Multi-Stakeholder Research and Analysis for Collective Action in Undergoverned Spaces

Chapter Thirteen

ROBERT J. LEMPERT, KELLY KLIMA, AND SARA TURNER,
RAND CORPORATION

This chapter is extracted from *Adaptive Engagement for Undergoverned Spaces: Concepts, Challenges, and Prospects for New Approaches*, by Aaron B. Frank and Elizabeth M. Bartels, eds., RR-A1275-1, 2022 (available at www.rand.org/t/RRA1275-1).

Prepared for the Defense Advanced Research Projects Agency,
Defense Sciences Office
Approved for public release; distribution unlimited

For more information on this publication, visit **www.rand.org/t/RRA1275-1**.

About RAND

The RAND Corporation is a research organization that develops solutions to public policy challenges to help make communities throughout the world safer and more secure, healthier and more prosperous. RAND is nonprofit, nonpartisan, and committed to the public interest. To learn more about RAND, visit www.rand.org.

Research Integrity

Our mission to help improve policy and decisionmaking through research and analysis is enabled through our core values of quality and objectivity and our unwavering commitment to the highest level of integrity and ethical behavior. To help ensure our research and analysis are rigorous, objective, and nonpartisan, we subject our research publications to a robust and exacting quality-assurance process; avoid both the appearance and reality of financial and other conflicts of interest through staff training, project screening, and a policy of mandatory disclosure; and pursue transparency in our research engagements through our commitment to the open publication of our research findings and recommendations, disclosure of the source of funding of published research, and policies to ensure intellectual independence. For more information, visit www.rand.org/about/research-integrity.

RAND's publications do not necessarily reflect the opinions of its research clients and sponsors.

Published by the RAND Corporation, Santa Monica, Calif.

© 2022 RAND Corporation
RAND® is a registered trademark.

Limited Print and Electronic Distribution Rights

This publication and trademark(s) contained herein are protected by law. This representation of RAND intellectual property is provided for noncommercial use only. Unauthorized posting of this publication online is prohibited; linking directly to its webpage on rand.org is encouraged. Permission is required from RAND to reproduce, or reuse in another form, any of its research products for commercial purposes. For information on reprint and reuse permissions, please visit www.rand.org/pubs/permissions.

CHAPTER THIRTEEN

Multi-Stakeholder Research and Analysis for Collective Action in Undergoverned Spaces

Robert J. Lempert, RAND Corporation
Kelly Klima, RAND Corporation
Sara Turner, RAND Corporation

The challenges of competition and collaboration in undergoverned spaces (UGS) raise many issues and opportunities for multi-stakeholder research. These run the gamut from understanding the mental models and relationships among multiple stakeholders to adaptive governance processes that involve stakeholders in the decision processes themselves. Recent years have seen expanding interest, understanding, and experience in engaging stakeholders as a key target for collaboration and decisionmaking, across all aspects of complex problem management, including research. Many opportunities exist for research that can improve the capabilities for engaging multiple stakeholders in UGS.

This chapter provides an overview of how multiple stakeholders can be involved in the research process and also considers how these different modalities relate to one another. We focus on approaches that center stakeholders as either the focus of research or as the coproducers of research and on how each can add value for policymakers. Second, we examine each of these modalities, in turn, identifying the general principles of practice, the different approaches and tools in conducting research in these modalities, and the challenges of doing so. We next examine future investments that could catalyze improvements in multi-stakeholder research and make the case for how these investments could drive improved multi-stakeholder governance.

How Multiple Stakeholders Can Be Involved in the Research Process

Multi-stakeholder research is any research process that involves a diverse group of people, businesses, governments, or other entities that have some interest in the process or outcome of the research. In some contexts, this may be an output of a research group representing different interests, while, in other cases, it might represent an engagement with stakehold-

ers who are the subjects of research and collaborators in its production. Different stakeholders might have different questions they want answered by the research; the questions might evolve over time, and stakeholders might have different incentives to share results or engage other parties. Questions, methods, and partnerships will evolve over time as research needs shift in response to changes in the operational and strategic landscape.

Multi-stakeholder research can take many forms, varying in how stakeholders and researchers interact and in the goals of the research, as shown in Table 13.1.

Research focused on stakeholders can help the United States better understand and provide communications that are responsive to existing stakeholder frames. Stakeholders can also participate in research designed to help the U.S. government and other actors communicate with one another, come to common understandings, and jointly manage UGS. In these approaches, research questions and methods may be driven by government agencies or their proxies in a top-down approach to research.

Stakeholders as participants can coproduce knowledge that facilitates common understandings and engagement, and they can provide local or specialized knowledge accessible only through some stakeholders. To facilitate multi-actor and adaptive governance, stakeholders can also participate in research facilitating deliberation designed to develop new mental models and understanding of problems. *Adaptive governance* refers to *flexible and learning-based collaborations and decisionmaking processes involving both state and nonstate actors, often at multiple levels, with the aim of adaptively negotiating and coordinating the management of complex systems.* Research with stakeholders as participants addresses questions that are driven from the bottom up by stakeholder needs and interests or through a two-way dialogue between the subjects of research and the relevant stakeholders.

We discuss both of these: stakeholders as the focus of research and stakeholders as participants in research.

Stakeholders as the Focus of Research

To enhance understanding (see Table 13.1), multi-stakeholder research uses numerous methods—such as interviews, surveys, and such direct observations as lab experiments and games—to identify cognitive biases, mental models, and worldviews. In UGS, examining observed interactions among stakeholders could prove particularly useful. These methods typically focus on observed interactions among stakeholders (e.g., to inform how a post on

TABLE 13.1
Types of Multi-Stakeholder Research

	Focus	
Goals	Stakeholders as the Focus of Research	Stakeholders as the Participants in Research
Generate knowledge	Understand	Coproduce
Offer new frames	Communicate	Deliberate

social media or an in-person workshop should be structured so people can interact with each other). The focus is on understanding stakeholder beliefs, interests, and interactions to better understand the dynamics of their relationships and to answer related research questions. These activities can be targeted at specific populations of interest in which understanding of these populations is crucial to answering policy-relevant research questions.

To enhance communication, multi-stakeholder research can focus on how various groups can be encouraged to understand and change behavior on the basis of specific research outputs and/or other information. The audiences for such communications might include both the stakeholders who were the focus of research and other audiences of interest to policymakers sponsoring and consuming the research. Sponsoring agencies are often, but not always, the consumers of research. In the cases in which they are not, communications might need to consider both sponsor and consumer needs and different communications targeted to each when possible. Research on effective communication methods encompasses too broad a space to cover in depth within this chapter, but interested researchers can refer to the citations in the footnotes on where to find more information on effective communication with stakeholders[1] and research methods for evaluating stakeholder communications.[2] For instance, multi-stakeholder research might investigate indigenous perspectives on how to allocate economic resources as a core research question, but additional work might be needed to understand the perspectives of the states in which these populations live and to explore how best to communicate results to U.S. federal and state governments, the governments of other nations, nonstate actors, civic organizations, and indigenous populations.

Stakeholders as Participants in Research

Coproduction of knowledge (see Table 13.1) refers to processes in which multiple stakeholders representing different sources of knowledge—such as research, policy, business, and civil society communities—collaborate to cocreate information relevant to decisionmaking.[3] Coproduction can range from unidisciplinary research through multi- and interdisciplinary research that add increasing levels of depth and subject-matter breadth to transdisciplinary

[1] National Academies of Science Engineering and Medicine, *Communicating Science Effectively: A Research Agenda*, Washington, D.C.: National Academies Press, 2017; Dietram A. Scheufele, "Science Communication as Political Communication," *Proceedings of the National Academy of Sciences*, Vol. 111, 2014; and Baruch Fischhoff, "The Sciences of Science Communication," *Proceedings of the National Academy of Sciences*, Vol. 110, 2013.

[2] Lawrence Frey, Carl H. Botan, and Gary Kreps, *Investigating Communication*, New York: Allyn & Bacon, 2000; Thomas R. Lindlof and Bryan C. Taylor, *Qualitative Communication Research Methods*, Thousand Oaks, Calif.: Sage, 2017; Werner J. Severin and James W. Tankard, *Communication Theories: Origins, Methods, and Uses in the Mass Media*, New York: Longman, 1997; and David M. Boje, *Narrative Methods for Organizational & Communication Research*, Thousand Oaks, Calif.: Sage, 2001.

[3] Ida Nadia S. Djenontin and Alison M. Meadow, "The Art of Co-Production of Knowledge in Environmental Sciences and Management: Lessons from International Practice," *Environmental Management*, Vol. 61, 2018.

convergence research that applies the methods of transdisciplinary research to answer pressing social problems.[4] Regardless of how many areas of expertise are involved, coproduction involves stakeholders in multiple stages of research: the problem definition, development of research questions, research design, data collection and analysis, interpretation, testing of results, and the dissemination process.

For instance, the Arctic Council (AC)'s Alaska Native Tribal Health Consortium established the local environmental observer (LEO) network in 2009 to collect concerns about environmental change and pollution in the region. Stakeholders—in this case, subnational private actors residing in the Arctic—are deeply involved in the data collection process of the LEO network, helping to coproduce knowledge about environmental change and arctic contaminants. Such coproduction does not preclude research on stakeholders; rather it widens the aperture to involve more participants in the research, with the goal of increasing the relevance and usability of the resulting information.

A deliberative process (see Table 13.1) can be defined as a method that allows a group of actors to receive and exchange information, critically examine an issue, and come to an agreement that makes or recommends particular decisions.[5] Deliberation can take many forms and engage different groups of stakeholders in structured discussions designed to enrich understanding and shift or develop preferences, with the goal of contributing to decisions to improve the management of a particular problem. Deliberative processes often involve iterative cycles of analysis and decisionmaking, wherein the analytical products and decisionmaking processes jointly inform one another as learning occurs about the problem at hand. These multi-stakeholder decision processes can draw from a variety of theoretical backgrounds (e.g., game theory, negotiation theory, deliberation with analysis), but all involve structured ways of navigating the different preferences, levels of knowledge, institutional roles, and capabilities of different actors to arrive at feasible solutions.

The following two sections look at the two modalities in terms of their core principles, their tools and approaches, and the challenges involved in using the tools and approaches—specifically in terms of long-term competition and UGS.

Approaches to Multi-Stakeholder Research: Stakeholders as a Focus of Research

We first consider approaches to multi-stakeholder research that treat stakeholders as a focus of the research process. This involves both efforts to understand what stakeholders are think-

[4] Lori Peek, Jennifer Tobin, Rachel M. Adams, Haorui Wu, and Mason Clay Mathews, "A Framework for Convergence Research in the Hazards and Disaster Field: The Natural Hazards Engineering Research Infrastructure CONVERGE Facility," *Frontiers in Built Environment*, Vol. 6, July 2020.

[5] James D. Fearon, "Deliberation as Discussion," in J. Elster, ed., *Deliberative Democracy*, Cambridge, Mass.: Cambridge University Press, 1998.

ing, feeling, and experiencing and to develop communication approaches that are effective in reaching target populations of interest. The benefits of working to understand these worldviews can be substantial. This process offers researchers and policymakers more insight into the beliefs, motivations, biases, and values of relevant populations. This insight can identify areas of cooperation, complementarity, or competition among different groups; potential areas for misunderstanding and misinterpretation between groups; and solutions to policy problems that might otherwise be overlooked. Furthermore, research focusing on stakeholders allows researchers to determine how to subsequently engage stakeholders in a way that fits with those stakeholders' worldviews, generating improved understandings of problems and enabling the development of communications that are effective at reaching populations of interest.

An example in which research on the motivations and capabilities of stakeholders has been productively employed is a recent study of the benefits and risks of private-sector attribution of cyberattacks.[6] In this study, the authors clearly lay out the differing motivations of private-sector actors to attribute cyberattacks to nation-states and discuss the benefits and risks of doing so to U.S. government interests. Ultimately, the study argues that the complementary interests and capabilities of the U.S. government and the private sector provide significant opportunities to collaborate in attributing cyberattacks as a form of deterrence in an undergoverned competitive space. Work like this makes clear that multi-stakeholder-focused research on security problems can help identify opportunities for increased collaboration and communication.

Prior to developing communication messaging, or opportunities for collaboration, multi-stakeholder-focused research efforts must first identify the underlying beliefs, values, and perceptions of the populations of interest (referred to as either *worldviews* or *mental models*). To determine a worldview, researchers should use several basic principles to (1) understand cognitive biases that might be affecting mental models; (2) deploy methods to obtain those mental models given the cognitive heuristics; and (3) account for special needs for stakeholder engagement in UGS. These steps are iterative, and researchers might find that they need to move between steps 1 and 2 several times to adequately specify a mental model.

Many ways exist to understand a stakeholder's mental models and associated cognitive biases (e.g., work conducted between the 1960s and 1980s by such authors as Edwards, Einhorn, and Hogarth).[7] Hundreds of biases have been identified, including in online settings.[8] Three biases are worth briefly mentioning because they may particularly affect the

[6] Sasha Romanosky and Benjamin Boudreaux, "Private-Sector Attribution of Cyber Incidents: Benefits and Risks to the U.S. Government," *International Journal of Intelligence and Counterintelligence*, Vol. 34, No. 3, 2021.

[7] Paul Slovic, Baruch Fischhoff, and Sarah Lichtenstein, "Behavioral Decision Theory," *Annual Review of Psychology*, Vol. 28, No. 1, 1977; and Hillel J. Einhorn and Robin M. Hogarth, "Behavioral Decision Theory: Processes of Judgement and Choice," *Annual Review of Psychology*, Vol. 32, No. 1, 1981.

[8] Daniel Kahneman, Paul Slovic, and Amos Tversky, eds., *Judgment Under Uncertainty: Heuristics and Biases*, Cambridge, United Kingdom: Cambridge University Press, 1982; Steven J. Sherman and Eric Corty, "Cognitive Heuristics," in R. S. Wyer, Jr., and T. K. Srull, eds., *Handbook of Social Cognition*, Vol. 1, Mahwah, N.J.: Lawrence Erlbaum Associates, 1984; Slovic, Fischhoff, and Lichtenstein, 1977; Susan Mineka

practice of multi-stakeholder research; we refer the reader to the citations on each bias listed in the next sentence for further reading. They are anchoring (and adjustment),[9] affect,[10] and confirmation[11] biases. These are described extensively in the literature and the focus here is on how those biases may operate in the context of long-term competition and UGS.

Anchoring and Adjustment Biases

Anchoring and adjustment biases occur when a person uses a piece of information to help inform later answers. This cognitive bias may especially come into play in an undergoverned space because information may not be as readily available and thus information from a trusted source may be relied on even more heavily than normal. Researchers may need to be particularly aware of this bias when structuring their communications.

Affect Biases

Regarding affect, it is important to understand stakeholders' moods, which would alter how they respond to the research questions and processes. Different stakeholders might respond to events in significantly different ways according to a variety of varying contextual and indi-

---

and Steven K. Sutton, "Cognitive Biases and the Emotional Disorders," *Psychological Science*, Vol. 3, No. 1, 1992; Richard R. Lau and David P. Redlawsk, "Advantages and Disadvantages of Cognitive Heuristics in Political Decision Making," *American Journal of Political Science*, Vol. 45, October 2001; Carlo C. Jaeger, Thomas Webler, Eugene A. Rosa, and Ortwin Renn, "Decision Analysis and Rational Action," in S. Rayner and E. L. Malone, eds., *Human Choice and Climate Change*, Vol. 3, *Tools for Policy Analysis*, Columbus, Ohio: Battelle Press, 1998; Graham Loomes and Robert Sugden, "Regret Theory: An Alternative Theory of Rational Choice Under Uncertainty," *Economic Journal*, Vol. 92, No. 4, 1982; and Miriam J. Metzger and Andrew J. Flanagin, "Credibility and Trust of Information in Online Environments: The Use of Cognitive Heuristics," *Journal of Pragmatics*, Vol. 59, 2013.

