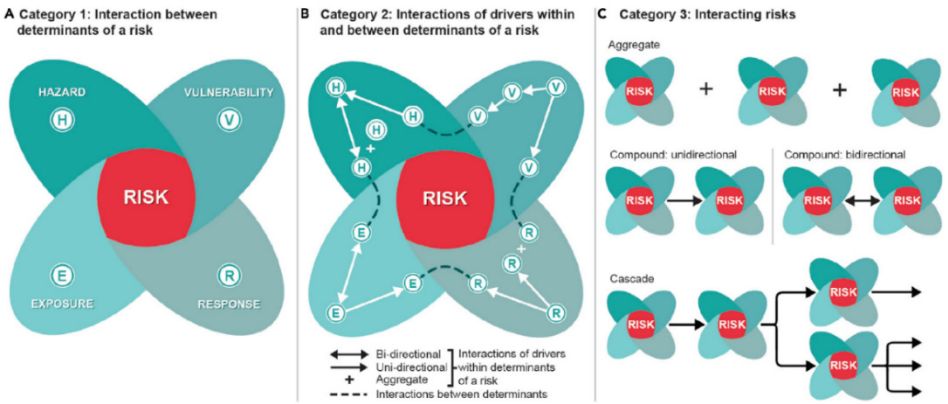

FIGURE 1-5. Conceptualizing complex risk. Three categories of increasingly complex climate change risk: (a) A single risk (shown in red) emerges from the interactions between four determinants (shown in green)—hazard, vulnerability, exposure, and response to climate change; (b) drivers can interact to influence a single determinant and also interact across determinants of a risk; and (c) multiple risks can interact by aggregating, compounding, or cascading interactions. "Determinant" refers to hazard, vulnerability, exposure, and response, within which the term "driver" refers to individual components, such as heavy precipitation (a driver within the hazard determinant) or access to shelter (a driver within the vulnerability determinant), that interact to affect the overall risk (e.g., flood mortality). SOURCE: Simpson et al., 2021.

2
Climate, Development, and Security Challenges in South Asia

Highlights from Panel Discussion[1]

- Climate-related risks stem from the impacts of physical climate change on people and society and—just as importantly—from the societal transitions that climate change sets into motion. A transition to a low-carbon economy poses risks to food, water, and energy security, as well as sustainability and equity, in developing regions. These risks can be mitigated by minimizing the trade-offs between climate mitigation goals and the sustainable development priorities that are central to building and maintaining human and political security in regions like South Asia.
- Much remains unknown about climate–conflict pathways. Several mediating factors can influence whether violent conflict results from a climate disaster, including the strength of civic institutions, the capacity of national authorities to provide services, and existing levels of societal harmony.
- Opportunities to resolve interstate disputes and contestation in South Asia are severely constrained by the lack of regional cooperation or solutions mechanisms.

Workshop participants explored some of the underlying climate, development, and geopolitical dynamics at play in the South Asia region through a panel discussion with two invited experts. Dr. Joyashree Roy, the Director of the Centre on South and Southeast Asia Multidisciplinary Applied Research Network on Transforming Societies of Global South at the Asian Institute of Technology, shared an environmental and energy economics perspective on "Multidimensional Security Issues While Moving Towards a Decarbonised World." Mr. Sarang Shidore, of the Quincy Institute, offered a geopolitical perspective on "Climate–Conflict Pathways in South Asia."

SECURITY ISSUES ASSOCIATED WITH A LOW-CARBON ENERGY TRANSITION

Roy prefaced her remarks by noting that climate-related security risks stem from more than just the impacts of physical climate change on people and society; the societal transitions that occur in response to climate change can also create new security risks. As the international community seeks to accelerate and deepen its climate mitigation actions, she noted that a rapid transition to a low-carbon economy poses a particular set of risks to the security of developing regions. In her presentation, Roy explored the fundamental challenge of achieving a secure, sustainable, and just decarbonization transition within the regional circumstances and context of South Asia. Focusing her attention on the energy sector, she described the multidimensional security issues associated with decarbonization, explored the linkages between climate mitigation options and sustainable development goals, and highlighted opportunities to maximize the synergies between them.

[1] This list is the rapporteurs' summary of the points made by individual speakers, and the statements have not been endorsed or verified by the National Academies of Sciences, Engineering, and Medicine.

Roy argued that decarbonization must occur through a climate-compatible economic development pathway for South Asia that addresses a basic energy trilemma: how to create a low-carbon economy in a way that ensures (1) energy security (i.e., by maintaining a reliable and resilient energy system); (2) sustainability (i.e., by maximizing the climate and environmental benefits of energy policy); and (3) equity (i.e., by ensuring accessible and affordable energy across society) (Figure 2-1). In practical terms, this would involve managing the decarbonization transition through institutions and policies that can meet the growing demand for non–fossil fuel energy sources, avoiding job loss and building new skilled human capacity, and addressing the stranded assets of fossil fuel infrastructure. Roy argued that decarbonization must also balance its climate mitigation goals with the sustainable development priorities that are central to building and maintaining human and political security in South Asia. She noted that climate mitigation policies can interact positively (through synergies) or negatively (through trade-offs) with these development priorities.

Roy offered a few examples of how climate mitigation and sustainable development pathways could involve significant trade-offs. With respect to food and water security, she noted that mitigation policies emphasizing land-based carbon sequestration or water-intensive energy technologies could increase demands for land and water, displacing food crops and communal water supply. With respect to energy security, an emphasis on broad-based electrification could increase electricity demand and potentially reduce the affordability and accessibility of energy in poorer communities; an emphasis on nuclear energy generation could intensify risks related to radioactive waste; and policies emphasizing hydrogen could create risks related to fuel storage and transportation. Roy noted that the security risks related to these types of trade-offs would be expected to be more severe in geographies where human lives and livelihoods are impacted by general poverty, weak institutions, poor governance, and persistent inequity—where development needs are the greatest.

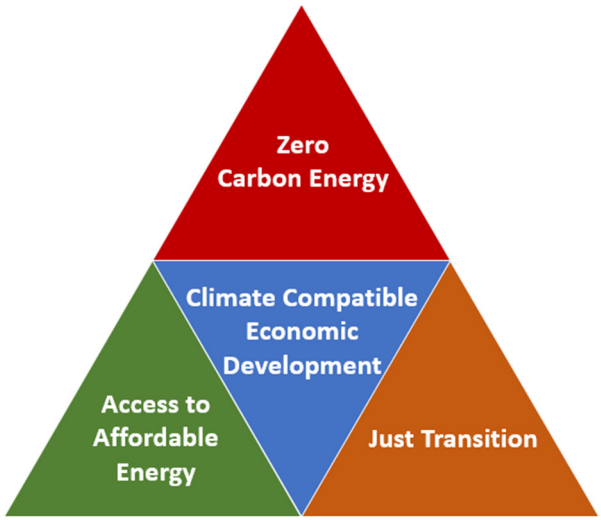

FIGURE 2-1. A schematic showing the energy trilemma: how to manage a climate-compatible economic development pathway that ensures energy security, sustainability, and equity. SOURCE: Adapted from Joyashree Roy workshop presentation, October 26, 2022.

Roy noted that many of the interactions between mitigation policies and development priorities are knowable and foreseeable, and there is an opportunity and a strong need for scientific assessments that can effectively identify potential synergies in different geographic contexts. She cited recent work that explored the specific linkages between climate mitigation and sustainable development in South Asia and highlighted opportunities to maximize the development co-benefits of climate mitigation in the region. The Hindu Kush Himalaya (HKH) assessment report, completed in 2019, considers plausible futures for the HKH region, which originates 10 major Asian river systems and supports the resource base and prosperity of 1.65 billion people directly downstream (Wester et al., 2019). In the most optimistic scenario, for a prosperous HKH, the region benefits from international climate finance commitments, as well as a portfolio of climate mitigation actions—particularly in the energy-demand and land-use sectors—that complement and support development goals. More broadly, the region realizes opportunities to strengthen its political and economic integration, innovate on technology, and improve cooperation both across and within national borders. Conversely, in the least optimistic, "downhill" scenario, the region fails to achieve a climate-compatible economic development pathway that addresses the challenges of poor governance, poor economic development, and political instability; in this scenario, socioeconomic conditions deteriorate as vulnerability to the impacts of climate change and environmental degradation increases.

Roy emphasized that climate mitigation and sustainable development synergies can be maximized by mitigation actions tailored to regional development circumstances and context. For the South Asia region, she cited her own ongoing research demonstrating particularly strong synergies on the energy-demand side that could be achieved through changes in infrastructure, including through the design of compact cities and efficient building spaces; sociocultural factors, including through dietary choices and changes in consumer behavior; and end-use technology adoption, such as the use of more energy-efficient appliances. Roy's research indicates that demand-side solutions can substantially reduce upstream greenhouse gas (GHG) emissions and energy use; moreover, many solutions are cost effective and involve off-the-shelf technologies (Creutzig et al., 2022).

Roy concluded her remarks by noting that the scientific assessment literature includes a significant knowledge gap on the interactions between climate and development challenges, as well as the potential solutions space. She noted that, in general, assessments do not holistically integrate mitigation pathways and development pathways. She also noted that many of the demand-side solutions for reducing climate emissions and energy use involve social and technical innovations at granular levels, which are not always integrated into the modeled pathways.

CLIMATE–CONFLICT PATHWAYS

In his remarks, Shidore described South Asia as a crucible of climate security analysis and reflected on the region's diverse climate hazards, varied security challenges, and the evolving understanding of the connections between them. He noted that research on the relationship between climate and conflict has produced some basic insights, but that much remains unknown about the pathways leading from climate change to violent conflict. In his presentation, Shidore briefly reviewed the current state of climate–conflict research and some of the key climate hazards in South Asia. He noted that conflict dynamics in the South Asia region can include civil war and militancy, national-level protests and social unrest, and localized conflicts at the scale of a village or a subnational region; however, he focused his remarks on three key interstate rivalries in the region: in the Indus River basin, between India and Pakistan; in the Brahmaputra River basin, between India and China; and in the India–Bangladesh–Myanmar corridor.

Shidore noted that research on climate and conflict has identified key climate influences, potential climate–conflict pathways, and mediating variables that can shape the security environment in South Asia. With respect to climate influences, shorter-term variability produces extreme conditions, including heatwaves, drought, intense rainfall, floods, and cyclones. Longer-term climate trends are projected to increase the frequency and intensity of these extremes, as well as produce other adverse conditions over time, such as lowered agricultural yields or degraded coastal communities. With respect to causal pathways, Shidore noted that one key pathway involves climate-related changes in critical resources such as food or water. He explained that either scarcity or abundance in a resource could pose security challenges, with an example of the latter being a situation where plentiful resources advantage one particular party in an existing conflict or result in contestation over access to that additional resource. Another key pathway involves climate-induced migration or displacement. Shidore pointed out that the climate–migration–conflict linkage is vigorously debated in the expert community, with basic questions still unanswered about the expected scale of migration under different climate scenarios, the respective roles of migrants and receiving communities in sparking conflict, and the extent to which this type of conflict actually engenders violence. With respect to mediating variables, Shidore pointed out that even in a setting where a clear causal pathway may exist, several factors can influence whether the adverse consequences of a climate extreme or disaster will include conflict. These include the presence of civic institutions, from subnational to international levels, that can effectively cope with the impacts of climate change; the capacity of national authorities to conduct humanitarian assistance and disaster relief (HADR) operations and provide services after a disaster; and the degree of harmony between different communities, ethnic groups, and social classes that can prevent fracturing along traditional fault lines in a crisis.

Shidore turned to an analysis of three specific interstate rivalries in the region. The first case was in the Indus River basin, between India and Pakistan (Shidore, 2020; see Figure 2-2). He explained that the distribution and management of the waters of the Indus and its tributaries is governed by the Indus Water Treaty, signed in 1960, which partitions the river system, with water from three rivers predominantly awarded to India and water from the other three to Pakistan. The treaty delineates rights and responsibilities for both countries, but Shidore noted that there are grey areas where contestation and disputes can occur and that this issue bedevils water management in this region. He also pointed out that India is the upstream actor in this system and that a fundamental feature of transboundary water disputes is that upstream actors have disproportionate power.[2] Shidore noted that climate change is exacerbating existing challenges within the basin and creating opportunities for disputes. For example, he noted that the warming and melting of mountain glaciers will be spatially variable and have a differential impact on river flow rates across the basin. In the context of these evolving climate stressors, disputes over river development projects, as well as over general patterns of overconsumption and poor water management, have escalated. Shidore took stock of the prospects for the conflict dynamic between India and Pakistan. As a positive, he noted the existence of an international treaty that has survived wars and repeated contestation. On the negative side, however, he noted that there was significant distrust between the two nations since border skirmishes in 2016. He also noted that there are no effective peace-building institutions, noting that the South Asia Regional Cooperation is moribund. In addition, he noted the general challenges to peace posed by poor domestic governance and the challenges of poverty and poor infrastructure, especially in Pakistan.

[2] Since some rivers flowing from India to Pakistan originate in or pass through Kashmir, a disputed region that has triggered multiple India–Pakistan wars, the Kashmir issue is a major reason why water disagreements between India and Pakistan are inherently securitized (see https://climate-diplomacy.org/case-studies/water-conflict-and-cooperation-between-india-and-pakistan).

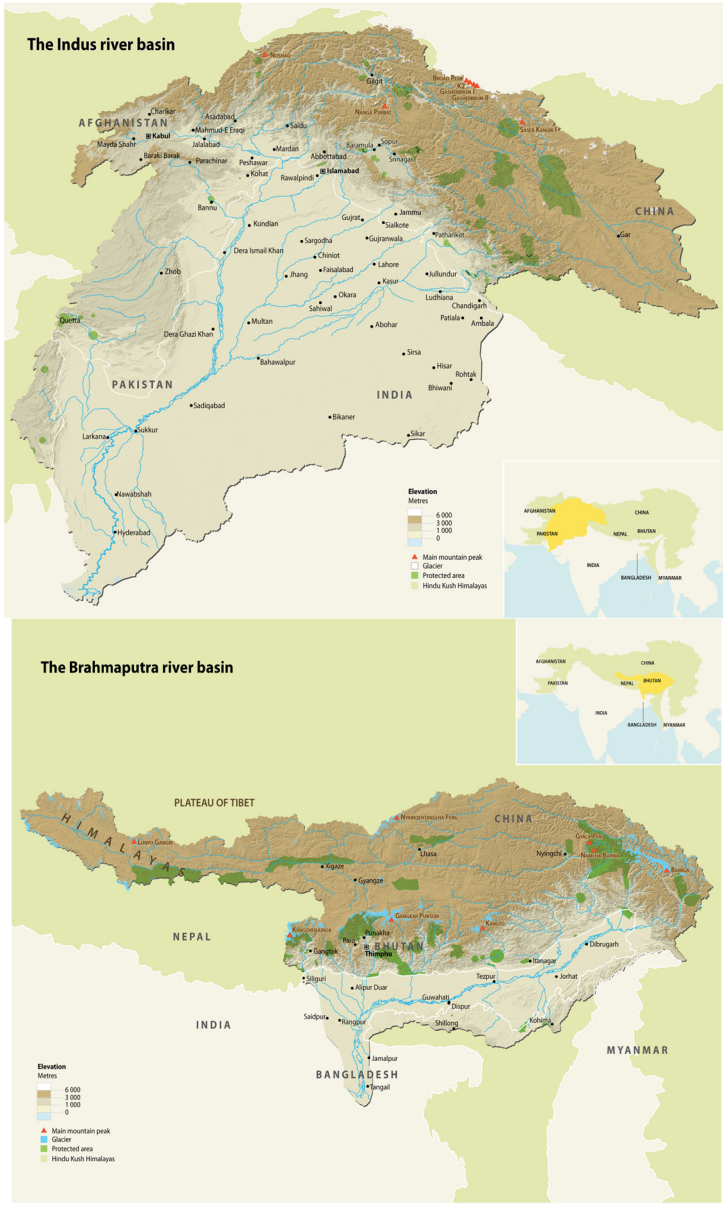

FIGURE 2-2. Maps of the Indus River basin and Brahmaputra River basin, showing political boundaries, rivers, and locations of major infrastructure projects and disputes between nations. SOURCE: GRID-Arendal, 2015.

