CHAPTER 29
RESEARCH NEEDS FOR CLIMATE AND GLOBAL CHANGE ASSESSMENTS

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This chapter identifies key areas of research to provide foundational understanding and advance climate assessments. Many of these research topics overlap with those needed for advancing scientific understanding of climate and its impacts and for informing a broader range of relevant decisions.

The research areas and activities discussed in this chapter were identified during the development of the regional and sectoral technical input reports, from the contributions of over 250 National Climate Assessment (NCA) chapter authors and experts, and from input from reviewers. The five high-level research goals, five foundational cross-cutting research capabilities, and more specific research elements described in this chapter also draw from a variety of previous reports and assessments. These lists are provided as recommendations to the Federal Government. Priority activities for global change research across 13 federal agencies are coordinated by the U.S. Global Change Research Program, which weighs all activities within the more than $2 billion annual climate science portfolio relative to one another, considering agency missions, priorities, and budgets.

The last National Climate Assessment report, released by the U.S. Global Change Research Program (USGCRP) in 2009, recommended research on: 1) climate change impacts on ecosystems, the economy, health, and the built environment; 2) projections of climate change and extreme events at local scales; 3) decision-relevant information on climate change and its impacts; 4) thresholds that could lead to abrupt changes in climate or ecosystems; 5) understanding the ways to reduce the rate and magnitude of climate change through mitigation; and 6) understanding how society can adapt to climate change.

Some of these topics have received continued or increased attention in the last five years – such as ecosystem impacts, downscaled climate projections, and mitigation options – but the current assessment finds that significant knowledge gaps remain for all of the research priorities identified in 2009. This conclusion is reinforced by the findings of many subsequent reviews by the National Research Council (NRC) and others who have continued to identify these as priorities. For example, the NRC’s America’s Climate Choices Panel on Advancing the Science of Climate Change and the Panel on Informing Effective Decisions and Actions, highlighted several priorities that are relevant to climate assessments (see “Cross-Cutting Themes for the New Era of Climate Change Research Identified by America’s Climate Choices”). These included the need for a more comprehensive, interdisciplinary, use-inspired, and integrated research enterprise that combines fundamental understanding of climate change and response choices, that improves understanding of human-environment systems; that supports effective adaptation and mitigation responses, and that provides better observing systems and projections. In recognition of fiscal limitations, it is clear that research agencies and partners will need to work together to leverage resources and ensure coordinated and collaborative approaches.

**Research Goals and Cross-Cutting Capabilities**

**Five Research Goals**
- Improve understanding of the climate system and its drivers
- Improve understanding of climate impacts and vulnerability
- Increase understanding of adaptation pathways
- Identify the mitigation options that reduce the risk of longer-term climate change
- Improve decision support and integrated assessment

**Five Foundational Cross-Cutting Research Capabilities**
- Integrate natural and social science, engineering, and other disciplinary approaches
- Ensure availability of observations, monitoring, and infrastructure for critical data collection and analysis
- Build capacity for climate assessment through training, education, and workforce development
- Enhance the development and use of scenarios
- Promote international research and collaboration
The U.S. Global Change Research Program’s 2012-2021 Strategic Plan lists a number of strategic goals and objectives for advancing science, informing decisions, conducting sustained assessments, and communicating and educating about global change. The plan includes research priorities to understand Earth system components, their interactions, vulnerability and resilience; advance observations, modeling, and information management; and evaluate assessment processes and products.

This chapter focuses specifically on the research identified through the National Climate Assessment process as needed to improve climate assessments. It is not intended to cover the full range of goals and related research priorities of the USGCRP and other groups, but instead to focus on research that will improve ongoing assessments. Therefore, many USGCRP priorities for climate change and global change science more broadly are not reflected here. The chapter does, however, directly support the USGCRP Strategic Plan’s sustained assessment activities (see “Goal 3 of the USGCRP Strategic Plan”).

During the development of this report, the authors were concerned that several important topics could not be comprehensively covered. In addition, several commenters noted the absence of these topics and felt that they were critical to consider in future reports. These include analyses of the economic costs of climate change impacts (and the associated benefits of mitigation and adaptation strategies); the implications of climate change for U.S. national security as a topic integrated with other regional and sectoral discussions; and the interactions of adaptation and mitigation options, including consideration of the co-benefits and potential unintended consequences of particular decisions.

