

Insights for Phoenix's Shade Data Plan: Literature Review & Research

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The Shade Data Plan is Phoenix's effort to bring order and consistency to how the city collects, manages, and uses data on shade and heat mitigation. At present, data is gathered in different ways across departments, which makes it difficult to compare information, track progress, or make citywide decisions with confidence. This lack of standardization also makes it harder to evaluate the effectiveness of shade and cooling interventions, a key concern in a city facing rising heat risks. The background challenge is clear: Phoenix needs a governance system that ensures consistency and accountability while respecting the operational realities of individual departments.

The aim of this capstone project is to help design such a system by developing a governance framework for the Shade Data Plan. The specific objectives of the literature review are to identify strategies from other cities that could be adapted for Phoenix, to assess organizational frameworks that support coordination and accountability, and to examine how processes can strike a balance between consistency and flexibility. In other words, the review is not just about summarizing what's out there; it's about pulling together the most relevant lessons to build a practical, locally grounded roadmap for Phoenix.

This review is also an integral part of the methodological approach for the project. Since the capstone emphasizes applied problem-solving, the literature serves as a foundation for testing and adapting strategies in the Phoenix context. By looking across academic frameworks, international case studies, U.S. municipal strategies, and practitioner perspectives, the review builds an evidence base that highlights both what has worked elsewhere and where the gaps

remain. The goal is to ensure that the recommendations developed later in the project are not just well-intentioned but anchored in tested practices and responsive to the city's needs.

Method

For this capstone, my focus is on the Shade Data Plan and how Phoenix can develop a standardized yet flexible system for collecting and governing data across departments. Because the questions are more about systems, relationships, and practical implementation than about testing a narrow hypothesis, I'm taking a qualitative, applied approach. My main methods are process mapping, document analysis, and comparative case study. Together, these allow me to see how data currently moves through the system, what policies and procedures already exist, and how other cities have tackled similar challenges.

This approach makes sense here because it's practical and directly tied to the problem at hand. Process mapping shows where the bottlenecks and inconsistencies are. Document analysis helps establish what standards or policies are already on paper. Comparative case study lets me borrow strategies and frameworks from other cities and adapt them to Phoenix's context. It's less about producing a generalizable model and more about creating something usable for the city right now.

I did consider other methods, such as surveys of staff, quantitative analysis of data quality, or even a randomized trial of different reporting processes. Those might be valuable in the future, but they weren't the right fit for this stage. The Shade Plan needs a clear governance framework and a practical roadmap more than it needs statistical testing.

Of course, this methodology has its trade-offs. Its strength is that it's grounded, flexible, and designed to generate real solutions. It also allows for collaboration with stakeholders, which is essential for governance work. The limitation is that the findings may not be easily generalizable beyond Phoenix, and the success of the approach depends heavily on access to stakeholders and documentation. Still, given the scope of this project and the city's needs, I believe it's the right balance of rigor and practicality.

Identification, Selection, and Analysis of Literature

For this review, I focused on gathering literature that spoke directly to the challenges Phoenix faces with the Shade Data Plan: how to standardize data collection while keeping it flexible, how to hold departments accountable without creating bottlenecks, and how to prepare for emerging technologies like AI. I pulled from four main places: peer-reviewed academic journals, international case studies, U.S. city strategies, and practitioner or industry reports. The idea was to mix theory, lived municipal practice, and forward-looking technical guidance so the review wouldn't get stuck in just one perspective.

To make sense of the material, I grouped the sources into four categories: (1) conceptual frameworks, which set out what good governance should look like; (2) international case studies that show how other cities have tried to do this work; (3) U.S. municipal strategies and policies that are closer to Phoenix's context; and (4) practitioner and industry perspectives, which often highlight AI and technical implementation. Putting them into categories helped me see patterns across different contexts and made it easier to compare what's theory, what's tested in practice, and what's emerging in the field.

Altogether, I included twelve sources: three conceptual articles, four international municipal case studies, three U.S. strategies, and two industry/practitioner guides. Several other articles and reports were reviewed, but I excluded pieces that repeated the same checklist-style advice or that weren't clearly tied to municipal practice. The goal here wasn't to be exhaustive; it was to be strategic, pulling in a set of sources that, together, offer the most relevant insights for designing a governance model that can actually work in Phoenix.

