Consensus Study Report

MARCH 2021

HIGHLIGHTS

Global Change Research Needs and Opportunities for 2022-2031

Climate change is affecting the health and well-being of Americans across all parts of the country. Coastal areas are enduring more frequent and severe flooding due to sea level rise and storm surge; western states and Alaska have had increasingly devastating wildfires driven in part by hotter, drier, and longer fire seasons; and communities across the nation have suffered through extreme precipitation events and heat waves.

For more than three decades, the U.S. Global Change Research Program (USGCRP) has coordinated global change research across the federal government. USGCRP is an interagency program established by Congress under the Global Change Research Act in 1990, and consists of 13 federal agencies and departments. It is overseen by the National Science and Technology Council. Fostered by USGCRP, interagency partnerships and collaborations with experts across the nation and the world have led to an unprecedented effort to observe, understand, predict, and project changes in natural and built environments.

This report advises USGCRP on how to best meet the mandate of the Global Change Research Act for the coming decade, in light of the significant climate change impacts happening today and the increases in their magnitudes and changes in their patterns that are projected for the future. This report identifies critical climate change risks, research needed to support decision making relevant to managing these risks, and opportunities for USGCRP's participating agencies and other partners to advance these research priorities.

FOCUS FIRST ON URGENT RISKS TO AMERICAN WELL-BEING

Climate model projections indicate that each additional unit of warming will further increase risks for nearly all impacts of climate change. New research and coordination are needed to understand and communicate complex interactions among changes in the physical climate system, ecosystems, and human systems, with particular focus on urgent risks to the well-being of Americans today and over the coming decades—including to health, food, energy, water, and economic security.

While USGCRP has taken steps to frame past climate assessments in terms of risk, USGCRP and its participating agencies should center their next decadal plan, and the resulting priorities and activities, using an integrated risk-framing approach. The approach should consider the risks to human systems posed by climate change and integrate other global change when appropriate. Crucially, new research

The National Academies of
SCIENCES • ENGINEERING • MEDICINE

is needed on strategies to effectively and efficiently manage risks, taking into account that risks associated with climate change are not distributed equitably across sectors, regions, or populations. This is critical for informing the design and implementation of risk-reduction strategies in government, private sector firms, and society.

The numbers of decisions that need to be made at local to regional scales place new demands for knowledge generation at relevant, actionable levels. Scientific advances over the next decade can be enhanced by USGCRP and its participating agencies purposefully including as users highly diverse segments of the U.S. and global populations, including racial and ethnic minorities, socioeconomically disadvantaged people, environmental justice communities, and others.

RECOMMENDATION: Apply an integrated risk-framing approach to identify research priorities for the next 10 years that provide insights to avoid the worst potential consequences of urgent risks to human and natural systems from current and future climate change.

EXPLORE COMPLEX INTERACTIONS BETWEEN GLOBAL CHANGE AND HUMAN SYSTEMS

Traditional climate research that projects changes in the natural environment and then estimates the potential consequences of these changes for human systems, typically within sectors, is not fully meeting decision-makers' needs because these projections rarely consider the complex multi-directional interactions among human and natural systems.

The committee recommends that USGCRP focus research on supporting integrated risk-based management based on the complex, multidirectional interactions between physical manifestations of climate change and human systems, including health, food, water, energy, transportation and infrastructure, the economy, and national security (see Figure 1). Research to reduce and manage uncertainties would promote effective decision-making. In addition, investments in social science research are critical to improving understanding of the socioeconomic consequences of climate change and include the study of behavioral, institutional, and political drivers of climate at different scales.

Meeting the urgent decision needs of the next decade will require a much greater commitment to research efforts that take a systems approach, involve collaborations among experts from across the health, social, engineering, and natural sciences, and more explicitly consider the interactions among human and natural systems.

RECOMMENDATION: Accelerate the integration and communication of research on coupled human and natural systems to advance understanding of effective options for managing urgent climate change risks at local to international scales.