**Research to Improve Understanding of Human-Environment Systems**
1. Climate forcings, feedbacks, responses, and thresholds in the Earth system
2. Climate-related human behaviors and institutions

**Research to Support Effective Responses to Climate Change**
3. Vulnerability and adaptation analyses of coupled human-environment systems
4. Research to support strategies for limiting climate change
5. Effective information and decision support systems

**Research Tools and Approaches to Improve Both Understanding and Responses**
6. Integrated climate observing systems
7. Improved projections, analyses, and assessments

*Source: America’s Climate Choices, Advancing the Science of Climate Change, National Academy of Sciences 2010, p. 92.*

**Goal 3 of the USGCRP Strategic Plan**

**Conduct Sustained Assessments:** Build sustained assessment capacity that improves the Nation’s ability to understand, anticipate, and respond to global change impacts and vulnerabilities.

The USGCRP will conduct and participate in national and international assessments to evaluate past, current, and likely future scenarios of global change and their impacts, as well as how effectively science is being used to support and inform the United States’ response to change. The USGCRP will integrate emerging scientific understanding of the Earth system into assessments and identify critical gaps and limitations in scientific understanding. It will also build a standing capacity to conduct national assessments and support those at regional levels. The USGCRP will evaluate progress in responding to change and identify science and stakeholder needs for further progress. The program will use this regular assessment to inform its priorities.
Research Goals

Research Goal 1: Improve understanding of the climate system and its drivers

Research investments across a broad range of disciplines are critically important to building understanding of, and in some cases reducing uncertainties related to, the physical and human-induced processes that govern the evolution of the climate system. This assessment demonstrates the continued need for high quality data and observations, analysis of Earth system processes and changes, and modeling that increases understanding and projections of climate change across scales. Social science research is also essential to improved understanding and modeling of the drivers of climate change, such as energy use and land-use change, as well as understanding impacts. Assessing a changing climate requires understanding the role of feedbacks, thresholds, extreme events, and abrupt changes and exploring a range of scenarios that drive changes in the climate system.

This assessment reveals several research needs including:

- Continue efforts to improve the understanding, modeling, and projections of climate changes, especially at the regional scale, including driving forces of emissions and land-use change, changes in temperature, precipitation, soil moisture, runoff, groundwater, evapotranspiration, permafrost, ice and snow cover, sea level change, and ocean processes and chemistry;

- Improve characterization of important sources of uncertainty, including feedbacks and possible thresholds in the climate system associated with changes in clouds, land and sea ice, aerosols (tiny particles in the atmosphere), greenhouse gases, land use and land cover, emissions scenarios, and ocean dynamics;

- Develop indicators that allow for timely reporting and enhanced public understanding of climate changes and that allow anticipation and attribution of changes, including abrupt changes and extreme events in the context of a changing climate; and

- Advance understanding of the interactions of climate change and natural variability at multiple time scales, including seasonal to decadal changes (and consideration of climate oscillations including the El Niño Southern Oscillation, Pacific Decadal Oscillation, and the North Atlantic Oscillation), and extreme events (such as hurricanes, droughts, and floods).

Research Goal 2: Improve understanding of climate impacts and vulnerability

Assessing the implications of climate change for the U.S. relies not just on studies of the threats associated with changing weather patterns due to climate change and emerging chronic stresses such as sea level rise, but also on studies of who or what is exposed and sensitive to those threats, their underlying vulnerability, the associated costs, and adaptive capacity. The detailed sectoral and regional chapters of this assessment show that considerable progress has been made in understanding the extent to which natural and human systems in the U.S. are vulnerable to climate change and how these vulnerabilities combine with climatic trends and exposures to create impacts, but there is still a need to build capacity for assessing vulnerability.

This assessment suggests related research goals and activities including:

- Maintain and enhance research and development of data collection and analyses to monitor and attribute ongoing and emerging climate impacts across the United States, including changes in ecosystems, pests and pathogens, disaster losses, water resources, oceans, and social, urban, and economic systems. Priorities include ensuring enhanced geographic coverage of impacts research; the assessment of economic costs and benefits, as well as comparative studies of alternative response options; social science research focused on impacts; and the use of geospatial data systems;

- Assess the impacts of climatic extremes, high-end temperature scenarios, and abrupt climate change on ecosystems, health, food, water, energy, infrastructure, and other critical sectors, and improve modeling capabilities to better project and understand the vulnerability and resilience of human systems and ecosystems to climate change and other stresses such as land-use change and pollution;

- Increase the understanding of how climate uncertainties combine with socioeconomic and ecological uncertainties and identify improved ways to communicate the combined outcomes;