Findings

RQ1: What proven strategies from other cities can inform Phoenix's standardized yet flexible data collection approach?

When I look at what other cities have done, a common thread is that no one starts with a perfect, citywide governance system. Instead, they start small, test approaches, and then build up. The city of Mainz in Germany is a good example of this. Their municipal data utility wasn't just dropped in overnight; it was developed around a few core strategies: set up a clear legal framework, make sure the technical infrastructure is standardized, and keep stakeholders engaged at every step (Lämmel et al., 2024). Those elements created a backbone for secure and consistent data sharing, while still letting different departments and municipalities participate in ways that made sense for them.

A similar lesson comes out of India's climate adaptation networks. Azhoni and colleagues (2024) show that coordination across institutions worked best when there was strong communication, resource flows, and attention to capacity building. That may sound obvious, but it reinforces a point Phoenix should keep in mind: a governance framework is only as strong as the relationships and resources that sustain it. Building in structures for regular communication

and support isn't just nice to have; it's what actually makes cross-departmental collaboration work.

Other cities also remind us that governance isn't just about creating new rules; it's about embedding those rules into the fabric of city operations. In Sweden, Kristianssen and Granberg (2021) found that adaptation moved forward in municipalities only when there was political prioritization and clear coordinating functions, like steering committees. Without that formal prioritization, efforts stayed ad hoc and uneven. For Phoenix, this is a nudge that a Shade Data governance framework will need more than technical standards; it will need political champions and a structure that departments recognize as legitimate.

On the U.S. side, Seattle's *One Seattle Data Strategy* (2023) and Green Bay's *Connect Green Bay Roadmap* (2025) both highlight how governance strategies can be paired with equity and community engagement. Seattle emphasizes governance playbooks, citywide standards, and literacy training, while also embedding equity analytics into decision-making. Green Bay frames its entire strategy around the Input to Impact process, essentially creating a feedback loop that connects resident input to service improvements. Both show how data governance can be designed not just for internal consistency but also to build public trust and responsiveness.

Taken together, these examples show Phoenix a range of strategies it can adapt: start with pilots and phased rollouts, establish legal and technical standards, prioritize strong communication and resources, create clear coordinating functions, and link data governance to broader equity and community goals. The lesson isn't that one city has it all figured out, but that the most successful strategies grow out of a balance between structure and flexibility, technical rigor and human relationships.

RQ2: Which organizational frameworks most effectively enable interdepartmental coordination and accountability?

Looking across the literature, the cities that make the most progress don't just rely on goodwill between departments; they put formal organizational frameworks in place. San José's new *Data Governance Policy* is probably the clearest example of this. It sets up a citywide Data Governance Board, chaired by the CIO, and requires each department to form its own committee with assigned roles: Owners, Stewards, and Custodians (City of San José, 2025). On paper, it might sound bureaucratic, but in practice, role clarity is what turns data governance from a vague ideal into an actual system of accountability. Everyone knows who is responsible for quality, who manages security, and who makes strategic decisions.

The Mainz municipal data utility points to a similar lesson, but through a different model. Instead of emphasizing internal roles, it created a shared platform where accountability is built into how data is accessed and shared (Lämmel et al., 2024). That technical backbone essentially forced coordination by giving departments a common space to work in, while legal agreements kept them accountable to one another. It's a reminder that organizational frameworks don't always have to be purely structural, they can be embedded in the very systems and contracts departments rely on.

Other research shows that without this kind of formalization, adaptation and governance often stall. In Sweden, progress was most visible in municipalities that created dedicated coordinating functions, like climate strategists or steering committees (Kristianssen & Granberg, 2021). Where those roles didn't exist, data and adaptation work fell through the cracks. And at the national level, the National League of Cities' *Model Data Governance Guide* makes the same

point from a practitioner's perspective: start with role definitions, inventories, and clear accountability structures, because those basics are what allow a governance system to scale (National League of Cities, 2023).

Finally, frameworks that go beyond structure to strategy seem especially powerful. Verhulst (2024) argues for data stewardship, where intermediaries or governance bodies don't just coordinate but actively manage the tensions between stakeholders. And PwC (2025) reframes governance as a strategic enabler, pushing it out of the compliance silo and into the realm of board-level responsibility. For Phoenix, both perspectives offer a reminder that coordination isn't only about avoiding mistakes; it's about building legitimacy and positioning governance as part of the city's core strategy.