Shidore's next case study explored the dispute between China and India in the Brahmaputra River basin (Shidore et al., 2021; see Figure 2-2). He noted that China is the upstream actor in this system and has proposed a large hydroelectric power project larger than the Three Gorges dam. If

completed, its size creates opportunities for real or perceived manipulation of river flows and perceptions of bad faith at a time when there is already distrust between the two countries following recent territorial disputes along their border. In assessing the prospects for avoiding conflict in this situation, Shidore noted, as a positive, that the dispute is in its very early stages with opportunities for agreements to avoid future conflict. He also noted that the river is very large and is mostly undeveloped, and that the two countries do already cooperate through an existing, albeit limited, data exchange mechanism. On the negative side, however, Shidore noted that there is no treaty or other framework in place to manage disputes, or even any obvious mediators between these two countries who are generally sensitive about sovereignty issues and not welcoming of external interventions.

Shidore's final case study focused on the India–Bangladesh–Myanmar corridor, which he characterized as a unique confluence of security problems. He noted that both eastern India and Bangladesh experience impacts from episodic political and communal violence, including an armed insurgency in the eastern Indian state of Chhattisgarh and refugees in Bangladesh escaping from violence in Myanmar, that exacerbates existing vulnerabilities in the region to climate hazards such as cyclones. Shidore laid out several climate-security scenarios that could transpire in a warming world. In the first, a "meltdown" in Myanmar due to political violence coincides with a tropical cyclone to produce a devastating humanitarian and security crisis for the region. In the next scenario, Bangladesh's economic development and governance pathways, following recent trends of the country's remarkable successes in these areas, are able to overcome its climate and security challenges, and the country correspondingly becomes a regional anchor and solutions provider. The third scenario involved a stalled Bangladesh due to climate challenges overwhelming positive trends, which then becomes a regional cautionary tale. In the final scenario, global impacts from climate change continue to grow, most countries become more inwardly focused, and international cooperation and assistance dramatically decreases. In this potential future, the most vulnerable countries and communities are no longer able to keep pace with the growing impacts from climate hazards.

Shidore concluded his remarks with perspectives on the opportunities to manage climate-related conflict in the South Asia region. He pointed out that opportunities to resolve disputes and contestation are severely constrained by the lack of regional cooperation or solutions mechanisms. Shidore also noted that China will play an important role in determining the region's security future, as it controls the "Third Pole"[3] of the Tibetan Plateau, where most of the region's major rivers originate, but is not part of any major institutions relevant to environmental and resource management in the region. China is also a major actor in the climate mitigation space, particularly in the development of renewable energy technologies, and could be a solutions provider for the region. Finally, Shidore noted the "irony of solutions," observing that many of the policy responses to climate risk may create their own adverse consequences for security and development in the region. For example, India's push to decarbonize its energy sector may lead to contestation over land, tensions between federal and local governments over policymaking authority, and a potentially unjust transition that leaves workers and communities dependent on this fossil fuel sector stranded. Also, China's motivation to develop hydropower resources is related to its own climate commitments but could spark disputes and conflicts that reduce climate resilience in the region. Shidore concluded by emphasizing that climate and security issues are tightly coupled arenas, with causality running both ways, and have multiple intervening variables, with institutions and capacity for cooperation as perhaps the most critical.

[3] The Third Pole comprises the Tibetan Plateau and surrounding mountains, and it represents the largest masses of ice, snow, and permafrost outside of the Arctic and Antarctic regions.

3
Historical Case Studies

Highlights from Panel Discussion[1]

- Examples of climate-related security threats that have manifested in post-independence India suggest that the shared infrastructure for water control in South Asia is more likely to be a flashpoint of interstate conflict than climate stresses themselves. Steps to improving security in the region could involve improvements in the safety and reliability of this infrastructure, as well as improvements to the water sharing agreements themselves to be more transparent and equitable.
- Recent Bangladeshi history provides an example of transformative climate adaptation policies that have substantially increased national disaster preparedness and greatly reduced climate-related mortality. The challenge moving forward will be to take actions to reduce morbidities and loss of livelihoods, which are potentially more consequential to security.
- Security crises can arise from the compounding interactions and feedbacks between climate impacts and existing societal challenges—in this sense, climate change acts as an amplifier of existing security issues. Examples are the humanitarian disaster following the 2022 floods in Pakistan, in which the direct impacts of the flooding were compounded by existing vulnerabilities in poor and underdeveloped communities, poor governance and management at national and local levels, and lack of public faith in institutions and the government.

A panel of invited experts shared their perspectives and engaged workshop participants on past events where climate drivers contributed to the evolution of security challenges. Dr. Sunil Amrith, of Yale University, shared an environmental historical perspective on the "History of Climate Crises and Security Challenges in South Asia." Dr. Saleemul Huq, of the International Centre for Climate Change and Development, offered a climate adaption perspective on the "Impact of Cyclones on Security in South Asia." Ms. Jumaina Siddiqui, of the U.S. Institute of Peace, offered a democracy and development perspective on "A Natural Security Crisis—Impacts of Climate Change on Pakistan's Stability and Security." A member of the workshop planning committee, Dr. Hariharasubramanian Annamalai, of the University of Hawaii, moderated the panel and also offered his own insights into climate dynamics in the region (see Box 1-1 in Chapter 1). Later, workshop participants broke into smaller, structured discussions, with a goal of advancing a "systems" understanding of the historical case studies.

CLIMATE CRISES AND SECURITY CHALLENGES IN SOUTH ASIA

In his remarks, Amrith applied lessons from South Asian environmental history to the accelerating climate impacts the region presently experiences. He noted that climate variability has been a fundamental concern to every government and ruler in the Indian subcontinent for centuries, from the Mogul Empire; through the British Empire; to the postcolonial governments of India, Pakistan, and Bangladesh. He noted that variability in rainfall and, in particular, the seasonal monsoon has

[1] This list is the rapporteurs' summary of the points made by individual speakers, and the statements have not been endorsed or verified by the National Academies of Sciences, Engineering, and Medicine.

shaped military tactics, the design of supply and transportation networks, the development of industrial and agricultural technologies, and the establishment of modern hydrometeorological services.

Amrith argued that in order to comprehend the climate-related security risks in contemporary South Asia, it is important to acknowledge the relationship of postcolonial political borders with existing natural and man-made hydrologic structures. In the west of the region, at the India–Pakistan border, he noted that the partition in 1947 bisected the great river basins of the Indus and Ganges, as well as a carefully planned network of irrigation canals created half a century earlier. In the east of the region, he described an opposite problem, where political borders were based on the natural hydrologic landscape but attempted to fix in place an inherently unstable boundary. In his view, this made climate and hydrologic variability a matter of existential importance—with the major security threats in the first decades after independence arising over the control of the infrastructure that had been put in place to mitigate climatic uncertainty and to redistribute water. Amrith then presented three recent historical examples (see Figure 3-1) of climate-related security threats that have manifested themselves in different parts of South Asia.

The first example focused on water disputes directly following the 1947 India–Pakistan partition, when makeshift arrangements to share transboundary waters of the Indus River basin fell apart. The water distribution networks that serviced the region had been designed and built as a unified system but were now divided by the political border. After years of negotiation, mediated by the World Bank, an agreement on an Indus Water Treaty was reached in 1960. The treaty is still in effect today but has been strained repeatedly by disputes over water management and border conflicts, as well as climate-related hydrologic variability.

The second example focused on the severe drought experienced by the Indian state of Bihar in the 1960s, which created a food shortage that threatened the political stability of the entire country. Amrith observed that a catastrophe was averted through actions by the U.S. government, which sent significant amounts of food aid, and by the Indian government, which successfully used the public distribution system to address food shortfalls on a local basis. Amrith noted that the U.S. government's planning for each shipment of food aid carefully integrated scientific assessment and projections of rainfall throughout the region. Amrith also shared that during the crisis, both governments secretly consulted on the possibility of using cloud-seeding techniques to break the drought and reduce Indian agriculture's vulnerability to the vagaries of weather.

FIGURE 3-1. Historical photos from (left) the signing of Indus Water Treaty by (from left to right) Jawaharlal Nehru, Prime Minister of India; Mohammed Ayub Khan, President of Pakistan; and William Iliff, World Bank vice president, to end the postpartition Indo-Pakistan water dispute; (middle) a meeting between Indian Prime Minister Indira Gandhi and U.S. President Lyndon B. Johnson to discuss the response to the 1966–1967 Bihar drought crisis; and (right) Bangladesh at the time of the Cyclone Bhola disaster. SOURCES: (left) World Bank, file #30263783; (middle) Yoichi Okamoto, public domain; and (right) Express Newspapers/ Getty Images, this work is now in the public domain.

Amrith's third example focused on the devastating tropical cyclone Bhola, which struck East Pakistan in 1970 and claimed the lives of almost half a million people. He noted that this event serves as perhaps the most prominent example in South Asia of a climatic event that had direct consequences for regional security. Amrith explained that the disaster played a triggering role, although not demonstrably causal, in the Bangladeshi war of liberation and its expansion into a war between India and Pakistan. Following the cyclone, criticism of the East Pakistan government's response undermined public confidence and strengthened pro-independence factions. At the same time, an influx of refugees displaced by the disaster into India gave the government a strategic stake in the conflict and a pretext for providing military backing to the Bangladeshi independence movement. The conflict ultimately widened into the Indo-Pakistani War of 1971 and concluded with the founding of Bangladesh.

Amrith offered two concluding thoughts. His first was that a critical factor linking climate change to security in South Asia has been the inherited infrastructure for water control that was created to even out existing natural spatial and temporal variability in rainfall. He noted that this shared infrastructure—for example, the system of interlinked canals and irrigation channels in the Indus basin—is more likely to be a flashpoint of interstate conflict than climate stresses themselves. Amrith observed that intensively engineered environments are often vulnerable to climate impacts; in his view, the essential steps to improving security in the region would involve improvements in the safety and reliability of this infrastructure as well as improvements to the water sharing agreements themselves to be more equitable, transparent, and less vulnerable to knee-jerk reactions when conflict arises in other domains. Amrith's second concluding thought, from a historical perspective, was that climate security in South Asia is bound with every other dimension of security, and that it should not be addressed in isolation from them. In South Asia, he argued, climate security maps directly onto economic security, political stability, border security, and regional peace and conflict.

CYCLONES IN SOUTH ASIA

Huq prefaced his remarks by noting that he was speaking to workshop participants remotely from Bangladesh, a day after tropical cyclone Sitrang made landfall on its southwestern coast. Reflecting on the storm's impacts,[2] he noted the successes achieved by Bangladesh in developing approaches to manage risks from tropical cyclones. He explained that in comparison to years past, when major cyclones would produce death tolls in the hundreds of thousands, the country now has the capacity to effectively evacuate and shelter a million people and has dramatically lowered mortality during even the most severe storms (Figure 3-2). He noted that early warning capabilities have been improved through investments in advanced satellite tracking of storms in the Bay of Bengal, as well as communications technologies that can deliver information and alerts across the country. He also noted that Bangladesh has developed a network of thousands of cyclone shelters in coastal zones, all within in a few hours walking distance for every resident. Shelter designs have been improved to make them more friendly to women as well as livestock, and also to serve as multipurpose buildings that can be used as schools or community centers in the non-cyclone season. Huq also described other adaptive actions to improve national preparedness, including conducting postmortems of the entire national response structure after every storm, organizing regular emergency drills in every primary and secondary school, and maintaining strong coordination with authorities in neighboring India.

[2] Sitrang caused the evacuation of about a million people, resulting in at least 35 deaths (see https://timesofindia.indiatimes.com/world/south-asia/cyclone-sitrang-kills-35-in-bangladesh-officials/articleshow/95085350.cms).

FIGURE 3-2. Examples of climate adaptation actions in Bangladesh. (top) Volunteers in Bangladesh's Cyclone Preparedness Programme take part in an early warning drill in Chila village, April 2022. (bottom) A multipurpose disaster shelter. SOURCES: (top) Image from Rafiqul Islam Montu, *The New Humanitarian* (2021): np. "How Bangladesh is beating the odds on climate disaster deaths"; and (bottom) image from H. Wright, *Flickr* (2013): np. "Multi-purpose cyclone shelter and school. Taken in Patuakhali, Bangladesh."

Huq reflected further on the status of the Bangladeshi people displaced by Sitrang at that moment, noting that tens of thousands of people who survived the initial disaster would not be easily able to return to their homes or resume their lives. He acknowledged that while the country has been very successful at minimizing loss of human lives, it has not yet achieved comparable success in coping with the loss of property and livelihoods that accompany climate shocks. Huq pointed out that many Bangladeshis displaced by cyclones and other disasters end up migrating to the capital Dhaka and other major cities, gravitating to communities where they have social and familial connections that can be leveraged to find work, schooling, and other resources. He noted, however, that sea-level rise and other climate stressors are expected to displace up to 13 million people from low-lying coastal areas and into cities by 2050 (Rigaud et al., 2018), and that it will be difficult to absorb so many migrants. Huq described the increasing flows of people into host communities that are increasingly unable to support them as they attempt to rebuild their lives as a "slow-moving humanitarian disaster."

Huq cited his ongoing work with colleagues at the International Centre for Climate Change and Development (ICCCAD) to develop climate-resilient, migrant-friendly towns as a potential solution to disperse the massive flows of climate migrants into Dhaka and provide opportunities for them to recover their communities and livelihoods (Alam et al., 2018; Khan et al., 2021). The ICCCAD effort has identified approximately 20 secondary towns distributed around the country,

each with the capacity to potentially integrate half a million refugees. ICCCAD is currently working with national and local authorities, as well as civil society partners, to plan and implement activities to build climate resilience—for example, through investments in the towns' infrastructure and sustainable technologies—and to foster peaceful co-existence of host communities and migrants—for example, through the design of informal dispute-resolution mechanisms. Other important elements of this effort would include incentivizing migrants to commit to staying in and contributing to their host communities, including through scholarships, skill development programs, and other ways to help them adapt to their new homes. Huq acknowledged that there is a long history of a failure of this type of controlled relocation, and that it is important to enable people to make these choices themselves. He noted that settlement of displaced people in towns that are nearer to their ancestral homes would allow them to maintain their existing psychological and cultural connections. He expressed hope that this type of approach would generate interest beyond the Bangladeshi context.

IMPACTS OF CLIMATE CHANGE ON PAKISTAN

In her remarks, Siddiqui reflected on the dynamic interactions between climate-related disasters and existing security challenges in Pakistan, focusing her attention on the intense rainfall and devastating floods experienced by the country in the summer of 2022 (Figure 3-3). She observed that the flooding, as well as the intense rainfall preceding it, was not a novel or unforeseen occurrence for the country and that Pakistan has experienced many previous climate-related disasters, including record flooding in 2020. She noted that the national hydrometeorological service is capable of issuing advance warnings, although the complex geography makes forecasting difficult, and that disaster management authorities at the national and provincial levels do have disaster plans in place. The magnitude of the 2022 flooding, however, exceeded the resources allocated in those plans, particularly for temporary shelters, and the emergency response was not able to match the scale of the disaster. Siddiqui described the magnitude of the humanitarian crisis that followed, noting the large number of displaced people; the large spatial extent of flooding; the damage to agriculture and livestock; and socioeconomic impacts such as inflation, unemployment, and disruption of education (Salikuddin and Siddiqui, 2022). She observed that the direct impacts of the flooding were compounded by existing vulnerabilities in poor and underdeveloped communities, poor governance of rural and urban construction and development, and lack of public faith in institutions and the government.

