CHAPTER 1

Introduction to Oklahoma's Wicked Problems

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CHAPTER 1

Introduction to Oklahoma's Wicked Problems

Like many states across the U.S., Oklahoma is confronting a set of complex, interrelated challenges involving weather variability, water quality and availability, land use transitions, and infrastructure resilience. Over the past five years, researchers and practitioners from across the state have engaged in a collaborative effort to better understand and address these challenges. This introductory chapter defines the concept of "wicked problems," and introduces the S3OK project—an interdisciplinary initiative aimed at developing *socially sustainable solutions* for water, land use, and infrastructure systems in Oklahoma.

What is a Wicked Problem?

Complex issues that defy straightforward solutions, sometimes known as "wicked problems," are emerging with increasing frequency and intensity. According to Webber, Lack, and Steel[1], wicked problems are complex social or cultural issues that are difficult or impossible to solve due to their interconnected and multifaceted nature, lack of clear solutions, and real-world constraints. Key characteristics of wicked problems include:

1. Ambiguity: Wicked problems lack clear problem definition, have unclear aims, and therefore cannot be addressed with universally accepted solutions.

2. Interconnectedness: These problems span several policy domains and scales, impacting multiple stakeholders and involving overlapping jurisdictions, sectors, and systems.

3. Competing Values: Different stakeholders may have conflicting values and interests, and hold divergent priorities, making consensus difficult to achieve.

4. Unintended Consequences: Attempts at solving wicked problems frequently produce unforeseen or adverse consequences, requiring ongoing reevaluation and adaptation.

5. Evolving Conditions: Wicked problems evolve over time, requiring a tenacious and durable approach to advancing solutions.

6. No Final Solution: Rather than being "solved," wicked problems tend to be managed through sustained, iterative engagement.

In Oklahoma, such problems frequently emerge at the intersection of human activity, technological systems, and the natural environment. The S3OK project focused on those wicked problems that involve interactions between water resources, land systems, atmospheric conditions, and critical infrastructure.

Toward Sustainable Solutions

Initiatives designed to address wicked problems must involve multiple groups that represent a range of different interests. Because wicked problems are persistent and systemic, efforts to

address them must reflect similar tenacity and systemic thinking. Effective strategies must be:

- Long-term in orientation
- Durable across political and economic cycles
- Sustainable in environmental and social terms
- Incremental and adaptive, recognizing the necessity of partial solutions that evolve over time

Equally important is engaging a broad range of stakeholders representing the private sector, public agencies, scientific and technical communities, and civil society. This approach strengthens legitimacy and improves the likelihood that solutions will reflect both technical feasibility and community priorities across a range of actors. Success requires iterative processes, openness to revision, and a pragmatic tolerance for working through disagreement.

Given the complexity of wicked problems, sustainable solutions for Oklahomans must employ the full spectrum of our collective insight and skill sets. Successful strategies are contingent upon collaborations that leave room for substantial revision as stakeholders learn over time from science and experience. A willingness to pursue partial solutions, and a tolerance for and an ability to work around deep disagreements, is also necessary. Overall, a successful approach to addressing wicked problems must be as relentless as the wicked problems we face.

Oklahoma's Unique Context

At the start of this project, Oklahoma was uniquely situated to lead in developing responsive, scalable approaches to wicked problems. Our distinctive combination of natural resources and a longstanding ethic of resilience provided a rich opportunity to coalesce around challenges at the intersection of water, land, and critical infrastructure. The cross-cutting environmental challenges we face provide a robust foundation for applied experimentation with an interdisciplinary approach. Moreover, Oklahoma has fostered a tradition of self-reliance and ingenuity evident in the legacy of managing oil, gas, and agricultural resources through adaptive governance in resource-intensive contexts.

Importantly, Oklahoma's tradition of multi-stakeholder collaboration—across public, private, and tribal entities—offered a strong platform for assuring that a robust cross-section of stakeholder perspectives and knowledge were included in problem-solving. Local ownership and place-based solutions were critical: sustainable outcomes cannot be externally imposed. Instead, socially sustainable solutions must emerge through processes that are grounded in local contextual expertise and iterative engagement.