The thread running through these examples is clear: coordination and accountability only become real when they're formalized, through boards, roles, committees, shared platforms, or stewardship functions. Phoenix will need to choose the right mix of structural and strategic frameworks, but the principle is the same: accountability has to be built into the system, not left to chance.

RQ3: How can processes maintain consistency while preserving necessary departmental autonomy?

This question gets at the heart of the balancing act Phoenix will face. Cities want consistency so that data can be trusted, compared, and used across departments, but they also know that if they clamp down too hard, they risk stifling innovation or ignoring the realities of how departments actually work. The literature offers a few ways to walk this line.

Cuno and colleagues (2019) point out that the most effective governance models are the ones that bake adaptability into their criteria alongside accountability and interoperability. In other words, it's not enough to design a perfect standard; you need to design a system that can evolve. That resonates with Paskaleva et al. (2017), who argue that governance in sustainable smart cities only works when it's participatory and co-created with stakeholders, including residents. By embedding flexibility and collaboration into the process itself, cities can hold onto consistency without suffocating autonomy.

Verhulst (2024) takes the same idea and frames it as a set of tensions: local needs vs. global standards, equity vs. efficiency, openness vs. privacy. His answer is data stewardship, designating people or institutions to actively mediate those tensions rather than assuming they'll resolve on their own. That's a useful lesson for Phoenix: consistency and autonomy aren't problems to solve once; they're dynamics to manage over time.

On the technical side, Databricks (2025) shows how consistency and autonomy can be balanced in system design. Its Unity Catalog supports both centralized governance (for citywide standards) and distributed governance (for domain- or department-specific control). Metadata, lineage tracking, and quality standards ensure the data itself stays consistent, while departments keep flexibility in how they manage their own domains. PwC (2025) adds a strategic layer here, arguing that governance should adapt to emerging technologies like AI by setting standards high enough to guarantee quality, while leaving space for operational autonomy in how departments meet those standards.

San José's policy (2025) shows this balance in action at the city level. By combining a central Data Governance Board with departmental committees, the city ensures that standards

and accountability are consistent, but departments still retain ownership and decision-making power over their data. For Phoenix, this model is especially relevant: consistency doesn't have to mean uniformity, and autonomy doesn't have to mean chaos.

The takeaway is that maintaining both consistency and autonomy requires more than good intentions. It requires tools (like metadata standards), roles (like stewards), and structures (like boards and committees) that explicitly hold both values at once. Phoenix can learn from these examples that flexibility and structure aren't opposites, they're two sides of the same governance coin.

Gaps and Implications

Even with a diverse set of examples, the literature leaves some important gaps. For one, most of the detailed case studies come from Europe or other international contexts, Mainz, Sweden, India, Calgary, while U.S.-based examples are limited to recent strategy documents from San José, Seattle, and Green Bay. That means there's less empirical evidence about how U.S. municipalities have actually implemented and sustained governance frameworks over time. Phoenix will need to be mindful of differences in legal structures, political cultures, and resource constraints that may make direct translation tricky.

Another gap is the integration of emerging technologies. The academic literature is strong on frameworks, coordination, and adaptation, but it doesn't yet grapple deeply with AI. That's why the industry perspectives from PwC and Databricks are valuable, they bring AI into the conversation. Still, those sources are oriented toward private-sector or enterprise systems, so applying them to a public-sector, equity-driven initiative like the Shade Data Plan will take adaptation.

Equity is another area where the literature often stops short. Many documents, Seattle’s strategy, San José’s policy, Verhulst’s stewardship model, call for equity and participation. But they don’t always show what that looks like operationally. How do you build a feedback loop that actually shifts decision-making power? How do you ensure equity principles guide day-to-day data collection, not just high-level goals? Phoenix will need to experiment with ways of embedding equity into the Shade Plan’s processes in ways that are measurable and durable.

Taken together, these gaps point toward a few key implications for Phoenix. First, don’t just adopt another city’s model wholesale, borrow selectively, test locally, and adapt to Phoenix’s unique political and organizational context. Second, design governance with the future in mind: AI and other technologies will only grow in importance, so standards need to be robust enough to support them. And third, treat equity not as a side goal but as a design principle, building structures like stewardship roles, resident feedback loops, and departmental autonomy that make equity real in practice.