[9] Karen E. Jacowitz and Daniel Kahneman, "Measures of Anchoring in Estimation Tasks," *Personality and Social Psychology Bulletin*, Vol. 21, No. 11, 1995; and Nicholas Epley and Thomas Gilovich, "The Anchoring-and-Adjustment Heuristic: Why the Adjustments Are Insufficient," *Psychological Science*, Vol. 17, No. 4, 2006.

[10] George F. Loewenstein, Elke U. Weber, Christopher K. Hsee, and Ned Welch, "Risk as Feelings," *Psychological Bulletin*, Vol. 127, No. 2, 2001; Ellen Peters, Daniel Västfjäll, Tommy Gärling, and Paul Slovic, "Affect and Decision Making: A Hot Topic," *Journal of Behavioral Decision Making*, Vol. 19, No. 2, 2006; Jennifer S. Lerner and Larissa Z. Tiedens, "Portrait of the Angry Decision Maker: How Appraisal Tendencies Shape Anger Influence on Decision Making," *Journal of Behavioral Decision Making*, Vol. 19, No. 2, 2006; Paul Slovic, Melissa L. Finucane, Ellen Peters, and Donald G. MacGregor, "Risk as Analysis and Risk as Feelings: Some Thoughts About Affect, Reason, Risk and Rationality," *Risk Analysis*, Vol. 24. No. 2, 2004; Jennifer S. Lerner, Roxana M. Gonzalez, Deborah A. Small, and Baruch Fischhoff, "Effects of Fear and Anger on Perceived Risks of Terrorism," *Psychological Science*, Vol. 14, No. 2, 2003; and W. Richard Walker and John J. Skowronski, "The Fading Affect Bias: But What the Hell Is It For?" *Applied Cognitive Psychology: The Official Journal of the Society for Applied Research in Memory and Cognition*, Vol. 23, No. 8, 2009.

[11] Joshua Klayman, "Varieties of Confirmation Bias," *Psychology of Learning and Motivation*, No. 32, 1995; Raymond S. Nickerson, "Confirmation Bias: A Ubiquitous Phenomenon in Many Guises," *Review of General Psychology*, Vol. 2, No. 2, 1998; and Imran Demir, *Overconfidence and Risk Taking in Foreign Policy Decision Making: The Case of Turkey's Syria Policy*, New York: Springer, 2017.

vidual factors, including their emotional affect. Particularly in the context of UGS, affect has the potential to alter a respondent's perceptions about risk. For example, people who are more fearful (or less angry) exhibit increased risk estimates of terrorism. In the context of long-term competition, fading affect bias may result in memories of negative events remaining salient to stakeholders longer than equally strong positive events and continuing to influence decisions over a longer time.

Confirmation Bias

Confirmation bias, in which people are more likely to accept information that aligns with their worldviews, can lead to overconfidence, such as when Turkey's leadership was overconfident in its Syria policies because the policies agreed with what it thought was true and did not fully take into account how other actors would actually behave.[12] Recognizing confirmation bias is particularly important for U.S. government officials making decisions about how to intervene in poorly understood settings. Decisionmaking frameworks for engaging in UGS, such as the Act-Sense-Decide-Adapt (ASDA) cycle, depend on making decisions, sensing the consequences to learn about the system, and then adapting strategy. However, confirmation bias hinders the ability of decisionmakers to accurately sense consequences and thus to adapt when needed.

Once worldviews are fully understood, research teams can work to design communications that meet the needs of key populations. For interested readers, there is a substantial amount of existing literature on effective science and policy communication tools. The body of work in this space emphasizes the challenges of communicating research effectively in a crowded, contested media environment, the need to use communication tools to build trust between parties, and the need for research on how to communicate research to bridge the divide between science and policy. For example, the Intelligence Community (IC) and its initial briefings to presidential candidates not only help the presidential candidates digest the material but also gather information about the candidates to better inform future engagements between the parties. This effort affords the IC the opportunity to determine what kinds of communications are most likely to be effective. For this chapter, we do not survey the literature in depth—because good summaries are available elsewhere (see earlier discussion about citations); instead, we briefly describe some existing tools and note that research into effective multi-stakeholder communication is crucial for developing trust and partnerships between researchers, policymakers, research subjects, and other relevant parties and should not be neglected relative to other areas of multi-stakeholder research discussed later.

Tools Available for Research with Stakeholders as a Focus

Understanding how cognitive heuristics and biases influence worldviews and decisionmaking requires targeted research efforts to identify and characterize these belief systems. Typically,

[12] David C. Gompert, Hans Binnendijk, and Bonny Lin, *Blinders, Blunders, and Wars: What America and China Can Learn*, Santa Monica, Calif.: RAND Corporation, RR-768-RC, 2014; Demir, 2017.

methods seek to identify either stated or revealed preferences. Here we describe two general methods of identifying these preferences: asking people (via interviews, surveys, and focus groups) and observing people. Table 13.2 summarizes some commonly used methods and identifies some of the challenges that could arise when these methods are deployed in undergoverned and long-term competitive contexts. It is not a comprehensive list of such methods; it is designed to provide an overview of what each method offers in a multi-stakeholder context and how they might be challenged in complex environments.

Interviews

Interviews are a commonly used method to gather multi-stakeholder input. Interviews can be open-ended or semistructured, seeking to gather oral histories or specific metrics. Interviews provide the ability to question stakeholders, with a time length that can be tailored in near real time. As a result of their flexibility, interviews have been used to gather data in an undergoverned space, such as interviews following a plane crash in the Ukraine.[13] Dyadic interviews (where two stakeholders are interviewed together)[14] have the additional benefit of revealing interactions between people. For example, in a study in Syria, researchers asked parents about health care for Syrian children and explicitly focused on interactions and points of disagreement.[15]

TABLE 13.2
Select Methods to Engage Multiple Stakeholders as Focus of Research

Approach	Concept	Challenges
Interviews	Individual researcher–stakeholder interaction to elicit worldviews that allow discussion and follow-up	Access may be restricted; follow-up interviews with same subjects may be difficult in UGS
Surveys or polls	Individual one-way researcher–stakeholder interaction to elicit stakeholder worldviews	Trade-off between open-ended responses and standardized information
Focus groups	Multidirectional stakeholder interaction moderated by researcher to elicit group views	Difficult to infer individual views without additional methods
Direct observation	Interaction-free observation of stakeholder by researcher to infer worldviews	Potential gaps in what can be inferred through passive observation; nonrepresentative data

[13] C. Joris Yzermans, "The Experience of Sudden Loss of a Colleague or Neighbor Following the MH17 Plane Crash in the Ukraine: A Qualitative Interview Study," *BMC Psychology*, Vol. 8, No. 1, 2020.

[14] David L. Morgan, Jutta Ataie, Paula Carder, and Kim Hoffman, "Introducing Dyadic Interviews as a Method for Collecting Qualitative Data," *Qualitative Health Research*, Vol. 23, No. 9, 2013.

[15] Riham M. Alwan, "Beliefs, Perceptions, and Behaviors Impacting Healthcare Utilization of Syrian Refugee Children," *PloS One*, Vol. 15, No. 8, 2020.

Surveys

Surveys often come after a set of interviews to flesh out the initial mental model. Survey methodology is well studied and can be tailored to nearly any kind of research question.[16] For example, surveys can answer questions about open-ended thoughts, discrete choices, or public perceptions.[17] In an undergoverned space, surveys were used to, for example, determine multi-stakeholder input on the health and environmental situation in Aleppo households in war-torn Syria.[18] Note, questions must sometimes be carefully constructed to decrease unnecessary risk to the participant. For example, wartime surveys in Afghanistan might be structured to compare groups of people rather than individual responses.[19]

Focus Groups

A focus group is a small number of diverse stakeholders brought together to consider a topic with the goal of gaining representation from different groups (demographic and otherwise) that might affect the result.[20] Its primary value is that it can gather a variety of views on a specific topic in a relatively short time and, in conjunction with other methods, can allow researchers to understand how individual views may shift or be expressed differently in group settings. However, on its own, a focus group can make it difficult to extract individual under-

---

[16] Robert M. Groves, *Survey Errors and Survey Costs*, Hoboken, N.J.: John Wiley & Sons, 2004; Floyd J. Fowler, Jr., *Survey Research Methods*, Thousand Oaks, Calif.: Sage, 2013.

[17] Margaret E. Roberts, "Structural Topic Models for Open-Ended Survey Responses," *American Journal of Political Science*, Vol. 58, No. 4, 2014; Frederieke Kleij and Pieter A. D. Musters, "Text Analysis of Open-Ended Survey Responses: A Complementary Method to Preference Mapping," *Food Quality and Preference*, Vol. 14, No. 1, 2003; Moshe Ben-Akiva and Steven R. Lerman, *Discrete Choice Analysis: Theory and Application to Travel Demand (Transportation Studies)*, Cambridge, Mass.: MIT Press, 2018; David A. Hensher and Lester W. Johnson, *Applied Discrete-Choice Modelling*, London, United Kingdom: Routledge, 2018; Gabrielle Wong-Parodi and Kelly Klima, "Preparing for Local Adaptation: A Study of Community Understanding and Support," *Climatic Change*, Vol. 145, No. 3–4, 2017; Kelly Klima and Alessandra Jerolleman, "A Rose by Any Other Name—Communicating Between Hazard Mitigation, Climate Adaptation, Disaster Risk Reduction, and Sustainability Professionals," *Journal of Environmental Studies and Sciences*, Vol. 7, No. 1, 2017; Forrest E. Morgan, Benjamin Boudreaux, Andrew J. Lohn, Mark Ashby, Christian Curriden, Kelly Klima, and Derek Grossman, *Military Applications of Artificial Intelligence: Ethical Concerns in an Uncertain World*, Santa Monica, Calif.: RAND Corporation, RR-3139-1-AF, 2020.

[18] Wasim Maziak, Kenneth D. Ward, Fawaz Mzayek, Samer Rastam, M. E. Bachir, Fouad M. Fouad, Fadi Hammal, Taghrid Asfar, Jeremiah Mock, Iman Nuwayhid, et al., "Mapping the Health and Environmental Situation in Informal Zones in Aleppo, Syria: Report from the Aleppo Household Survey," *International Archives of Occupational and Environmental Health*, Vol. 78, No. 7, 2005; Larissa Vernier, "High Levels of Mortality, Exposure to Violence and Psychological Distress Experienced by the Internally Displaced Population of Ein Issa Camp Prior to and During Their Displacement in Northeast Syria, November 2017," *Conflict and Health*, Vol. 13, Article 33, 2019.

[19] Jason Lyall, Graeme Blair, and Kosuke Imai, "Explaining Support for Combatants During Wartime: A Survey Experiment in Afghanistan," *American Political Science Review*, Vol. 107, No. 4, 2013.

[20] David L. Morgan, *The Focus Group Guidebook*, Thousand Oaks, Calif.: Sage, 1997; Holly Edmunds, "The Focus Group Research Handbook," *The Bottom Line*, Vol. 12, No. 3, 1999; Fatemeh Rabiee, "Focus-Group Interview and Data Analysis," in *Proceedings of the Nutrition Society*, Vol. 63, No. 4, 2004.

standings from the group's discussion, because the social dynamics and moderator behavior can influence how people respond.[21]

Direct Observation

Another method to obtain multi-stakeholder input is through direct observation.[22] In certain UGS or remote spaces where one cannot interact with people and there is no advanced technology, direct observation might be one of the only methods to obtain data on stakeholders' mental models. For example, in a study on a tribe in central Amazonia, researchers used direct observation techniques to gather improved understanding on subsistence hunting.[23] Direct observation can be targeted to in-person or online actions and behavior. For example, browsing history, transactional data tracking, meeting notes and attendance records, and interactions on social media would all be considered forms of direct observation. All these data collection efforts help identify stakeholders' actions, preferences, and possibly mental models. These types of methods are quite commonly used in cyberspace.[24] For example, social media data could be used to monitor the needs for emergency first responders as has been recommended for the U.S. Coast Guard.[25] For example, one could use these types of methods to understand longitudinal tweets in Syria,[26] to determine stakeholders' inputs on social movements in Africa,[27] or to understand the behavior of citizens in cyberspace.[28] Of

[21] Tobias O. Nyumba, Kerrie Wilson, Christina J. Derrick, and Nibedita Mukherjee, "The Use of Focus Group Discussion Methodology: Insights from Two Decades of Application in Conservation," *Methods in Ecology and Evolution*, Vol. 9, No. 1, 2018.

[22] Ellen Taylor-Powell and Sara Steele, *Collecting Evaluation Data: Direct Observation, Program Development and Evaluation*, Madison, Wisc.: University of Wisconsin-Extension, 1996.

[23] Rosélis Remor de Souza-Mazurek, "Subsistence Hunting Among the Waimiri Atroari Indians in Central Amazonia, Brazil," *Biodiversity & Conservation*, Vol. 9, No. 5, 2000.

[24] Michael Forte, "Learning Human Behavioral Profiles in a Cyber Environment," in *2010 IEEE Systems and Information Engineering Design Symposium*, Charlottesville, Va.: IEEE, 2010.

[25] Douglas Yeung, Sarah A. Nowak, Sohaela Amiri, Aaron C. Davenport, Emily Hoch, Kelly Klima, and Colleen M. McCullough, *U.S. Coast Guard Emergency Response and Disaster Operations: Using Social Media for Situational Awareness*, Santa Monica, Calif.: RAND Corporation, RR-4296-DHS, 2020b; Douglas Yeung, Sarah A. Nowak, Sohaela Amiri, Aaron C. Davenport, Emily Hoch, Kelly Klima, and Colleen M. McCullough, "How the U.S. Coast Guard Can Leverage Social Media and Enhanced Cell Phone Data to Improve Emergency Response," Santa Monica, Calif.: RAND Corporation, RB-10102-DHS, 2020a.

[26] Deen Freelon, Marc Lynch, and Sean Aday, "Online Fragmentation in Wartime: A Longitudinal Analysis of Tweets About Syria, 2011–2013," *Annals of the American Academy of Political and Social Science*, Vol. 659, No. 1, 2015.

[27] Farid Shirazi, "Social Media and the Social Movements in the Middle East and North Africa," *Information Technology & People*, Vol. 26, No. 1, 2013.

[28] Beth Simone Noveck, "Designing Deliberative Democracy in Cyberspace: The Role of the Cyber-Lawyer," *Boston University Journal of Science & Technology Law*, Vol. 9, No. 1, 2003.

importance is the need to interrogate assumptions about the credibility of sources and information from social media.[29]

Challenges in Using Multiple Stakeholders as a Focus of the Research

For research to be impactful, it must be useful and relevant to stakeholders. There are multiple ways to achieve this goal, and there are significant benefits to be gained by considering multiple stakeholders in the research process. Most significantly, focusing on stakeholders in research provides an opportunity for researchers to develop a deeper understanding of the beliefs driving stakeholder actions and insight into which issues and messages are most important to particular individuals and groups. This understanding can translate into improved messaging and communication with different groups, but it can also help identify opportunities for more engaged coproduction or deliberation processes.