Siddiqui argued that climate disasters will compound the domestic and international challenges facing Pakistan and ultimately undermine the security of the country and the wider South Asia region. Within Pakistan, Siddiqui observed that the massive fatalities and financial losses associated with recurring climate disasters have strained the nation's emergency management capacity to its limits; created disputes over scarce national resources; and placed the nation's food, water, and energy systems at risk.

At the same time, the country has experienced significant political disruption, in the form of protests and unrest; a constitutional crisis that removed an elected prime minister; and a power transition to a fractured coalition government that has had difficulty managing the humanitarian crisis produced by the most recent floods. Outside of its borders, Pakistan faces challenges related to the recent U.S. withdrawal from Afghanistan and international concerns over Pakistan's ability to maintain control over its own nuclear arsenal. Siddiqui noted that cooperation and coordination on these issues is hampered by the difficult past 20 years of history between the United States and Pakistan.

FIGURE 3-3. 2022 Pakistan floods. (top) Photo of an inundated community in Sindh province and (bottom) satellite imagery of flooding along the Indus River from June to October 2022. The blue and green colors indicate standing water and inundated land. SOURCES: (top) Shutterstock (2022): np. "Stock Photo ID: 2216877839 / Afad Tuncay. 14 September 2022 flood disaster Pakistan Sindh province Dadu City humanitarian aid" (bottom). NASA Earth Observatory.

Siddiqui examined the downstream effects and security implications of the initial humanitarian disaster. She noted that the floods destroyed critical health infrastructure and increased the incidence of infectious and water-borne diseases, as well as halted the education and disrupted the livelihoods of millions of people.

Where the government failed to address these dislocations, Siddiqui noted that other groups have stepped in to provide services, potentially including religious extremist or terrorist organizations. In a political environment characterized by infighting and inattention to the needs of new climate refugees, people could turn to extremist groups. The education crisis, in particular, potentially leads to children ceasing to receive a holistic education and only receiving religious instruction, which would create a learning deficit and also make them more susceptible to recruitment into the extremist organizations. She pointed out that the messaging from religious organizations and on social media has already spread extremist rhetoric through misinformation and disinformation about the crisis, including messages saying the floods were a divine punishment on society for not being appropriately religious, or that India had caused rivers to flood by opening up dams upstream.

Siddiqui touched on a range of challenges, and their associated opportunities, related to the climate disaster and broader security issues. She argued that the extended political transition in Pakistan has disconnected science from policy and planning, noting that Pakistan's national security policy—which does discuss climate change and its separate impacts on food, water, and health security—needs to be more holistic. Pakistan may benefit from a national Command and Operation Center on climate, and she pointed to the lessons learned from the COVID-19 pandemic, for which Pakistan developed smart lockdowns along with targeted assistance and food aid. Another opportunity is that the U.S. withdrawal from Afghanistan has removed capacity for HADR operations in the region, so that Pakistan is more reliant on its own domestic equipment and personnel. A security stressor will be the movement of displaced people into the already-stressed urban centers.

Siddiqui noted some of the outstanding security questions moving forward. One is the safety of Pakistan's nuclear sites. There has not been any deep analysis or research on whether they were damaged by the floods or what would happen to those sites in a postdisaster environment. There has not been strategic thinking around it against the backdrop of the ongoing leadership transitions in the political and military power structure. It is also an open question as to how the rise of populism and ethnic nationalism, especially in middle-class communities, will affect how political parties deal with the interplay between climate disasters and political security issues. It remains to be seen how political actors in Pakistan and across South Asia are thinking about and planning for the emerging climate-related security challenges in the region. There will be consequential elections over the next few years in different countries.

PARTICIPANT DISCUSSIONS

Workshop participants broke out into three smaller, structured discussions intended to advance a "systems" understanding of the historical examples provided by the expert panel. Each group selected one or more of the case studies, or agreed to explore a new one, and received some organizing prompts for their discussion:

- *Understanding the climate security risks:* What were the key security risks that emerged in this setting? Were they expected or unexpected? What were the relevant external influences/underlying conditions/systems interactions that shaped the evolution of this risk?
- *Considering human responses:* How did human responses and choices modulate (amplify or reduce) risk in the setting? What were the response options for decisionmakers in this setting?
- *Considering tipping points and near misses:* Did the setting approach/cross any tipping points?
- *Anticipating and avoiding risks:* Were there key intervention points for mitigating security risk?

After participants reconvened in plenary, representatives from each of the three groups (A, B, and C) summarized their discussions and shared key points.

Group A chose to compare and contrast the historical experiences of flooding in Bangladesh and Pakistan as a way of understanding security risk in the region. In considering the factors influencing the evolution of this risk, the group's representative shared three main factors that accounted for the different outcomes observed in each country. The first was lack of adequate preparation and assessment of needs beforehand, particularly related to maintaining human and social infrastructure, which would hamper an effective response. The second factor was a lack of public trust

in institutions and government, which would undermine their ability to deliver services before, during, and after the disaster. The third factor was a lack of effective coordination and collaboration between authorities within a country and also between countries.

In considering human responses, the Group A representative suggested forced migration and displacement as key areas where human responses modulated security risk. The representative noted that in comparison to Pakistan, Bangladesh took an anticipatory approach by investing in resilient migrant-receiving communities. A substantial and unresolved challenge for both countries, however, was returning displaced people to their homes and recovering their lost property and livelihoods. In considering opportunities to anticipate and avoid future climate disaster risks, the Group A representative suggested a few key intervention points. These included conducting needs assessments and prestaging relief efforts in the periods between disasters, as well as working at the local and provincial levels to determine the best agents of action for a disaster response. The representative also noted that the Bangladesh and Pakistan flooding cases illustrate that climate security risk in a given setting reflects the cumulative burden of persistent inequity and existing environmental health threats, such as poor air and water quality, as well as the climate hazard itself.

Group B used its discussion to describe overall takeaways that emerged from the panel discussion, and the group's representative presented three key perspectives. The first was that in both Bangladesh and Pakistan, the strong institutions and social cohesion that were important contributors to the successes achieved in managing climate risk were absent where there were failures. The second key message was that a substantial, broad-based level of development is not necessarily required to improve resilience to climate impacts. The Group B representative noted, for example, that Bangladesh is a relatively poorer country but has made great strides in building resilience to cyclones. The final key message was that the metrics used to assess climate impacts strongly influence our understanding of security implications. As an example, the representative noted that cyclone mortality may provide a good measure of success in saving lives, but that levels of displacement and loss of livelihoods are just as consequential to security outcomes.

Group C used its discussion to compare and contrast the historical experiences for Bangladesh and Pakistan but considered a broader range of security challenges over recent decades. The group's representative shared some observations on how the two nations have diverged in their approaches to those challenges. The first observation was that domestic societal factors have strongly influenced the approach to security risk in both countries. These factors include the strength of social cohesion, the degree of military influence within government, the degree of religious influence within government and local communities, and the strength of governance and social support systems. The group's representative noted, for example, that social cohesion is stronger in Bangladesh. The second observation was that the two nations have distinct approaches to security risk management due to their very different political histories and roles within the South Asia region. Group C's representative noted that Pakistan was an important regional player during the Cold War, receiving significant foreign military and economic assistance, and is currently a nuclear state. These conditions may have contributed to a national government that has historically been less interested in addressing internal societal issues. By contrast, Bangladesh has historically played a more passive role in the region, often acting as a "shock absorber." The country's successes in building national resilience may reflect its stronger history of democratic conditions, the government's more inclusive view of its citizens, and a smaller overall wealth imbalance. Group C's representative noted, however, that while Bangladesh has had success in reducing its climate mortality, the country still faces significant challenges in protecting livelihoods and this may ultimately be a stronger driver of security risk.

4
Possible Futures

Highlights from Panel Discussion[1]

- Climatic and socioeconomic conditions are both highly variable across South Asia. Security in the region is critically influenced by interactions between these two sources of natural and societal heterogeneity. The uncertainties in their future variability constrain our ability to anticipate future security risk.
- South Asia is characterized by a high degree of both vulnerability and exposure to climate hazards, which are likely to continue. Heatwaves are expected to increase dramatically in their frequency, areal extent, duration, and the number of people exposed. River flooding is expected to increase, in relation to increases in precipitation, which will come mostly in the form of extreme events rather than uniformly distributed rainfall across the season. Food security will be affected mainly through water impacts, since food security in the region is essentially a function of water availability.
- Security discussions often focus on the relationship between climate change, migration, and conflict, but the evidence indicates that the linkages are indirect and somewhat context dependent. The clearest linkage between climate, migration, and security in South Asia is through the risks posed by climate to poorer and disadvantaged communities, who would be disproportionately mobilized by those risks.

A panel of invited experts shared their perspectives and engaged workshop participants on scenarios for how climate change, and human responses to it, could precipitate security challenges in South Asia. Dr. Upmanu Lall, of Columbia University, shared perspectives on "Access to Water Resources and Security Conflicts." Professor Vimal Mishra, of the Indian Institute of Technology in Gandhinagar, explored "Drought and Food Security in South Asia." Mr. Chris Richter, the Regional Migration, Environment and Climate Change Specialist at the International Organization for Migration (IOM), offered perspectives on "Human Mobility in a Changing Climate: Understanding the Nuances of a Complex Topic." A member of the workshop planning committee, Dr. Katharine Mach, of the University at Miami, moderated the panel and facilitated a plenary discussion. Later, workshop participants broke into smaller, structured discussions on the scenarios to build a "systems" understanding of the potential risks.

ACCESS TO WATER RESOURCES AND SECURITY CONFLICTS

Lall prefaced his remarks by reflecting on the spatial variability in both rainfall and socioeconomic conditions across South Asia. He noted that security in the region is critically influenced by interactions between these two sources of natural and societal heterogeneity, and that the uncertainties in their future variability constrain our ability to anticipate security risk. He pointed to the floods and resulting humanitarian crisis in Pakistan during the summer of 2022 as a clear example of the need to understand future variability. From a meteorological perspective, Lall explained that the 2022 floods resulted from an earlier drought and weather conditions that allowed a tropical cyclone born in the Bay of Bengal to penetrate across the continent and generate record

[1] This list is the rapporteurs' summary of the points made by individual speakers, and the statements have not been endorsed or verified by the National Academies of Sciences, Engineering, and Medicine.

rainfalls in Pakistan and in northwestern India. He noted that, while this phenomenon has been relatively infrequent in those regions, it is a fairly common occurrence in northeastern India. An important question going forward, in his view, was whether a future state of the climate might shift these statistics so that intense rainfall events and flooding become more common in the northwest. Given the significant human and national security impacts of these disasters, he argued that conversations on climate change must shift away from their current focus on climate conditions in the mean—for example, a 1.5- or 2-degree warming—and much more toward understanding future climate variability—for example, the likelihood of extreme events.

Lall framed his presentation from a water conflict perspective and offered an analysis of the current security landscape in South Asia, using the 2022 Pakistan floods as a framing example. He also described the climate teleconnections linking observed and projected rainfall variability in the region to the evolution of the larger climate system. Finally, he considered the possibilities for water-related conflicts in the region in the future.

Lall shared a conceptual framework for understanding the interactions between natural and societal systems in South Asia and emergent conditions such as human and national security risks (Figure 4-1). He identified pathways to conflict that connect climate impacts on key environmental factors of concern, such as heatwaves and water cycle extremes, to the resultant environmental degradation, decreasing agricultural productivity, and loss of habitability that produce resource scarcity and drive human migration. At the same time, Lall noted that resource scarcity is also significantly influenced by population growth and urbanization, through pathways of economic growth, per capita consumption, and growing social inequity. He noted that the form and strength of governance constitutes a critical underlying condition affecting the evolution of security risks but is very heterogenous across the region. In both Pakistan and India, Lall noted that national adaptive capacity has been constrained by relatively large defense expenditures compared to public spending in infrastructure and food provision.

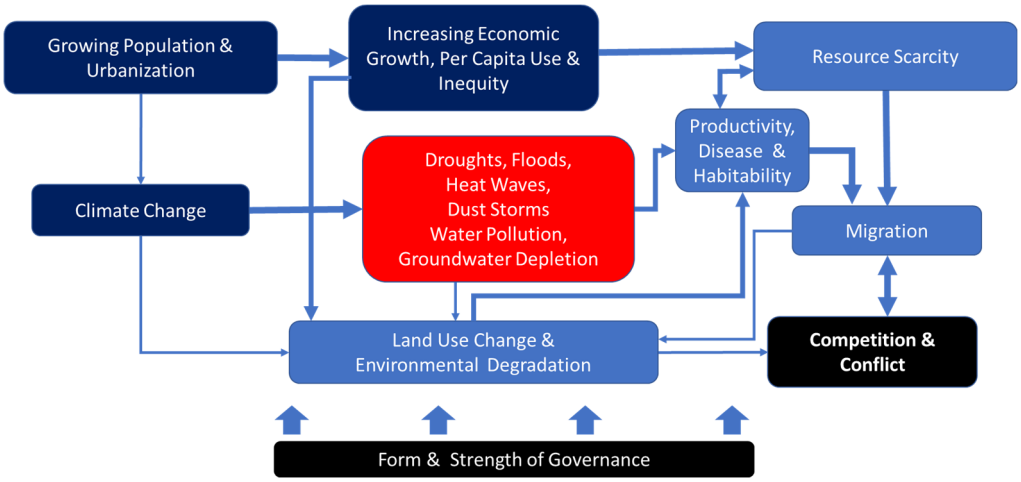

FIGURE 4-1. A conceptual framework for understanding the interactions between natural and societal systems in South Asia and emergent conditions such as human and national security risks. SOURCE: Adapted from Upmanu Lall workshop presentation, October 26, 2022.

Lall suggested that the 2022 Pakistan floods map strongly onto this conceptual framework and provide a view of a potential climate future. He recounted the immediate impacts of the disaster, including destruction of homes, infrastructure, and crops and livestock, along with water-borne disease outbreaks. These occurred against a backdrop of political instability and upheaval, in which multinational investment and governance capacity were both significantly reduced. He suggested that a plausible future for Pakistan, and the wider region, would be one of more persistent and intense climate extremes, with higher temperatures and rainfall, but also longer droughts. In addition, society will experience a number of worsening compounding challenges, including poverty, economic inequity, and extremism, all exacerbated by continued political instability.

Lall explained that South Asia is teleconnected to climate and societal variability elsewhere in the world. A particularly important climate teleconnection is the interannual oscillation between El Niño and La Niña conditions in the tropical Pacific Ocean, which imprints itself on temperature and precipitation patterns around the world. Lall noted that the 2022 Pakistan floods have been associated with the prevailing La Niña climate conditions at the time. In addition to the climate system, an important societal teleconnection occurs through the international economic system. Lall noted that 2005–2008 droughts in grain-producing regions of Eurasia led to significant increases in food prices globally and impacts in food-importing regions in sub-Saharan Africa and elsewhere.