The S3OK initiative exemplifies how cross-sector collaboration can be mobilized to tackle wicked problems. Our approach emphasizes incremental, adaptive strategies that are flexible enough to evolve as conditions change over time. S3OK highlights the importance of sustained investment in processes that are inclusive, iterative, and informed by both science and lived experience. In the sections that follow, we describe the core challenges Oklahoma faces and present a framework for responding to them that draws on the state's unique assets and commitment to long-term, socially sustainable change.

> Oklahoma's unique blend of natural resources and culture of resilience make it an ideal environment to test and refine solutions for wicked problems.

By cultivating champions from within, fostering collaborative networks, and utilizing our expansive resource base, S3OK seeks to develop and refine responses that are locally effective and globally relevant while serving as a model to others seeking to achieve similar aims.

Socially Sustainable Solutions for Water, Land Use, and Infrastructure (S3OK)

The Socially Sustainable Solutions for Water, Land Use, and Infrastructure Resilience in Oklahoma (S3OK) project was designed to advance science-based assessments of wicked problems, coupled with systematic and iterative engagement with Oklahoma stakeholders, to develop socially sustainable solutions. S3OK's primary objective is to develop and test sustainable solutions for wicked problems at the intersection of the following challenges:

- Changing weather patterns
- Variable water quality and availability
- Land use transitions
- Critical aging infrastructure systems

This chapter focuses on two integrated components of the S3OK project and includes:

1. A summary of the 5-year collaborative research program that focused on land, water, and infrastructure resilience across Oklahoma.

2. A description of the S3OK framework, which distills the core findings and strategies developed through the project into a practical guide for future planning, policy, and implementation.

The distinguishing feature of S3OK is its emphasis on interaction and iteration. Over the course of five years, researchers and technical experts worked in close coordination with an Opinion Leader Advisory Network (OLAN) to refine priorities and approaches. Rather than advancing siloed science—developed without external inputs—the project embraced ongoing dialogue and co-production of knowledge among scientists from multiple fields, practitioners, and policymakers coupled with a regular input stream from the Oklahoma public. This approach enabled S3OK to surface solutions that reflect both the complexity of the systems involved and the values and constraints of the communities affected by them.

The S3OK approach provides a compelling basis for the identification, modeling, and quantification of solution sets that can be applied to problems facing Oklahoma, the Great Plains, and the nation. The S3OK framework builds from an understanding of how sub-seasonal-to-seasonal (S2S) weather patterns

The Opinion Leader Advisory Network *consisted of leaders from Oklahoma's public, private, and nonprofit sectors. OLAN members offered constructive feedback and direction to S3OK researchers on the direction and impact of S3OK research while helping integrate science and policy into strategic solutions for Oklahoma.*

affect Oklahoma's water quality and quantity, land use, and critical infrastructure. Researchers hypothesize that sustainable solutions cut across challenge areas and fields of practice, where policy beliefs and preferences are less polarized. Through the S3OK framework, researchers have worked to develop solutions that address these overlapping problems in ways that resonate with Oklahoma's communities and policymakers.

As a result of iterative engagement between scientists and practitioners, over the five-year project, researchers' focus evolved as data and insight were gained from interaction with project stakeholders—including the OLAN, the public, and a scientific advisory network (Figure 1.1). For example, an initial focus on carbon transitioned to a focus on land use over time. After an extensive qualitative and quantitative process of problem identification, narrative enumeration, researchers homed in on three, highly impactful and intersecting problem domains with the potential to have large-scale impacts on the state's future:

- Exploration of Hybrid Treatment and Reuse Alternatives for Wastewater and Stormwater in a Municipal Context
- Enhancing Water Availability for Agricultural and Oilfield Applications
- Natural Hazards and Utility Resilience

The S3OK Project Overview

The S3OK project was designed to foster cross-sector collaboration and expand the capacity of Oklahoma-based researchers and practitioners to tackle complex, interrelated environmental and infrastructure challenges. By breaking down disciplinary silos, the project enabled creative, systems-oriented problem-solving and generated actionable strategies to address the state's most urgent and emerging issues.