The decision to involve multiple stakeholders in research can also carry costs and risks that researchers should consider in their planning. These could be higher costs to engage with many heterogeneous stakeholders and to reach particularly isolated or difficult-to-access groups. The increased time required to conduct engagements can also be a source of tension in situations in which an adaptive management process needs to quickly respond to changing conditions on the ground. Many of these challenges can additionally translate into larger transportation, food, or lodging expenses. Other challenges to accessing these stakeholders might be low internet availability and usage and slower data collection if using asynchronous online data collection methods. Populations of interest may also be distrustful of researcher intentions, thus requiring engagement over longer periods—or the use of different research partners—to develop trust and rapport that enables good research.

Physical risks to researchers and stakeholders are also a consideration, because it may be dangerous to physically reach some groups. In many settings where there may be some need to smooth tensions in person, it is standard practice to use a trained moderator.[30] A corollary exists in the online space; when a communication tool to engage stakeholders is online, it can quickly become a target for bad actors or provide information to adversaries about researcher intentions and resources.[31] Depending on the topic and context, it may be that increased security or privacy measures are needed, for example, to prevent cyberhacking into an event. Effective communication is crucial and made more difficult when multiple stakeholders may

[29] For more, see Xialing Lin, Patric R. Spence, and Kenneth A. Lachlan, "Social Media and Credibility Indicators: The Effect of Influence Cues," *Computers in Human Behavior*, Vol. 63, 2016.

[30] Joseph S. Dumas and Beth A. Loring, *Moderating Usability Tests: Principles and Practices for Interacting*, Amsterdam, Netherlands: Elsevier, 2008.

[31] Todd Helmus, "Social Media and Influence Operations Technologies: Implications for Great Power Competition," in Thomas F. Lynch III, ed., *Strategic Assessment 2020: Into a New Era of Great Power Competition,* Washington, D.C., National Defense University, 2020.

come from different places or communities of practice (where jargon can be meaningfully different).[32] For example, a very difficult survey problem might be producing maps that let U.S. soldiers interact with locals, but locals did not use the same place names as the official maps; also, place names could vary by group.[33] Privacy risk can be a major concern in these contexts, where professional, reputational, and even physical safety can be affected by a privacy failure.

In the context of long-term competition, the impacts of these failures can have enduring consequences. To the extent that researchers are (or are believed to be) representatives of the U.S. government, then actions that breach social trust in populations can make it harder to conduct research with the same groups in future. Approaches to ameliorating this risk—such as sampling enough participants to be able to aggregate and anonymize the results without fear that any person will be identified—can increase costs. In settings where people interact, implementing ground rules, such as the Chatham House rules (i.e., participants are welcome to use what they learned but not to attribute it to someone), could be one way to lower this risk. This extends to people after they have left UGS; consider, for example, a study of Afghan refugees in the United States[34] that highlights findings on how to ask the questions while preserving privacy (and reducing other risks, such as emotional risk).

Finally, work in UGS can carry substantial emotional risk to participants. Proper review by groups, such as Institutional Review Boards, will help identify sources of, and reduce risks to, participants (although, in some cases, this may mean that the research is not allowable). This may also lead the researcher to use remote technologies (such as virtual reality [VR] or augmented reality [AR]) or increase cyber protections for the participants. Another concept of importance is working to provide positive experiences and feedback opportunities. It helps to define workshop roles and responsibilities in advance, such as by providing a biography sheet to the participants in advance of the workshop. Obviously, a large part of this aspect is creating a research environment where stakeholders feel welcomed to participate and provide input and that their interactions moderated in a positive, constructive manner. For more on political psychology, see works by Jervis and Larson.[35]

While stakeholder-focused research in the context of long-term competition and UGS can carry substantial risks and impose higher costs on the research team, these risks can often be mitigated and may be outweighed by the substantial benefits that can accrue.

---

[32] Klima and Jerolleman, 2017.

[33] Roos Haer and Inna Becher, "A Methodological Note on Quantitative Field Research in Conflict Zones: Get Your Hands Dirty," *International Journal of Social Research Methodology*, Vol. 15, No. 1, 2012.

[34] Valerie J. Smith, "Ethical and Effective Ethnographic Research Methods: A Case Study with Afghan Refugees in California," *Journal of Empirical Research on Human Research Ethics*, Vol. 4, No. 3, 2009.

[35] Robert Jervis, *Perception and Misperception in International Politics*, Princeton, N.J.: Princeton University Press, 2017; Deborah Welch Larson, *Origins of Containment: A Psychological Explanation*, Princeton, N.J.: Princeton University Press, 1985.

Approaches to Multi-Stakeholder Research: Stakeholders as Participants in Research

Stakeholder research that treats stakeholders as partners in the coproduction of knowledge or in deliberation requires thinking about the nature of the problem being analyzed and designing ways to bring stakeholders into the research process itself. This type of multi-stakeholder research can use or rely on the approaches to stakeholder focus described earlier, but it can also open the door to deeper collaboration in which diverse groups actively participate in the framing and formulation of problems to be studied and decisions about what to do with the resulting knowledge. Although not appropriate in all contexts, this focus of multi-stakeholder research can have significant benefits, particularly in efforts to address complex problems and design adaptive policy. One of the primary benefits of this type of research is that it can help identify previously unexplored problem framings and solutions by allowing stakeholders to discuss and synthesize imperfect, partial understandings of a problem. Moreover, bringing stakeholders into research processes at the question formulation, data collection, or analysis phases could help create opportunities to develop shared language and understandings of problems over the research effort that might help minimize conflict over results at the end of the process.

Several frameworks for dealing with complex problem environments exist. We focus here on one that emphasizes both competitive and collaborative strategies for addressing a complex stakeholder environment. Following the work of Nancy Roberts, we can conceive of the multi-stakeholder landscape for research partnership according to the following three questions, the answers to which shape the space for research strategies:[36]

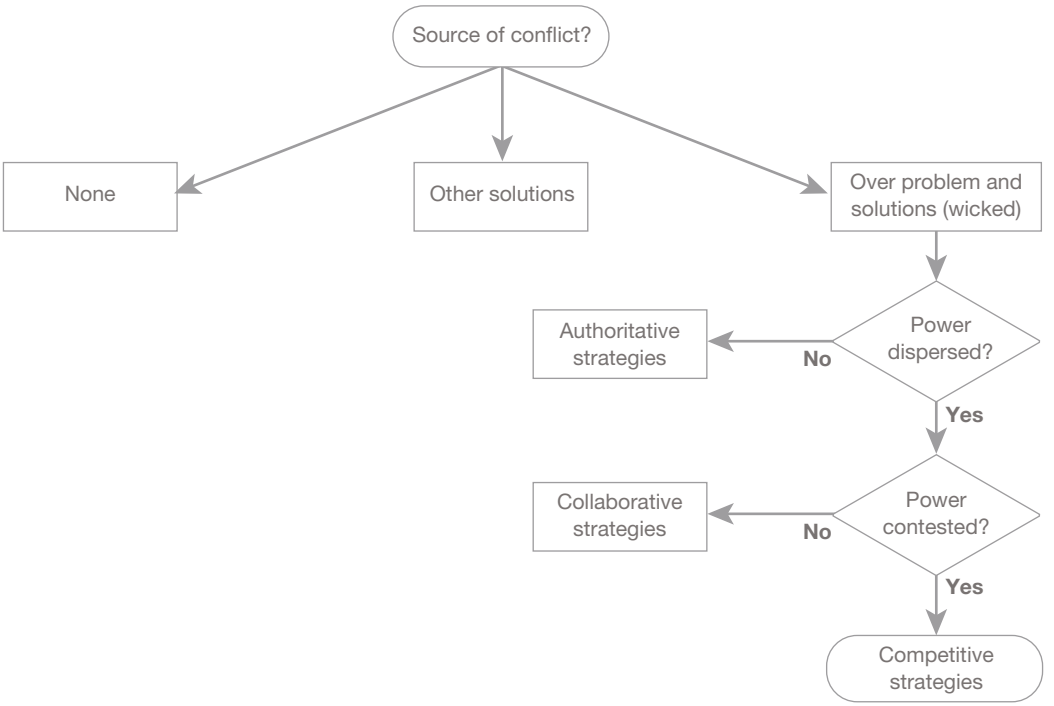
- What is the source of conflict over the problem?
- How dispersed is the power to address the problem?
- To what degree is that power contested by different stakeholders?

The first question is used to assess the degree of dispute over the nature of the problem and potential solutions; the second, to assess where power to address the problem is centered; and the third, to identify the degree to which that authority is contested by other actors, as represented in Figure 13.1. Both adaptive governance and multi-stakeholder research are most useful for *wicked problems*, in which there is conflict over both problem definition and solutions. But the other two questions can help inform what approaches can be deployed. If the power to address a problem is concentrated with just a few stakeholders, it may be possible for research to be developed and driven by a small core group or parties using authoritative approaches.[37] However, when power is dispersed among groups, actors interested in multi-

[36] Nancy Roberts, "Wicked Problems and Network Approaches to Resolution," *International Public Management Review*, Vol. 1, No. 1, 2000.

[37] Roberts, 2000.

FIGURE 13.1
Strategies for Responding to Wicked Problems



SOURCE: Adapted from Roberts, 2000, p. 3.

stakeholder research must analyze the landscape to determine the degree to which that power is contested. If power is highly contested, actors may compete for dominance to influence who has the authority to implement their preferred solution. Collaborative strategies by contrast are feasible when the level of power contestation is lower or when the perceived benefit of collaboration outweighs the benefit of competition. Importantly, the choice of a collaborative solution can still occur when actors have different beliefs, values, and goals.

Researchers could also consider how stakeholders interact with one another in choosing strategic approaches to research with multiple stakeholders as participants. Such approaches can consider not only relative power imbalances but also the degree to which interests differ and knowledge is fragmented across actors.[38]

In more tractable cases, knowledge is complete, interests are aligned, and power imbalances are low, creating conditions for cooperative solutions. In less tractable situations, knowledge is fragmented, interests compete, and power is dispersed and contested. Almost by definition, long-term competition in UGS is likely to be of the latter kind. However, such underlying con-

[38] John Alford and Brian W. Head, "Wicked and Less Wicked Problems: A Typology and a Contingency Framework," *Policy and Society*, Vol. 36, No. 3, 2017.

ditions are not fixed over time. Actors can try to change the level of knowledge fragmentation, power dispersion, and competition to advance their interests and to speed or slow progress in addressing specific topics. In some cases, research with multiple stakeholders as participants can involve frame reflection processes in which actors seek to understand how their own and others' worldviews shape how a problem is viewed, to see the problem through others' eyes, and to identify and create new problem framings that could bridge interests and generate previously unimagined cooperative solutions. A good example of this has occurred in climate change, where strong environmental regulation and economic growth were initially seen as in conflict but are now increasingly framed as complementary, with high-value taxpayers seeking out cities with clean air, water, green space, and environmental regulation.[39]

In assessing research problems in this manner, program designers should keep in mind that specific facets of a problem might have different degrees of conflict associated with them. As an example, while addressing the overall challenge of climate change may be a collaborative problem where nation-state authority to set internal policies to achieve the Paris goals is uncontested and the outcome is considered a win-win, the question of how to develop and supply the renewable and decarbonization technologies needed to achieve that win-win goal might be highly contested both by companies and states and demonstrate competitive features. Indian efforts to prevent the import of Chinese solar panels to protect and grow India's own nascent domestic research and development and manufacturing processes is an example of this kind of competition.

These considerations affect coproduction and deliberative processes in distinct ways. Collaborative deliberative processes in highly contested spaces may be much more difficult to coordinate and manage than coproduction processes, largely because deliberative and decisionmaking processes can shape the outcomes of contested questions. The research portfolio of the AC (discussed earlier) was initiated in a period of relatively low geostrategic conflict (the 1990s) and explicitly excludes military concerns. Since that time, the geopolitical landscape has become much more contested, and the structure and the provisions of the council may no longer be well designed to address deliberation needs in such a more hotly contested environment, even though the knowledge coproduction tools may still be valuable to address less-sensitive questions.[40]

Tools Available for Research with Stakeholders as Participants in the Research

Many already existing tools can be used to do research with stakeholders both as the focus of the research and as coproducers in the research process. It is often possible to use these

[39] Michael Bloomberg, "City Century: Why Municipalities Are the Key to Fighting Climate Change," *Foreign Affairs*, Vol. 94, No. 5, 2015.

[40] Oran R. Young, "Is It Time for a Reset in Arctic Governance?" *Sustainability (Switzerland)*, Vol. 11, No. 16, 2019.

methods for multiple purposes, and differing methods can be used to achieve similar goals. Researchers may also need to consider how the choice of method may influence the relationship between researcher and stakeholders and how the research is perceived. The choice to incorporate or exclude specific groups from a research coalition or the choice of how engagement is structured can have substantial impacts on the perceived legitimacy of a research effort. Note that although we structure this section to consider specific tools for stakeholder engagement, these tools are rarely used in isolation. Participatory research methods can serve the dual purpose of helping the researchers and stakeholders learn more about each other and setting up a trust basis for future interaction.

Table 13.3 summarizes selected methods to engage multiple stakeholders as participants in coproducing, consuming, interpreting, or acting on information from a research product. Note that while most forms of research might also use some of these methods to create the research product, here we focus on using these as tools to engage stakeholders.

We have ordered these approaches roughly according to the structure of the research process. At one end of the spectrum, scenario processes provide researchers relatively more control over the process and what insights emerge, while at the other end of the spectrum lie such techniques as deliberative processes, in which stakeholder interests and concerns weigh most heavily in shaping the outcomes of the process. Most of these tools may serve multiple purposes, although some are easier to use than others to inform modalities of multi-stakeholder work: knowledge, communication, coproduction, and deliberation. In practice, most research with stakeholders as participants will also use stakeholder-as-focus methods, such as interviewing and focus groups. Many of these techniques can also be applied as teaching techniques and analytic tools. It is incumbent on the researchers to be clear about the purposes they intend any multi-stakeholder work to serve, because that should inform the design

TABLE 13.3
Select Methods to Engage Multiple Stakeholders as Participants in Research

Approach	Concept	Challenges
Scenarios	Generation of future potential conditions and challenges	Ad hoc contents; a small number of cases may not span space of possibilities;[a] lack of critical interrogation of assumptions
Participatory modeling	Group processes for designing models of complex systems	Mental models informing system may be incomplete or incorrect
Gaming, wargaming, and tabletop exercises	Group processes for understanding implications of actions in complex problems	Mental models may be incomplete or incorrect; payoffs may be misidentified or may change over time
Deliberation methods	Structured methods that help stakeholders to identify and select possible courses of action	May not be possible to get all relevant stakeholders engaged; time-consuming, unpredictable results

[a] For more information on this, see Aaron B. Frank, "Toward Computational Net Assessment," *Journal of Defense Modeling and Simulation*, Vol. 14, No. 1, 2017.

and content of the procedure chosen. Newer research has begun to provide design principles to aid in structuring these engagements.[41]

Scenarios

Scenario development, exploration, and analysis methods can help engage stakeholders in concepts that they did not know ahead of time (e.g., *unknown unknowns*). There are many examples of scenario exploration used in UGS, such as a scenarios workshop on future directions for European Union–Chinese relations[42] and efforts to understand the future of Arctic exploration by various stakeholders.[43] They have been widely used in U.S. military planning historically, and recent research has identified ways to improve the process to meet the challenges of an increasingly complex threat environment.[44] Successful use of scenarios requires developing buy-in from stakeholders on the parameters considered; otherwise, stakeholders may "fight the scenario."

