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SYSTEMIC GOVERNANCE: A SYSTEMATIC REVIEW OF THE USE OF SYSTEMS THINKING IN PUBLIC POLICY GOVERNANCE STRUCTURE

Bruno Nunes Vaz
Aeronautics Institute of Technology (ITA)
brunovaz@ita.br

Margeret Elizabeth Lynne Heath
The Cybernetics Society
margeretheath@gmail.com

Lucas Novelino Abdala
Aeronautics Institute of Technology (ITA)
lucas@ita.br

Abstract

Governance increasingly faces problems whose complexity, interdependence, and pace exceed the reach of linear, control-based approaches. This paper investigates how Systems Thinking (ST) is used in public policy governance structures. Despite the growing use of ST in public policy governance, two main gaps remain in the literature. 1) The absence of a systematic mapping of how ST is operationalized in public policy governance and of the consolidation of its theoretical insights into integrated governance functions. 2) The limited integration between ST-based diagnostic insights and the prescriptive design of viable governance arrangements. To address these gaps, a systematic review of 48 documents was conducted following the PRISMA 2020 guidelines, and the documents were retrieved from Web of Science, Scopus, and Elicit. The findings are synthesized along eight analytical dimensions: wicked problems, methodologies, system pathologies, frameworks, organizational learning, policy, governance systems, and variety and viability. These dimensions are consolidated into four governance functions: reframing the challenge, designing viable structures, operationalizing tools and guides, and enabling adaptive policy learning. The corresponding research gaps are identified. Building on this synthesis, the paper introduces the concept of cybernetic state capacity, defined as the integrated institutional ability to sense environmental variety, coordinate across recursive levels, learn from feedback, and adapt over time. The paper contributes to theory by mapping how ST is used in public policy governance and by framing four research gaps that orient a future research agenda focused on the prescriptive design of viable governance arrangements. The paper contributes to practice by clarifying, for three audiences, namely 1) policymakers, 2) public sector managers, and 3) governance researchers and consultants, the methodological resources, particularly the Viable System Model, Critical Systems Heuristics, Soft Systems Methodology, and System Dynamics, available when designing governance arrangements for complex policy domains.

Keywords

Systems Thinking, Public Policy Governance, Cybernetic State Capacity, Complexity, Adaptive Governance.

1 | Introduction

The term governance lacks a single, universally accepted definition in the academic literature. Despite its widespread use over the past three decades, scholars still disagree on what it includes and on its main constitutive elements (Bressers & Kuks, 2003; Ruhanen et al., 2010). Although governance is clearly distinct from both government and management, encompassing a broader scope that involves guiding, setting rules, and managing relationships among multiple actors, its

meaning varies widely across disciplines (Ison & Schlindwein, 2015). This conceptual uncertainty has important consequences. When governance is poorly defined, it becomes difficult to identify failures, develop effective solutions, or evaluate how well public institution's function. The challenge intensifies in the *Anthropocene*, in which governance must address complex problems across ecological, social, economic, and technological domains while navigating interconnected, rapidly changing systems (Bevir, 2011; Ison et al., 2018).

Systems Thinking (ST) provides a promising response. By reframing governance not as a fixed set of institutional arrangements but as a dynamic, adaptive process of social coordination, ST introduces concepts such as variety, feedback, recursion, and viability, all directly relevant to the design of governance structures capable of managing complexity (Espejo, 2015; Katina et al., 2019). Among the methodologies applied, with varying degrees of success, to public policy governance are the Viable System Model (VSM), Soft Systems Methodology (SSM), Critical Systems Heuristics (CSH), and System Dynamics (SD). Despite increasing interest, however, the field remains fragmented. No systematic synthesis has yet mapped how ST is being used in public policy governance structures, what theoretical insights it has yielded, or what critical gaps remain.

The concept of the Anthropocene emphasizes how human activities have become the dominant force shaping the Earth's geology, producing complex and lasting environmental changes (Crutzen & Stoermer, 2000). Governing in this new epoch requires understanding the interconnected and non-linear relationships between social and biophysical systems. Yet traditional governance methods, rooted in fragmented and linear thinking, have become increasingly inadequate for addressing the uncertainties and *wicked problems* of this era. This situation underscores the need for a fundamental shift towards systemic awareness and cyber-systemic approaches that strengthen institutional empowerment, learning, and adaptability (Ison et al., 2018).