Lall next considered how future climate impacts might translate into conflict in South Asia. As an example, he noted that the region experiences significant internal migration related to seasonal agricultural labor and also to urban growth. In this setting, climate shocks could destroy rural livelihoods, increase rural-to-urban migration, and intensify stresses on urban and peri-urban environments. If governments were unable to provide adequate services and cope with these changes, there would be a higher potential for radicalization or conflict. As another example, Lall noted that much of the water infrastructure in the region is more than 50 years old and susceptible to climate-related failures as water extremes intensify and become more frequent. Dam failures, in particular, would create disruptions in food production, energy generation, and transportation and supply chains. Droughts could also impact water access through groundwater depletion and constraints on thermoelectric energy production. Lall judged that the prospects for these conditions to manifest and produce unrest and conflict are quite high across the entire region.

Lall also considered the potential for interstate conflict in the region and identified two broad categories related to transboundary water conflicts. The first group of conflicts, involving India, Pakistan, and China, might occur through disputes over dams in the Indus River basin. The second group, involving India, Bangladesh, Nepal, and China, might occur through Chinese actions to dam or modify in some way the flow of the Brahmaputra River. Lall assessed that the potential for these conflicts is modest, and that concerns over transboundary waters have historically been resolved through conversation and cooperation. He acknowledged, though, that lack of transparency in agreements could lead to conflict.

Lall concluded by identifying his most critical water-related concern, which would be a succession of years of significant floods and droughts that disrupt lives and livelihoods and challenge socioeconomic recovery. In addition, he expressed concerns over increased migration and potential conflicts with receiving communities. He noted that concerns would be intensified during times of political instability and when global teleconnections, both natural and societal, would synchronize disruptions in South Asia with other regions.

DROUGHT AND FOOD SECURITY IN SOUTH ASIA

Mishra prefaced his remarks by noting that South Asia is characterized by a very high degree of both vulnerability and exposure to climate-related hazards, due largely to the region's high

population density, relatively low level of adaptive capacity, and relatively high number of climate hazards. He cited the high national and regional mortality rates in response to recent storms, floods, and droughts as evidence of the vulnerability of large, densely packed populations exposed to frequent and varied climate hazards. He also recalled the significant mortality and other adverse impacts of India's most recent heatwave, noting that the country simply had more heat for more people.

Against this backdrop Mishra reviewed the current understanding of key climate drivers and impacts in the region, focusing on food security and nutrition. He noted that South Asia's high level of climate exposure and vulnerability are likely to continue, given the most current Intergovernmental Panel on Climate Change (IPCC) projections for the region. For temperature, there is a very strong indication that the region will continue to warm on an annual and seasonal basis. For precipitation, although the projections are not as robust as for temperature, the majority of climate models indicate that precipitation will increase in the future, including during the key monsoon season. For variables linked to agriculture, such as soil moisture, the projections are mixed and point to an uncertain future. Mishra explained that the key impacts of projected climate change will stem from extreme events, including more frequent and intense heatwaves and droughts, and will occur in new locations where such extremes may not have been observed previously. In addition, compounding and cascading interactions between extreme events will amplify their impacts.

With respect to food security, Mishra explained that the most current Global Hunger Index scores conditions in the South Asia region as "serious." He noted that, relative to a decade ago, several important factors indicate a continuing regional vulnerability to climate change. The region has more undernourished people, with a sharp increase since 2020; has food prices at their highest-ever levels, despite a decrease earlier in the decade; and has more than double the number of conflicts. While the number of people living in extreme poverty has dropped steadily, the COVID-19 pandemic created an increase in 2020, for the first time this century. Mishra further noted that climate change is affecting food security mainly through water impacts, and that food security in the region is essentially a function of water availability. He shared his own recent research findings demonstrating that changes in food production in India over the past 70 years have been very tightly coupled to temperature and monsoonal precipitation and temperature, with higher grain yields associated with lower temperatures and more rainfall. Despite the fact that rainfall is projected to increase in India over the next century, Mishra explained that its interaction with concurrent warming would also create drought conditions that would continue to affect crop production and food security (Figure 4-2).

Mishra reviewed some of the key impacts from recent climate events that have affected agriculture and food production in South Asia and provided a glimpse into the region's future. Heatwaves in India and Pakistan in 2019 and the premonsoon heatwave across South Asia in 2022 both resulted in significant mortality and large numbers of hospitalizations, creating tremendous pressures on public health infrastructure. The heatwaves also produced record temperatures that were unprecedented in terms of magnitude as well their timing early in the year, with both overlapping with key crop growing seasons and lowering yields by 10–35%. Directly following the 2022 heatwave, devastating monsoon rains and flooding in Pakistan affected millions of acres of crops, killed hundreds of thousands of livestock, disrupted the lives and livelihoods of agrarian communities, and precipitated a national humanitarian and socioeconomic crisis. Mishra commented that the flooding serves as a canonical example of the types of events that are expected to occur with greater frequency in the future. Looking ahead, Mishra reviewed recent climate modeling research and projections for heatwaves and flooding in the region (see Mishra et al., 2017, 2020; IPCC, 2022). Heatwaves are expected to increase dramatically in their frequency, areal extent, duration, and the number of people exposed. River flooding is expected to increase in relation to increases in precipitation, which will come mostly in the form of extreme events rather than uniformly distributed

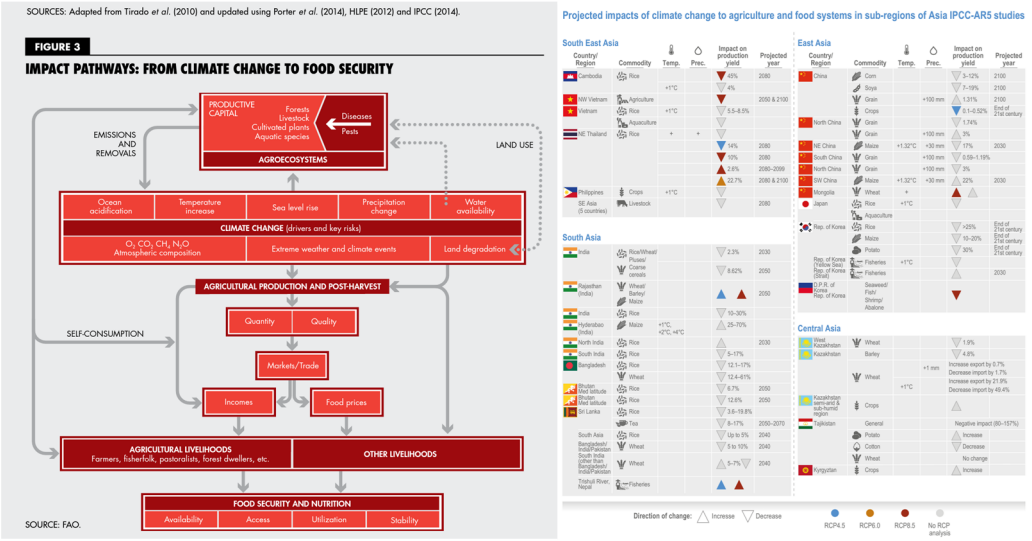

FIGURE 4-2. Impacts of climate change on agricultural and food systems, showing (left) cascading effects of climate change impacts on food security and nutrition and (right) projected impacts on agricultural yields, with the arrows indicating the direction of projected change in agricultural yield by the target year. SOURCES: (left) FAO, 2016; (right) Shaw et al., 2022.

rainfall across the season. Mishra explained that this would be due to a lower number of rainy days but greater rainfall on those days, which would create flooding.

Mishra concluded his remarks by sharing an IPCC summary assessment of the feasibility of different adaptation options for managing risks to food and water security (see IPCC, 2022). The response actions included improved water use efficiency and water management (assessed as medium feasibility), improved cropland management (medium feasibility), and efficient livestock systems (low feasibility). Mishra also noted several cross-cutting actions that were assessed as highly feasible. These include improved disaster risk management and development of climate services, including early warning systems. Mishra cautioned that no matter what adaptation actions society takes, the region will not entirely avoid the negative impacts of climate disasters.

HUMAN MOBILITY IN A CHANGING CLIMATE

In his remarks, Richter reflected on the complex and varied relationship between migration, the environment, and climate change, noting that environmental factors and climate change are rarely, if ever, the sole determinant of migration. He explained that environmental drivers are just one of many context-specific factors that influence human movement (Figure 4-3). He shared a theoretical framework for understanding how the contributions of demographic, economic, environmental, social, and political drivers can collectively shape human decisions to stay or move from a given place. Importantly, Richter noted that environmental change may also exert an influence on the other drivers. As an example, climate change may impact economic drivers of mobility such as employment opportunity, particularly in settings with environmentally sensitive industries like agriculture.

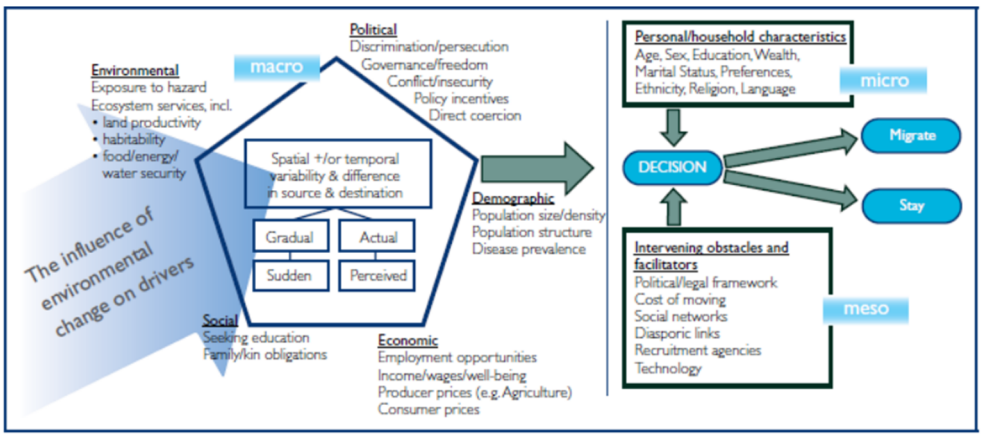

FIGURE 4-3. Human mobility in a complex world: a conceptual framework for the drivers of migration. SOURCE: Jarawura, 2021.

Richter noted that just as there are multiple drivers of climate mobility, there are also multiple forms this mobility can take. Disaster displacement, emergency evacuation, and planned relocation are forms of climate mobility that generally result from decisions to avoid impending hazards but which can involve very different degrees of agency and empowerment of the people that are moving. By contrast, transhumance[2] and migration are examples of established patterns of mobility that can be reshaped and/or disrupted by climate change. Richter described a similarly diverse set of possibilities for the distances and durations people will ultimately move, noting that most human mobility in the context of climate change takes place within countries. He noted that the motivations and decision processes of people who are displaced, evacuating, relocating, or migrating are very distinct and highly context specific. Given the diversity of climate mobility drivers, forms, and outcomes, Richter argued that the policy approaches developed by the security community should also be tailored to specific contexts.

Turning his attention to South Asia, Richter offered an assessment of the magnitude of human mobility in the region. With respect to cross-border migration, he noted that South Asia is a significant migration region, with India being the top migrant origin country in 2020. With respect to displacement, he noted that the South Asia region accounted for the second largest share of disaster displacement globally in 2021, with 5.25 million people forced to leave their homes due to sudden onset hazards. Over the preceding decade, this number aggregates to more than 60 million people displaced internally within the region, with India accounting for more than 40 million (IDMC, 2022).

Richter turned to the question of how human mobility might evolve in the future in South Asia. He first acknowledged the difficulties of building scenarios for human mobility, especially in the context of climate change. Given the diversity of mobility drivers, forms, and outcomes, it would be extremely challenging to estimate future patterns of climate mobility accurately—particularly as the climate state itself is changing. He noted that several previous efforts have attempted to quantify the potential future scale of human mobility linked to climate change, but that many of

[2] Transhumance refers to the regular movements of livestock between seasonal pastures and, by extension, to the movements of people who tend the livestock. Transhumance is a form of pastoralism or nomadism.

those analyses utilized oversimplified methodologies and did not adequately account for the diverse factors that drive migration. Long-standing challenges related to data availability and quality are also significant barriers. Richter noted, however, that methodologies have become more sophisticated over time. He highlighted that while significant gaps persist, efforts to improve data availability are continuing. IOM, for example, holds the largest global repository of displacement data. Richter also expressed optimism regarding several new tools that can help researchers gain deeper insights into migration. These include early warning systems, model-based forecasts, survey-based forecasts, and foresight frameworks that have taken on an increasingly important space in humanitarian and development programming and policymaking. With respect to forecasting displacement, Richter noted that other approaches are helping to identify risk "hotspots" for disaster displacement, using standard hazard-exposure-vulnerability frameworks. These types of analysis indicate that displacement risk has quadrupled since the 1970s, an increase he attributed to factors including rapid, unplanned urbanization and development in hazard-prone areas of developing countries.

Richter considered the question of how climate-related human mobility might undermine security conditions in South Asia. From his perspective, the key area of concern is the risk that climate impacts pose to human security, since it is well understood that the poorest and most disadvantaged households and individuals are disproportionately impacted by climate risks. Each person experiences human mobility differently and faces different risks, so human-centered solutions are essential. Richter commented on linkages to conflict, noting that security discussions often focus on the relationship between climate change, migration, and conflict. He explained that the connection is usually grounded in a few different scenarios, generally involving resource stress, disputes, tensions, and ultimately conflict. Depending on the scenario, the displacement may drive resource stress or be engendered by it. In some other scenarios, displaced people in fragile settings become vulnerable to recruitment or victimization by armed groups. Richter explained that while there is robust evidence linking climate impacts to resource stress and disasters, the evidence for a general link between climate impacts, migration, and conflict is less conclusive, and indicates that the linkages are indirect and somewhat context dependent. In a similar vein, Richter commented that widely discussed linkages between climate impacts, migration, and human trafficking are largely based on anecdotal evidence and that more research and evidence is needed on this particular topic.

Richter concluded his remarks by addressing the need for a holistic response to climate mobility. He noted that IOM has identified a set of key actions for the international community that are based on three pillars. The first is to look to migration as a positive adaptation strategy that can take people out of harm's way, and for governments to create conditions for safe, orderly, and regular passage of climate migrants. The second is to create climate solutions for people already on the move or who have been displaced, and to find ways to assist and protect them from climate risk. The third element would be to look for solutions that allow people to stay in their communities if they want to, and to build resilience and address adverse environmental drivers so that migration becomes a choice and not a necessity.

PARTICIPANT DISCUSSIONS

Workshop participants broke out into three smaller, structured discussions intended to advance a "systems" understanding of the scenarios explored by the expert panel. Each group selected one or more of the case studies, or agreed to explore a new one, and received some organizing prompts for their discussion:

- *"Gaming out" a scenario:* What are plausible pathways for security risks to continue evolving into the future? What external influences, underlying conditions, and systems interactions could shape that evolution?
- *Prioritizing climate security risks:* What are the most pressing current and emerging climate security risk pathways in the South Asia region? What analytic capabilities and capacities are needed to anticipate these risks? What data, information, and understandings are most urgently required?

After the breakout sessions, participants from each group (A, B, and C) reconvened in plenary to reflect on and synthesize the key points from their discussions.

The group discussions explored multiple current and anticipated security risks in South Asia arising from physical climate hazards, such as heatwaves, droughts, and flooding, as well as climate-driven societal transitions, such as rapid decarbonization. Collectively, the groups described climate-related risks to food, water, and energy security; human health; and livelihoods. In addition, Group C discussed four major risk categories reflecting U.S. security interests in the region. These include geopolitical security, global health, economic security, and domestic security.

In plenary, participants discussed some of the key challenges related to understanding how these risks could interact with each other and scale relative to each other. A representative from Group A noted that their discussion had explored the nonlinear behavior of impacts resulting from successive or overlapping events involving, for example, sequential floods or simultaneous heatwaves and droughts. A representative from Group B shared that their discussion considered the question of how to prioritize different risks relative to each other, and what information was needed to make the prioritization. Ultimately, the group chose to apply the IPCC's framework for assessing severity of a given climate risk, based on evaluation of its magnitude, likelihood, temporal behavior, and the societal ability to respond to that risk.