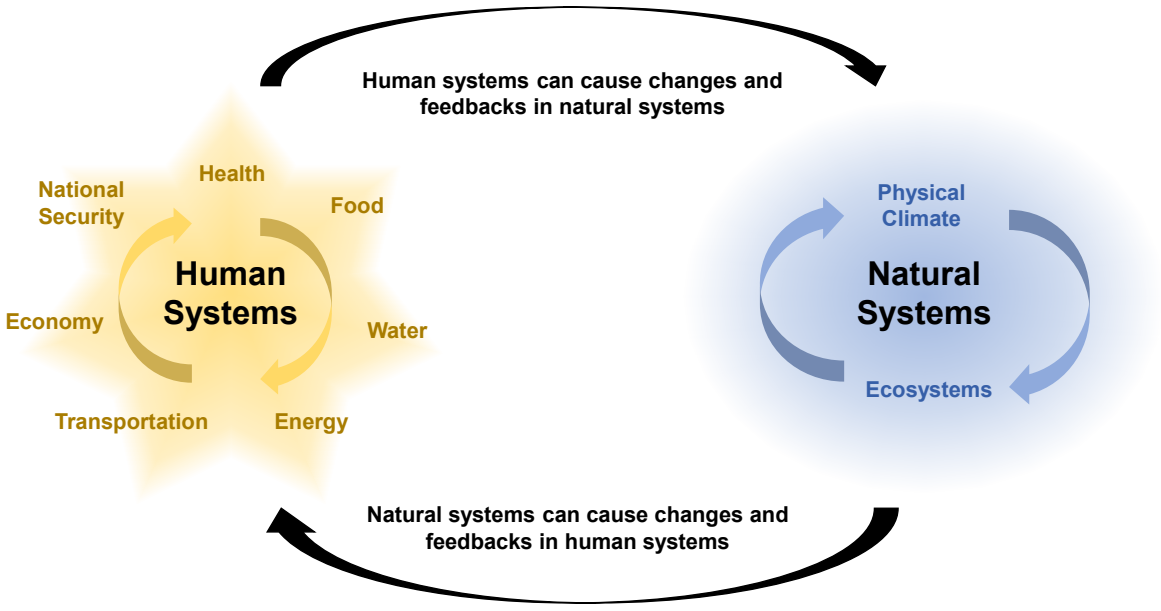

FIGURE 1. Coupled human-natural systems are systems with interconnected, interdependent, and complex interactions among human systems, the physical climate system, and ecosystems. These interactions include the dynamics within one or more natural systems; the dynamics within one or more human systems; the processes through which the natural systems affect the human systems; and the processes through which the human systems affect the natural systems.

DECISION SUPPORT FOR MITIGATION AND ADAPTATION STRATEGIES

As climate consequences continue to increase across the globe, there is an urgent need to set policies that will *manage* those risks to protect human and natural systems. The primary risk-management strategies are **mitigation**, reducing global emissions and removing CO_2 from the atmosphere, and **adaptation**, preparing for and managing the harmful effects of global change. These strategies can be reinforcing, or have unintended consequences. Given the complexity of interactions across risks and response, research that integrates climate risk management strategies and policies is required to support decision making across local, national, and international scales.

Reducing Global Greenhouse Gas Emissions and Atmospheric Concentration

Achieving net-zero emissions of carbon dioxide (CO_2) from human activities is critical to lowering future risks through avoided or captured emissions. Pursuing and informing mitigation-related policies will require better understanding of: emissions targets and associated impacts; thresholds and tipping points in both human and natural systems; approaches for CO_2 removal, reliable sequestration, and utilization; and improved ability to accurately quantify and verify emissions at national and global scales.

Increasing Resilience to Climate Change Risks

As stated in the Global Change Research Act, adaptation to climate threats is essential to society's responses to global changes, and has been on USGCRP's research agenda for the past two decades. New research, enhanced coordination, and expanded communication efforts are needed to advance society's ability to adapt to risks that are often arising sooner and more intensely than projected, in the context of increasingly complex interactions among these risks. Further, longer-term evaluation is needed to monitor the effectiveness of adaptation practices over time and across spatial scales, to identify adjustments needed to enhance resilience.

Effective risk management will also require the processes of decision-making to manage synergies and trade-offs over multiple scales, and between different adaptation and mitigation options, in the context of deep uncertainties. Many strategies for reducing emissions or removing carbon from the atmosphere have implications for the resiliency to other risks, underscoring the need for integrated research.

RECOMMENDATION: Prioritize research related to managing climate risks, including (1) reducing global greenhouse gas emissions and lowering their atmospheric concentrations; (2) increasing resilience to current and anticipated climate-related security risks; and (3) expanding research on incentives for and the synergies and trade-offs between these risk-management approaches.

CROSSCUTTING RESEARCH NEEDED TO SUPPORT MANAGEMENT OF CLIMATE RISKS

An integrated, systems-based approach—one that considers the multi-directional interactions among the physical climate system, ecosystems, and human systems— would benefit from pursuit of several crosscutting priorities. With its long history of providing high-level coordination and communication of the research conducted at federal agencies, USGCRP is especially well-suited to make progress on crosscutting research efforts that would facilitate cross-comparison, provide consideration of the intersections of impacts (and responses) across multiple systems, and eliminate redundancy in underlying analyses.

The committee recommends expanding research in **five crosscutting areas** that will contribute to addressing climate change risks: (1) extremes, thresholds, and tipping points; (2) simulation of local and regional-scale climate including uncertainty characterization; (3) a stakeholder-driven, scenarios-based approach to project climate change, associated risks, and effectiveness of mitigation an adaptation policies; (4) equity and justice dimensions of change, including the inequitable distribution of impacts and underlying drivers of exposure and vulnerability; and (5) advanced data and analysis frameworks.