- Develop measurement tools and valuation methods for documenting the economic consequences of climate changes;

- Expand climate impact analyses to focus on understudied but significant economic sectors such as natural resources and energy development (for example, mining,
油、气和木材）、制造业；基础设施、土地开发、城市区域；金融及其他服务；零售；以及公共卫生和福祉；和

- 调查气候变化影响如何受到或影响到特定地区。
- 调查如何适应气候变化的影响，以及与适应和缓解活动的关系。
- 其他压力。

研究目标3：增加对适应路径的理解

本评估和其他，包括《美国的气候选择：缓解气候变化的影响》报告第2章和第4章（关于适应和缓解选项及其响应）在政府间气候变化专门小组（IPCC）AR4综合报告中描述的广泛研究需求提供了基础。这些包括研究适应过程、适应能力、适应选项识别、实施和评估，以及适应风险管理过程和适应管理的机遇。

重要的需求包括研究适应的限制、时间的适应，以及气候适应性与适应性活动的适应性，其他压力，以及更广泛可持续性问题。

本评估建议进行的研究活动包括：

研究目标4：识别缓解气候变化的选项

气候变化的影响有多严重，在美国以及美国以外的长期适应需要取决于对努力减少或吸收温室气体（GHG）排放的努力，特别是与能源、农业、林业、健康和福祉、贸易和技术等领域的非碳足迹相关的排放。管理本世纪气候变化的后果将取决于减少温室气体浓度的需要。

虽然各国都面临着全球挑战，但美国的温室气体排放仍显著，是全球温室气体排放的重要组成部分。此外，还存在其他许多因素，如基础设施、土地使用的变化，将对气候变化的后果产生重大影响，例如在地方和区域层面，例如天气。

因此，缓解部分气候变化的影响（第27章：缓解）强调了研究的重要性，以了解气候变化和全球变化情景及其影响；提供一套选项来减少对气候变化和全球变化的风险；以及开发允许同时缓解和适应的策略，如建筑，以及能源效率更高、更适应气候变化的基础设施。

更广泛地说，《美国的气候选择：限制气候变化的影响》报告推荐美国应迅速制定并实施适当的策略来减少温室气体排放，并确定了重要研究需求，包括研究是否可行、成本和不同缓解选项的后果。此外，该报告建议研究支持新技术和有效实施现有选项的研究，研究如何监测减排和遵守国际协议的最好方法，以及研究如何将缓解与适应的联系起来，以及研究如何以更广泛的方式实施和评估。

研究第三次全国气候评估也建议进行以下研究活动：

- 开发支持分析的新技术信息，为能源生产、使用、碳捕获和存储、农业和土地使用、以及其他可能减少或抵消温室气体排放的技术提供支持，研究政策机制，可以用来促进创新和发展；分析成本、效益、交易和协同作用；以及在不同的行动和组合中都很有不同作用和协同作用的行动，并改进对潜在风险和地球工程的了解。
- 调查协同、交互、反馈和在适应和缓解之间的权衡与适应和缓解之间的权衡和协同作用。
- 调查以特定区域为特定目的的协同、交互、反馈和在适应和缓解之间的权衡。
the built environment. This involves, as a priority, the assessment of the economics of impacts, mitigation, and adaptation;

- **Improve understanding of the effectiveness and timescales of mitigation measures** through deepened understanding of the relationship between the fate of human-induced and natural carbon emissions, uptake by the terrestrial biosphere and oceans, and atmospheric concentrations; and

- **Identify the critical social, cultural, institutional, economic, and behavioral processes that present barriers and opportunities for mitigation** at the federal and international levels and by individuals, state and local governments, and corporations.

**Research Goal 5: Improve decision support and integrated assessment**

For assessments to be useful to policy makers, they need to provide integrated results that can be used in decision-making. Research can develop tools that facilitate decision-making and the integration of knowledge.

Critical gaps in knowledge for decision support include the issues that affect the capacity of agencies, individuals, and communities to access and use the best available scientific information in support of decision-making, including the need to assess the ability of existing institutions, legal, and regulatory structures to respond to highly interdependent climate impacts. There are instances where policy barriers, institutional capacity or structure, or conflicting laws and regulations can create barriers to effective decisions. For instance, Chapter 12 (Indigenous Peoples) notes that there is no institutional framework for addressing village relocation in response to climate change in Alaska, and Chapter 3 (Water) points out that existing water management institutions may be inadequate in the context of rapidly changing conditions. These instances point to research to evaluate whether the existing legal and regulatory structures, largely developed to address specific issues in isolation, can adequately respond to the highly interconnected issues associated with climate change. Decision support and integrated assessment also require research into the behavioral and other factors that influence individual decisions.

