CHAPTER 5

Social and Scientific Challenges

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CHAPTER 5

Social and Scientific Challenges

This chapter examines the complex social and scientific challenges that S3OK – a team of scientists, practitioners, and stakeholders – has faced in tackling wicked problems at the intersection of weather, water, land use, and infrastructure in Oklahoma. These challenges arise from shifting environmental risks, entrenched disciplinary boundaries, political polarization, and deep-seated cultural divides. Recognizing these barriers, S3OK has worked deliberately to bridge gaps between expertise areas, foster dialogue across sectors, and develop research-based materials to support decision-making and implementation.

By approaching these issues through an interdisciplinary and cross-sectoral lens, this section outlines how S3OK has navigated challenges while seeking common ground. Specifically, the following sections detail how S3OK has:

1. Responded to evolving environmental risk landscapes
2. Bridged social and scientific divides to enable collaboration
3. Identified domains of agreement despite ideological and disciplinary differences

Responding to Evolving Environmental Risk Landscapes

Oklahoma's environmental risks no longer sit still. Extreme heat, sudden downpours, and longer dry spells now collide with aging infrastructure, shifting land use, and rising water demands, creating a single, intertwined threat rather than separate problems. As **Figure 5.1** illustrates, the old "average" weather on which planners once relied has lost its meaning. Managing today's risks, therefore, requires an adaptive, cross-sector playbook—one that treats climate and infrastructure stresses as moving targets and updates strategies as conditions evolve.

Figure 5.1. Shifting weather patterns produce both drought and flooding, making resilience planning more difficult and upending long-held assumptions. *Photo Credit: Sean Ernst.*

At the core of this challenge is the interdependence of natural and built systems. Decisions about land use, whether related to Oklahoma's robust agricultural or energy development sectors or municipal planning, directly impact water availability and quality as well as infrastructure resilience. In turn, legacy water management systems, stormwater infrastructure, and well-established land-use policies struggle to accommodate the increasing variability in subseasonal-to-seasonal weather patterns. More frequent droughts, extreme precipitation events, and shifting groundwater

dynamics complicate long-term planning for municipal water supplies, agricultural irrigation, and flood control, leading to greater uncertainty in managing Oklahoma's essential resources.

These environmental shifts also bring social and political complexities. Competing demands for water, land, and infrastructure investments often reflect historical tensions and conflicting priorities between communities, industries, and governance. As a result, resilience strategies that fail to consider the broader social, economic, and political landscape risk deepening existing challenges rather than addressing them. The problem is not only scientific but also deeply tied to governance, policy, and public perception.

The S3OK project explored these intersections, leveraging scientific research, data-driven forecasting, and interdisciplinary collaboration to develop more integrated approaches and socially sustainable solutions to wicked problems. This chapter examines the emerging environmental risk landscape, the limitations of traditional methods in addressing it, and the scientific and social challenges that must be overcome. In doing so, it provides key context for advancing understanding of how to better align land, water, infrastructure, and climate resilience strategies in a world where environmental risk is constantly evolving.

Bridging Social and Scientific Divides

Navigating the wicked problems S3OK seeks to address presents a set of complex, interwoven challenges that span both social and scientific domains. While scientific advancements offer technical pathways to identify solutions to these challenges, the effectiveness and durability of these solutions depend on their alignment with social realities, community needs, and policy frameworks. The S3OK initiative recognizes that scientific expertise alone cannot drive meaningful change. Solutions must be co-developed with stakeholders, accounting for political feasibility, economic pressures, and public perceptions.

Bridging the Gap between Scientific Research and Societal Needs

One primary core challenge the S3OK project sought to address is the challenge of bridging the gap between scientific research and societal needs in the solution development process. While researchers work to develop better predictive models, adaptive water management strategies, and climate-informed land-use policies, these advancements can struggle to gain traction if they do not align with the priorities and needs of communities, industries, and decision-makers.

Moreover, if such advances are technically and practically inaccessible and siloed, the scale of potential influence is limited. For example, while data-driven approaches to water allocation may highlight the long-term benefits of conservation, immediate economic concerns—such as agricultural productivity or municipal water access—often take precedence in policy discussions.

Furthermore, if such innovative data-driven approaches to water allocation are circulated within scholarly networks or venues alone, key findings and insights might not make their way into the hands of practitioners in positions to benefit from their implementation. The challenge lies in integrating technical solutions into decision-making processes that are inherently shaped by political, economic, and social considerations.

Balancing Technical Solutions with Social Realities

Balancing technical solutions with social realities is particularly difficult in contexts where scientific recommendations conflict with economic interests or deeply held cultural beliefs. Infrastructure innovations designed to mitigate flooding or optimize water distribution, for example, may face resistance if they do not adequately consider factors related to land ownership and land use norms, agricultural practices, or urban planning regulations. Similarly, efforts to enhance forecasting capabilities for drought or extreme weather are only effective if policymakers, water

managers, and the public trust and use the information.