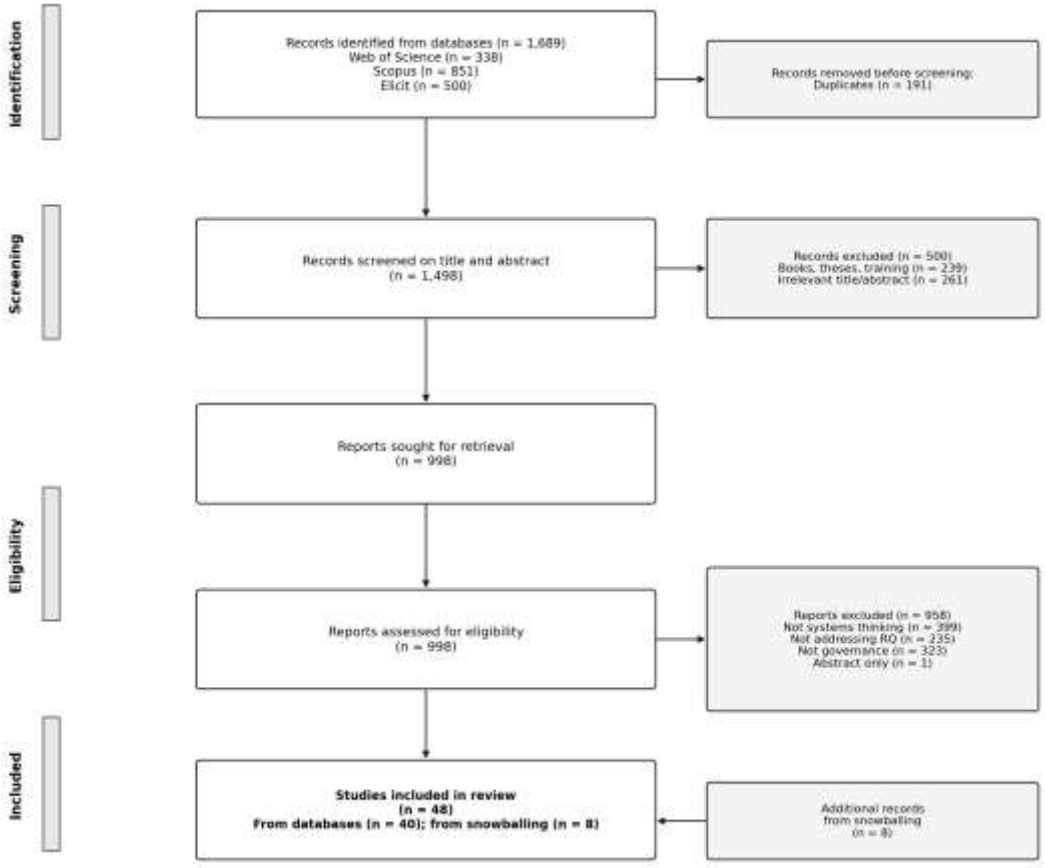
This paper systematically reviews 48 scientific documents to examine the role of Systems Thinking in public policy governance. The research question is stated as follows. RQ1: How is Systems Thinking being used in public policy governance structures? Despite the growing use of ST in public policy governance, two main gaps remain in the literature. 1) The absence of a systematic mapping of how ST is operationalized in public policy governance and the consolidation of its insights into integrated governance functions. 2) The limited integration between ST-based diagnostic insights and the prescriptive design of viable governance arrangements. The contribution of this study is threefold. First, the paper maps the main ST theories, tools, and frameworks currently applied in public policy governance. Second, the paper identifies and consolidates research gaps into four interconnected synthesis groups, organized around the governance functions of reframing the challenge, designing viable structures, operationalizing tools and guides, and enabling adaptive policy learning, thereby establishing a diagnostic agenda for future development. Third, the paper synthesizes these gaps through the concept of *cybernetic state capacity*, introducing a foundation for the prescriptive design of viable governance arrangements. The remainder of the paper is organized as follows. Section 2 describes the methodology. Section 3 presents the results through four exhibits, including the systematic findings and the consolidated research gaps. Section 4 discusses the theoretical and practical implications. Section 5 concludes by proposing a renewed research agenda.