Assessments can benefit from research activities that:

- **Identify decision-maker needs** within regions and sectors, and support the development of research methods, tools, and information systems and models for managing carbon, establishing early warning systems, providing climate and drought information services, and analyzing the legal, regulatory, and policy approaches that support adaptation and mitigation efforts in the context of a changing climate;

- **Develop tools to support risk-based decision processes**, including tools to identify risk management information needs, develop transferable vulnerability assessment techniques, and evaluate alternative adaptation options. In addition, tools are needed to improve understanding of consumption patterns and environmental consequences; effective resource management institutions; iterative risk management strategies; and social learning, cognition, and adaptive processes;

- **Improve, fill gaps, and enhance research efforts to evaluate the effectiveness, costs, and benefits of mitigation and adaptation actions**, including economic and non-economic metrics that evaluate the costs of action, inaction, and residual impacts. Focus is also needed on the development of methods and baseline information supporting evaluation of completed and ongoing adaptation, mitigation, and assessment efforts that will foster adaptive learning; and

- **Develop, test and, expand integrated assessment models** that link decisions about emissions with impacts under different development pathways and ways to categorize uncertainties in the supporting data.
Foundational Cross-Cutting Research Capabilities to Support Future Climate Assessments

This assessment identifies a set of five foundational cross-cutting research capabilities that are essential for advancing our ability to continue to conduct climate and global change assessments and for addressing the five research goals.

1. Integrate natural and social sciences, engineering, and other disciplinary approaches

Continued advances in comprehensive and useful climate assessments will rely on additional interdisciplinary research. Understanding of the coupled human-environment system is enriched by combining research from natural and social sciences with research and experience from the engineering, law, and business professions.

Because human activities and decisions are influencing many Earth system processes, models and observations of natural and social changes at planetary, regional, and local scales are needed to understand how climate is changing, its impacts on people and environments, and how human responses feedback on the Earth system.

Building experienced interdisciplinary research teams that are able to understand each other’s theories, methods, and language as well as the needs of stakeholders will allow for more rapid and effective assessments.

Interdisciplinary research is needed, for example, to:

- Understand how hydrological drivers of water supply interact with changing patterns of water demand and evolving water management practices to increase risks of drought, or influence the effectiveness of adaptation and mitigation options;
- Understand climate change in the context of multiple stresses on Earth, ecological, and human systems;
- Bring together economic and quantitative assessment of climate impacts and policies with other more qualitative assessments that include non-market and cultural values; and
- Integrate the understanding of human behavior, engineering, and genomics to expand the range of choice in responding to climate change by providing and thoroughly evaluating new options for adoption and mitigation that improve economic development, energy, health, and food security.

2. Ensure availability of observations, monitoring, and infrastructure for critical data collection and analysis

Our understanding and ability to assess changes in climate and other global processes is based on a comprehensive and sustained system of observations that document the history of climate, socioeconomic, and related changes at spatial and time scales relevant to global, regional, and sectoral needs. The most recent USGCRP Strategic Plan states that to advance scientific knowledge of an integrated natural and human Earth system, an interoperable and integrated observational, monitoring, and data access capability is also essential. This observational capability is needed to gain the fundamental scientific understanding of essential status, trends, variability, and changes in the Earth system. It should include the physical, chemical, biological, and human components of the Earth system over multiple space and time scales.

To attain their full value, observational systems must provide data that are responsive to the needs of decision-makers in government, industry, and society. These needs include observations and data that can inform the nation’s strategies to respond to climate and global change, including, for example, efforts to limit emissions, monitor public health, capture and store carbon, monitor changes in ocean processes, and implement adaptation strategies. This will require establishing explicit baseline conditions, specifying spatial detail and temporal frequency of observations, including social data, and setting standards for metadata (information about collected data), interoperability, and regulatory and voluntary reporting, such as those outlined in the Informing an Effective Response to Climate Change Panel Report of the National Research Council’s Americas Climate Choices series. These data need to be openly and widely available in order to support the best and most comprehensive science and for use in decision-making by a range of stakeholders.