Central to S3OK was a commitment to science-informed solutions to wicked problems. Project-affiliated scientists and practitioners collaborated to advance science-informed solutions that could be piloted, assessed, and implemented across contexts. S3OK served as a test bed for developing these solutions, through which innovative ideas were put into practice, assessed, and scaled. The novelty of the S3OK project was in its approach: a social science-led, interdisciplinary collaboration that incorporated the perspectives of competing social narratives to disentangle the numerous current roadblocks that impede the development of effective, socially sustainable solutions to complex problems in Oklahoma. This approach allowed for better definition and development of a shared understanding that is critical for addressing challenges resulting from the interactions of humans with the natural and built environment in Oklahoma.

Figure 1.1. Over five years, the EPSCoR project evolved from problem identification to identifying and finalizing solutions.

S3OK prioritized initial problem domains that reflected the complexity and urgency of the challenges that faced Oklahoma and the broader Great Plains. These issues are technically complex, socially contested, and deeply intertwined. They include:

- Shifting seasonal weather patterns and extremes at the subseasonal to seasonal scale
- Increasing variability in water supply, along with rising volumes of marginal-quality water
- Changes in carbon dynamics in and on the Oklahoma landscape—both natural and managed
- Growing threats to the sustainability of the state's energy, transportation, and water infrastructure systems

Problem focus areas were selected because they addressed an intertwined set of seemingly intractable challenges that are fraught with disagreement. These problem-focus areas are not only environmental—they are also political, economic, and social. In many cases, public debate is shaped by disagreement over the severity of the problems and the viability or fairness of potential solutions. The S3OK approach acknowledges these tensions and works within them, developing strategies that are evidence-based, adaptive, and responsive to stakeholder priorities.

Integrated and Interdisciplinary Approach

The S3OK project applied an integrated social science framework grounded in iterative engagement and empirical analysis to identify how Oklahomans perceive and are willing to respond to science-based solutions for interconnected, high-stakes challenges. Using multiple modes of engagement through annual project-wide meetings and smaller scale focused meetings and working groups, we traced linkages across the project's focus areas and assessed public acceptance of policy interventions, accounting for Oklahoma's wide range of value orientations, economic interests, and cultural narratives (Figure 1.2).

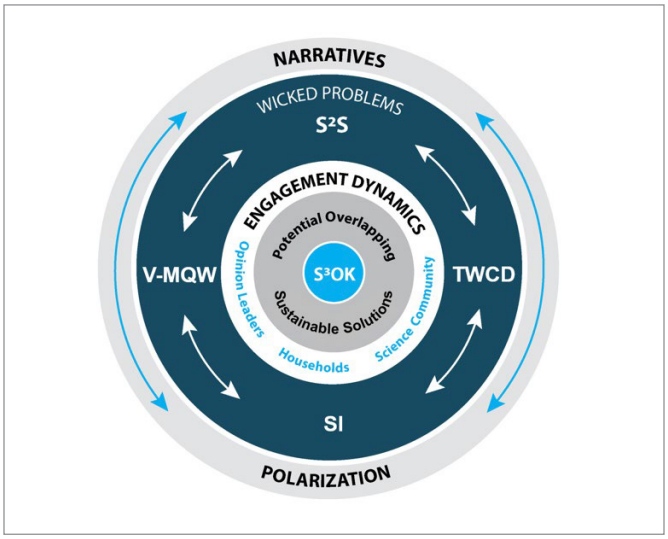
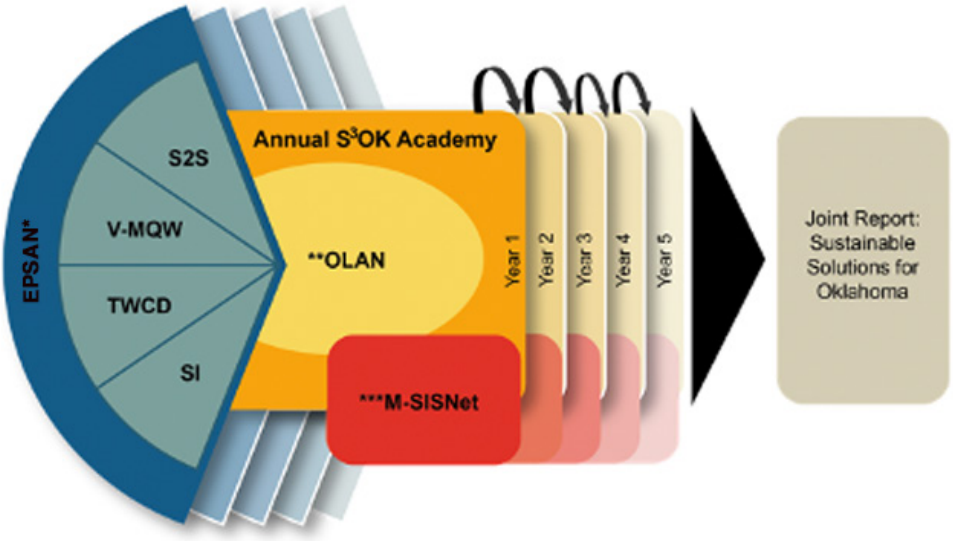