One of the greatest barriers to working across social and scientific challenges is effective risk communication. Different groups interpret scientific uncertainty, probabilistic models, and policy trade-offs in different ways. Scientific recommendations are often based on probabilistic outcomes, while decision-makers may seek clear-cut answers about when, where, and how a specific risk will materialize in order to make informed decisions. When forecasts or scientific assessments fail to provide certainty, or when different experts present conflicting views, public trust in science and institutions can erode.

In Oklahoma, where land and water use policies are shaped by varied and sometimes conflicting interests, the role of trust in institutions and expertise becomes a key determinant of whether resilience measures are adopted, contested, or ignored. Skepticism toward science, government regulation, and external expertise can create resistance to policies that can promote effective solutions to challenges related to water quality and quantity, land use, and mitigation practices. Conversely, local knowledge and historical experience, along with industry and practitioner priorities, often hold significant weight in shaping community-level decisions. Building long-term relationships with key stakeholders rather than engaging them only in moments of crisis can help ensure that scientific insights and decision-making priorities are well aligned to meet the new and established challenges. As S3OK researchers worked across disciplines and stakeholder groups, fostering trust and transparency in communication while developing meaningful professional relationships was essential.

Social Divisions and Conflicting Narratives

The challenges of working across social and scientific boundaries are further complicated by long-standing divisions and historical tensions in decision-making processes. The following section explores how cultural divides, legacy ties, and polarization shape public perceptions of environmental risk. These tensions must be acknowledged and addressed if resilience planning efforts are to be effective and sustainable in the face of increasingly unpredictable environmental conditions.

Honoring Multiple Perspectives

Oklahoma's unique mix of urban and rural landscapes, along with strong regional and cultural differences, presents rich opportunities and unique challenges in developing socially sustainable solutions at the intersection of land use, water quality and quantity, and infrastructure in the face of changing seasonal to sub-seasonal weather patterns. Equipped with different resources and characterized by different needs, Oklahomans hold differing perspectives and priorities that can create tensions if advancing a 'one-size-fits-all' approach to solution development. Not only does such an approach lack credibility and applicability, but it also presents the challenge of inappropriately leveraging scientific expertise and developing policy recommendations that conflict with local observations. Overcoming this divide requires not just improving technical accuracy but also incorporating insights from across the full extent of Oklahoma's landscape while seeking to build trust and foster two-way communication between scientists and local stakeholders.

Legacy Ties and Local Context

Oklahoma's economic and historical engagement with the select sectors has created deep cultural and identity-based connections to traditional industries in the state. Communities, particularly those with economies built around such sectors, such as traditional energy production and agriculture, may view innovative strategies designed to adapt to a changing environment as threats to their economic stability **(Figure 5.2)**. Resistance to change is not merely about skepticism toward new technologies; it is also about protecting livelihoods, maintaining local economies, and preserving a way of life.

This dynamic is evident in debates over energy security planning, policies focused on water

quality, quantity, or land use, and traditional climate adaptation strategies. Proposals to shift away from familiar measures to address challenges in these areas may face opposition from communities where resources available to support new initiatives are limited and where jobs in traditional industries are central to local identity and economic survival.

Figure 5.2. Oklahomans are deeply divided about changing technologies and traditions. *Photo Credit: Sean Ernst.*

Similarly, tensions arise when adaptation policies impact agricultural and ranching communities, which have long-standing relationships with land and water resource managers. Restrictions on water use, incentive structures, or changes to land management regulations may be viewed as unnecessary government intervention, even when designed with long-term improvements in mind. Without meaningful input from the public and the development of solutions that address both economic realities and environmental risks, adaptation strategies can be perceived as top-down impositions rather than collaborative efforts.

Polarization and Conflicting Priorities

In addition to challenges oriented around legacy, local context, and balancing multiple perspectives, conflicting priorities across stakeholder groups pose a challenge to the development of sustainable solutions to wicked problems. While stakeholders may acknowledge the wicked problems Oklahoma faces, their interpretations of risk and subsequent priorities may diverge based on economic, institutional, and social interests. These differences can create competition for resources, policy gridlock, and challenges in achieving long-term, coordinated resilience strategies.

One such example of this kind of conflict exists between agricultural, municipal, and industrial water users. Farmers and ranchers, for example, may prioritize consistent water access for irrigation and livestock, while municipalities focus on drinking water security and urban flood mitigation. Meanwhile, industrial stakeholders, including energy producers and manufacturers, often require large water allocations for production processes. As variability in subseasonal to seasonal weather threatens water availability, disputes over allocation rights and regulations can intensify, making it difficult to develop effective policies.