This assessment shows that enhanced research and development will be necessary to ensure that the scope and integration of relevant scientific data improves overall utility for decision-makers, including better ways to communicate metadata, data quality, and uncertainties. The observations must include critical geophysical variables such as temperature, precipitation, sea level changes, ocean circulation, atmospheric composition, and hydrology; the essential parameters that describe the biosphere; and social science information on drivers, impacts, and responses to climate and other global changes. More comprehensive and integrated data capabilities are needed to document the processes and patterns that drive natural and social feedbacks and better describe the mechanisms of abrupt change. Progress is needed in particular for data-poor regions,
focusing on inadequately documented socioeconomic, ecological, and health-related factors, and under-observed regional and sectoral data. There are opportunities to take advantage of citizen science observations where appropriate; monitor system resilience and robustness; and attend to physical and social systems that are not currently observed with sufficient temporal or spatial resolution to enable vulnerability analysis and decision support at regional and sectoral scales. More explicitly, strategic integration of our nation’s observations, monitoring, and data capabilities should be considered in order to:

- Sustain and integrate the nation’s capacity to observe long-term changes in the Earth system and improve fundamental understanding of the complex causes and consequences of global change, including integration of essential socioeconomic, health, and ecological observations;

- Maintain and enhance advanced modeling capability, including high-performance computing infrastructure, improvements in analysis of large and complex data sets, comprehensive Earth system and integrated assessment models, reanalysis, verification, and model comparisons;

- Better integrate observations and modeling to advance scientific understanding about past, present, and future climate within government, industry, and civil society; and

- Develop more fully the components and structure of a national climate and global change indicator system to support assessment that includes indicators of climate change, impacts, vulnerabilities, opportunities, and preparedness as well as trends and changes in land use, air and water pollution, water supply and demand, extreme events, diseases, public health, and agronomic data, coastal and ocean conditions (such as marine ecosystem health, ocean acidity, sea level, and salinity), cryosphere data (such as snow, sea ice conditions, ice sheets and glacier melt rates), and changes in public attitudes and understanding of climate change. All of these are important to assessing climate change, and should eventually be better coordinated at local, as well as national and regional levels in collaboration with local agencies.

3. Build capacity for climate assessment through training, education, and workforce development

Building human capacity for improved assessments requires expansion of skills within the existing public and private sectors and developing a much larger workforce that excels at critical and interdisciplinary thinking. Useful capacities include the ability to facilitate and communicate research and practice, manage collaborative processes to allow for imaginative analysis and solutions, develop sustainable technologies to reduce climate risks, and build tools for decision-making in an internationally interdependent world.

A deeper understanding of the processes and impacts of climate change, disaster risk reduction, energy policy impacts, ecosystem services and biodiversity, poverty reduction, food security, and sustainable consumption requires new approaches to training and curriculum, as well as research to evaluate the effectiveness of different approaches to research and teaching.

Assessments will benefit from activities that:

- Strengthen approaches to education about climate, impacts, and responses including developing and evaluating the best ways to educate in the fields of science (natural and social), technology, engineering, and mathematics and related fields of study (such as business, law, medicine, and other relevant professional disciplines). Ideally, such training would include a deeper understanding of the climate system, natural resources, adaptation and energy policy options, and economic sustainability, and would build capacity at colleges and institutions, including minority institutions such as tribal colleges; and

- Identify increasingly effective approaches to developing a more climate-informed society that understands and can participate in assessments, including alternative media and methods for communication; this could also include a program to certify climate interpreters to actively assist decision-makers and policymakers to understand and use climate scenarios.8
4. Enhance the development and use of scenarios

Scenarios are “coherent, internally consistent and plausible descriptions of possible future states of the world” that provide reasoned projections of energy and land use, future population levels, economic activity, the structure of governance, social values, and patterns of technological change. They survey, integrate, and synthesize science, within and among scientific disciplines and across sectors and regions. Such scenarios are essential tools that enable projections of emissions, climate, vulnerabilities, and global change. They are indispensable for linking science and decision-making and for assessing choices about America’s climate future.

Stakeholders and scientists within this assessment identified a need for more fully developed scenario-building capabilities that better enable assessments at regional and sectoral scales in timeframes of relevance to policy and decision-making and that more effectively reflect climate and global change at these scales.

Achieving capacity in scenario development will:

- Enhance understanding of how and why climate may change and its implications, especially at the regional scale. For example, a set of scenarios can be used to better understand the way energy, land use, and policy choices create alternative emissions pathways; how changes at global scales can be downcaled to estimate local climate possibilities; how various socioeconomic development pathways increase or decrease climate vulnerability; and to assess alternative strategies for reducing emissions and implementing adaptation; and

- Develop new methods, tools, and skills for applying scenarios to policy development at local levels in order to broaden society’s understanding of a changing climate and to analyze the full range of policy choices. In addition, improve capabilities in integrated assessment modeling to inform policy analysis and allow stakeholders to co-produce information and explore options for local and national decisions.