Participatory Modeling

Participatory modeling directly engages stakeholders alongside researchers in creating formalized and shared representations of reality instantiated in various modeling formalisms, such as influence diagrams, causal loop diagrams, and Agent-Based Modeling.[45] These representations aim to capture the implicit and explicit knowledge of the stakeholders—in particular, mental models of relevant systems and the dynamics under various conditions. Emerging work in this space has included work to apply fuzzy cognitive mapping in participatory contexts.[46] These representations can also be used as boundary objects to facilitate under-

---

[41] Annette Boaz, Stephen Hanney, Robert Borst, Alison O'Shea, and Maarten Kok, "How to Engage Stakeholders in Research: Design Principles to Support Improvement," *Health Research Policy and Systems*, Vol. 16, No. 1, 2018.

[42] Johannes Gabriel and Susanne Schmelcher, "Three Scenarios for EU-China Relations 2025," *Futures*, Vol. 97, 2018.

[43] Stephanie Pezard, Abbie Tingstad, and Alexandra Hall, *The Future of Arctic Cooperation in a Changing Strategic Environment: Insights from a Scenario-Based Exercise Organised by RAND and Hosted by NUPI*, Santa Monica, Calif.: RAND Corporation, PE-268-RC, 2018.

[44] Michael J. Mazarr, Katharina Ley Best, Burgess Laird, Eric V. Larson, Michael E. Linick, and Dan Madden, *The U.S. Department of Defense's Planning Process: Components and Challenges*, Santa Monica, Calif.: RAND Corporation, RR-2173/2-A, 2019.

[45] Natalie A. Jones, "Evaluating Participatory Modeling: Developing a Framework for Cross-Case Analysis," *Environmental Management*, Vol. 44, No. 6, 2009; Rebecca Jordan, Steven Gray, Moira Zellner, Pierre D. Glynn, Alexey Voinov, Beatrice Hedelin, Eleanor J. Sterling, Kirsten Leong, Laura Schmitt Olabisi, Klaus Hubacek, et al., "Twelve Questions for the Participatory Modeling Community," *Earth's Future*, Vol. 6, No. 8, 2018; Alexey Voinov, Nagesh Kolagani, Michael K. McCall, Pierre D. Glynn, Marit E. Kragt, Frank O. Ostermann, Suzanne A. Pierce, and Palaniappan Ramu, "Modelling with Stakeholders—Next Generation," *Environmental Modelling and Software*, Vol. 77, March 2016.

[46] Steven A. Gray, Stefan Gray, Jean Luc De Kok, Ariella E. R. Helfgott, Barry O'Dwyer, Rebecca Jordan, and Angela Nyaki, "Using Fuzzy Cognitive Mapping as a Participatory Approach to Analyze Change, Preferred

standing and communication among groups and to generate simulation models that can be used in analyses that help to identify and compare the impacts of alternative solutions and their ability to achieve various goals. The process of coproducing models with stakeholders and researchers helps engage both expert and local knowledge and can also enhance the salience, legitimacy, and credibility of the analyses for all involved. Although commonly used in environmental studies, participatory modeling has also been applied to some UGS, such as implementing fiscal policy in Ukraine.[47]

Gaming, Wargaming, and Tabletop Exercises

Chapter Nineteen in this report, by Elizabeth M. Bartels, Aaron B. Frank, Jasmin Léveillé, Timothy Marler, and Yuna Huh Wong, provides a longer description of the use of gaming, wargaming, and other tabletop exercises for multi-stakeholder efforts[48] broadly used in military planning for the Navy, Secretary of Defense, between different commands, and in the cyber domain.[49] A recent example is a study in the Baltics, where the use of wargaming led to the realization that the eastern flank of the North Atlantic Treaty Organization was vulnerable in the event of military invasion by Russia regardless of strategy employed.[50]

States, and Perceived Resilience of Social-Ecological Systems," *Ecology and Society*, Vol. 20, No. 2, 2015.

[47] Halyna Voznyak and Andriy Pelekhatyy, "Participatory Budgeting as a Tool for the Implementation of the Fiscal Policy of Regional Development of Ukraine," *Economic Annals–XXI*, Vol. 167, Nos. 9–10, 2017.

[48] Elizabeth M. Bartels, Aaron B. Frank, Jasmin Léveillé, Timothy Marler, and Yuna Huh Wong, "Gaming Undergoverned Spaces: Emerging Approaches for Complex National Security Policy Problems," in Aaron B. Frank and Elizabeth M. Bartels, eds., *Adaptive Engagement for Undergoverned Spaces: Concepts, Challenges, and Prospects for New Approaches,* Santa Monica, Calif.: RAND Corporation, RR-A1275-1, 2022.

[49] Yuna Huh Wong, Sebastian Joon Bae, Elizabeth M. Bartels, and Benjamin Smith, *Next-Generation Wargaming for the U.S. Marine Corps: Recommended Courses of Action*, Santa Monica, Calif.: RAND Corporation, RR-2227-USMC, 2019; Christopher Paul, Yuna Huh Wong, and Elizabeth M. Bartels, *Opportunities for Including the Information Environment in U.S. Marine Corps Wargames*, Santa Monica, Calif.: RAND Corporation, RR-2997-USMC, 2020; Elizabeth M. Bartels, Jeffrey A. Drezner, and Joel B. Predd, *Building a Broader Evidence Base for Defense Acquisition Policymaking*, Santa Monica, Calif.: RAND Corporation, RR-A202-1, 2020; Elizabeth M. Bartels, Adam R. Grissom, Russell Hanson, and Christopher A. Mouton, *OCEANS 17 Tabletop Exercise: Findings and Recommendations*, Santa Monica, Calif.: RAND Corporation, RR-2521-OSD, 2019; Edward Colbert, Daniel Sullivan, and Alexander Kott, "Cyber Wargaming on SCADA Systems," in Adam R. Bryant, Juan R. Lopez, and Robert Mills, eds., *Proceedings of the 12th International Conference on Cyber Warfare and Security (ICCWS 2017)*, Reading, United Kingdom: Academic Conferences and Publishing International Limited, 2017; David B. Fox, *Cyber Wargaming: Framework for Enhancing Cyber Wargaming with Realistic Business Context*, McLean, Va.: MITRE Corporation, 2018; and Edward Colbert, Alexander Kott, and Lawrence P. Knachel, "The Game-Theoretic Model and Experimental Investigation of Cyber Wargaming," *Journal of Defense Modeling and Simulation*, Vol. 17, No. 1, 2020.

[50] David A. Shlapak and Michael W. Johnson, *Reinforcing Deterrence on NATO's Eastern Flank: Wargaming the Defense of the Baltics*, Santa Monica, Calif.: RAND Corporation, RR-1253-A, 2016.

Deliberation

Deliberative methods encompass a wide variety of means to involve multiple stakeholders in structured group discussions. As with other forms of public engagement, deliberation can be used in various types of venues distinguished by the amount of inclusiveness among those invited to participate and the extent to which the participants are empowered to make decisions. Inclusiveness can range from working with a small, select group of carefully chosen stakeholders to being open to everyone. Empowerment can range from the deliberating group only providing information to those making the decision to having full decisionmaking authority.[51] Although there are different models (e.g., Fishkin,[52] Cohen,[53] and Gutmann and Thompson[54]), deliberation typically proceeds with a specific process that involves both discussion or consensus-building and voting. Here, we describe three illustrative methods.[55]

Group Consensus Methods

Delphi and other group consensus methods provide a way for research teams to recruit individuals for repeated activities centered on rating and evaluating information.[56] The focus could range from estimating uncertain parameter values to evaluating potential actions. One of the benefits of Delphi approaches is that they can be run and facilitated remotely and anonymously.[57] Although such methods were originally developed to facilitate the assessment of quantitative information, more-recent innovations can be employed to allow researchers to also use it in qualitative contexts.[58]

---

[51] Archon Fung, "Varieties of Participation in Complex Governance," *Public Administration Review*, Vol. 66, No. 1, 2006; Amy Gutmann and Dennis F. Thompson, *Why Deliberative Democracy?* Princeton, N.J.: Princeton University Press, 2009; John S. Dryzek, *Deliberative Democracy and Beyond: Liberals, Critics, Contestations*, Oxford, United Kingdom: Oxford University Press, 2002.

[52] James S. Fishkin and Robert C. Luskin, "Experimenting with a Democratic Ideal: Deliberative Polling and Public Opinion," *Acta Politica*, Vol. 40, No. 3, 2005.

[53] Joshua Cohen, James Bohman, and William Rehg, "Deliberation and Democratic Legitimacy," reprinted in James Bohman and William Rehg, eds., *Deliberative Democracy: Essays on Reason and Politics*, Cambridge, Mass.: MIT Press, 1997.

[54] Gutmann and Thompson, 2009.

[55] Elinor Ostrom, *Governing the Commons: The Evolution of Institutions for Collective Action*, New York: Cambridge University Press, 1990.

[56] Rob C. de Loë, Natalya Melnychuk, Dan Murray, and Ryan Plummer, "Advancing the State of Policy Delphi Practice: A Systematic Review Evaluating Methodological Evolution, Innovation, and Opportunities," *Technological Forecasting and Social Change*, Vol. 104, 2016.

[57] Dmitry Khodyakov, Terrance D. Savitsky, and Siddhartha Dalal, "Collaborative Learning Framework for Online Stakeholder Engagement," *Health Expectations*, Vol. 19, No. 4, 2016.

[58] Shane R. Brady, "Utilizing and Adapting the Delphi Method for Use in Qualitative Research," *International Journal of Qualitative Methods*, Vol. 14, No. 5, 2015.

Deliberative Polling and Citizen Juries

With this method, a small group of randomly sampled individuals, representative of the demographics from a particular community, comes together for a few hours to a few days to discuss and reach a collective decision or recommendation on some policy questions. These discussions are informed by carefully balanced briefing materials, often skilled facilitation, and sometimes direct testimony and interaction with experts.[59] Citizen juries have been used to make recommendations on constitutional reform, climate policy, and ballot initiatives.[60] Deliberative polling bookends such deliberations with opinion polling to measure the effect of the deliberations on views of representative citizens.

Deliberation with Analysis

Deliberation with analysis represents an iterative process in which stakeholders deliberate on their objectives, options, and problem framings; researchers (analysts) generate decision-relevant information; and stakeholders revisit their objectives, options, and problem framings in response to interactions with each other and with researchers' information.[61] The process is intended for situations in which the problem framings and stakeholders' understandings evolve through these interactions. Such frame reflection is often valuable when boundaries between research and policy may be shifting or fluid.[62] Deliberation with analysis often relies on computer simulations, and a typical case would involve the deliberative body deciding assumptions to use and policies to test and then making initial recommendations and requesting analysis of additional policy options after viewing the results of the initial simulation runs.

Challenges in Engaging Multiple Stakeholders as Participants of the Research

Expanding beyond thinking of stakeholders as the focus of research to coproducers can enrich adaptive decisionmaking, but doing so also carries costs. First, it creates opportunities for new structures for research and decisionmaking. Previously excluded actors may become involved, thus enriching the understanding of a problem, particularly in cases in which certain types of information may only be accessible or interpretable to some groups or individuals. Coproduction, deliberation, and multi-actor decisionmaking processes can create spaces

[59] Fishkin and Luskin, 2005.

[60] Graham Smith and Corinne Wales, "Citizens' Juries and Deliberative Democracy," *Political Studies*, Vol. 48, No. 1, 2000.

[61] George E. Apostolakis and Susan E. Pickett, "Deliberation: Integrating Analytical Results into Environmental Decisions Involving Multiple Stakeholders," *Risk Analysis*, Vol. 18, No. 5, 1998; National Research Council, *Public Participation in Environmental Assessment and Decision Making*, Washington, D.C.: National Academy of Sciences Press, 2008.

[62] Donald Schoen and Martin Rein, *Frame Reflection: Toward the Resolution of Intractable Policy Controversies*, New York: Basic Books, 1995.

in which iterative cycles of analysis and decisionmaking can occur, thus helping to develop cycles of adaptation that are essential in responding effectively to complex problems.

However, such processes may not be appropriate in all cases because they present challenges and risks while requiring nontrivial adjustments to the traditional process of public management and research for management. As noted by Head and Alford,

> The conventional structures and systems of the public sector are not scoped to address the tasks of conceptualizing, mapping, and responding to wicked problems. Project management for tackling wicked problems through long-term targeted interventions would require a substantial and unaccustomed degree of flexibility in the structures and systems of public governance.[63]

Some of these challenges are familiar and similar to costs discussed already when thinking about stakeholders as participants: increased time and costs to doing research and increased potential for information to leak to hostile parties or bad actors. Others are more specific to the challenges of making decisions in highly complex spaces. These are discussed in reference to Robert's framework.

In cases in which authority is concentrated and uncontested (large power differential but considered legitimate), Roberts makes the case that an authoritative body can simply decide and act to solve the complex problem.[64] However, determining when legitimate authority exists and is truly uncontested is not a trivial matter, and there is significant potential to miscategorize a problem as meeting conditions for authoritative solutions, when that is not the case.[65] When that occurs, problems may be inappropriately simplified, thus missing opportunities for better solutions. Even though authoritative approaches offer benefits to policymakers (e.g., rapid implementation and organizational simplicity), these benefits can undermine desired outcomes in complex problems. This is because strategies devised using authoritative approaches can ignore key features of complex problems because those strategies are "usually beyond the cognitive capacity of any one mind to diagnose or comprehend."[66]

In cases in which authority is dispersed and contested, Roberts advises a competitive approach to problem-solving. While these approaches can spur fast rates of innovation, structuring research activities in this fashion is challenging within the traditional framework of public management and can be costly; it could increase conflict or consume resources (e.g., litigation, defensive investments, deterrence) that could otherwise be devoted to solving

---

[63] Brian W. Head and John Alford, "Wicked Problems: Implications for Public Policy and Management," *Administration and Society*, Vol. 47, No. 6, 2015.

[64] Roberts, 2000.

[65] James C. Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*, New Haven, Conn.: Yale University Press, 1999.

[66] Alford and Head, 2017.

complex problems.[67] Furthermore, competitive approaches can create incentives to withhold knowledge, block opportunities for those closest to the problem to provide feedback up the chain, drive turf wars, increase emphasis on outputs rather than outcomes, and reify existing silos.[68] Also, the idea of leveraging competition as a tool to foster new knowledge and identify clumsy solutions to complex problems may be unfamiliar to the organizational culture and mission of agencies within UGS. This may make it difficult to identify and structure opportunities to leverage competition as a problem-solving tool in cases where applicable.