With respect to the climate and security risk pathways in the region, all of the groups recognized that risks will involve multiple interactions between natural systems and societal systems such as food, energy, water, finance, and governance. The groups also noted the critical influence that social cohesion and strong institutions have in modulating the evolution of risk. Group C's discussion also highlighted that significant risk pathways may involve slow-onset climate impacts, not just sudden onset events, and may involve unprecedented or previously unknown impacts.

5
Tools for Analysis and Forecasting

Highlights from Panel Discussion[1]

- Based on a scenario development process that produced three plausible futures at the climate–migration–development nexus, the number of migrants, globally and in the South Asia region, is expected to increase by 2050. The degree of increase will depend on the particular emissions and development trajectories the world and the region follow.
- Impact-based forecasting is a new way of framing weather forecasts from a risk perspective that examines the overlap of hazards, vulnerability, and exposure to produce risk. This approach moves away from forecasting what the weather will be to what it will do—in order to anticipate the impacts and support preparation and response efforts. A particular challenge for impact-based forecasting is how to manage compounding and cascading climate and weather events.

A panel of invited experts shared their perspectives and engaged workshop participants on the tools for analysis and forecasting that are currently available and what is missing for the South Asian context and beyond. Dr. Kanta Kumari Rigaud, of the World Bank, provided an environmental management and climate adaptation perspective on "Plausible Climate Migration Scenarios: Harnessing Data, Models, and Simulations." Dr. Erin Coughlan de Perez, at Tufts University, offered a climate risk management perspective on "Impact-Based Forecasting." Dr. Kathy Pegion, at the University of Oklahoma, shared her perspectives on "Tools for Climate Predictions and Projections." Workshop planning committee member Dr. Virginia Burkett, of the U.S. Geological Survey, moderated the panel and facilitated a plenary discussion.

PLAUSIBLE CLIMATE MIGRATION SCENARIOS

Rigaud presented findings from recent work at the World Bank to develop scenarios for global climate migration in 2050. The effort was motivated by her earlier research showing that without concrete international action to address climate and development priorities, climate impacts by the mid-century could lead more than 216 million people across six global regions to migrate within their own countries (Clement et al., 2021). Her latest work was intended to support a constructive dialogue that could drive informed policies and actions at global and national levels to address the drivers of climate migration.

Rigaud described the scenario development process, which produced three plausible futures at the climate–migration–development nexus: a "pessimistic" reference case, in which emissions were high and development was unequal, and two more cases identical to the reference except with either a lower emission (i.e., climate friendly) or more inclusive development pathway (Figure 5-1). Rigaud described four basic questions the scenarios were intended to explore: how many climate migrants there might be by mid-century, where potential hotspots of movement might occur, the extent to which different climate futures would drive mobility, and the implications for medium- and longer-term development planning.

[1] This list is the rapporteurs' summary of the points made by individual speakers, and the statements have not been endorsed or verified by the National Academies of Sciences, Engineering, and Medicine.

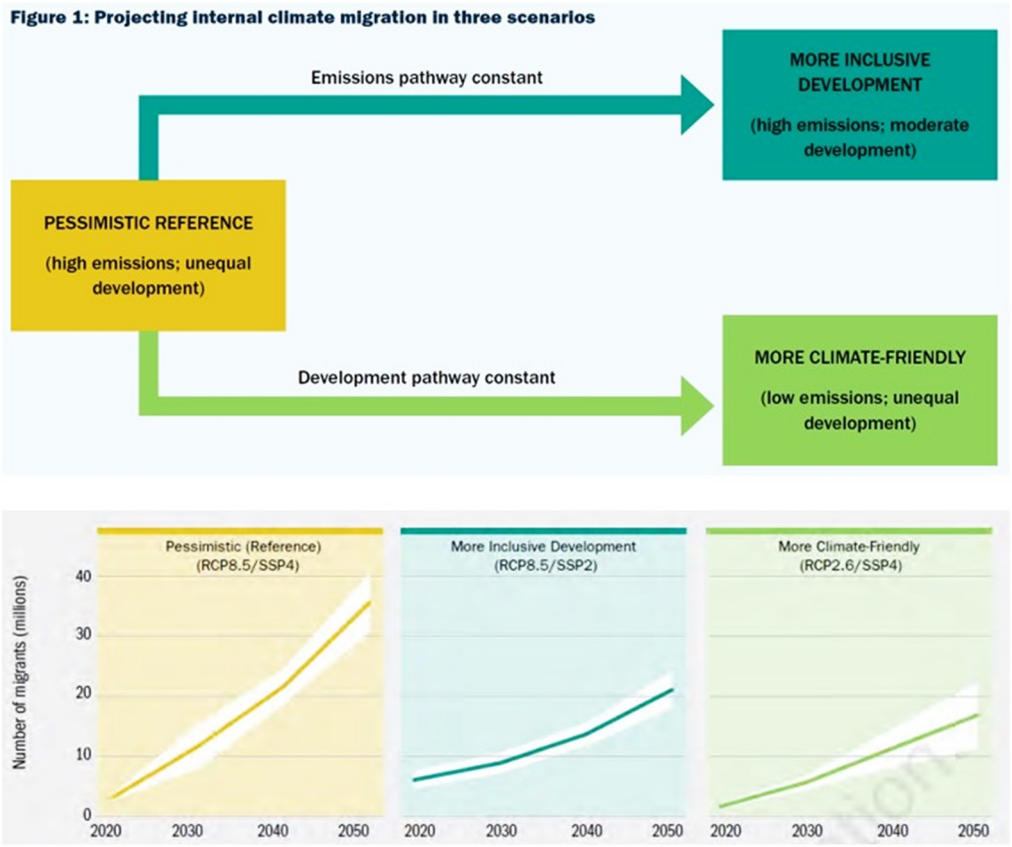

FIGURE 5-1. Modeling of potential futures for internal migration in South Asia. (top) The futures are described using three scenarios—a pessimistic reference case, a pathway emphasizing more inclusive socioeconomic development, and a pathway emphasizing climate mitigation—and (bottom) the projected number of internal climate migrants in South Asia in the three scenarios, 2020–2050. The dark lines represent the average of four separate model runs for each scenario, and the white envelopes represent the distribution of model runs around the average. SOURCE: Clement et al., 2021.

Rigaud shared the main takeaway messages from the study. With respect to total global numbers of climate migrants, the scenarios return a range of values: 44 million people under the climate-friendly pathway, to 216 million under the reference pathway. At the regional level, time series of total migrants show that the climate migration trajectory ramps up to 2050 virtually everywhere, with the steepest increases associated with the pessimistic scenario. In South Asia, Rigaud pointed out a sixfold increase in the number of total migrants. She noted that a window of opportunity exists early on to bend these curves, but that it is closing quickly. With respect to climate migration hotspots, the study indicated substantial heterogeneity over time, with some hotspots emerging as early as 2030 and spreading by 2050, and also across geographies, with hotspots clustering in subregions prone to climate hazards, particularly Bangladesh in the northeast (Clement et al., 2021).

Rigaud concluded her remarks by noting four key areas for action at the intersection of climate, migration, and development. They include dropping global GHG emissions to reduce the climate pressures that drive migration; integrating climate migration into far-sighted green, resilient, and inclusive development planning; planning for each phase of migration—before, during, and after—to ensure positive adaptation and development outcomes; and investing in understanding the drivers of climate migration. She reiterated that the window of opportunity to act is still open but not for long.

IMPACT-BASED FORECASTING

Coughlan de Perez offered a perspective focusing on shorter-term timescales and the forecasting approaches that can anticipate impacts from weather and climate events, as well as support humanitarian efforts. This forecasting addresses basic questions around what conditions public service providers, humanitarian organizations, and others can anticipate in the short term, and what actions can be taken ahead of a particular event. Coughlan de Perez described different technical approaches to answer these questions, focusing her attention on impacts more related to national security and conflict.

Coughlan de Perez described impact-based forecasting as a new way of framing weather forecasts from a risk perspective that examines the overlap of hazards, vulnerability, and exposure to produce risk. She explained that an impacts-based approach moves away from forecasting what the weather will be to what it will do—for example, where a flood is expected to inundate roads and homes and where emergency supplies can be pre-positioned. She provided examples of impacts-based forecasting efforts around the world that are providing this kind of detailed information to communities before they experience hazards. These include a UK Met Office effort to create national maps showing the expected locations of specific types of storm damage, and a partnership between the Mongolian Red Cross and government to develop a forecast-based financing system to identify vulnerable populations ahead of the winter season and provide assistance.

Coughlan de Perez also shared her perspectives on the future directions of impact-based forecasting, noting that compounding and cascading climate and weather events pose a particular challenge. She shared a typology of these events, identifying four general cases where the forecasting community needs to focus attention (adapted in Table 5-1). One type is preconditioned events, where an initial driver creates conditions that magnify impacts from a subsequent driver, such as when snowfall creates a snow-covered surface on which a subsequent heavy rainfall could produce greater flooding. A second type is multivariate events, where a modulating factor creates multiple drivers and/or hazards, such as when a La Niña event creates droughts and heatwaves. A third type is temporally compounding events involving sequential drivers in the same location, such as when repeated heavy rainfall events produce flooding. A fourth type is spatially compounding events, where a single modulating factor creates drivers and impacts in multiple regions at the same time, such as when an El Niño event leads to globally synchronized crop failures.

Coughlan de Perez pointed out the particular challenge that unprecedented extremes pose for the impact-based forecasting community. She posed the question of how to approach communities and talk about impacts that have never occurred in those locations. She noted that there is an opportunity to use some of the novel techniques employed in the climate world, including the use of storylines and scenarios to explore possible and plausible future conditions.

Considering the potential applications of impact-based forecasting in the security space, Coughlan de Perez concluded her remarks with a cautionary note about how pathways to impact may integrate assumptions that are not fully interrogated. She cited the war in Syria as a case where

TABLE 5-1 Typology of Compound Weather and Climate Events

Compound Event Themes	Description	Example
Preconditioned	An initial driver creates conditions that magnify impacts from a subsequent driver.	Heavy rainfall after a drought leads to greater flood damage.
Multivariate	A modulating factor creates multiple drivers and/or hazards leading to an impact.	La Niña conditions create concurrent droughts and heatwaves leading to agricultural losses.
Temporally compounding	A modulating factor creates a succession of hazards in a single place, leading to an impact.	Atmospheric conditions produce repeated heavy rainfall events leading to greater flood damage.
Spatially compounding	A modulating factor creates multiple, concurrent hazards in different regions, leading to a distributed, aggregated impact.	El Niño conditions lead to droughts in multiple places, leading to distributed crop failures.

a dominant view of the climate–conflict connection involved a pathway between drought and conflict that may have crowded out some alternative pathways that might be better supported by evidence. As an example, she cited recent research suggesting that societal drought vulnerability and the Syrian climate–conflict nexus are better explained by agriculture than meteorology.

TOOLS FOR CLIMATE PREDICTIONS AND PROJECTIONS

In her remarks, Pegion described the tools used to develop predictions and projections within the weather and climate community. She noted that the weather and climate variability of concern for security questions exists on a continuum that extends from timescales of days and weeks to multi-decadal and centennial scales. In the shorter term, weekly and subseasonal events include floods and droughts, while seasonal timescales can include major shifts in temperature and rainfall. On interannual timescales, variability includes the well-known impacts of the El Niño and La Niña events. Beyond that, climate system variability on multi-decadal and centennial scales involves the longer-term trends in temperature, precipitation, and sea-level rise that are part of the IPCC's discussions. Pegion noted that the research community is often stratified along these different timescales but emphasized that variability can be highly interrelated across scales. She noted that a seasonal prediction does not exclude climate impacts, since climate impacts can occur on seasonal timescales.

Pegion noted that a fundamental feature of climate predictions and projections is that their quality decreases as timescales increase. She led the audience through the series of projects within the weather and climate community, each of which grapples with this challenge within their particular range of concerns (Figure 5-2). She shared examples that the types of forecasting products produced in each range and discussed where predictive skill has been demonstrated and where it has not. Focusing on South Asia, she noted that multiyear predictive skill is not consistent across the region, and that it should be a key area for further exploration. Pegion concluded her remarks by evaluating the current data products from the various weather and climate projects. On subseasonal and seasonal timescales, the datasets are operational and able to be utilized in real time to make predictions.

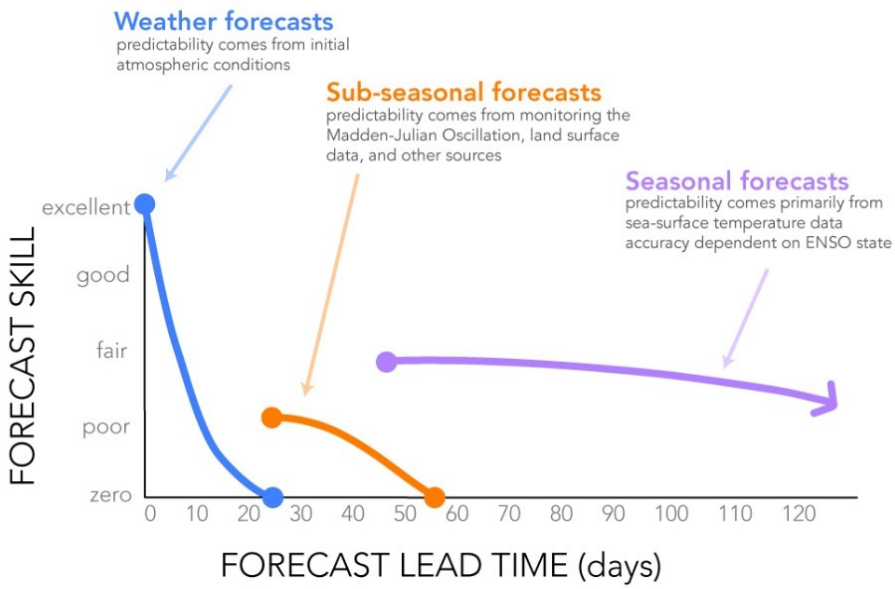

FIGURE 5-2. A qualitative estimate of skill against timescales, from weather forecasts to seasonal, interannual, and multi-decadal predictions to long-term projections. Each category includes a list of the main sources of predictability for variability on those timescales. SOURCE: Gawthrop, 2015.

6
Reflecting on Climate Security Risk in South Asia

Highlights[1]

- Societal transitions, both planned and unplanned, occurring in response to climate risks are an important driver of risk themselves. For instance, policy actions to mitigate GHG emissions and decarbonize societal sectors may create political conflict.
- Risk pathways involving the impacts of climate hazards on livelihoods and community structures are particularly relevant to security analysis. In particular, the cascading impacts from humanitarian disasters are a concern, since they can push vulnerable people into "problematic pathways" involving isolation, alienation, radicalization, and/or mental illness.
- With respect to radicalization, the disproportionate climate vulnerability of groups that are already poorly served and marginalized by the general society creates added risk for their recruitment into violent extremist organizations.
- A key area for security analysis is the development of datasets, tools, and techniques that are tailored to the South Asian context. For example, measuring morbidity rather than mortality in relation to cyclone impacts may be more valuable for assessing the security implications of the disaster.

A central aim of the workshop, as expressed in its Statement of Task (Box 1-4), was to advance an integrative systems understanding of climate change and security in South Asia. Over the two days of the workshop, participants examined important underlying conditions and external factors influencing climate-related security risk; key internal systems, entities, and linkages that determine the pathways leading to climate-related security problems; and critical analytic capacity and capabilities to analyze climate security in the region.