5. Promote international research and collaboration

Research efforts in support of climate assessment are very dependent on the international research community. International teams conduct Earth system monitoring and analysis using observing systems that cannot be funded and maintained by any one country alone. Many of the impacts of climate change in the U.S. are closely linked to how climate affects other parts of the world. There is general understanding that impacts of climate change on U.S. socioeconomic systems are mediated or amplified through globally connected commodity chains and prices; more detailed research on climate change and its impacts elsewhere is needed to provide accurate assessments of what could happen to U.S. regional and local economies. The U.S. has the capacity to leverage investments in collaborative international climate and global change scientific research efforts, examples of which include IGBP (International Geosphere-Biosphere Programme), WCRP (World Climate Research Programme), DIVERSITAS (an international program of biodiversity science), IHDP (International Human Dimensions Programme) (as they evolve into or in affiliation with the new Future Earth program), and IGFA (International Group of Funding Agencies for Global Change Research).

Supporting international collaborative research will:

- Contribute to international systems of data collection, monitoring, indicators, and modeling that closely track and project changes in Earth system dynamics, climate, human drivers, and climate impacts that are needed for national and international assessments;

- Assess the implications of climate change for globally shared common resources such as the oceans, polar regions, and migratory species; and

- Fill important gaps in understanding of how climate change in other countries affects U.S. food, energy, health, manufacturing, and national security.
Conclusions

This chapter summarizes research recommendations across a broad range of topics – research that the assessment authors deem essential to support future assessments. The authors recognize that federal agencies and others are making progress on many of these research areas and that sustained assessment is included in the goals of the USGCRP.

While the research goals discussed in this chapter are not ranked, the objectives listed below can be used as criteria for prioritizing these activities. The nation’s federal research investments in support of the sustained assessment strategy should be designed to enhance the nation’s ability to limit climate-related risk and increase the utility of scientific understanding in supporting decisions.

- **Promote understanding of the fundamental behavior of the Earth’s climate and environmental systems:** The consequences of climate variability and change will require enhanced investment in use-inspired research using both fundamental and applied analysis, providing a foundation for the nation’s sustained assessment process;

- **Promote understanding of the socioeconomic impacts of a changing climate:** Provide comprehensive understanding, including the development of indicators of the impacts and consequences of climate variability and change for regions and sectors within the United States;

- **Build capacity to assess risks and consequences:** Support improved, timely, and accessible estimations and projections of climate and other global change risks, their consequences and relevance for stakeholders, associated costs and benefits, and interactions with other stresses;

- **Support research that enables infrastructure for analysis:** Sustain and enhance critical infrastructure, including observations and data essential to monitoring trends, projecting climate risks, and evaluating the effectiveness of responses in decision-making and policy implementation;

- **Build decision-support capacity:** Build the knowledge base essential for decision support including developing and evaluating climate mitigation and adaptation solutions, technology innovation, institutions, and behavioral change; and

- **Support engagement of the private sector and investment communities:** Develop strategies to leverage federal research investments by engaging the private sector more fully in research and technology development, including partnerships with the nation’s universities and scientific research institutions, to address critical gaps in knowledge and to build the nation’s future scientific, technical, and sustained assessment capacities.

- **Leverage private sector, university, and international resources and partnerships:** Take advantage of topics and expertise where the U.S. can leverage and complement private sector and university capabilities, obtain return on research investments, and lead internationally on research investment efforts; build capacity through education and training; support humanitarian response; and fill critical gaps in global knowledge of relevance to the United States.
References


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Chapter Process:

The author team asked each of the other chapter author teams to identify important gaps in knowledge and key research needs in the course of writing their chapters, particularly in the context of the needs for research to support future assessments. In addition to the lists provided by each chapter author team, the team also drew on analyses from over 100 technical and public review suggestions and a wide variety of technical and scholarly literature, especially the U.S. Global Change Research Program’s Strategic Plan⁵ and the National Research Council’s America’s Climate Choices reports,² ³ ⁴ ⁸ ¹⁰ to compile a list of potential research needs. Using expert deliberation, including a number of teleconference meetings and email conversations among author team members, the author team agreed on high-priority research needs, organized under five research goals.