Finally, collaborative approaches to coproduction can also be costly. They require adjustments to the traditional understanding of the roles of decisionmaking and analysis to bring researchers and policymakers into dialogue. These adjustments may require using communication and negotiation principles to navigate the boundary between science and policy.[69] Agreement on new principles for guaranteeing the quality and unbiasedness of information may be required to effectively connect knowledge and action. Existing criteria are salience, credibility, and legitimacy, but actors may have different definitions and interpretations of what these components mean in practice, leading to disagreements over the quality and appropriate use of different research outputs.[70]

Emerging models in the physical sciences suggest ways to address these challenges. Convergence research draws on insights on the function of scientific teams to identify conditions and processes that can inform how diverse teams can work together most efficiently. The Natural Hazards Engineering Research Infrastructure Facility represents one way to build systems of interdisciplinary and transdisciplinary research that enable collaboration across diverse organizations and disciplines to answer applied science questions.[71] However, even with an explicit commitment to this type of work, deep interdisciplinary research is difficult to conduct in the context of institutional structures, incentives, and training processes. Addressing these difficulties requires restructuring management systems, which will be addressed in more detail by Steven W. Popper in Chapter Eleven.[72] However, alongside these

---

[67] Alford and Head, 2017.

[68] Head and Alford, 2015; Alford and Head, 2017.

[69] Carina Wyborn, "Co-Productive Governance: A Relational Framework for Adaptive Governance," *Global Environmental Change*, Vol. 30, January 2015.

[70] David Cash, William C. Clark, Frank Alcock, Nancy M. Dickson, Noelle Eckley, and Jill Jäger, "Salience, Credibility, Legitimacy and Boundaries: Linking Research, Assessment and Decision Making," Cambridge, Mass.: Harvard University, KSG Working Papers Series, 2003.

[71] Peek et al., 2020.

[72] Steven W. Popper, "Designing a Robust Decision–Based National Security Policy Process: Strategic Choices for Uncertain Times," in Aaron B. Frank and Elizabeth M. Bartels, eds., *Adaptive Engagement for Undergoverned Spaces: Concepts, Challenges, and Prospects for New Approaches,* Santa Monica, Calif.: RAND Corporation, RR-A1275-1, 2022. Also see Chapter Twelve (Paul K. Davis, "Toward an Analytic Architecture to Aid Adaptive Strategy for Competing in Undergoverned Spaces," in Aaron B. Frank and Elizabeth M. Bartels, eds., *Adaptive Engagement for Undergoverned Spaces: Concepts, Challenges, and Prospects for New Approaches,* Santa Monica, Calif.: RAND Corporation, RR-A1275-1, 2022).

broad changes to the way that public systems are governed, a more narrow set of tools exists that can be used to develop cooperation and collaboration, reframe thinking about variables, links and options, and design multi-stakeholder research practices tailored to the needs of long-term competition in UGS or alternatively governed spaces.[73] In the next section, we focus on investments that could be used to improve this narrower set of tools to facilitate research in multi-stakeholder settings.

Key Investments to Catalyze Multi-Stakeholder Research

This section discusses some examples of places where investments could catalyze improvements to the practice of multi-stakeholder research in undergoverned and long-term competitive contexts. This is not intended to be a comprehensive survey; rather, it is intended to provide a few examples of potentially productive avenues for research. We begin with several areas in which investments could generate returns across a variety of multi-stakeholder research activities. Then, returning to the original taxonomy proposed in Table 13.1, we discuss investments according to whether they are intended to improve understanding, communication, coproduction, or deliberation. However, we caution against interpreting these as hard categories. Scientific developments in one of these areas may also enhance practice across others.

Recent years have witnessed significant advances in the analytic tools, practices, and institutional context for multi-stakeholder engagement that enhance capabilities for understanding, communication, coproduction, and deliberation in complex decisionmaking contexts. Innovations in this space are the result of both changes in technology and advances in social science that both improve the use of these tools and inform the spaces in which they are used. Many of these advances have occurred in the field of environmental management, which is a more governed space and generally perceived as more collaborative than others discussed in this report. Similarities are the long-term nature of the complex problems and the importance of initial conditions and path dependence in shaping the future option space. As a result, many of these advances have relevance to contested, less-governed spaces of national security and defense. Some can be translated relatively directly from collaborative environmental contexts and used to improve adaptive planning and governance, while others would require more fundamental restructuring.

Overarching Issues

Multi-stakeholder research is particularly valuable for problems involving complexity, uncertainty, and ambiguity. In these cases, multiple values, goals, and understandings of a problem

[73] Head and Alford, 2015.

can inhibit effective decisionmaking to address policy problems.[74] Multi-stakeholder research provides a way for researchers to engage these different worldviews, characterize and develop new and different problem framings, and identify opportunities for compromise, or winning coalitions of interests, and pockets of potential strategic advantage. Social science provides tools to develop and understand these worldviews, and decision support enables searching the policy space for responses that meet success criteria. Representing these decision spaces in complex environments has been a core focus of environmental policy that could be adapted for the defense space.

Like decision support, investments in tools to facilitate engagement also hold value for multi-stakeholder research. The past 25 years have seen an explosion of different engagement methods for increasing the salience, relevance, and credibility of decisionmaking processes for addressing complex policy problems.[75] Some of these methods might be applicable in the defense space, but it is also possible to identify places where new types of engagements might be necessary to serve needs in competitive spaces. These methods can be structured along axes defining their levels of empowerment and inclusiveness. In collaborative environmental management problems, more-empowered structures of decisionmaking have been the focus, with varying degrees of openness. Work to identify which of these processes might apply to interagency decisionmaking or even international defense and security decisions could help create test cases for different approaches to engagement.

Successfully applying research in these focal areas to UGS requires three specific kinds of research investments—those aimed at (1) understanding how competition influences the design of tools for decisionmaking, (2) improving structures to facilitate deeper engagement across disciplines and stakeholders and sustaining that engagement over a research program, and (3) employing regular, rigorous evaluation.

Some basic features of competitive spaces differentiate them from collaborative research and affect which approaches to multi-stakeholder research may prove most appropriate. It may be hard to identify and engage a research coalition in a highly competitive context. It may be difficult to align the timescale of decisionmaking with the speed of multi-stakeholder research processes. Even something as simple as the questions being asked can reveal privileged information to competitors and place research subjects and strategic aims at risk. This chapter has necessarily focused on collaborative spaces that account for the significant bulk of existing research. Future research might examine how best to deploy these techniques in competitive spaces.

How best to develop and sustain multi-stakeholder research coalitions is an unsolved question in the environmental space and one likely to bedevil national security applications. Institutional missions, performance metrics, siloed information, time pressure, inertia, and

[74] Horst W. J. Rittel and Melvin M. Webber, "Dilemmas in a General Theory of Planning," *Policy Sciences*, Vol. 4, No. 2, June 1, 1973; Head and Alford, 2015.

[75] National Research Council, 2008; Thomas Webler and Seth Tuler, "Four Decades of Public Participation in Risk Decision Making," *Risk Analysis*, Vol. 41, No. 3, 2018.

many other factors drive many interdisciplinary research coalitions to fracture along institutional or disciplinary lines, thus preventing knowledge synthesis and effective coproduction, which are crucial in complex decision environments. Research that tests new structures and approaches for stakeholder research in competitive contexts, such as ad hoc committees or the type of partnerships used in the convergence research already discussed,[76] could help improve understanding and avoid some of the pitfalls that have frustrated the application of these methods in environmental spaces.

Finally, evaluation is a core part of design for complicated engineered systems. In governing complex problems, decision support tools and engagement processes are the core technologies that enable adaptive governance. They should be evaluated with the same rigor as we would the components of a physical system.

Investments to Improve Understanding

Generating knowledge from or with stakeholders in undergoverned or competitive contexts can require creative approaches to data collection and analysis, because in-person processes may not be possible or because stakeholders in the research may be unwilling to fully participate. Remote engagements facilitated by technology can help provide researchers with valuable information about target populations when in-person access is not possible, but these same remote and virtual engagements through traditional technologies may miss highly valuable elements of nonverbal or contextual information.

One newer technology that can facilitate interaction methods is virtual, augmented, and mixed reality (VAMR).[77] VAMR couples three different but closely related immersive technologies. VR presents computer-generated or prerecorded images through a VR headset that conceals the wearer's eyes and isolates the wearer from the real world.[78] Users view images and sometimes receive other haptics (e.g., sound, joystick movement) that convey presence in a virtual environment. AR combines VR computer graphics with real-world scenes and interactions.[79] It overlays fully virtual worlds with contacts, interactions, and navigation with the real world. For example, AR can be understood as a graphics technology where the layer of the virtual world is placed on top of the real world without allowing the two to interact.

[76] CONVERGE is an NSF-funded initiative to increase capacity for rapid response interdisciplinary disaster research through research network development, training, funding, and data management (see Natural Hazards Center, University of Colorado Boulder, "About CONVERGE," webpage, undated).

[77] Apostolakis and Pickett, 1998.

[78] Michael Deering, "High Resolution Virtual Reality," *Proceedings of the 19th Annual Conference on Computer Graphics and Interactive Techniques*, Vol. 26, No. 2, 1992.

[79] Borko Fuhrt, ed., *Handbook of Augmented Reality*, Berlin, Germany: Springer Science and Business Media, 2011.

Mixed reality is an advanced version of AR, where the physical and digital world are allowed to interact.[80]

Not only can VAMR reduce transportation costs, but it can also reduce physical risk; consider, for instance, U.S. Air Force efforts on live, virtual, and constructed training environments, where pilots can test certain moves in the safety of a constructed environment. Testing the potential use of VAMR in developing knowledge coproduction and deliberation processes could also help improve the viability of remote multi-stakeholder research using these techniques. VAMR might enhance engagement and trust as well as serve as a platform for true collaborative modeling or other methods of coproduction.

Data collection at scale is another area for development, given that it improves the capacity of researchers to gain valuable knowledge about stakeholders when direct engagement (even remote) is not feasible. Extracting information from remote sensing, Internet of Things (IoT), social media, and other secondary sources can provide important information about population beliefs and behavior, but it can be challenging because of the potential for bias in the data and the difficulty of quality checking the findings from existing tools to exploit large data sets.

Finally, research to address the privacy implications of some of these remote and passive data collection activities would be valuable. For example, in the context of VAMR, research suggests that machine-learning (ML) algorithms can learn to identify individuals with high accuracy using their physical movements while interacting with these systems.[81] Similarly, the extension of IoT capabilities to the internet of bodies presents both powerful new research opportunities and significant new privacy risks. Understanding these privacy risks, learning how they could affect research participants, and developing tools to mitigate against them are crucial for rendering these technologies acceptable to participants, particularly in contexts where subjects might be at heightened risk of harm if their information were to be exposed.

Investments to Improve Communication

Regardless of whether knowledge is generated through unidirectional or bidirectional processes, communication is key to multi-stakeholder research, and improved technical approaches for rapid, accurate, interpretable, and trustworthy communication channels and improved understanding of how to design communication for multi-stakeholder purposes are needed.

Developing culturally appropriate instantaneous translations can significantly improve the ability to communicate research findings or develop coproduction processes with differ-

[80] Adriana de Souza e Silva and Daniel M. Sutko, eds., *Digital Cityscapes: Merging Digital and Urban Playspaces*, Bern, Switzerland: Peter Lang, 2009.

[81] Mark Roman Miller, Fernanda Herrera, Hanseul Jun, James A. Landay, and Jeremy N. Bailenson, "Personal Identifiability of User Tracking Data During Observation of 360-Degree VR Video," *Scientific Reports*, Vol. 10, No. 1, 2020.

ent groups. This aspect needs to go beyond efforts to translate words and involve finding ways to visually and narratively present research findings that are acceptable and interpretable to different groups.[82] For language and related communication issues, there is the possibility to improve such tools as Google Translate. This improvement could enhance the ability of people who speak different languages to interact without the need for a person as a translator.

Trusted communication channels are crucial for ensuring that messages are heard and responses are appropriate. Researchers attempting to build a base for future multi-stakeholder coproduction or deliberation processes will find that developing ways to ensure the trust in, and the credibility of, information channels is a crucial precondition for deeper engagement efforts. Research efforts to reduce privacy risks while still communicating crucial information, defang misinformation efforts, and improve cybersecurity are all essential to this process. Questions about how to improve access to information while simultaneously ensuring the quality of the information accessed is an important secondary issue. For instance, research into fifth-generation (5G) technology is beyond the scope of this chapter, but it is relevant to some of the topics discussed here.

As multi-stakeholder research engages with new methods and procedures for communication, it also raises several questions related to privacy and emotional risk. For instance, research on how to obscure the purpose or intent of research questions from some actors may also be necessary in highly contested spaces, both to protect U.S. strategic interests and to protect individuals or populations involved in multi-stakeholder research.

Research on multi-stakeholder communications increasingly recognizes that humans preferentially receive and process information according to consistency with group identity and comfort with the communications networks through which it arrives.[83] To address these challenges, one research frontier uses social network analysis to understand how information flows within communities and then applies influence maximization algorithms on the network to understand how to best disseminate messages. These algorithms can be designed to help pursue different constellations of goals—for example, ensuring equitable distribution of messages to all the members of a community irrespective of the density of their networking and the particular groups to which they belong.[84] To date, this work has largely been focused on uncontested messages involving good health practices and warnings of natural disasters. But future research might usefully extend these concepts and methods to more contested information—for instance, by seeking to understand and manage the flows of information to individuals that they might find consistent and inconsistent with their values and identity.

[82] National Academies of Science Engineering and Medicine, 2017.

[83] Dan M. Kahan and Donald Braman, "Cultural Cognition and Public Policy," *Yale Law & Policy Review*, Vol. 24, 2006.

[84] Aida Rahmattalabi, Shahin Jabbari, Himabindu Lakkaraju, Phebe Vayanos, Eric Rice, and Milind Tambe, "Fair Influence Maximization: A Welfare Optimization Approach," in *Proceedings of the Thirty-Fifth AAAI Conference on Artificial Intelligence*, Edinburgh, Scotland, 2020.

Investments to Improve Coproduction

Research needs and opportunities exist related to both the process of coproduction and tools that might enhance it. Although there is widespread agreement and much anecdotal evidence that coproduction processes yield significant benefits, coproduction practitioners report many challenges—for example, power imbalances among participants, such as those between researchers who may have increased access to funding, specialized knowledge, and prestige relative to many stakeholders. Power imbalances also exist among the stakeholders, and cultural differences may make it easier for some to participate relative to others. Addressing such barriers is an important area of research in environmental areas and may be at least as salient when using such methods in less governed spaces.

Coproduction processes aim to enhance learning. For instance, participatory modeling has been shown to help participants understand multiple perspectives, promote systems thinking, and improve relationships among participants.[85] But understanding of such learning processes remains limited, with little understanding of how long any new understandings persist among participants after the exercise, whether and how new understandings diffuse among those who did not participate, and how new understanding affects action. Some studies have used surveys, interviews, discourse analysis, and mental model elicitation to track such effects,[86] but future research could greatly improve the ability to derive benefits for coproduction processes. Future research could also explore the use of new technologies for data collection in the context of coproduction. An example would be the use of VAMR (discussed earlier) as a tool to facilitate collective model-building.[87] Ideally, coproduction could enhance the learning and response cycles inherent in such processes as ASDA cycles. But such learning processes present significant challenges from misaligned incentives and inadequate mental models.[88] Work in political and economic forecasting suggests that different types of accountability systems affect decision processes and outcomes.[89] Future research could examine how changing incentives on participants in the kinds of problems typically encountered by the Defense Advanced Research Projects Agency, the U.S. Department of

[85] Jordan et al., 2018.