EXAMPLES OF KEY ELEMENTS OF A SYSTEMS FRAMEWORK FOR CLIMATE SECURITY IN SOUTH ASIA

At the outset of the workshop, participants were introduced to a conceptual framework, previously developed by the CSRT, that comprises two key sets of factors that shape the evolution of climate-related security risk in a given setting (Figure 1-4). These include *external influences and stressors* that act from outside of the setting and the *network interactions* between the interconnected and interdependent systems and sectors within the setting. The discussions among workshop participants highlighted many examples of these key elements for South Asia (Figure 6-1).

With respect to the external influences and stressors that are most relevant to climate-related security risk in South Asian contexts, the discussions highlighted a range of environmental and non-environmental factors. The following list describes some of the main perspectives from participant discussions during the workshop:

[1] This list is the rapporteurs' summary of the points made by individual speakers, and the statements have not been endorsed or verified by the National Academies of Sciences, Engineering, and Medicine.

- Environmental drivers of security risk in the region include climate change, ecosystem disruption, and pollution. Climate-related stressors that are most relevant to South Asia include extreme heat, drought, extreme precipitation, floods, and sea-level rise.
- Non-environmental drivers of security risk in the region include the influence of international economic and geopolitical processes, as well as of underlying demographic and socioeconomic conditions. Examples of economic and political influences that are most relevant to South Asia include China's domestic and foreign policy actions, particularly related to climate and energy, and the potential trade-offs between global policies for decarbonization and sustainable development. Examples of relevant underlying conditions include ongoing population growth, urbanization, and technological transitions, as well as existing political, religious, and communal tensions in the region.
- Natural and societal teleconnections link variability within the region to changes occurring elsewhere in the world. As an example of a natural teleconnection, the impacts of climate-related stressors in South Asia are strongly modulated by global modes of climate variability—in particular, the interannual oscillations between El Niño and La Niña climate states. As an example of a societal teleconnection, prices for food and fuel in South Asia have been strongly impacted by the disruptions in global commodity markets and supply chains caused by political shocks such as the war in Ukraine.

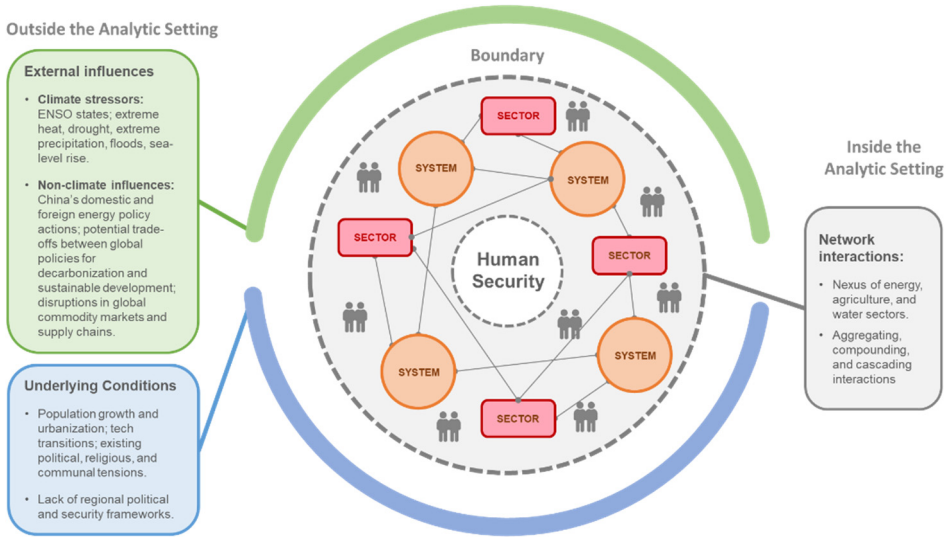

FIGURE 6-1. CSRT conceptual framework introduced in Chapter 1 (see Figure 1-4) populated with information specific to the South Asia region.

With respect to the key network interactions within the South Asia region, workshop discussions highlighted the complex interdependence between infrastructure, governance, and socioeconomic systems, as well as between specific societal sectors in the region.

- The nexus of energy, agriculture, and water sectors, in particular, can play a critical role in shaping the evolution of climate-related security risk in South Asia. As an example,

an energy transition that emphasizes biofuels would be expected to have large implications for food and water security in the region, through the potential displacement of food crops and increased agricultural demands on water resources.

- Aggregating, compounding, and cascading interactions between individual climate-related risks can further increase the overall risk to society from climate change. As an example, concurrent storm damage in urban and rural settings could produce an influx of migrants into cities, searching for new livelihoods, just as the urban centers no longer have adequate infrastructure to support those livelihoods. At the same time, loss of power, communications, and work in cities could reduce people's ability to provide remittances to family in the country, undercutting an important line of support for rural communities.

EXAMPLES OF HIGH-PRIORITY CLIMATE SECURITY THREATS IN SOUTH ASIA

During the workshop, participants explored pressing threats and security risk pathways in the region. The following list describes some of the major themes that surfaced during those discussions:

- Societal transitions, both planned and unplanned, occurring in response to climate risks are an important driver of risk themselves. For instance, policy actions to mitigate GHG emissions and decarbonize societal sectors may create political conflict. As an example, one participant noted that Chinese commitments to reduce GHG emissions have spurred development of domestic hydroelectric power generation capacity, including along the Brahmaputra (Tsangpo) River, which has produced tensions with India. In addition, another participant noted that India's own commitments to renewable energy generation, particularly through land-intensive solar energy developments, have created disputes between federal and local authorities.
- Risk pathways involving the impacts of climate hazards on livelihoods and community structures are particularly relevant to security analysis. In particular, the cascading impacts from humanitarian disasters are a concern, since they can push vulnerable people into "problematic pathways" involving isolation, alienation, radicalization, and/or mental illness. As an example, multiple participants noted that the communities affected by the 2022 floods in Pakistan were not just displaced from their homes but also experienced significant livelihood and educational disruptions. In the absence of strong social and governance structures, the potential has risen for victimization by, or recruitment into, terrorist and extremist organizations. Another participant noted that mistrust in public institutions combined with government failures to provide adequate emergency services have enabled alternative narratives to unfold around the disaster—in some cases through stories that the floods were caused by deliberate actions to release flood waters in the Indus River basin by upstream actors.

PARTICIPANT IDEAS FOR ANALYTICAL NEEDS

A running theme of workshop discussions concerned examples of the basic analytical needs for an integrative analysis of climate security in South Asia. The following list describes a few of the themes that surfaced during those discussions:

- A key area for security analysis is the development of datasets, tools, and techniques that are tailored to the South Asia setting. One participant emphasized the importance of analyses that describe the social environment—for example, through social network data—or detect or anticipate rare events—for example, through artificial intelligence and machine learning approaches. Multiple participants emphasized the need for analyses to integrate data and information at the subnational, local, and granular levels—including, in particular, spatially explicit data for describing the flow of people at fine temporal scales.
- Indicators and early warnings involve measurement of appropriate variables. Multiple participants noted that how climate impacts are measured can affect decisionmakers' understanding of their security implications. As an example, multiple participants noted that measuring morbidity rather than mortality in relation to a cyclone may be more valuable for assessing the security implications of the disaster.

References

Alam, S. S., Huq, S., Islam, F., and Hoque, H. M. A. 2018. Building Climate-Resilient, Migrant-Friendly Cities and Towns. Policy Brief, International Centre for Climate Change and Development. https://www.icccad.net/wp-content/uploads/2018/10/Policy-Brief-on-Climate-Migration-and-Cities.pdf.

Birkmann, J., Jamshed, A., McMillan, J. M., Feldmeyer, D., Totin, E., Solecki, W., Zaiton Ibrahim, Z., Roberts, D., Bezner Kerr, R., Poertner, H.-O., Pelling, M., Djalante, R., Garschagen, M., Leal Filho, W., Guha-Sapir, D., and Alegría, A. 2022. Understanding human vulnerability to climate change: A global perspective on index validation for adaptation planning. *Science of the Total Environment*, 803. https://doi.org/10.1016/j.scitotenv.2021.150065.

Cissé, G., McLeman, R., Adams, H., Aldunce, P., Bowen, K., Campbell-Lendrum, D., Clayton, S., Ebi, K. L., Hess, J., Huang, C., Liu, Q., McGregor, G., Semenza, J., and Tirado, M. C. 2022. Health, wellbeing, and the changing structure of communities. In *Climate Change 2022: Impacts, Adaptation and Vulnerability* (pp. 1041–1170). Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, and B. Rama (eds.)]. Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/9781009325844.009.

Clement, V., Rigaud, K. K., de Sherbinin, A., Jones, B., Adamo, S., Schewe, J., Sadiq, N., and Shabahat, E. 2021. *Groundswell Part 2: Acting on Internal Climate Migration*. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/36248.

Creutzig, F., Roy, J., Devine-Wright, P., Díaz-José, J., Geels, F. W., Grubler, A., Maïzi, N., Masanet, E., Mulugetta, Y., Onyige, C. D., Perkins, P. E., Sanches-Pereira, A., and Weber, E. U. 2022. Demand, services and social aspects of mitigation. In *IPCC, 2022: Climate Change 2022: Mitigation of Climate Change*. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P. R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, and J. Malley (eds.)]. Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/9781009157926.

Ellis, P., and Roberts, M. 2016. *Leveraging Urbanization in South Asia: Managing Spatial Transformation for Prosperity and Livability*. Washington, DC: World Bank. https://openknowledge.worldbank.org/entities/publication/f1ba8d07-e6d1-5b8e-8a16-899838f1c884.

FAO (Food and Agricultural Organization of the United Nations). 2016. Climate Change and Food Security: Risks and Responses. Prepared by V. Gitz, A. Meybeck, L. Lipper, C. De Young, and S. Braatz. Rome, Italy: FAO.

Gawthrop, E. 2015, July 1. Q&A: Subseasonal Prediction Project. International Research Institute for Climate and Society, Columbia Climate School. https://iri.columbia.edu/news/qa-subseasonal-prediction-project/.

GRID-Arendal. 2015. The Himalayan Climate and Water Atlas, produced by R. Pravettoni. https://www.grida.no/resources/6703.

Hafeez, E., and Faseeh, S. 2018. Growing population of Pakistani youth: A ticking time bomb or a demographic dividend. *Journal of Education and Educational Development*, 5. https://doi.org/10.22555/joeed.v5i2.2022.

IDMC (Internal Displacement Monitoring Centre). 2022. Global Report on Internal Displacement 2022. https://www.internal-displacement.org/publications/2022-global-report-on-internal-displacement

IPCC (Intergovernmental Panel on Climate Change). 2022. Summary for policymakers [H.-O. Pörtner, D. C. Roberts, E. S. Poloczanska, K. Mintenbeck, M. Tignor, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, and A. Okem (eds.)]. In *Climate Change 2022: Impacts, Adaptation and Vulnerability* (pp. 3–33). Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, and B. Rama (eds.)]. Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/9781009325844.001.

Jarawura, F. X. 2021. Dynamics of drought-related migration among five villages in the savannah of Ghana. *Ghana Journal of Geography*, 13(1):103–125.

Khan, M. R., Chowdhury, M., and Huq, S. 2021. Climate-Resilient Migrant-Friendly Towns: A Conceptual Framework. Policy Brief, International Centre for Climate Change and Development. https://www.icccad.net/wp-content/uploads/2022/01/pb-crmft-final.pdf.

Mishra, V., Mukherjee, S., Kumar, R., and Stone, D. A. 2017. Heat wave exposure in India in current, 1.5°C, and 2.0°C worlds. *Environmental Research Letters,* 12(12):124012.

Mishra, V., Kaustubh, T., Sing, D., and Saran, A. 2020. Future exacerbation of hot and dry summer monsoon extremes in India. *NPJ Climate and Atmospheric Science*, 3(1).

NASEM (National Academies of Sciences, Engineering, and Medicine). 2021. *Global Change Research Needs and Opportunities for 2022-2031*. Washington, DC: The National Academies Press. https://doi.org/10.17226/26055.

NIC (National Intelligence Council). 2021a. Global Trends 2040: A More Contested World. Technical Report NIC 2021-02339. Washington, DC. https://www.dni.gov/files/ODNI/documents/assessments/GlobalTrends_2040.pdf.

NIC. 2021b. Climate Change and International Responses Increasing Challenges to US National Security Through 2040. National Intelligence Estimate NIC-NIE-2021-10030-A. Washington, DC. https://www.dni.gov/files/ODNI/documents/assessments/NIE_Climate_Change_and_National_Security.pdf.

NRC (National Research Council). 2012. *Himalayan Glaciers: Climate Change, Water Resources, and Water Security.* Washington, DC: The National Academies Press. https://doi.org/10.17226/13449.

O'Neill, B., van Aalst, M., Zaiton Ibrahim, Z., Berrang Ford, L., Bhadwal, S., Buhaug, H., Diaz, D., Frieler, K., Garschagen, M., Magnan, A., Midgley, G., Mirzabaev, A., Thomas, A., and Warren, R. 2022. Key risks across sectors and regions. In *Climate Change 2022: Impacts, Adaptation and Vulnerability* (pp. 2411–2538). Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, and B. Rama (eds.)]. Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/9781009325844.025.

Reed, P., Hadjimichael, A., Moss, R., Monier, E., Alba, S., Brelsford, C., Burleyson, C., Cohen, S., Dyreson, A., Gold, D., Gupta, R., Keller, K., Konar, M., Macknick, J., Morris, J., Srikrishnan, V., Voisin, N., and Yoon, J. 2022. MultiSector Dynamics: Scientific Challenges and a Research Vision for 2030, A Community of Practice Supported by the United States Department of Energy's Office of Science. https://doi.org/10.5281/zenodo.5825889.

Reisinger, A., Garschagen, M., Mach, K. J., Pathak, M., Poloczanska, E., van Aalst, M., Ruane, A. C., Hoden, M., Hurlber, M., Mintenbeck, K., Pedace, R., Rojas Corradi, M., Viner, D., Vera, C., Kreibiehl, S., O'Neill, B., Pörtner, H.-O., Sillmann, J., Jones, R., and Ranasinghe, R.

2020. *The Concept of Risk in the IPCC Sixth Assessment Report: A Summary of Cross-Working Group Discussions: Guidance for IPCC Authors*. Intergovernmental Panel on Climate Change.

Rigaud, K. K., Sherbinin, A., Jones, B., Bergmann, J., Clement, V., Ober, K., Schewe, J., Adamo, S. B., McCusker, B., Heuser, S., and Midgley, A. 2018. *Groundswell: Preparing for Internal Climate Migration*. Washington, DC: World Bank. https://doi.org/10.1596/29461.

Salikuddin, T., and Siddiqui, J. 2022. Pakistan's Deadly Floods Come Amid Deluge of Crises. Analysis and Commentary. United States Institute of Peace. https://www.usip.org/publications/2022/09/pakistans-deadly-floods-come-amid-deluge-crises.

Shaw, R., Luo, Y., Cheong, T. S., Abdul Halim, S., Chaturvedi, S., Hashizume, M., Insarov, G. E., Ishikawa, Y., Jafari, M., Kitoh, A., Pulhin, J., Singh, C., Vasant, K., and Zhang, Z. 2022. Asia. In *Climate Change 2022: Impacts, Adaptation and Vulnerability* (pp. 1457–1579). Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, and B. Rama (eds.)]. Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/9781009325844.012.

Shidore, S. 2020. Climate Change and the India-Pakistan Rivalry. The Council on Strategic Risks Briefer No. 4. Washington, DC. https://councilonstrategicrisks.org/wp-content/uploads/2020/02/ShidoreJan23ClimatePakistan.pdf.