Figure 1.2. The project uses an interdisciplinary approach that applies feedback from opinion leaders and Oklahoma households to focus research on finding sustainable solutions for wicked problems. S3OK focused on wicked problems at the intersection of Subseasonal-to-Seasonal Weather Patterns (S2S), Variable and Marginal Quality Water Supplies (VMQW), Terrestrial Water and Carbon Dynamics (TWCD), and Sustainable Infrastructure (SI) using a Social Dynamics (SD) framework.

The interdisciplinary problem-focus-area science teams explored technical innovations that had a high potential to converge on solutions that cut across competing social narratives that have impeded collective decisions in the past. These innovations aimed to provide pragmatic, science-informed solutions that bridged ideological divides and historical tensions around shared infrastructure, water resources, and land management.

The annual S3OK "Academy" meetings in each of the five years of the project enabled engagement between the focus area teams, the Extended Peer Science Advisory Network (EPSAN), and the Opinion Leader Advisory Network (OLAN), employing modified approaches to civic engagement to iterate in on the most promising and acceptable approaches.

Through these multiple modes of inquiry and engagement, the S3OK project identified scientifically and socially promising shared definitions of problems and science-based solutions for wicked problems, culminating in a consensus report providing a vision and pathway for science-based solutions for wicked problems in Oklahoma (Figure 1.3).



* Extended Peer Science Advisory Network
** Opinion Leader Advisory Network
*** Meso-Scale Integrated Socio-geographic Network – a panel survey of Oklahoma households

Figure 1.3. Five annual academies provided opportunities for face-to-face interaction between all parties involved, resulting in consensus in direction and results.

Engagement

Changes over time in patterns of sub-seasonal to seasonal (S2S) weather extremes (e.g., increasing rate of shifts between pluvial events and severe drought) have affected Oklahoma's landscape-carbon cycle, water availability and quality, and the resilience of the state's water and energy infrastructure. At the same time, changes in land use, water availability, and infrastructure interact with each other in important ways that affect both scientific understanding of the problem and potential solutions. However, Oklahoma citizens are divided – as are those of the country as a whole – by opposing social narratives about these issues. Our previous research confirmed through data collected from the Meso-scale Integrated Socio-geographic Network (M-SISNet) that conflicting beliefs and value priorities impede the actions required to address the urgent and connected set of water, landscape-carbon cycle, and infrastructure resilience challenges facing Oklahoma today[2].

The divides across cultural and ideological groups concerning the causes and consequences of these problems are substantial. Wide disparities are evident between Oklahoma's conservative individualists and liberal egalitarians concerning:

- Anthropogenic causes of climate change
- Adequacy of future water supplies
- Changing frequency of wildfires
- Causes of earthquakes

Similarly, Oklahomans' views concerning potential solutions – e.g., carbon taxes, public investment in sequestration, and imposition of state regulations to manage induced seismicity – all show large divides[2].Coupling problems with specific sets of prescribed solutions – e.g., restrictive regulations designed to reduce carbon dioxide emissions or induced seismicity – appears to many Oklahomans to be linked to broader ideological beliefs or cultural worldviews that conflict with their own.