[86] Joshua Radinsky, Dan Milz, Moira Zellner, Kelsey Pudlock, Curtis Witek, C. Hoch, and Leilah Lyons, "How Planners and Stakeholders Learn with Visualization Tools: Using Learning Sciences Methods to Examine Planning Processes," *Journal of Environmental Planning and Management*, Vol. 60, No. 7, 2017; Jones, 2009.

[87] Alexey Voinov, Karen Jenni, Steven Gray, Nagesh Kolagani, Pierre D. Glynn, Pierre Bommel, Christina Prell, Moira Zellnerg, Michael Paolissoh, Rebecca Jordani, et al., "Tools and Methods in Participatory Modeling: Selecting the Right Tool for the Job," *Environmental Modelling and Software*, Vol. 109, November 2018.

[88] Kai N. Lee, *Compass and Gyroscope: Integrating Science and Politics for the Environment*, Washington, D.C.: Island Press, 1994.

[89] Welton Chang, Shefali Patil, and Philip E. Tetlock, "Accountability and Adaptive Performance Under Uncertainty: A Long-Term View," *Judgement and Decision Making*, Vol. 12, No. 6, 2017.

Defense (DoD), and the interagency process could similarly improve adaptive learning and decisionmaking in multi-stakeholder research contexts.

Improving coproduction is hampered by a lack of conceptual clarity about what is occurring in multi-stakeholder processes.[90] Consolidating research across fields on the dynamics of group decisionmaking could help address this challenge by improving measures of participation and expanding evaluation of stakeholder engagement processes. Highly detailed, large data sets on how different groups interact across engagements and how multi-stakeholder processes evolve would be highly valuable in driving the field forward and enhancing understanding of the actual processes that are occurring. This requires moving beyond simplistic understandings of how information and knowledge are exchanged across stakeholder groups. Knowledge exchange between stakeholders, including comanagement processes, is highly shaped by research field, and work to translate lessons across fields would be a valuable step.[91]

In addition to improving understanding of the coproduction process, there may also be important opportunities to improve the available tools. For instance, the VAMR tools could greatly enhance engagement and help stakeholders obtain a more visceral understanding of the dynamics of systems. ML and other statistical tools might help elicit explicit representations of causal relationships contained in the mental models of many participants. Research has only begun to explore potential possibilities in such areas.

Investments to Improve Deliberation

Much literature and practice suggest that facilitating deliberation among diverse stakeholders requires an ability and propensity to respect and consider multiple points of view, particularly for situations in which important aspects of the challenge are contested. The traditional quantitative tools of risk and policy analysis are organized around single, best-estimate probability distributions to describe uncertainty about the state of the world and often aggregate preferences into a single utility function to rank alternative outcomes. These methods and tools are poorly designed to bring quantitative information into debates with contested problem framings. One promising research area aims to develop analytic, multi-scenario, multi-objective decision support tools that better reflect such multiple points of view. Such approaches are often gathered under the label Decision Making Under Deep Uncertainty (DMDU).

---

[90] Ioan Fazey, Lukas Bunse, Joshua Msika, Maria Pinke, Katherine Preedy, Anna C. Evely, Emily Lambert, Emily Hastings, Sue Morris, and Mark S. Reed, "Evaluating Knowledge Exchange in Interdisciplinary and Multi-Stakeholder Research," *Global Environmental Change*, Vol. 25, No. 1, 2014; Andrew M. Parker, Sinduja V. Srinivasan, Robert J. Lempert, and Sandra H. Berry, "Evaluating Simulation-Derived Scenarios for Effective Decision Support," *Technological Forecasting and Social Change*, Vol. 91, 2015; and Min Gong, Robert Lempert, Andrew Parker, Lauren A. Mayer, Jordan Fischbach, Matthew Sisco, Zhimin Mao, David H. Krantz, and Howard Kunreuther, "Testing the Scenario Hypothesis: An Experimental Comparison of Scenarios and Forecasts for Decision Support in a Complex Decision Environment," *Environmental Modelling and Software*, Vol. 91, No. 3, 2017.

[91] Fazey et al., 2014.

For instance, scenarios are commonly used to facilitate deliberations among diverse stakeholders. Traditionally, scenarios are developed and chosen by human judgment. Although often effective as communication devices, such scenarios can appear biased, contain important inconsistencies, fail to appropriately sample the space of most policy-relevant futures, or prove ineffectual at distinguishing among alternative policy choices.[92] In recent years, quantitative methods, such as scenario discovery,[93] scenario diversity,[94] and cross-impact balance approaches[95] have been developed to help choose more decision-relevant sets of scenarios. For instance, scenario discovery applies classification algorithms to large databases of simulation model runs to identify the small number of key factors that best distinguish futures in which a strategy meets and misses its goals. One recent application identified important but not previously considered scenarios generated by the integrated assessment used in climate policy research, although these models had been used by hundreds of researchers.[96] Future research could improve the classification and other algorithms used by such methods and improve the ability to communicate their results to diverse audiences.

Other DMDU work explicitly facilitates deliberations among multiple stakeholders in the context of polycentric governance. For instance, recent work using multi-objective Robust Decision Making (MORDM) methods helped four neighboring cities in North Carolina jointly link and then manage their water systems in the presence of differing objectives and under conditions of deep uncertainty about future demand and climate.[97] In the context of ASDA, the resulting strategies were dynamic—that is, they evolved over time in response to financial and environmental triggers, and they covered multiple timescales, such as short-

[92] Robert J. Lempert, "Scenarios That Illuminate Vulnerabilities and Robust Responses," *Climatic Change*, Vol. 117, No. 4, 2013.

[93] Benjamin P. Bryant and Robert J. Lempert, "Thinking Inside the Box: A Participatory, Computer-Assisted Approach to Scenario Discovery," *Technological Forecasting and Social Change*, Vol. 77, No. 1, 2010.

[94] Henrik Carlsen, Robert Lempert, Per Wikman-Svahn, and Vanessa Schweizer, "Choosing Small Sets of Policy-Relevant Scenarios by Combining Vulnerability and Diversity Approaches," *Environmental Modelling & Software*, Vol. 84, No. 1, 2016; Jan H. Kwakkel and Marc Jaxa-Rozen, "Improving Scenario Discovery for Handling Heterogeneous Uncertainties and Multinomial Classified Outcomes," *Environmental Modeling and Software*, Vol. 79, 2016.

[95] Vanessa Jine Schweizer and Elmar Kriegler, and Elmar Kriegler, "Improving Environmental Change Research with Systematic Techniques for Qualitative Scenarios," *Environmental Research Letters*, Vol. 7, No. 4, 2012.

[96] Jonathan R. Lamontagne, Patrick M. Reed, Robert Link, Katherine V. Calvin, Leon E. Clarke, and James A. Edmonds, "Large Ensemble Analytic Framework for Consequence-Driven Discovery of Climate Change Scenarios," *Earth's Future*, Vol. 6, No. 3, 2018.

[97] Jonathan D. Herman, Harrison B. Zeff, Patrick M. Reed, and Gregory W. Characklis, "Beyond Optimality: Multistakeholder Robustness Tradeoffs for Regional Water Portfolio Planning Under Deep Uncertainty," *Water Resources Research*, Vol. 50, No. 10, 2014; Harrison B. Zeff, Jonathan D. Herman, Patrick M. Reed, and Gregory W. Characklis, "Cooperative Drought Adaptation: Integrating Infrastructure Development, Conservation, and Water Transfers into Adaptive Policy Pathways," *Water Resources Research*, Vol. 52, No. 9, 2016.

term operational decisions (e.g., reservoir management rules) and long-term infrastructure investments. The analysis linked timescales by shifting the operational decisions from rule-based procedures to dynamic risk-of-failure triggers and by shifting the infrastructure investments from static to adaptive policy pathways. The analytics were then organized in visualization packages and decision support processes that facilitated deliberations among representatives from the four cities to help them develop independent but coordinated strategies that satisfied multiple objectives in many plausible scenarios.

Recent work links such multi-scenario, multi-objective decision support approaches to social science approaches that recognize that stakeholders go beyond having differing objectives and expectations, actually clustering into distinct worldviews.[98] Such worldviews consist of correlated sets of values, beliefs, and policy preferences that shape how individuals understand, judge, and act in the world. Mixed qualitative and quantitative approaches, such as fuzzy cognitive mapping, can provide insights into the multilayered understandings of complex problems held by different stakeholders.[99] With these new approaches, social scientists use many of the methods described in the discussion earlier in this report to identify the worldviews in a community (see the "Approaches to Multi-Stakeholder Research: Stakeholders as a Focus of Research" section). Analysts then work separately with stakeholders from each worldview to coproduce a quantitative policy analysis. The solutions from each worldview are then viewed from the vantage of the others. In general, the solutions are each dynamic, as already described. These information products can then facilitate deliberations seeking to improve understanding among the parties, potential reframing of each of the worldviews, and potential compromise solutions. Such work is in its initial stages, and future research might improve each of its understanding, coproduction, and deliberation elements.

Finally, as with coproduction, deliberation processes would also benefit substantially from efforts to develop consistent evaluation metrics and protocols to understand which processes are most effective in driving salient, credible, and legitimate multi-stakeholder decisions, specifically, differing degrees of power dispersion and contestation. Trust in processes is crucial to developing trusted research outputs, and in contested spaces, the basis of trust may vary from traditional scientific rationalities. Bureaucratic imperatives, social relationships, existing sources of authority and legitimacy, and cross-cutting issues all influence what research processes are considered salient, legitimate, and credible. Once lost, credibility and legitimacy can be difficult to restore in the short term, so additional research should particularly focus on how to maintain trust among multi-stakeholder research partners, raise

[98] Robert J. Lempert and Sara Turner, "Engaging Multiple Worldviews with Quantitative Decision Support: A Robust Decision Making Demonstration Using the Lake Model," *Risk Analysis*, Vol. 41, No. 6, June 2021; Marco Verweij, "The Remarkable Restoration of the Rhine: Plural Rationalities in Regional Water Politics," *Water International*, Vol. 42, No. 2, 2017.

[99] Alison Singer, Steven Gray, Artina Sadler, Laura Schmitt Olabisi, Kyle Metta, Renee Wallace, Maria Claudia Lopez, Josh Introne, Maddie Gorman, and Jane Henderson, "Translating Community Narratives into Semi-Quantitative Models to Understand the Dynamics of Socio-Environmental Crises," *Environmental Modelling & Software*, Vol. 97, 2017.

the costs of defection in cases in which partners might be ambivalent, but input is essential, and incentivize commitment to multi-stakeholder engagement as an approach to knowledge generation and decisionmaking.

Concluding Thoughts

Multi-stakeholder research can significantly improve the ability of the U.S. government to pursue its interests in competitive UGS. The research investments suggested here could enhance the practice of multi-stakeholder research. First, such research could expand the types of stakeholders engaged in the research process and the ways in which they are drawn into the process (as consumers, creators, or subjects) and could help research teams identify and address practical problems more effectively. Therefore, broadening the number of groups engaged in research could increase the types and levels of expertise engaged in solving a problem and prevent the capture of the research process by any one stakeholder interest.

Second, this research could also speed the ability of research teams to derive and adjust problem framings and mental models. An enhanced understanding of how participation and decisionmaking function in multi-stakeholder spaces would improve both conceptual thinking about these methods and the ability of practitioners to deploy them in a wide variety of contexts, particularly in cases in which they are not considered part of standard practice (such as AI research, or research conducted with strategic competitors). It could also enhance the ability of research teams to build trust among disparate actors by choosing processes that are most likely to achieve the goals of salience, credibility, and legitimacy.

Third, rigorous testing and evaluating of these approaches could help dramatically improve and consolidate practices in this space, driving an improvement in quality across a variety of fields. Coupled with investments in tool-building to speed the ability of multi-stakeholder teams to create shared languages and visions and identify spaces for compromise, this could enhance the nimbleness of multi-stakeholder research and enable more fluid engagements to respond to changing conditions and compositions of stakeholder groups. Most important, research investments would be required to design or adapt tools to enable multi-stakeholder research in competitive contexts.

Finally, there is much research on the governance of complex problems, but the practice of adaptive governance is significantly hampered by the lack of practical tools that can be deployed, either to change the practice of public management or work within its confines to enhance nimbleness in changing and uncertain contexts and adapt them to the specific needs of DoD stakeholders. The review presented here has described some core principles and tools that already exist for multi-stakeholder engagement and tried to identify some areas where investment in the tools of research would help improve the quality of insight derived from these complex multi-stakeholder research processes in research on long-term competition and UGS.

Acknowledgments

The authors thank the Acquisition and Technology Policy program of RAND's National Defense Research Institute, the Defense Advanced Research Projects Agency for their support, and the editors of this report, Aaron B. Frank and Elizabeth M. Bartels, for their encouragement and many helpful comments.

Abbreviations

AC	Arctic Council
AR	augmented reality
ASDA	Act-Sense-Decide-Adapt
DMDU	Decision Making Under Deep Uncertainty
DoD	U.S. Department of Defense
IC	Intelligence Community
IoT	Internet of Things
LEO	local environmental observer
ML	machine learning
UGS	undergoverned spaces
VAMR	virtual, augmented, and mixed reality
VR	virtual reality

References

Alford, John, and Brian W. Head, "Wicked and Less Wicked Problems: A Typology and a Contingency Framework," *Policy and Society*, Vol. 36, No. 3, 2017, pp. 397–413.

Alwan, Riham M., "Beliefs, Perceptions, and Behaviors Impacting Healthcare Utilization of Syrian Refugee Children," *PloS One*, Vol. 15, No. 8, 2020.

Apostolakis, George E., and Susan E. Pickett, "Deliberation: Integrating Analytical Results into Environmental Decisions Involving Multiple Stakeholders," *Risk Analysis*, Vol. 18, No. 5, 1998, pp. 621–634.

Bartels, Elizabeth M., Jeffrey A. Drezner, and Joel B. Predd, *Building a Broader Evidence Base for Defense Acquisition Policymaking*, Santa Monica, Calif.: RAND Corporation, RR-A202-1, 2020. As of October 29, 2021:
https://www.rand.org/pubs/research_reports/RRA202-1.html

Elizabeth M. Bartels, Aaron B. Frank, Jasmin Léveillé, Timothy Marler, and Yuna Huh Wong, "Gaming Undergoverned Spaces: Emerging Approaches for Complex National Security Policy Problems," in Aaron B. Frank and Elizabeth M. Bartels, eds., *Adaptive Engagement for Undergoverned Spaces: Concepts, Challenges, and Prospects for New Approaches,* Santa Monica, Calif.: RAND Corporation, RR-A1275-1, 2022. As of July 2022: https://www.rand.org/pubs/research_reports/RRA1275-1.html

Bartels, Elizabeth M., Adam R. Grissom, Russell Hanson, and Christopher A. Mouton, *OCEANS 17 Tabletop Exercise: Findings and Recommendations*, Santa Monica, Calif.: RAND Corporation, RR-2521-OSD, 2019. As of October 29, 2021: https://www.rand.org/pubs/research_reports/RR2521.html

Ben-Akiva, Moshe, and Steven R. Lerman, *Discrete Choice Analysis: Theory and Application to Travel Demand (Transportation Studies)*, Cambridge, Mass.: MIT Press, 2018.

Bloomberg, Michael, "City Century: Why Municipalities Are the Key to Fighting Climate Change," *Foreign Affairs*, Vol. 94, No. 5, 2015, pp. 116–124.