Shidore, S., Naegele, A., Baillargeon, N., Fleishmann, R., Holland, M., and Schwalm, C. 2021. Melting Mountains, Mounting Tensions: Climate Change and the India-China Rivalry. Report. The Council on Strategic Risks, and Woodwell Climate Research Center. https://councilonstrategicrisks.org/wp-content/uploads/2021/06/Melting-Mountains-Mounting-Tensions_Climate-Change-and-the-India-China-Rivalry_2021_05_13.pdf.

Simpson, N. P., Mach, K. J., Constable, A., Hess, J., Hogarth, R., Howden, M., Lawrence, J., Lempert, R. J., Muccione, V., Machey, B., New, M. G., O'Neill, B., Otto, F., Pörtner, H.-O., Reisinger, A., Roberts, D., Schmidt, D. N., Seneviratne, S., Strongin, S., van Aalst, M., Totin, E., and Trisos, C. H. 2021. A framework for complex climate change risk assessment. *One Earth*, 4(4):489–501. https://doi.org/10.1016/j.oneear.2021.03.005.

USGCRP (U.S. Global Change Research Program). 2018. *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [D. R. Reidmiller, C. W. Avery, D. R. Easterling, K. E. Kunkel, K. L. M. Lewis, T. K. Maycock, and B. C. Stewart (eds.)]. Washington, DC: U.S. Global Change Research Program. https://doi.org/10.7930/NCA4.2018.

Wester, P., Mishra, A., Mukherji, A., and Shrestha, A. B. 2019. *The Hindu Kush Himalaya Assessment—Mountains, Climate Change, Sustainability and People*. Cham: Springer Nature Switzerland AG. https://doi.org/10.1007/978-3-319-92288-1.

Zscheischler, J., Martius, O., Westra, S., Bevacqua, E., Raymond, C., Horton, R. M., van den Hurk, B., AghaKouchak, A., Jézéquel, A., Mahecha, M. D., Maraun, D., Ramos, A. M., Ridder, N. N., Thiery, W., and Vignotto, E. 2020. A typology of compound weather and climate events. *Nature Reviews Earth & Environment*, 1:333–347. https://doi.org/10.1038/s43017-020-0060-z.

Appendix A
National Academies Climate Security Roundtable

In 2020, the U.S. Congress created an interagency Climate Security Advisory Council (CSAC) to deepen collaboration and bridge organizational boundaries between federal agencies on climate security issues. The CSAC is chaired by the Office of the Director of National Intelligence (ODNI) and convenes senior officials from intelligence agencies and federal science agencies to better understand and anticipate the ways climate change affects U.S. national security interests.

The following year, in 2021, Congress directed ODNI and the National Academies of Sciences, Engineering, and Medicine to work together to establish a Climate Security Roundtable (CSRT or Roundtable) as a platform for federal officials to engage a much larger community of climate experts outside of government (see Box A-1). The Roundtable convenes volunteer members drawn from academia, the private sector, and civil society to support the U.S. Intelligence Community in leveraging expertise and capabilities outside of the federal government and to better inform national security assessments. The Roundtable also includes the CSAC officials as members ex officio. At the direction of Congress, the National Academies hosts quarterly Roundtable meetings and organizes at least two workshops each year focusing on priority topics identified by its members.

BOX A-1
CSRT Statement of Task

The National Academies of Sciences, Engineering, and Medicine (National Academies) will establish a Climate Security Roundtable, with a goal of supporting the Climate Security Advisory Council to anticipate, prepare, and ultimately prevent climate security crises from escalating into national security challenges and threats. The Roundtable will address topics to include:

1. Emerging, abrupt, and understudied risks associated with the changing climate that could have implications for national security.
2. Best practices for the broad exchange of data, knowledge, and expertise on the topic of climate security and viable solutions to address gaps.
3. Earth system observing, modeling, research, collection, and analytic priorities relevant to improving understanding and to helping anticipate, prepare for, and prevent climate security crises.
4. Understanding human behavior in the context of social, political, economic, and other stresses related to climate change.
5. Indicators and early warnings of risks to national security from changing climate.
6. Capacity building across the intelligence community.
7. Other assistance, resources, or capabilities that the sponsoring entities deem necessary.

Appendix B
Workshop Agenda

Day 1—Wednesday, October 26	
08:00 AM	***Breakfast & Informal Conversations (1 hr | East Court)***
09:00 AM	**Session 01: Welcome and Workshop Overview *(45 min | Lecture Room)*** **Goal**: A shared understanding of the workshop's purpose, structure, and process. **Flow**: • **Welcome from Climate Security Roundtable Co-Chairs** *Barbara Schaal, Washington University in St. Louis* *Karen Seto, Yale University* • **Welcome from the Office of the Director of National Intelligence (ODNI)** • **Logistics and Slide Information** *Julie Pavlin, National Academies of Sciences, Engineering, and Medicine Staff Lead* • **Overview Workshop and Expected Outcomes** *Anjali Mahendra, Chair of Workshop Planning Committee*
09:45 AM	**Session 02: Climate and Security Challenges in South Asia *(1 hr | Lecture Room)*** **Goal**: Review the most likely risks of climate impacts, resulting human security challenges, response capabilities, and needs in South Asia. **Flow**: Two 15-minute presentations followed by 30 minutes of Q&A. • **Multidimensional Security Issues While Moving Towards a Decarbonised World** *Joyashree Roy, Asian Institute of Technology* • **Climate–Conflict Pathways in South Asia** *Sarang Shidore, Quincy Institute & Council on Strategic Risks*
10:45 AM	***Break | 15 min***
11:00 AM	**Session 03: Case Studies—Scenarios from South Asia (*1.5 hr | Lecture Room*)** **Goal**: Review past scenarios where climate change precipitated a security issue. **Flow**: Expert presentations followed by Q&A for each presentation. • **History of Climate Crises and Security Challenges in South Asia** *Sunil Amrith, Yale University* • **Impact of Cyclones on Security in South Asia**

	Saleemul Huq, International Centre for Climate Change and Development • **Impacts of Climate Change on Pakistan's Stability and Security** *Jumaina Siddiqui, U.S. Institute of Peace* • **Climate Threats over South Asia in a Warming World** *H. Annamalai, University of Hawaii*
12:30 PM	***Lunch | 1 hr***
01:30 PM	**Session 04: Potential Future Scenarios (*1.25 hr | Lecture Room*)** **Goal**: Review potential scenarios where climate change and the response to it could precipitate a security issue. **Moderator**: *Katie Mach* *Professor of Environmental Science and Policy* *Rosenstiel School & Abess Center* *University of Miami* **Flow**: Expert presentations followed by Q&A for each presentation. • **Access to Water Resources and Security Conflicts** *Upmanu Lall* *Alan & Carol Silberstein Professor of Engineering* *Director, Columbia Water Center, Columbia University* • **Drought and Food Security in South Asia** *Vimal Mishra* *Professor, Civil Engineering* *IIT Gandhinagar* • **Human Mobility in a Changing Climate: Understanding the Nuances of a Complex Topic** *Chris Richter* *Regional Migration, Environment and Climate Change Specialist* *International Organization for Migration*
02:45 PM	***Break | 15 min***
03:00 PM	**Session 05: Existing and Needed Tools for Analyzing and Forecasting Climate Security Risks, Indicators, and Mitigation Methods (*1 hr | Lecture Room*)** **Goal**: Determine what is available and what is missing for the South Asian context and beyond. How do we get from there to 10–20 years out? **Moderator**: *Virginia Burkett* *United States Geological Survey*

	Flow: Expert presentations followed by Q&A. • **Impact-Based Forecasting** *Erin Coughlan de Perez* *Dignitas Associate Professor* *Tufts University* • **Tools for Climate Predictions and Projections** *Kathy Pegion* *Associate Professor Williams Chair* *School of Meteorology, University of Oklahoma* • **Plausible Climate Migration Scenarios: Harnessing Data, Models, and Simulations** *Kanta Kumari Rigaud* *Lead Environmental Specialist* *World Bank*
04:00 PM	**Session 06: Breakout Groups to Review Case Studies (*1 hr*)** **Goal**: Identify first-order impacts of the climate event. Determine inflection points, when did warnings occur, and what could have been done to mitigate outcomes? **Flow**: Multiple breakout sessions to discuss questions on climate hazards, security risks, and response.
05:00 PM	***Reconvene, Summary of Day 1 and Plan for Day 2***
05:10 PM	***Social Break | 1 hr 20 min*** *(East Court)*
07:00 PM	***Working Dinner | 2 hr*** *(CIRCA at Foggy Bottom)—CSRT members, planning committee members, and workshop speakers.*
09:00 PM	**Adjourn Day 1**
Day 2—Thursday, October 27	
08:00 AM	***Breakfast & Socializing* (*1 hr | North Court)***
09:00 AM	**Session 07: Case Studies Discussion and Next Steps (*1.5 hr | Room 120*)** **Goal**: Review outcomes from breakout group discussions. As a group, identify second- and third-order impacts of the climate event and risk pathways. Determine gaps in getting data, research, partnerships, and processes needed. **Moderator**: *Karen Seto* *Frederick C. Hixon Professor of Geography and Urbanization Science,* *Yale School of the Environment* *Yale University*

	Flow: Representative from each group summarizes their conclusions for two or three main takeaways. Moderator brings together thoughts on overarching inflection points.
10:30 AM	***Break | 15 min***
10:45 AM	**Session 08: Breakout Groups to Discuss Priority Climate Security Threats in South Asia (*1.75 hr*)** **Goal**: Determine climate hazards and climate responses that pose the highest risk of developing into security threats, especially regional/across borders. Discuss research, data, partnerships, and processes needed to better integrate climate assessments.
12:30 PM	***Lunch | 1 hr***
01:30 PM	**Session 09: Finalize Prioritized List of Climate Security Threats in South Asia (*2.25 hr*)** **Goal**: With the knowledge of South Asia risks, prior experiences, available modeling and other tools, and using the framework, determine highest risk of climate exacerbated security risks. **Moderator**: *Anjali Mahendra* *Director of Global Research, Ross Center for Sustainable Cities* *World Resources Institute (WRI)* **Flow:** Each breakout group gives their analysis (including Q&A) of underlying threats followed by discussion to obtain an overall opinion.
03:00 PM	***Break | 15 min***
03:15 PM	***Session 09 - Reconvene***
04:00 PM	**Session 10: Summary and Next Steps (*30 min | Room 120*)** **Goal**: Review the process and final outcome and determine what is still needed for the next workshop. **Moderator**: *Barbara Schaal* *Mary-Dell Chilton Distinguished Professor, Department of Biology* *Washington University in St. Louis* **Flow**: Moderated discussion.
04:30 PM	**Adjourn Day 2**

Appendix C
Workshop Planning Committee Biographical Sketches

Anjali Mahendra (Chair) is the Director of Global Research at World Resources Institute's (WRI's) Ross Center for Sustainable Cities. She is an internationally known expert on the relationship between urban development and climate change, experienced in leading research to inform policy and practice. She led WRI's flagship World Resources Report series "Towards a More Equal City" (2015–2021), exploring how growing cities can ensure equitable access to urban services and infrastructure, while solving citywide environmental challenges and increasing economic opportunity for all. She has developed resources on Inclusive Climate Action Planning for C40 Cities that are currently used to guide planning and train city officials worldwide. Dr. Mahendra has taught courses and authored numerous publications on urban transportation and land-use policies, their public health impacts, their economic and equity impacts, and their role in climate change mitigation and adaptation. She led research for WRI's India office prior to her global role. Prior to WRI, she led projects for the U.S. Environmental Protection Agency, the U.S. Department of Transportation, the Transportation Research Board (TRB), U.S. state and local agencies, and international organizations as a senior consultant at ICF International and the World Bank. Dr. Mahendra served on TRB's Committee on Transportation in Developing Countries from 2006 to 2012 and Committee on Congestion Pricing from 2011 to 2017. Her academic training includes master's degrees (city planning, transportation) and a Ph.D. (urban and regional planning) from the Massachusetts Institute of Technology.

Hariharasubramanian Annamalai is currently a senior researcher and Associate Director of the International Pacific Research Center (IPRC), University of Hawaii. IPRC, with a focus on the Asia-Pacific region, seeks to understand the climate system and how it may respond to human activity by conducting experiments with computer simulation models and by analyzing the many direct and remote observations related to climate. His areas of research expertise include understanding processes responsible for climate variability and climate change over the Asian-Australian monsoon region, and over Hawaii and the Pacific Islands. Besides understanding how the El Niño-Southern Oscillation–induced teleconnections impact South Asian monsoon precipitation, and their expected impact on the monsoon in a warmer planet, his research focuses on elucidating sources of climate model errors in representing tropical climate and its variability. Prior to joining IPRC, he received a Ph.D. in meteorology from Indian Institute of Technology, Kharagpur, and worked as a postdoctoral scientist in the Center of Global Atmospheric Modeling, University of Reading, United Kingdom.

Casey Brown is a Provost Professor of Civil and Environmental Engineering at the University of Massachusetts Amherst and an adjunct associate research scientist at Columbia University. He is an internationally recognized expert in water resources systems analysis and climate risk assessment. His primary research interest is the development of analytical methods for improving the use of scientific observations and data in decisionmaking, with a focus on climate and water resources, and he has worked extensively on projects around the world in this regard. He has received the Presidential Early Career Award for Science and Engineering, the National Science Foundation

CAREER award, the Huber Research Prize from the American Society of Civil Engineers, and the Climate Science Award from the California Department of Water Resources. He currently serves on the Steering Committees of the Alliance for Global Water Adaptation, World Wildlife Fund Basin Report, and City Water Resilience Framework. He also consults for the World Bank, private sector, state agencies, and municipalities and serves on the National Academies of Sciences, Engineering, and Medicine's Committee on Independent Scientific Review of Everglades Restoration Progress. Dr. Brown earned a doctorate in environmental engineering science from Harvard University.

Virginia Burkett is the Chief Scientist for Climate and Land Use Change, International Programs at the U.S. Geological Survey (USGS). Previously, she served as the USGS Chief Scientist for Global Change Research and as the USGS Associate Director for Climate and Land Use Change. Burkett was appointed co-chair of the U.S. Global Change Research Program in 2016 and served as chair during 2017–2019. Burkett is the United States' alternate representative to the Executive Committee of the international Group on Earth Observations, which coordinates the collection and delivery of satellite and in situ Earth observations from 108 nations. Prior to her federal service, Burkett was Secretary/Director of the Louisiana Department of Wildlife and Fisheries, where she had formerly served as Deputy Secretary. She has also directed the Louisiana Coastal Zone Management Program and served as Assistant Director of the Louisiana Geological Survey. Burkett has published extensively on the topics of global change and low-lying coastal zones. She was a Lead Author of the United Nations Intergovernmental Panel on Climate Change (IPCC) Third, Fourth, and Fifth Assessment Reports and the IPCC Technical Paper on Water. She was a Lead Author of the First, Second, and Third U.S. National Climate Assessments and she served on the Federal Steering Committee for the Fourth National Climate Assessment (2018). Burkett received her doctoral degree in forestry from Stephen F. Austin State University in Nacogdoches, Texas, in 1996.