2 | Materials and Methods

This section presents the systematic review design and the data sources used to address RQ1. The review followed the PRISMA 2020 guidelines (Page et al., 2021) and consisted of four main phases. 1) Database search across Web of Science, Scopus, and Elicit, conducted from inception up to 11 October 2025, limited to English-language papers and combining systems thinking with governance and public policy search terms: ("systems thinking" OR "system* approach*") AND ("governance structur*" OR "public policy"). 2) Title and abstract screening of 1,498 records, after

removal of 191 duplicates. 3) Full-text eligibility assessment of 998 records against four exclusion criteria: (i) not related to systems thinking or systems approaches; (ii) not addressing the research question; (iii) not discussing aspects of governance; (iv) containing only abstracts. 4) Snowball expansion via reference screening of the 40 included papers, adding 8 further studies (Streeton et al., 2004; Ting et al., 2025; Wohlin, 2014). Triangulation across the three electronic databases and the snowball sampling method enhanced the corpus's comprehensiveness. The selected papers were managed using EndNote, and a content analysis was conducted to synthesize theories, frameworks, and tools across the included documents. Exhibit 1 outlines the process of identification, screening, and selection in accordance with the PRISMA 2020 guidelines (Page et al., 2021).

Exhibit 1. PRISMA flow of identification, screening, and inclusion.



A total of 1,689 records were identified across three electronic databases: Web of Science (n = 338), Scopus (n = 851), and Elicit (n = 500). After removing 191 duplicate records, 1,498 studies were screened on titles and abstracts. Of these, 500 records were excluded because they were books, theses, dissertations, or training materials (n = 239), or because their titles and abstracts indicated irrelevance (n = 261). A total of 998 records were retrieved and assessed for eligibility. After full-text screening, 958 papers were excluded for the following reasons: not related to systems thinking or systems approaches (n = 399), not addressing the research question (n = 235), not discussing governance (n = 323), or containing only abstracts (n = 1). Forty studies met the inclusion criteria, and an additional eight records were identified through reference screening,

bringing the total to 48 papers included in the qualitative synthesis via the snowball method (Streeton et al., 2004; Ting et al., 2025; Wohlin, 2014).

3 | Results

A prior systematic review of the implementation of systems thinking in public policy was instrumental in shaping the present synthesis. It describes tools such as Causal Loop Diagrams (CLD), rich pictures, Soft Systems Methodology (SSM), System Dynamics (SD) modeling, and stock-and-flow diagrams, along with their key benefits, major barriers, and practical recommendations (Nguyen et al., 2023). It also highlights benefits such as a richer understanding of complex and *wicked* problems, the integration of diverse perspectives, the encouragement of stakeholder participation, the reshaping of mental models, and improved collective learning and decision-making under uncertainty. The findings of the present review are organized into eight dimensions, as shown in Exhibit 2: wicked problems, systems thinking, system pathologies, frameworks, organizational learning, policy successes and failures, governance systems, and variety and viability. These dimensions progress from problem framing and methodological tools to governance design and institutional learning.

Exhibit 2. Main findings on the literature answering the research question.

Exhibit 3 provides a structured overview of the main findings across the eight dimensions, summarizing how each dimension operationalizes ST within public policy governance structures and highlighting the key authors associated with each area.

Exhibit 3. Main literature findings about the use of ST in public policy governance structures.

Dimension	How ST is used in public policy governance structures	Key Authors
1. Wicked Problems	ST is used to reframe governance problems: rather than applying linear, technical solutions, it helps policymakers recognize complexity, interdependence, and the limits of control, shifting governance towards adaptive, collaborative responses.	Head & Alford (2015); Durham et al. (2018); Ison et al. (2015, 2018); Crowley et al. (2020)
2. Main Methodologies	ST is operationalized through cybernetic and systemic methodologies, VSM, CSH, SSM, Causal	Ulrich (1983); Midgley (1992); Beer (1989);