Boaz, Annette, Stephen Hanney, Robert Borst, Alison O'Shea, and Maarten Kok, "How to Engage Stakeholders in Research: Design Principles to Support Improvement," *Health Research Policy and Systems*, Vol. 16, No. 1, 2018, pp. 1–9.

Boje, David M., *Narrative Methods for Organizational & Communication Research*, Thousand Oaks, Calif.: Sage, 2001.

Brady, Shane R., "Utilizing and Adapting the Delphi Method for Use in Qualitative Research," *International Journal of Qualitative Methods*, Vol. 14, No. 5, 2015.

Bryant, Benjamin P., and Robert J. Lempert, "Thinking Inside the Box: A Participatory, Computer-Assisted Approach to Scenario Discovery," *Technological Forecasting and Social Change*, Vol. 77, No. 1, 2010, pp. 34–49.

Carlsen, Henrik, Robert Lempert, Per Wikman-Svahn, and Vanessa Schweizer, "Choosing Small Sets of Policy-Relevant Scenarios by Combining Vulnerability and Diversity Approaches," *Environmental Modelling & Software*, Vol. 84, No. 1, 2016, pp. 155–164.

Cash, David, William C. Clark, Frank Alcock, Nancy M. Dickson, Noelle Eckley, and Jill Jäger, "Salience, Credibility, Legitimacy and Boundaries: Linking Research, Assessment and Decision Making," Cambridge, Mass.: Harvard University, KSG Working Papers Series, 2003.

Chang, Welton, Shefali Patil, and Philip E. Tetlock, "Accountability and Adaptive Performance Under Uncertainty: A Long-Term View," *Judgement and Decision Making*, Vol. 12, No. 6, 2017, pp. 610–626.

Cohen, Joshua, James Bohman, and William Rehg, "Deliberation and Democratic Legitimacy," reprinted in James Bohman and William Rehg, eds., *Deliberative Democracy: Essays on Reason and Politics*, Cambridge, Mass.: MIT Press, 1997, pp. 67–92.

Colbert, Edward, Alexander Kott, and Lawrence P. Knachel, "The Game-Theoretic Model and Experimental Investigation of Cyber Wargaming," *Journal of Defense Modeling and Simulation*, Vol. 17, No. 1, 2020, pp. 21–38.

Colbert, Edward, Daniel Sullivan, and Alexander Kott, "Cyber Wargaming on SCADA Systems," in Adam R. Bryant, Juan R. Lopez, and Robert Mills, eds., *Proceedings of the 12th International Conference on Cyber Warfare and Security (ICCWS 2017)*, Reading, United Kingdom: Academic Conferences and Publishing International Limited, 2017.

Davis, Paul K., "Toward an Analytic Architecture to Aid Adaptive Strategy for Competing in Undergoverned Spaces," in Aaron B. Frank and Elizabeth M. Bartels, eds., *Adaptive Engagement for Undergoverned Spaces: Concepts, Challenges, and Prospects for New Approaches,* Santa Monica, Calif.: RAND Corporation, RR-A1275-1, 2022. As of July 2022: https://www.rand.org/pubs/research_reports/RRA1275-1.html

Deering, Michael, "High Resolution Virtual Reality," *Proceedings of the 19th Annual Conference on Computer Graphics and Interactive Techniques*, Vol. 26, No. 2, 1992, pp. 195–202.

de Loë, Rob C., Natalya Melnychuk, Dan Murray, and Ryan Plummer, "Advancing the State of Policy Delphi Practice: A Systematic Review Evaluating Methodological Evolution, Innovation, and Opportunities," *Technological Forecasting and Social Change*, Vol. 104, 2016, pp. 78–88.

Demir, Imran, *Overconfidence and Risk Taking in Foreign Policy Decision Making: The Case of Turkey's Syria Policy*, New York: Springer, 2017.

de Souza e Silva, Adriana, and Daniel M. Sutko, eds., *Digital Cityscapes: Merging Digital and Urban Playspaces*, Bern, Switzerland: Peter Lang, 2009.

de Souza-Mazurek, Rosélis Remor, "Subsistence Hunting Among the Waimiri Atroari Indians in Central Amazonia, Brazil," *Biodiversity & Conservation*, Vol. 9, No. 5, 2000, pp. 579–596.

Djenontin, Ida Nadia S., and Alison M. Meadow, "The Art of Co-Production of Knowledge in Environmental Sciences and Management: Lessons from International Practice," *Environmental Management*, Vol. 61, 2018, pp. 885–903.

Dryzek, John S., *Deliberative Democracy and Beyond: Liberals, Critics, Contestations*, Oxford, United Kingdom: Oxford University Press, 2002.

Dumas, Joseph S., and Beth A. Loring, *Moderating Usability Tests: Principles and Practices for Interacting*, Amsterdam, Netherlands: Elsevier, 2008.

Edmunds, Holly, "The Focus Group Research Handbook," *The Bottom Line*, Vol. 12, No. 3, 1999.

Einhorn, Hillel J., and Robin M. Hogarth, "Behavioral Decision Theory: Processes of Judgement and Choice," *Annual Review of Psychology*, Vol. 32, No. 1, 1981, pp. 53–88.

Epley, Nicholas, and Thomas Gilovich, "The Anchoring-and-Adjustment Heuristic: Why the Adjustments Are Insufficient," *Psychological Science*, Vol. 17, No. 4, 2006, pp. 311–318.

Fazey, Ioan, Lukas Bunse, Joshua Msika, Maria Pinke, Katherine Preedy, Anna C. Evely, Emily Lambert, Emily Hastings, Sue Morris, and Mark S. Reed, "Evaluating Knowledge Exchange in Interdisciplinary and Multi-Stakeholder Research," *Global Environmental Change*, Vol. 25, No. 1, 2014, pp. 204–220.

Fearon, James D., "Deliberation as Discussion," in J. Elster, ed., *Deliberative Democracy*, Cambridge, Mass.: Cambridge University Press, 1998, pp. 44–68.

Fischhoff, Baruch, "The Sciences of Science Communication," *Proceedings of the National Academy of Sciences*, Vol. 110, 2013, pp. 14033–14039.

Fishkin, James S., and Robert C. Luskin, "Experimenting with a Democratic Ideal: Deliberative Polling and Public Opinion," *Acta Politica*, Vol. 40, No. 3, 2005, pp. 284–298.

Forte, Michael, "Learning Human Behavioral Profiles in a Cyber Environment," in *2010 IEEE Systems and Information Engineering Design Symposium*, Charlottesville, Va.: IEEE, 2010.

Fowler, Floyd J., Jr., *Survey Research Methods*, Thousand Oaks, Calif.: Sage, 2013.

Fox, David B., *Cyber Wargaming: Framework for Enhancing Cyber Wargaming with Realistic Business Context*, McLean, Va.: MITRE Corporation, 2018.

Frank, Aaron B., "Toward Computational Net Assessment," *Journal of Defense Modeling and Simulation*, Vol. 14, No. 1, 2017, pp. 79–94.

Freelon, Deen, Marc Lynch, and Sean Aday, "Online Fragmentation in Wartime: A Longitudinal Analysis of Tweets About Syria, 2011–2013," *Annals of the American Academy of Political and Social Science*, Vol. 659, No. 1, 2015, pp. 166–179.

Frey, Lawrence, Carl H. Botan, and Gary Kreps, *Investigating Communication*, New York: Allyn & Bacon, 2000.

Fuhrt, Borko, ed., *Handbook of Augmented Reality*, Berlin, Germany: Springer Science and Business Media, 2011.

Fung, Archon, "Varieties of Participation in Complex Governance," *Public Administration Review*, Vol. 66, No. 1, 2006, pp. 66–75.

Gabriel, Johannes, and Susanne Schmelcher, "Three Scenarios for EU-China Relations 2025," *Futures*, Vol. 97, 2018, pp. 26–34.

Gompert, David C., Hans Binnendijk, and Bonny Lin, *Blinders, Blunders, and Wars: What America and China Can Learn*, Santa Monica, Calif.: RAND Corporation, RR-768-RC, 2014. As of November 2, 2021:
https://www.rand.org/pubs/research_reports/RR768.html

Gong, Min, Robert Lempert, Andrew Parker, Lauren A. Mayer, Jordan Fischbach, Matthew Sisco, Zhimin Mao, David H. Krantz, and Howard Kunreuther, "Testing the Scenario Hypothesis: An Experimental Comparison of Scenarios and Forecasts for Decision Support in a Complex Decision Environment," *Environmental Modelling and Software*, Vol. 91, No. 3, 2017, pp. 135–155.

Gray, Steven A., Stefan Gray, Jean Luc De Kok, Ariella E. R. Helfgott, Barry O'Dwyer, Rebecca Jordan, and Angela Nyaki, "Using Fuzzy Cognitive Mapping as a Participatory Approach to Analyze Change, Preferred States, and Perceived Resilience of Social-Ecological Systems," *Ecology and Society*, Vol. 20, No. 2, 2015.

Groves, Robert M., *Survey Errors and Survey Costs*, Hoboken, N.J.: John Wiley & Sons, 2004.

Gutmann, Amy, and Dennis F. Thompson, *Why Deliberative Democracy?* Princeton, N.J.: Princeton University Press, 2009.

Haer, Roos, and Inna Becher, "A Methodological Note on Quantitative Field Research in Conflict Zones: Get Your Hands Dirty," *International Journal of Social Research Methodology*, Vol. 15, No. 1, 2012, pp. 1–13.

Head, Brian W., and John Alford, "Wicked Problems: Implications for Public Policy and Management," *Administration and Society*, Vol. 47, No. 6, 2015, pp. 711–739.

Helmus, Todd, "Social Media and Influence Operations Technologies: Implications for Great Power Competition," in Thomas F. Lynch III, ed., *Strategic Assessment 2020: Into a New Era of Great Power Competition,* Washington, D.C., National Defense University, 2020, pp. 153–166.

Hensher, David A., and Lester W. Johnson, *Applied Discrete-Choice Modelling*, London, United Kingdom: Routledge, 2018.

Herman, Jonathan D., Harrison B. Zeff, Patrick M. Reed, and Gregory W. Characklis, "Beyond Optimality: Multistakeholder Robustness Tradeoffs for Regional Water Portfolio Planning Under Deep Uncertainty," *Water Resources Research*, Vol. 50, No. 10, 2014, pp. 7692–7713.

Jacowitz, Karen E., and Daniel Kahneman, "Measures of Anchoring in Estimation Tasks," *Personality and Social Psychology Bulletin*, Vol. 21, No. 11, 1995, pp. 1161–1166.

Jaeger, Carlo C., Thomas Webler, Eugene A. Rosa, and Ortwin Renn, "Decision Analysis and Rational Action," in S. Rayner and E. L. Malone, eds., *Human Choice and Climate Change*, Vol. 3, *Tools for Policy Analysis*, Columbus, Ohio: Battelle Press, 1998, pp. 141–215.

Jervis, Robert, *Perception and Misperception in International Politics*, Princeton, N.J.: Princeton University Press, 2017.

Jones, Natalie A., "Evaluating Participatory Modeling: Developing a Framework for Cross-Case Analysis," *Environmental Management*, Vol. 44, No. 6, 2009, pp. 1180–1195.

Jordan, Rebecca, Steven Gray, Moira Zellner, Pierre D. Glynn, Alexey Voinov, Beatrice Hedelin, Eleanor J. Sterling, Kirsten Leong, Laura Schmitt Olabisi, Klaus Hubacek, et al., "Twelve Questions for the Participatory Modeling Community," *Earth's Future*, Vol. 6, No. 8, 2018, pp. 1046–1057.

Kahan, Dan M., and Donald Braman, "Cultural Cognition and Public Policy," *Yale Law & Policy Review*, Vol. 24, 2006, pp. 149–172.

Kahneman, Daniel, Paul Slovic, and Amos Tversky, eds., *Judgment Under Uncertainty: Heuristics and Biases*, Cambridge, United Kingdom: Cambridge University Press, 1982.

Khodyakov, Dmitry, Terrance D. Savitsky, and Siddhartha Dalal, "Collaborative Learning Framework for Online Stakeholder Engagement," *Health Expectations*, Vol. 19, No. 4, 2016, pp. 868–882.

Klayman, Joshua, "Varieties of Confirmation Bias," *Psychology of Learning and Motivation*, No. 32, 1995, pp. 385–418.

Kleij, Frederieke, and Pieter A. D. Musters, "Text Analysis of Open-Ended Survey Responses: A Complementary Method to Preference Mapping," *Food Quality and Preference*, Vol. 14, No. 1, 2003, pp. 43–52.

Klima, Kelly, and Alessandra Jerolleman, "A Rose by Any Other Name—Communicating Between Hazard Mitigation, Climate Adaptation, Disaster Risk Reduction, and Sustainability Professionals," *Journal of Environmental Studies and Sciences*, Vol. 7, No. 1, 2017, pp. 25–29.

Kwakkel, Jan H., and Marc Jaxa-Rozen, "Improving Scenario Discovery for Handling Heterogeneous Uncertainties and Multinomial Classified Outcomes," *Environmental Modeling and Software*, Vol. 79, 2016, pp. 311–321.

Lamontagne, Jonathan R., Patrick M. Reed, Robert Link, Katherine V. Calvin, Leon E. Clarke, and James A. Edmonds, "Large Ensemble Analytic Framework for Consequence-Driven Discovery of Climate Change Scenarios," *Earth's Future*, Vol. 6, No. 3, 2018, pp. 488–504.

Larson, Deborah Welch, *Origins of Containment: A Psychological Explanation*, Princeton, N.J.: Princeton University Press, 1985.

Lau, Richard R., and David P. Redlawsk, "Advantages and Disadvantages of Cognitive Heuristics in Political Decision Making," *American Journal of Political Science*, Vol. 45, October 2001, pp. 951–971.

Lee, Kai N., *Compass and Gyroscope: Integrating Science and Politics for the Environment*, Washington, D.C.: Island Press, 1994.

Lempert, Robert J., "Scenarios That Illuminate Vulnerabilities and Robust Responses," *Climatic Change*, Vol. 117, No. 4, 2013, pp. 627–646.

Lempert, Robert J., and Sara Turner, "Engaging Multiple Worldviews with Quantitative Decision Support: A Robust Decision Making Demonstration Using the Lake Model," *Risk Analysis*, Vol. 41, No. 6, June 2021, pp. 845–865.

Lerner, Jennifer S., Roxana M. Gonzalez, Deborah A. Small, and Baruch Fischhoff, "Effects of Fear and Anger on Perceived Risks of Terrorism," *Psychological Science*, Vol. 14, No. 2, 2003, pp. 144–150.

Lerner, Jennifer S., and Larissa Z. Tiedens, "Portrait of the Angry Decision Maker: How Appraisal Tendencies Shape Anger Influence on Decision Making," *Journal of Behavioral Decision Making*, Vol. 19, No. 2, 2006, pp. 115–137.

Lin, Xialing, Patric R. Spence, and Kenneth A. Lachlan, "Social Media and Credibility Indicators: The Effect of Influence Cues," *Computers in Human Behavior*, Vol. 63, 2016, pp. 264–271.

Lindlof, Thomas R., and Bryan C. Taylor, *Qualitative Communication Research Methods*, Thousand Oaks, Calif.: Sage, 2017.