Professional silos further exacerbate these divides. Local, state, and federal agencies often have overlapping yet disconnected roles in managing water resources, land use regulations, and infrastructure funding. These agencies may operate under different mandates and priorities, leading to fragmented decision-making processes that make it difficult to coordinate large-scale resilience efforts. For instance, while one agency may push for drought contingency plans, another may prioritize short-term economic growth strategies that increase water demand, leading to policy misalignment.

Resolving these conflicts requires strategic engagement, cross-sector dialogue, and collaborative planning approaches. Rather than approach solving these wicked problems as

zero-sum competitions between stakeholders, the S3OK approach identified solutions that provide shared benefits that serve multiple interests while advancing solutions to wicked problems incrementally. By creating opportunities for consensus-building, the S3OK initiative aims to bridge institutional divides and stakeholder conflicts, ensuring that resilience strategies are both scientifically grounded and socially feasible. Of equal importance is that the process builds trust among stakeholders through successfully and jointly tackling tough problems, which makes addressing the next (perhaps even more challenging) problems less daunting.

Scientific Challenges

Developing socially sustainable solutions to wicked problems in Oklahoma requires both scientific advancements and social feasibility. While technical solutions offer new pathways for resilience, scientific limitations in forecasting, data access, and interdisciplinary collaboration create obstacles to implementation. Developing socially sustainable solutions demands not only improved models and datasets but also institutional coordination and knowledge-sharing across multiple stakeholder groups to increase trust and build problem-solving capacity.

Forecasting Limitations

Effective management of water resources, land use, and infrastructure resilience is driven, in part, by weather variability and the associated impacts. This is particularly acute in Oklahoma, where the unique geography and meteorological conditions present varied and hazardous weather dynamics on a seasonal basis.

On this point, one of the greatest scientific challenges lies in the predictability gap in subseasonal-to-seasonal (S2S) forecasting. Known as the "predictability desert," this gap represents the difficulty in producing reliable weather and climate forecasts for the critical 10-to-90-day timeframe—a window that is too long for short-term weather models but too short for long-term climate projections. This limits the relevance of forecasting models in the short to medium range timeframe for stakeholders, such as agricultural workers, water systems managers, and utility operators, to anticipate and respond to droughts, extreme precipitation events, and compounding hazards.

The gap between forecasting models and actionable decision-making timelines complicates resilience efforts, particularly given the gap between timescales in forecasting and local planning. While forecasting models at the subseasonal-to-seasonal scale can indicate near-term trends in temperature, precipitation, and hydrological conditions, they often lack the spatial and temporal precision needed for specific local applications. This limits their utility for short-term operational decisions, such as enacting temporary water use restrictions or preparing utility systems for infrastructure stress. In contrast, longer-term decisions, such as large-scale water purchases or land-use regulation, typically rely on multi-year climate outlooks and broader planning frameworks. Without clearly linking forecast products to relevant decision timelines, the potential for forecasting tools to support adaptive responses remains underrealized.

Compounding these challenges is the difficulty in predicting multi-event disruptions, where extreme conditions occur simultaneously or in succession. For example, an S2S forecast may indicate an upcoming heatwave, but how that heat wave interacts with prolonged drought, wildfire risk, or energy demand spikes remains highly uncertain. The inability to forecast these complex interactions undermines efforts to develop early warning systems and proactive mitigation strategies for infrastructure, agriculture, and water resource management.

Data Availability

The effectiveness of scientific modeling and resilience planning is further constrained by gaps in data availability and accessibility. In Oklahoma, where utilities, government agencies, and private industries all manage critical infrastructure and water resources, proprietary or classified datasets often limit researchers' ability to develop comprehensive, real-time analyses and hinder

meaningful synergistic collaboration. Electric grid operations, water usage statistics, and land development records are frequently unavailable to researchers due to legal, regulatory, or competitive restrictions, making it difficult to create models that reflect real-world conditions.

Even when data are accessible, they are often fragmented and inconsistent across disciplines. Hydrologists, social scientists, climatologists, land-use planners, and engineers work with distinct datasets, methodologies, and analytical frameworks, creating barriers to interdisciplinary collaboration. For example, a watershed model developed by hydrologists may not align with the infrastructure planning models used by municipal agencies, leading to misaligned resilience strategies. Without standardized data-sharing agreements and mutual understanding, researchers, policymakers, and industry leaders struggle to create holistic, cross-sector solutions to resilience challenges.

Institutional and Disciplinary Silos

Beyond data constraints, institutional and disciplinary silos create further barriers to collaborative planning and solution development. Many efforts at solution development are sector-specific and implemented in a way that addresses challenges from a singular perspective. This results in impacted stakeholder groups operating independently of one another. This lack of integration makes it difficult to coordinate policies, share expertise, and implement cross-cutting solutions.