ENABLING USGCRP TO SUPPORT A RISK MANAGEMENT PARDIGM

The ability for the nation to understand, adapt to, and respond to global changes will require investment from the U.S. research enterprise commensurate with the challenges posed by these interacting systems. Meeting this mandate will require a significant paradigm shift for USGCRP. Federal agencies that are already part of USGCRP will need to intensify their engagement in the program, increasing involvement of sub-organizations that bring relevant expertise and operational responsibilities to the table. It will also require greater participation of federal mission agencies that historically have not participated in USGCRP, but have relevant resources and expertise.

RECOMMENDATION: To accompany the shift in the USGCRP paradigm, the Program should

explore organizational and operational changes to enhance relevance and effectiveness of its work.

In addition to enhancing participation in USGCRP among federal agencies and departments, the committee suggests USGCRP further develop and expand public-private partnerships in support of climate change research and science-to-action activities. Besides adding intellectual and financial resources, public-private partnerships can increase the engagement of Americans in climate change—its causes, its impacts, and its solutions.

The committee also recommends **four operational changes** to support the paradigm shift:

1. Prioritize diversity and justice, including diversity in both the Program and USGCRP activities by greatly expanding efforts to be inclusive and representative; and justice by prioritizing research that highlights consequences and opportunities for underserved communities;
2. Increase the usability and relevance of research by adopting a co-production approach to research, recommitting to the sustained assessment process, and establishing a standing user working group or advisory mechanism as a forum for input on user needs;
3. Advance program integration and accountability by increasing transparency of the management structure and criteria for setting priorities, sequencing investments, and guiding development of an integrated program across the individual agencies; and
4. Develop an evidence-based strategy for monitoring, evaluation, and learning for USGCRP's activities, including the next strategic plan, with flexibility for setting priorities and activities to adapt to and incorporate learning on an ongoing basis.

USGCRP has the opportunity to put forward a strategic plan that explains how global change research, particularly climate change research, contributes to the knowledge set needed to address these multiple interrelated challenges, and ultimately prepare society to create a more resilient future. The Global Change Research Act (GCRA) of 1990 provides the flexibility for USGCRP to include the agency participation necessary to meet the nation's needs for useful information. The GCRA also mandates that USGCRP provide readily usable information to guide effective strategies to mitigate and adapt to the effects of global change. An integrated systems-based risk management approach would enhance USGCRP's ability to meet this mandate.

COMMITTEE TO ADVISE THE U.S. GLOBAL CHANGE RESEARCH PROGRAM

Jerry M. Melillo (Chair, NAS), Marine Biological Laboratory; **Kristie L. Ebi** (Vice Chair), University of Washington; **Arrietta Chakos**, Urban Resilience Strategies; **Peter Daszak** (NAM), EcoHealth Alliance; **Thomas Dietz**, Michigan State University; **Philip B. Duffy**, Woodwell Climate Research Center; **Baruch Fischhoff** (NAS, NAM), Carnegie Mellon University; **Paul Fleming**, Microsoft; **Sherri W. Goodman**, Woodrow Wilson International Center for Scholars, CNA; **Nancy B. Grimm** (NAS), Arizona State University; **Henry D. Jacoby**, Massachusetts Institute of Technology; **Linda O. Mearns**, National Center for Atmospheric Research; **Richard H. Moss**, Princeton University; **Margo Oge**, U.S. Environmental Protection Agency (ret.); **S. George H. Philander** (NAS), Princeton University; **Benjamin L. Preston**, RAND Corporation; **Paul A. Sandifer**, College of Charleston; **Henry G. Schwartz, Jr.** (NAE), Jacobs Engineering (ret.); **Kathleen Segerson**, University of Connecticut; and **Brian L. Zuckerman**, Institute for Defense Analyses Science and Technology Policy Institute. Staff of the National Academies of Sciences, Engineering, and Medicine: **Amanda Purcell** (Senior Program Officer); **Amanda Staudt** (Director, Board on Atmospheric Sciences and Climate); **Toby Warden** (Director, Board on Environmental Change and Society); **Jenell Walsh-Thomas** (Program Officer); **Alex Reich** (Associate Program Officer); **Rita Gaskins** (Administrative Coordinator); and **Rob Greenway** (Program Associate).

For More Information . . . This Consensus Study Report Highlights was prepared by the National Academies of Sciences, Engineering, and Medicine based on the Consensus Study Report *Global Change Research Needs and Opportunities for 2022-2031* (2021). The study was sponsored by the National Aeronautics and Space Administration. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of any organization or agency that provided support for the project. Copies of the Consensus Study Report are available from the National Academies Press, (800) 624-6242; http://www.nap.edu or via the Board on Atmospheric Sciences and Climate web page at http://www.nationalacademies.org/basc.

Division on Earth and Life Studies

The National Academies of
SCIENCES · ENGINEERING · MEDICINE

The nation turns to the National Academies of Sciences, Engineering, and Medicine for independent, objective advice on issues that affect people's lives worldwide.
www.national-academies.org