Loewenstein, George F., Elke U. Weber, Christopher K. Hsee, and Ned Welch, "Risk as Feelings," *Psychological Bulletin*, Vol. 127, No. 2, 2001, pp. 267–286.

Loomes, Graham, and Robert Sugden, "Regret Theory: An Alternative Theory of Rational Choice Under Uncertainty," *Economic Journal*, Vol. 92, No. 4, 1982, pp. 805–824.

Lyall, Jason, Graeme Blair, and Kosuke Imai, "Explaining Support for Combatants During Wartime: A Survey Experiment in Afghanistan," *American Political Science Review*, Vol. 107, No. 4, 2013, pp. 679–705.

Mazarr, Michael J., Katharina Ley Best, Burgess Laird, Eric V. Larson, Michael E. Linick, and Dan Madden, *The U.S. Department of Defense's Planning Process: Components and Challenges*, Santa Monica, Calif.: RAND Corporation, RR-2173/2-A, 2019. As of November 2, 2021: https://www.rand.org/pubs/research_reports/RR2173z2.html

Maziak, Wasim, Kenneth D. Ward, Fawaz Mzayek, Samer Rastam, M. E. Bachir, Fouad M. Fouad, Fadi Hammal, Taghrid Asfar, Jeremiah Mock, Iman Nuwayhid, et al., "Mapping the Health and Environmental Situation in Informal Zones in Aleppo, Syria: Report from the Aleppo Household Survey," *International Archives of Occupational and Environmental Health*, Vol. 78, No. 7, 2005, pp. 547–558.

Metzger, Miriam J., and Andrew J. Flanagin, "Credibility and Trust of Information in Online Environments: The Use of Cognitive Heuristics," *Journal of Pragmatics*, Vol. 59, 2013, pp. 210–220.

Miller, Mark Roman, Fernanda Herrera, Hanseul Jun, James A. Landay, and Jeremy N. Bailenson, "Personal Identifiability of User Tracking Data During Observation of 360-Degree VR Video," *Scientific Reports*, Vol. 10, No. 1, 2020, pp. 1–10.

Mineka, Susan, and Steven K. Sutton, "Cognitive Biases and the Emotional Disorders," *Psychological Science*, Vol. 3, No. 1, 1992, pp. 65–69.

Morgan, David L., *The Focus Group Guidebook*, Thousand Oaks, Calif.: Sage, 1997.

Morgan, David L., Jutta Ataie, Paula Carder, and Kim Hoffman, "Introducing Dyadic Interviews as a Method for Collecting Qualitative Data," *Qualitative Health Research*, Vol. 23, No. 9, 2013, pp. 1276–1284.

Morgan, Forrest E., Benjamin Boudreaux, Andrew J. Lohn, Mark Ashby, Christian Curriden, Kelly Klima, and Derek Grossman, *Military Applications of Artificial Intelligence: Ethical Concerns in an Uncertain World*, Santa Monica, Calif.: RAND Corporation, RR-3139-1-AF, 2020. As of November 2, 2021: https://www.rand.org/pubs/research_reports/RR3139-1.html

National Academies of Science Engineering and Medicine, *Communicating Science Effectively: A Research Agenda*, Washington, D.C.: National Academies Press, 2017.

National Research Council, *Public Participation in Environmental Assessment and Decision Making*, Washington, D.C.: National Academy of Sciences Press, 2008.

Natural Hazards Center, University of Colorado Boulder, "About CONVERGE," webpage, undated. As of November 2, 2021:
https://converge.colorado.edu/about

Nickerson, Raymond S., "Confirmation Bias: A Ubiquitous Phenomenon in Many Guises," *Review of General Psychology*, Vol. 2, No. 2, 1998, pp. 175–220.

Noveck, Beth Simone, "Designing Deliberative Democracy in Cyberspace: The Role of the Cyber-Lawyer," *Boston University Journal of Science & Technology Law*, Vol. 9, No. 1, 2003, pp. 1–18.

Nyumba, Tobias O., Kerrie Wilson, Christina J. Derrick, and Nibedita Mukherjee, "The Use of Focus Group Discussion Methodology: Insights from Two Decades of Application in Conservation," *Methods in Ecology and Evolution*, Vol. 9, No. 1, 2018, pp. 20–32.

Ostrom, Elinor, *Governing the Commons: The Evolution of Institutions for Collective Action*, New York: Cambridge University Press, 1990.

Parker, Andrew M., Sinduja V. Srinivasan, Robert J. Lempert, and Sandra H. Berry, "Evaluating Simulation-Derived Scenarios for Effective Decision Support," *Technological Forecasting and Social Change*, Vol. 91, 2015, pp. 64–77.

Paul, Christopher, Yuna Huh Wong, and Elizabeth M. Bartels, *Opportunities for Including the Information Environment in U.S. Marine Corps Wargames*, Santa Monica, Calif.: RAND Corporation, RR-2997-USMC, 2020. As of October 29, 2021:
https://www.rand.org/pubs/research_reports/RR2997.html

Peek, Lori, Jennifer Tobin, Rachel M. Adams, Haorui Wu, and Mason Clay Mathews, "A Framework for Convergence Research in the Hazards and Disaster Field: The Natural Hazards Engineering Research Infrastructure CONVERGE Facility," *Frontiers in Built Environment*, Vol. 6, July 2020, pp. 1–19.

Peters, Ellen, Daniel Västfjäll, Tommy Gärling, and Paul Slovic, "Affect and Decision Making: A Hot Topic," *Journal of Behavioral Decision Making*, Vol. 19, No. 2, 2006, pp. 79–85.

Pezard, Stephanie, Abbie Tingstad, and Alexandra Hall, *The Future of Arctic Cooperation in a Changing Strategic Environment: Insights from a Scenario-Based Exercise Organised by RAND and Hosted by NUPI*, Santa Monica, Calif.: RAND Corporation, PE-268-RC, 2018. As of November 2, 2021:
https://www.rand.org/pubs/perspectives/PE268.html

Popper, Steven W., "Designing a Robust Decision–Based National Security Policy Process: Strategic Choices for Uncertain Times," in Aaron B. Frank and Elizabeth M. Bartels, eds., *Adaptive Engagement for Undergoverned Spaces: Concepts, Challenges, and Prospects for New Approaches,* Santa Monica, Calif.: RAND Corporation, RR-A1275-1, 2022. As of July 2022:
https://www.rand.org/pubs/research_reports/RRA1275-1.html

Rabiee, Fatemeh, "Focus-Group Interview and Data Analysis," in *Proceedings of the Nutrition Society*, Vol. 63, No. 4, 2004, pp. 655–660.

Radinsky, Joshua, Dan Milz, Moira Zellner, Kelsey Pudlock, Curtis Witek, C. Hoch, and Leilah Lyons, "How Planners and Stakeholders Learn with Visualization Tools: Using Learning Sciences Methods to Examine Planning Processes," *Journal of Environmental Planning and Management*, Vol. 60, No. 7, 2017, pp. 1296–1323.

Rahmattalabi, Aida, Shahin Jabbari, Himabindu Lakkaraju, Phebe Vayanos, Eric Rice, and Milind Tambe, "Fair Influence Maximization: A Welfare Optimization Approach," in *Proceedings of the Thirty-Fifth AAAI Conference on Artificial Intelligence*, Edinburgh, Scotland, 2020.

Rittel, Horst W. J., and Melvin M. Webber, "Dilemmas in a General Theory of Planning," *Policy Sciences*, Vol. 4, No. 2, June 1, 1973, pp. 155–169.

Roberts, Margaret E., "Structural Topic Models for Open-Ended Survey Responses," *American Journal of Political Science*, Vol. 58, No. 4, 2014, pp. 1064–1082.

Roberts, Nancy, "Wicked Problems and Network Approaches to Resolution," *International Public Management Review*, Vol. 1, No. 1, 2000, pp. 1–19.

Romanosky, Sasha, and Benjamin Boudreaux, "Private-Sector Attribution of Cyber Incidents: Benefits and Risks to the U.S. Government," *International Journal of Intelligence and Counterintelligence*, Vol. 34, No. 3, 2021, pp. 463–493.

Scheufele, Dietram A., "Science Communication as Political Communication," *Proceedings of the National Academy of Sciences*, Vol. 111, 2014, pp. 13585–13592.

Schoen, Donald, and Martin Rein, *Frame Reflection: Toward the Resolution of Intractable Policy Controversies*, New York: Basic Books, 1995.

Schweizer, Vanessa Jine, and Elmar Kriegler, "Improving Environmental Change Research with Systematic Techniques for Qualitative Scenarios," *Environmental Research Letters*, Vol. 7, No. 4, 2012.

Scott, James C., *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*, New Haven, Conn.: Yale University Press, 1999.

Severin, Werner J., and James W. Tankard, *Communication Theories: Origins, Methods, and Uses in the Mass Media*, New York: Longman, 1997.

Sherman, Steven J., and Eric Corty, "Cognitive Heuristics," in R. S. Wyer, Jr., and T. K. Srull, eds., *Handbook of Social Cognition*, Vol. 1, Mahwah, N.J.: Lawrence Erlbaum Associates, 1984, pp. 189–286.

Shirazi, Farid, "Social Media and the Social Movements in the Middle East and North Africa," *Information Technology & People*, Vol. 26, No. 1, 2013, pp. 28–49.

Shlapak, David A., and Michael W. Johnson, *Reinforcing Deterrence on NATO's Eastern Flank: Wargaming the Defense of the Baltics*, Santa Monica, Calif.: RAND Corporation, RR-1253-A, 2016. As of November 2, 2021:
https://www.rand.org/pubs/research_reports/RR1253.html

Singer, Alison, Steven Gray, Artina Sadler, Laura Schmitt Olabisi, Kyle Metta, Renee Wallace, Maria Claudia Lopez, Josh Introne, Maddie Gorman, and Jane Henderson, "Translating Community Narratives into Semi-Quantitative Models to Understand the Dynamics of Socio-Environmental Crises," *Environmental Modelling & Software*, Vol. 97, 2017, pp. 46–55.

Slovic, Paul, Melissa L. Finucane, Ellen Peters, and Donald G. MacGregor, "Risk as Analysis and Risk as Feelings: Some Thoughts About Affect, Reason, Risk and Rationality," *Risk Analysis*, Vol. 24. No. 2, 2004, pp. 311–322.

Slovic, Paul, Baruch Fischhoff, and Sarah Lichtenstein, "Behavioral Decision Theory," *Annual Review of Psychology*, Vol. 28, No. 1, 1977, pp. 1–39.

Smith, Graham, and Corinne Wales, "Citizens' Juries and Deliberative Democracy," *Political Studies*, Vol. 48, No. 1, 2000, pp. 51–65.

Smith, Valerie J., "Ethical and Effective Ethnographic Research Methods: A Case Study with Afghan Refugees in California," *Journal of Empirical Research on Human Research Ethics*, Vol. 4, No. 3, 2009, pp. 59–72.

Taylor-Powell, Ellen, and Sara Steele, *Collecting Evaluation Data: Direct Observation, Program Development and Evaluation*, Madison, Wisc.: University of Wisconsin-Extension, 1996.

Vernier, Larissa, "High Levels of Mortality, Exposure to Violence and Psychological Distress Experienced by the Internally Displaced Population of Ein Issa Camp Prior to and During Their Displacement in Northeast Syria, November 2017," *Conflict and Health*, Vol. 13, Article 33, 2019.

Verweij, Marco, "The Remarkable Restoration of the Rhine: Plural Rationalities in Regional Water Politics," *Water International*, Vol. 42, No. 2, 2017, pp. 1–15.

Voinov, Alexey, Karen Jenni, Steven Gray, Nagesh Kolagani, Pierre D. Glynn, Pierre Bommel, Christina Prell, Moira Zellnerg, Michael Paolissoh, Rebecca Jordani, et al., "Tools and Methods in Participatory Modeling: Selecting the Right Tool for the Job," *Environmental Modelling and Software*, Vol. 109, November 2018, pp. 232–255.

Voinov, Alexey, Nagesh Kolagani, Michael K. McCall, Pierre D. Glynn, Marit E. Kragt, Frank O. Ostermann, Suzanne A. Pierce, and Palaniappan Ramu, "Modelling with Stakeholders—Next Generation," *Environmental Modelling and Software*, Vol. 77, March 2016, pp. 196–220.

Voznyak, Halyna, and Andriy Pelekhatyy, "Participatory Budgeting as a Tool for the Implementation of the Fiscal Policy of Regional Development of Ukraine," *Economic Annals–XXI*, Vol. 167, Nos. 9–10, 2017, pp. 53–56.

Walker, W. Richard, and John J. Skowronski, "The Fading Affect Bias: But What the Hell Is It For?" *Applied Cognitive Psychology: The Official Journal of the Society for Applied Research in Memory and Cognition*, Vol. 23, No. 8, 2009, pp. 1122–1136.

Webler, Thomas, and Seth Tuler, "Four Decades of Public Participation in Risk Decision Making," *Risk Analysis*, Vol. 41, No. 3, 2018.

Wong, Yuna Huh, Sebastian Joon Bae, Elizabeth M. Bartels, and Benjamin Smith, *Next-Generation Wargaming for the U.S. Marine Corps: Recommended Courses of Action*, Santa Monica, Calif.: RAND Corporation, RR-2227-USMC, 2019. As of November 2, 2021: https://www.rand.org/pubs/research_reports/RR2227.html

Wong-Parodi, Gabrielle, and Kelly Klima, "Preparing for Local Adaptation: A Study of Community Understanding and Support," *Climatic Change*, Vol. 145, No. 3–4, 2017, pp. 413–429.

Wyborn, Carina, "Co-Productive Governance: A Relational Framework for Adaptive Governance," *Global Environmental Change*, Vol. 30, January 2015, pp. 56–67.

Yeung, Douglas, Sarah A. Nowak, Sohaela Amiri, Aaron C. Davenport, Emily Hoch, Kelly Klima, and Colleen M. McCullough, "How the U.S. Coast Guard Can Leverage Social Media and Enhanced Cell Phone Data to Improve Emergency Response," Santa Monica, Calif.: RAND Corporation, RB-10102-DHS, 2020a. As of November 2, 2021: https://www.rand.org/pubs/research_briefs/RB10102.html

Yeung, Douglas, Sarah A. Nowak, Sohaela Amiri, Aaron C. Davenport, Emily Hoch, Kelly Klima, and Colleen M. McCullough, *U.S. Coast Guard Emergency Response and Disaster Operations: Using Social Media for Situational Awareness*, Santa Monica, Calif.: RAND Corporation, RR-4296-DHS, 2020b. As of November 2, 2021: https://www.rand.org/pubs/research_reports/RR4296.html

Young, Oran R., "Is It Time for a Reset in Arctic Governance?" *Sustainability (Switzerland)*, Vol. 11, No. 16, 2019.

Yzermans, C. Joris, "The Experience of Sudden Loss of a Colleague or Neighbor Following the MH17 Plane Crash in the Ukraine: A Qualitative Interview Study," *BMC Psychology*, Vol. 8, No. 1, 2020.

Zeff, Harrison B., Jonathan D. Herman, Patrick M. Reed, and Gregory W. Characklis, "Cooperative Drought Adaptation: Integrating Infrastructure Development, Conservation, and Water Transfers into Adaptive Policy Pathways," *Water Resources Research*, Vol. 52, No. 9, 2016, pp. 7327–7346.