Disciplinary silos also impede knowledge exchange between social scientists, engineers, policymakers, and industry leaders. While technical experts develop models and infrastructure solutions, social scientists focus on risk perception, stakeholder engagement, and policy implementation. However, without direct collaboration, scientific advancements may fail to account for social realities, and policy efforts may not reflect technical feasibility. Bridging this gap requires structured mechanisms for interdisciplinary dialogue that ensure that scientific research informs, and is informed by, societal needs.

Further complicating coordination are the overlapping yet disconnected responsibilities of federal, state, tribal, and local agencies. Water management, for example, is overseen by multiple agencies with different jurisdictions, leading to conflicting regulations and fragmented decision-making. This disconnect is particularly problematic when addressing multi-jurisdictional issues like groundwater depletion, flood control, and drought preparedness, where solutions require coordinated action across political and administrative boundaries.

Identifying Domains of Agreement Despite Divides

Identifying domains of agreement despite the challenges described above requires technical innovations that promote convergence solutions to wicked problems that cut across competing social narratives. S3OK researchers are uniquely positioned to lead these efforts through interdisciplinary science that advances cohesive solutions-oriented strategy despite cultural and disciplinary divides or fields of practice.

Despite Cultural Divides

Cultural orientations that shape perspectives on resource management and policy interventions often vary widely, particularly between urban and rural communities, and across stakeholder groups. To build consensus, efforts to develop socially sustainable solutions to wicked problems must:

- Identify and prioritize shared concerns rather than emphasizing politically divisive framing.
- Focus on risk management, making it clear that identifying solutions to wicked problems is about protecting livelihoods and critical resources, not advancing a political agenda.
- Emphasize collaboratively developed solutions that respect local values and priorities, ensuring that scientific solutions reflect the

needs, knowledge, and expertise of a region rather than imposing top-down policies.

Despite Disciplinary Divides

Addressing wicked problems in Oklahoma requires breaking down traditional academic and professional silos that separate social and physical sciences and keep practitioners, the public, and academics from developing synergistic relationships. S3OK seeks to erode these silos and foster collaboration by:

- Creating interdisciplinary research frameworks that integrate the full extent of scientific and scholarly expertise in the state across a broad network of institutional partners, ensuring a holistic approach to resilience.
- Encouraging the co-production of knowledge through cross-sector collaborations, so that scientific advancements are shaped by practical experience and community needs.
- Using innovative research methods to include local stakeholders in data collection, risk assessment, and policy development, ensuring that scientific analysis reflects on-the-ground realities.

Despite Fields of Practice/ Professional Orientation

Advancing socially sustainable solutions to wicked problems requires coordination across a wide range of professional groups, including utilities, policymakers, emergency managers, engineers, researchers, and the public. However, differing priorities, terminologies, and decision-making processes often hinder effective collaboration. To address this, S3OK promoted:

- Multi-stakeholder partnerships that brought together diverse expertise to design and implement integrated, actionable solutions.
- The development and maintenance of a shared language and common goals ensured that scientific data, policy frameworks, and engineering solutions were accessible and applicable across stakeholder groups.
- Ongoing dialogue and iterative learning processes, allowing for sustainable solutions to be refined over time based on new data, shifting environmental risks, and emerging social challenges.

Domains of Agreement

Despite key differences, careful efforts to identify core domains of agreement provided a foundation for the development of socially sustainable solutions. Identified domains included:

- Infrastructure reliability, energy security, and stability must remain a priority across government, industry, and communities.
- Data-driven decision-making is essential for enhancing preparedness and minimizing risk.
- Scientific solution generation must be adaptive to accommodate evolving risk landscapes associated with changing weather patterns, water availability, and land-use challenges while respecting the regulatory landscape and public priorities.
- Cost-effective solutions must balance economic, social, and environmental priorities to ensure long-term sustainability and stakeholder buy-in.

The S3OK approach bridged divides, integrated diverse expertise, and fostered collaboration to develop socially sustainable and scalable solutions for Oklahoma's wicked problems. Despite shifting risks and increasing uncertainty, researchers and stakeholders navigated cultural, economic, and political realities while making coordinated scientific, technical, and social advancements that can facilitate decision-making and policy adoption.

By focusing on shared priorities, S3OK helped create common ground among stakeholders who may otherwise have remained mired in conflicting perspectives. Through cross-sector dialogue and collaborative knowledge production, S3OK sought to ensure that science-informed solutions are not only effective but also have the potential for broad public acceptance and implementation. By breaking down institutional silos, addressing

conflicting narratives, and prioritizing long-term sustainability, S3OK helped build a future for Oklahoma that balances economic, social, and environmental priorities while ensuring a sustainable pathway forward.