This kind of value-driven response, reinforced by competing social narratives, undermines the capacity for accommodating constructive conversations about problems and solutions across cultural divides. The result is interlocking sets of wicked problems that are difficult or impossible to solve because of:

- Incomplete or contradictory knowledge
- A need for further technological innovation
- Diverse and conflicting narratives by which stakeholders make sense of the issue
- The interconnected nature of problems across distinct science and policy domains

Despite persistent wicked problems, there remain areas of agreement, for example, willingness to invest in infrastructure to address water problems[3] or to authorize prescribed burns to manage invasive species[4]. Such issues receive substantial support in Oklahoma from both conservative individualists and liberal egalitarians. These domains of agreement that straddle cultural divides illustrate a promising avenue for redefining problems and solutions in ways that permit finding more widely acceptable solutions. This project identified areas of potential agreement that are less entangled in narratives of cultural division to enable the social definition and technical and policy development of acceptable solutions to pressing societal problems.

Framework for Addressing Wicked Problems: A Narrative Overview

Addressing wicked problems requires a structured yet adaptive approach that integrates scientific, social, and policy perspectives. This framework provides a description of the systematic process that underpinned the efforts S3OK researchers took to develop a shared understanding of the problem, collaborate on solution generation, and begin implementing strategies to ensure a holistic response (Figure 1.4).

1. Understanding the Current State of the Problem

The first step in addressing a wicked problem involves identifying its key attributes and understanding the current state of the problem. For the wicked problems S3OK sought to address, this meant analyzing:

- Characteristics that make it wicked (e.g., what are the competing priorities, narratives,