Melissa D. Ho is Senior Vice President for Freshwater and Food at the World Wildlife Fund (WWF) in the United States, where she leads and supports WWF's initiatives focusing on regenerative and resilient food systems and the conservation of freshwater ecosystems for people, nature, and climate. Dr. Ho has more than 25 years of experience as a scientist, policy advisor, and development professional, working at the intersection of water and agriculture and the connections to health, energy, climate, and national security. She has served in both U.S. government bilateral development aid agencies. She oversaw a $1.5 billion portfolio of infrastructure investments in West Africa, primarily related to agriculture, irrigation, and energy, as part of the Millennium Challenge Corporation. She also served as the Technical Division Director and Senior Advisor in the Bureau for Food Security at the U.S. Agency for International Development. Earlier in her career, Dr. Ho developed and implemented the first agriculture water management strategy and grant portfolio for a major foundation. She has also served in the U.S. Congress in various capacities. Dr. Ho's academic training includes a Ph.D. in plant physiology from the Pennsylvania State University, an M.Sc. in soil science from the University of California, Davis, and a B.Sc. in environmental systems from Cornell University.

Sheila Jasanoff is a Pforzheimer Professor of Science and Technology Studies (STS) at the Harvard Kennedy School. A pioneer in the social sciences, she explores the role of science and technology in the law, politics, and policy of modern democracies. Her books include *The Fifth Branch*, *Science at the Bar*, *Designs on Nature*, *The Ethics of Invention*, and *Can Science Make Sense of Life?* She founded and directs the STS program at Harvard; previously, she was founding chair of the STS Department at Cornell. She has held distinguished visiting professorships at

leading universities in Europe, Asia, Australia, and the United States. Jasanoff served on the American Association for the Advancement of Sciences Board of Directors and as President of the Society for Social Studies of Science. Her honors include the Social Science Research Council's Hirschman prize, the Humboldt Foundation's Reimar-Lüst award, and a Guggenheim Fellowship. She is a member of the American Academy of Arts and Sciences and the American Philosophical Society, foreign member of the British Academy and the Royal Danish Academy, and member of the Council on Foreign Relations. She holds A.B., J.D., and Ph.D. degrees from Harvard, and honorary doctorates from the Universities of Twente and Liège.

Katharine Mach is a professor at the University of Miami's (UM) Rosenstiel School of Marine, Atmospheric, and Earth Science and a faculty scholar at the UM Abess Center. Her research assesses climate change risks and response options to address increased flooding, extreme heat, wildfire, and other hazards. Her work focuses on innovating approaches to evidence-based adaptation decisions. Dr. Mach was previously a Senior Research Scientist at Stanford University and the Director of the Stanford Environment Assessment Facility. Before that, she co-directed the scientific activities of Working Group II of the Intergovernmental Panel on Climate Change (IPCC). Dr. Mach is a lead author for the IPCC Sixth Assessment Report and a chapter lead for the U.S. Fifth National Climate Assessment. Mach is the 2020 recipient of the Piers Sellers Prize for world-leading contribution to solution-focused climate research. She serves as a co-editor in chief for *Climate Risk Management*, an editorial board member for *Oxford Open Climate Change*, and an advisory committee member for the Aspen Global Change Institute and the Stratospheric Controlled Perturbation Experiment. Dr. Mach earned her doctorate in biological sciences from Stanford University.

Appendix D
Workshop Speaker Biographical Sketches

Sunil Amrith is the Renu and Anand Dhawan Professor of History and current chair of the South Asian Studies Council at Yale University. His research focuses on the movements of people and the ecological processes that have connected South and Southeast Asia. Amrith's areas of particular interest include environmental history, the history of migration, and the history of public health. Amrith is the recipient of the 2022 A.H. Heineken Prize for History, a 2017 MacArthur Fellowship, and the 2016 Infosys Prize in Humanities. Amrith is the author of four books, including, most recently, *Unruly Waters* (2018).

Erin Coughlan de Perez bridges science, policy, and practice in her research on climate risk management around the world. She focuses on extreme events, exploring how droughts, floods, heatwaves, and other climate shocks can be anticipated before they happen. Coughlan de Perez works with humanitarian teams on the development of early action protocols to avoid disaster impacts, and she researches the adoption and effectiveness of climate change adaptation measures. Coughlan de Perez comes to the Feinstein Center at Tufts University from the Red Cross Red Crescent Climate Centre, where she built a global climate science team and led the first Forecast-based Financing pilots in the Red Cross Red Crescent Movement. Coughlan de Perez retains a technical advisor position at the Climate Centre to maintain links to humanitarian operations around the world. Coughlan de Perez was formerly an associate professor at Columbia University. Coughlan de Perez received her Ph.D. from VU University Amsterdam, her M.A. in climate and society from Columbia University, and her B.S. in environmental science and international development from McGill University. Coughlan de Perez is also a Lead Author of the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report. Her chapter is Decision-Making Options for Managing Risk, as part of the Working Group II on Impacts, Adaptation, and Vulnerability.

Saleemul Huq is the Director of the International Centre for Climate Change and Development and professor at the Independent University Bangladesh as well as Senior Associate of the International Institute on Environment and Development in the United Kingdom. In addition, he is the Chair of the Expert Advisory Group for the Climate Vulnerable Forum and also Senior Adviser on Locally Led Adaptation with the Global Center on Adaptation headquartered in the Netherlands. He is an expert in adaptation to climate change in the most vulnerable developing countries and has been a lead author of the Third, Fourth, and Fifth Assessment Reports of the Intergovernmental Panel on Climate Change; he also advises the Least Developed Countries group in the United Nations (UN) Framework Convention on Climate Change. In addition, he was affiliated with the UN Food System Summit for 2021 as co-chair of the Action Track 5 on Building Resilience to Vulnerabilities, Shocks & Stress. He has published hundreds of scientific as well as popular articles and was recognized as one of the top 20 global influencers on climate change policy in 2019 and top scientist from Bangladesh on climate change science. Recently he has been appointed Officer of the Order of the British Empire in the 2022 New Year Honours for services to combating international climate change.

Upmanu Lall is the Director of the Columbia Water Center and the Alan and Carol Silberstein Professor of Engineering at Columbia University. He has broad interests in hydrology, climate dynamics, water resource systems analysis, risk management, and sustainability. He is motivated

by challenging questions at the intersection of these fields, especially where they have relevance to societal outcomes or to the advancement of science toward innovative application. His current research covers three major initiatives that are developed through the Columbia Water Center. The Global Water Sustainability Initiative addresses global water scarcity and risk. The Global Flood Initiative is motivated by the need to predict, mitigate, and manage floods at a global scale, recognizing their climate drivers and supply chain impacts. America's Water seeks to develop sustainable water management and infrastructure design paradigms for the 21st century, recognizing the linkages between urban functioning, food, water, energy, and climate. These programmatic initiatives are backed by research on systems-level modeling of hydrology, climate, agronomy, and economics. Dr. Lall has pioneered the application of techniques from (1) nonlinear dynamical systems, (2) nonparametric methods of function estimation and their application to spatiotemporal dynamical systems, (3) hierarchical Bayesian models, (4) systems optimization and simulation, and (5) the study of multiscale climate variability and change as an integral component of hydrologic systems. He has published in journals that focus on hydrology, water resources, climate, physics, applied mathematics and statistics, risk, economic development, policy, and management science. He is the current editor-in-chief of the journal *Water Security*. He has been engaged in high-level public and scientific discussion through the media and the World Economic Forum, and with governments, foundations, development banks, and corporations interested in sustainability. He has served on several national and international panels. He was one of the originators of the Consortium of Universities for the Advancement of Hydrologic Science and is a past President of the Natural Hazards Focus Group of the American Geophysical Union.

Vimal Mishra is currently a professor in civil engineering and Earth sciences at the Indian Institute of Technology (IIT) Gandhinagar. Prior to joining IIT Gandhinagar, he completed his Ph.D. from Purdue University and postdoctoral fellowship from the University of Washington, Seattle. Dr. Mishra's research focuses on large-scale hydrologic modeling, remote sensing, and climate change impact assessment. Dr. Mishra's research work has been published in leading journals including *PNAS*, *Nature Geoscience*, *Geophysical Research Letters*, and *Water Resources Research*. Dr. Mishra received the Devendra Lal Memorial Medal from the American Geophysical Union (AGU) in 2021. He is a fellow of the AGU and the National Academy of Sciences, India. He is currently serving as an editor of *Earth's Future* and associate editor of the *Journal of Hydrology*.

Kathy Pegion is an associate professor and Williams Chair in the School of Meteorology at the University of Oklahoma. Dr. Pegion's research focuses on Earth system prediction on subseasonal to seasonal timescales using global weather and climate models, big data, and statistical and machine learning methodologies. Her research motto is "Better Forecasts. Better Decisions," with the goal of improving forecasts from two weeks to several years in support of better decisionmaking. She leads a National Oceanic and Atmospheric Administration–funded project called the Subseasonal Experiment. Dr. Pegion holds a Ph.D. in climate dynamics from George Mason University. She serves as associate editor of the *Journal of Climate* and co-chair of the National Center for Atmospheric Research Earth System Prediction Working Group.

Chris Richter is currently the Regional Migration, Environment and Climate Change Specialist at the International Organization for Migration's (IOM's) Regional Office in Bangkok. He was previously a Migration Officer with IOM's Office to the United Nations in New York, a position he held since 2012. He has also spent time at IOM's Headquarters in Geneva. In New York, Mr. Richter was responsible for the office's sustainable development portfolio, coordinating IOM's policy inputs to major United Nations (UN) processes and conferences, including the 2030 Agenda for Sustainable Development, the Addis Ababa Action Agenda on Financing for Development, the

SAMOA Pathway for Small Island Developing States, and the Habitat III New Urban Agenda, among others. Prior to joining IOM, Mr. Richter held several positions across the Australian government, covering a variety of thematic issues. He served as a Policy Officer with the UN and Human Rights Section of the Australian Agency for International Development, as well as on the Counter-Violent Extremism Taskforce at the Attorney-General's Department. More recently, he was also an Assistant Director of the Strategic Policy Section of the former Department of Immigration and Citizenship. Mr. Richter studied international relations and international law at the University of Queensland, and has a master's in international development from Deakin University in Melbourne. He has published a number of articles on migration and development, refugee law, and security policy.

Kanta Kumari Rigaud is a Lead Environmental Specialist at the World Bank with more than 25 years of professional experience in natural resources management, environmental management, and climate change adaptation. She joined the World Bank in 2004 and has worked in the Middle East North Africa Region and the Climate Change Group, and is currently working in the Africa Region as the Regional Climate Change Coordinator. In her current role, she led the development of the Next Generation Africa Climate Business Plan and continues to support the rollout and implementation of the plan and associated knowledge work, working with teams across the institution. She also works directly in Uganda and Kenya, including on their National Determined Contributions. Dr. Rigaud's professional work has also focused on advancing climate policy and action at the practitioner level. On this front, she led the development of the World Bank's climate and disaster risk screening tools to inform project design and national/sectoral plans and strategies as a contribution to climate mainstreaming across the institution. Recognizing the critical importance of climate-informed decision support, she went on to develop an online learning platform on weather and climate services resilient development for policymakers and practitioners on why and how to develop high-quality climate information products and services. As the World Bank team lead on the Africa Climate Resilient Investment Facility, a partnership with the African Union and United Nations Economic Commission for Africa, she led the development of the Resilience Booster Tool, which seeks to strengthen the integration of climate risks and opportunities into the design and delivery of investments by enhancing the capacity of people, assets, institutions, and infrastructure. Dr. Rigaud holds a Ph.D. from the University of East Anglia and was the recipient of the British Chevening Scholarship and the World Bank Graduate Scholarship award for her doctoral dissertation. She has a master of science in behavioral ecology from the University of Stirling, UK; a first-class bachelor of science honors degree in ecology; and a diploma in education from the University of Malaya. She has authored several publications and reports on natural resources, and environmental and climate issues.

Joyashree Roy is the Founder Director of the Centre on South and Southeast Asia Multidisciplinary Applied Research Network on Transforming Societies of Global South and the Inaugural Bangabandhu Chair Professor (2018–2022, July) at SERD, Asian Institute of Technology, Thailand. She is the founding advisor of the two multiyear projects at Jadavpur University: Global Change Programme and SYLFF-JU Programme. She is a former professor of economics in Jadavpur University, India. She is a national fellow of the Indian Council of Social Sciences Research. She was a Ford Foundation Postdoctoral Fellow at Lawrence Berkeley National Laboratory, Berkeley, California. She is the recipient of the 2021 Paradigm Award of The Breakthrough Institute, United States. She was in the Intergovernmental Panel on Climate Change (IPCC)-2007 Nobel Peace Prize winning panel and continues as Coordinating Lead Author in the Fifth and Sixth Assessment cycles of Working Group III of the IPCC. She has been a chapter author of *Global Energy Assessment*, has been associated with the Stern Review Report and many

other global, national, and subnational reports. She was on the winning team of the 2012 Prince Sultan Bin Aziz creativity award for water. She has published more than 160 peer-reviewed journal articles, and authored and edited books. She is in the steering/advisory committee of several national and international science-policy interactive platforms and in editorial boards of many international journals. Her research interests include resource and environmental economics, economics of pollution and climate change, modeling industrial and other sectoral energy demand, economy-wide modeling exercises for deriving policy implications, water quality demand modeling, water, energy, carbon pricing, sustainable development, natural resource accounting, valuing environmental services, developmental and environmental issues relevant for informal sectors, and coastal ecosystem service evaluation. She features in the documentary "Juice: How Electricity Explains the World," which explains among other things how developing countries are trying to bring people out of the dark and into the light and transforming lives.

Sarang Shidore is Director of Studies and Senior Research Fellow at the Quincy Institute, and a senior nonresident fellow at the Council on Strategic Risks. He is also adjunct faculty at George Washington University, where he teaches a class on the geopolitics of climate change. His areas of research and analysis are geopolitical risk, grand strategy, climate security, and the energy transition, with a special emphasis on Asia and South Asia. In the field of climate policy and climate security, Shidore has collaborated and published with the Brookings Institution, Center for Strategic and International Studies, Council on Foreign Relations, Council on Strategic Risks, Paulson Institute, and Woodwell Climate Research Center. He has more than 90 publications to his credit in journals, edited volumes, and media outlets in his areas of expertise, including in *Energy Policy* and *Energy Research & Social Science*. Prior to his current role at the Quincy Institute, Shidore was a senior research scholar at the University of Texas at Austin and senior global analyst at the geopolitical risk firm Stratfor Inc., and previously also spent more than a decade in engineering and product management in the technology industry.

Jumaina Siddiqui is the Program Director, Global Security and International Affairs at the American Academy of Arts and Sciences. She previously served as a senior program officer for South Asia at the U.S. Institute of Peace. Prior to that, she worked with the National Democratic Institute (NDI), where she served as the program manager for Pakistan, working on political party development, election observation and reforms, and increasing the participation of women and youth in the political process. Siddiqui was also a U.S.-Pakistan program fellow with the South Asia Center at the Atlantic Council, where her research focused on education reform efforts by political actors in Pakistan and the relationship between donors, civil society, politicians, and the government to move these reforms forward. Prior to joining NDI, she worked at Global Communities on a U.S. Agency for International Development–funded project to increase stability in the Federally Administered Tribal Areas of Pakistan by providing improved livelihood and economic growth opportunities. Siddiqui has extensive experience in program design and management as well as policy research and analysis. She has held positions at the American Bar Association's Rule of Law Initiative focusing on programs in Bangladesh, the Philippines, and Thailand, as well as thematic programs related to media legal defense and access to justice in Asia; at the Stimson Center examining nontraditional security issues in South Asia; and at the Protection Project at Johns Hopkins University, conducting research on international human trafficking and managing a training program on human trafficking in the United States. Siddiqui holds a bachelor's degree in political science from American University and a master's degree from New York University, where her work focused on democracy promotion and the rule of law in the Muslim world, culminating in a thesis on rebuilding justice systems in postconflict Afghanistan. She also holds a graduate certificate in environmental policy and management from the University of Denver.