The big lesson is that data governance isn’t only about managing data, it’s about managing relationships, expectations, and change. Phoenix’s Shade Plan can succeed if it uses the strategies and frameworks from other cities as inspiration, but builds a governance system that is locally grounded, forward-looking, and equity-driven.

Annotated Bibliography

Foundational & Conceptual Frameworks

- 1) **Cuno, S., Bruns, L., Tcholtchev, N., & Schieferdecker, I. (2019).** *Assessing data governance models for smart cities*. Data, 4(1), 16.

- **Annotation:** This article identifies evaluative criteria for effective urban data governance and benchmarks existing academic models against those standards. Strength lies in its structured comparison, though it is more conceptual than applied. Relevant for Phoenix's Shade Plan as it provides a checklist of what makes a governance model successful.
- 2) **Paskaleva, K., Evans, J., Martin, C., Linjordet, T., Yang, D., & Karvonen, A. (2017).** Data governance in the sustainable smart city. *Informatics*, 4(4), 41.
<https://doi.org/10.3390/informatics4040041>
- **Annotation:** This article develops a framework for sustainable smart city data governance, based on case studies in Manchester, Eindhoven, and Stavanger. It argues that governance must go beyond technical management to include stakeholder-driven processes that support sustainability. Key dimensions include co-creation with citizens, collaborative monitoring, and embedding governance across the data lifecycle. The study's strength is its integration of sustainability and governance with real-world pilots, though it is limited by its exploratory scope. For Phoenix, it highlights the importance of embedding sustainability, stakeholder engagement, and long-term data planning into governance frameworks to balance consistency with flexibility.
- 3) **Verhulst, S. (2024).** The need for climate data stewardship: Ten tensions and reflections regarding climate data governance. *Data & Policy*, 6, e52.
<https://doi.org/10.1017/dap.2024.52>
- **Annotation:** Verhulst outlines ten key tensions shaping climate data governance, such as balancing local and global needs, ensuring equity in access, and managing data quality and standards. The article advocates for "data stewardship" models, where intermediaries coordinate multi-stakeholder governance and enforce equitable practices. Its strength lies

in conceptualizing governance challenges as trade-offs, offering a framework Phoenix can use to anticipate tensions in building its Shade Plan data system. The limitation is its lack of empirical municipal case studies, but the stewardship lens directly informs the project's goal of balancing consistency with autonomy.

International & Comparative Case Studies

- 4) **Azhoni, A., Holman, I. P., Kuniyal, J. C., & Sabhapandit, S. (2024).** Climate change adaptation attributes across scales and inter-institutional networks: Insights from India. *Environmental Management*, 73(1), 1–16. <https://doi.org/10.1007/s11027-024-10156-y>
 - **Annotation:** This study examines climate change adaptation efforts across multiple governance scales in India, highlighting how inter-institutional networks influence adaptation outcomes. The authors identify key attributes—such as communication, capacity-building, and resource flows—that shape effectiveness. The study's strength lies in its network analysis approach, which shows how adaptation requires coordination across diverse institutions. Although the Indian context differs from U.S. municipalities, the findings offer valuable insights for Phoenix on how interdepartmental networks can balance autonomy with system-wide consistency.
- 5) **Kristianssen, A.-C., & Granberg, M. (2021).** Transforming local climate adaptation organization: Barriers and progress in 13 Swedish municipalities. *Climate*, 9(4), 52. <https://doi.org/10.3390/cli9040052>
 - **Annotation:** This comparative study analyzes barriers and organizational progress in 13 Swedish municipalities. Findings show that adaptation often suffers from lack of political prioritization, unclear roles, and limited resources, but that progress occurs when municipalities create dedicated coordinating functions or integrate adaptation into

comprehensive plans. The article highlights the importance of coordination, learning networks, and political support for effective local governance. While Sweden's welfare-state context differs from Phoenix, the study is useful for identifying organizational pitfalls and strategies to institutionalize adaptation work.