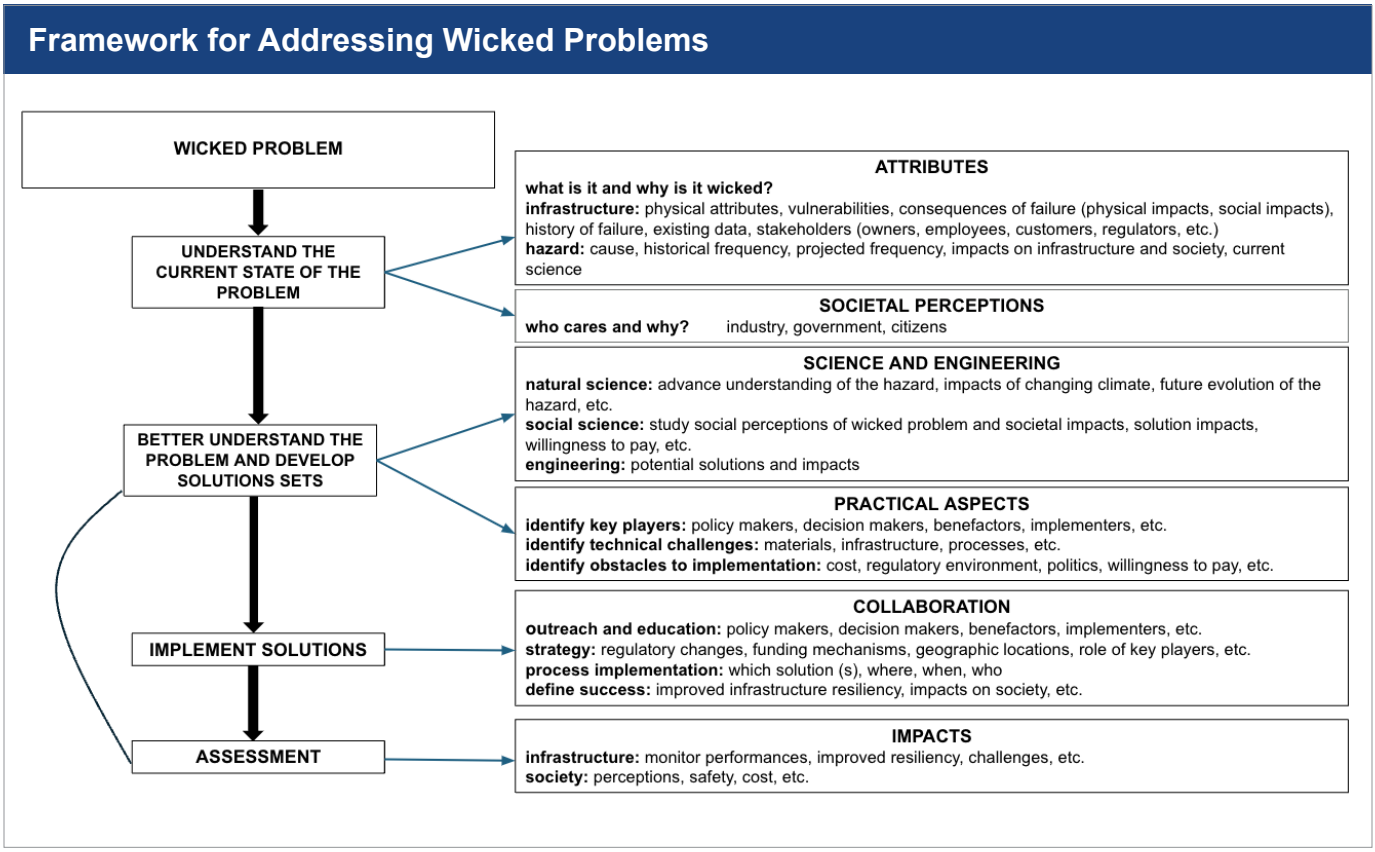


Figure 1.4. Detail of the framework used to address Oklahoma's wicked problems.

and understandings of this problem) and identifying potential points of synergy.
- Physical vulnerabilities and consequences of failure.
- Historical patterns of failure and past responses.
- Societal perspectives including industry, government, employees, customers, and regulators.
- Hazard characteristics, such as natural hazard frequency and intensity and their impacts.

At this stage, assessing societal perceptions of the issue is particularly crucial. Understanding who cares about the problem and why—from industry leaders and government officials to affected (and unaffected) citizens—helps define the urgency and scope of potential solutions.

2. Better Understanding the Problem and Developing Solutions

Once the problem is defined and its current state assessed, it is necessary to develop a deeper scientific and engineering understanding while also considering social and practical factors that influence solution viability. This involves:

- Natural Science Research – Understanding the hazard itself, such as hazard frequency, intensity, predictive abilities within appropriate timescales, and the potential future evolution of these hazards.
- Social Science Research – Studying how people perceive risk, public willingness to support solutions, and the social dimensions of resilience.
- Engineering Solutions – Exploring potential technological advancements to mitigate risks and enhance resilience.

Additionally, we must balance practical aspects and needs alongside the need to develop a deeper scientific and engineering understanding of wicked problems. This includes:

- Identifying key players (e.g., policymakers, decision-makers, infrastructure managers, and implementers).
- Recognizing technical challenges (e.g., materials, infrastructure design, and implementation logistics).
- Assessing barriers to implementation (e.g., cost, regulatory constraints, and political considerations).

3. Implementing Solutions

Effective solutions require collaboration across disciplines and sectors. This stage involves:

- Coordination and outreach – Engaging policymakers, decision-makers, and affected communities.
- Strategic planning – Understanding constraints and opportunities afforded by regulatory frameworks, securing funding, and defining roles.
- Process implementation – Determining who will implement solutions, when, and with what resources.
- Defining success – Establishing metrics to evaluate improved outcomes and how societal impacts are mitigated.

4. Assessing and Measuring Impacts

The final step of this process involves monitoring and evaluating the effectiveness of implemented solutions. This step is variable and contingent upon the unique characteristics of each wicked problem focus area. For example, in the context of Natural Hazards and Utility Resilience, this may include focusing on assessing and measuring impacts to:

- Infrastructure resilience – Measuring performance improvements, system adaptability, and identifying remaining challenges.
- Societal outcomes – Assessing public perceptions of safety, cost-effectiveness, and long-term sustainability.

By following this iterative framework, decision-makers can develop more adaptive, evidence-based responses to wicked problems. This structured yet flexible approach ensures that scientific understanding, engineering

solutions, and policy innovations are effectively integrated to build resilient, future-ready infrastructure systems.

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