- 6) **P., Merbeth, J., Cleffmann, T., & Koch, L. (2024).** *Towards municipal data utilities: Experiences regarding the development of a municipal data utility for intra- and intermunicipal actors within the German city of Mainz.* Smart Cities, 7(3), 1289–1303.
<https://doi.org/10.3390/smartcities7030054>
 - **Annotation:** This case study outlines how Mainz developed a municipal data utility to facilitate secure data sharing across departments and municipalities. Key lessons include the need for robust legal frameworks, standardized technical infrastructure, and continuous stakeholder engagement. Useful for Phoenix as a real-world applied example of interdepartmental coordination

U.S. City Strategies & Policies

- 7) **City of San José. (2025).** *Data Governance Policy (CPM 1.7.13).*
<https://www.sanjoseca.gov>
 - **Annotation:** This policy establishes San José's citywide governance framework through a central Data Governance Board and departmental committees with defined roles (Owners, Stewards, Custodians). It promotes accountability, interoperability, and compliance with privacy laws while supporting data catalogs, maturity assessments, dashboards, and an enterprise data lake. The policy also links governance to equity goals and prepares for emerging technologies like AI. Its strength is its clear structure balancing consistency with departmental autonomy, though its effectiveness is still

untested. For Phoenix, it offers a model for embedding equity and accountability into governance while planning for future technological needs.

8) **City of Seattle. (2023).** *One Seattle Data Strategy*. <https://www.seattle.gov>

- **Annotation:** This three-year strategy outlines Seattle’s “One Seattle” approach to institutionalizing data governance through four pillars: quality and governance, literacy and culture, equity analysis, and community engagement. It ties directly to the city’s Race and Social Justice Initiative, using demographic standards and equity guides to identify disparities. Its strength is combining technical governance with equity-driven practices and resident engagement, though it remains largely forward-looking. For Phoenix, it shows how to integrate equity analysis and culture change alongside governance structures to ensure consistency while allowing departmental collaboration and public participation.

9) **City of Green Bay. (2025).** *Connect Green Bay: Data Strategy Roadmap*.

<https://greenbaywi.gov>

- **Annotation:** This roadmap outlines Green Bay’s plan for a transparent, data-driven government built on three pillars: governance standards and policies, community engagement through open data and feedback, and a data-driven culture supported by training and performance management. A key feature is the “Input to Impact” process, which connects resident input directly to city services. Its strength is closing the feedback loop with residents to build accountability, though it remains forward-looking without evidence of outcomes. For Phoenix, it shows how to pair resident-facing processes with governance committees and standards to balance accountability with departmental autonomy.

10) **National League of Cities. (2023).** *Model Data Governance Guide*. <https://www.nlc.org>

- **Annotation:** This guide from the National League of Cities offers a framework for building municipal data governance, including governance bodies, defined roles, citywide inventories, compliance measures, and equity considerations. It provides adaptable tools such as sample policies and checklists, making it scalable across city sizes. Its strength is in offering a practical, replicable model, though it is more of a how-to manual than an empirical study. For Phoenix, it serves as a ready-made template for creating governance roles, accountability structures, and policies that balance consistency with flexibility.

Practitioner & Industry Perspectives

11) **Databricks. (2025, June 9).** Best practices for data and AI governance. *Databricks on AWS*. <https://docs.databricks.com/aws/en/data-governance/unity-catalog/best-practices>

- **Annotation:** This guide outlines best practices for data and AI governance using the Databricks Unity Catalog, emphasizing unified management, centralized access, lineage tracking, quality standards, and audit logging. It shows how centralized and distributed models can be integrated to balance consistency with departmental autonomy, with metadata and lineage strengthening compliance and transparency. Its strength is in providing detailed, system-level practices for modernizing infrastructure, though it is platform-specific. For Phoenix, it offers concrete guidance for building secure, auditable, and flexible governance systems to support sustainable analytics.

12) **PwC. (2025, August 7).** Responsible AI and data governance. *PwC Tech Effect*.

<https://www.pwc.com/us/en/tech-effect/ai-analytics/responsible-ai-data-governance.html>

- **Annotation:** This report argues that with the rise of AI, data governance has become a strategic enabler rather than just a compliance function. It highlights priorities such as

board-level accountability, modernized data architecture, rationalized sources, and embedding AI into governance, while noting that AI can also automate quality and anomaly detection. Its strength is linking governance directly to AI readiness with actionable guidance, though it reflects an industry perspective rather than peer-reviewed research. For Phoenix, it underscores the need to adapt governance frameworks for emerging technologies while maintaining accountability and high standards.

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