Dimension	How ST is used in public policy governance structures	Key Authors
	Mapping, and SoSM, each offering a structured way to map boundaries, analyze information flows, examine power relations, and select governance approaches according to context.	Aslipour & Zargar (2022); Cavana & Mares (2004); Ibrahim & Larsson (2017); Jackson & Keys (1984); Espejo (2015)
3. System Pathologies	ST is applied as a diagnostic lens to identify recurring governance dysfunctions, faulty feedback, disrupted flows, and hierarchical breakdowns, enabling policymakers to anticipate and prevent systemic failure rather than merely react to it.	Troncale (2013); Rasmussen (2024)
4. Frameworks	ST is structured into applied frameworks that guide governance practice by defining intervention points, levels of systemic change, stakeholder roles, and design principles for complex policymaking processes.	Burian (1989); Durham et al. (2018); Meadows (2015); Blomkamp (2022)
5. Organizational Learning	ST informs governance by underscoring that institutions must continuously revise their mental models and assumptions; simulation-based environments are proposed as tools to accelerate feedback and enable learning that real policy systems rarely provide on their own.	Espinosa (2022); Argyris (1995); Sterman (2006)
6. Policy	ST reveals why policies systematically fail, through non-linearity, emergence, and resistance, and guides governance by categorizing the conditions under which innovations succeed and by framing implementation as an emergent, self-organizing process rather than a top-down transfer.	Walker (2000); Mueller (2020); Carvalho et al. (2019); Sterman (2002, 2006); Mahroum (2013); Matland (1995); Butler & Allen (2008)
7. Governance Systems	ST reconceptualizes governance itself: rather than hierarchical command-and-control, governance is understood as a cyber-systemic process of steering social and biophysical systems through feedback, adaptive coordination, and distributed institutional arrangements.	Ison et al. (2015, 2018); Calida et al. (2016); Crowley et al. (2020); Espejo (2015); Wiener (1948)
8. Variety and Viability	ST frames variety management as a key condition for governance effectiveness, in which institutions develop requisite variety, through recursive structures, amplifiers, and attenuators, to remain viable in complex, changing environments.	Beer (1989); Espejo (2015); Espinosa (2022); Lissack (2020)

Exhibit 3 summarizes the main findings across the eight reviewed dimensions and illustrates how ST is implemented within public policy governance structures. Notably, the methodologies span various epistemological traditions, from the quantitative simulation of System Dynamics to the interpretive inquiry of SSM, the emancipatory critique of CSH, and the cybernetic structuralism of the VSM. This diversity is specifically addressed by the System of Systems Methodology (SoSM), which guides methodological choice based on problem context (Jackson & Keys, 1984). Across these dimensions, a consistent analytical pattern emerges. ST offers a conceptual shift in governance, from linear, control-focused models to adaptive, feedback-driven processes, while also providing practitioners with practical tools for diagnosis, design, and intervention. Wicked problems and system pathologies establish the problem landscape, framing governance

challenges as inherently complex and beyond the reach of purely technical or rational solutions. The main methodologies and frameworks operationalize this insight through structured instruments- VSM, CSH, SSM, Causal Mapping, SoSM- enabling practitioners to define system boundaries, analyze information flows, and select suitable interventions according to context. Governance systems, alongside concepts such as variety and viability, extend these insights to the institutional level, reconceptualizing governance as a cyber-systemic process in which requisite variety, recursive structure, and algedonic signaling are essential to institutional viability. Organizational learning, together with policy success and failure, completes this picture by highlighting cognitive and systemic barriers, defensive routines, delayed feedback, non-linearity, and policy resistance that prevent institutions from translating these insights into adaptive practice. Together, the eight dimensions demonstrate that ST does not propose a single unified theory of governance but rather a multi-layered analytical framework, the integration of which remains an open challenge.

Exhibit 4 provides a visual summary of the eight dimensions reviewed, organizing the main findings of the literature into the four governance functions that underpin this review: reframing the challenge, designing viable structures, operationalizing tools and guides, and enabling adaptive policy learning. The eight dimensions in Exhibit 3 are distributed across these four groups as follows. Wicked Problems and System Pathologies underpin Reframing the Challenge. Governance Systems and Variety and Viability inform the Design of Viable Structures. Systems Thinking and Frameworks constitute the Operationalizing Tools and Guides group. Organizational Learning, together with Policy Successes and Failures, form the Adaptive Policy Learning group. This visual overview illustrates the current distribution of ST-based knowledge across governance domains and establishes the framework for analyzing the consolidated research gaps in Exhibit 5.

Exhibit 4. Main literature findings and consolidated research gaps.

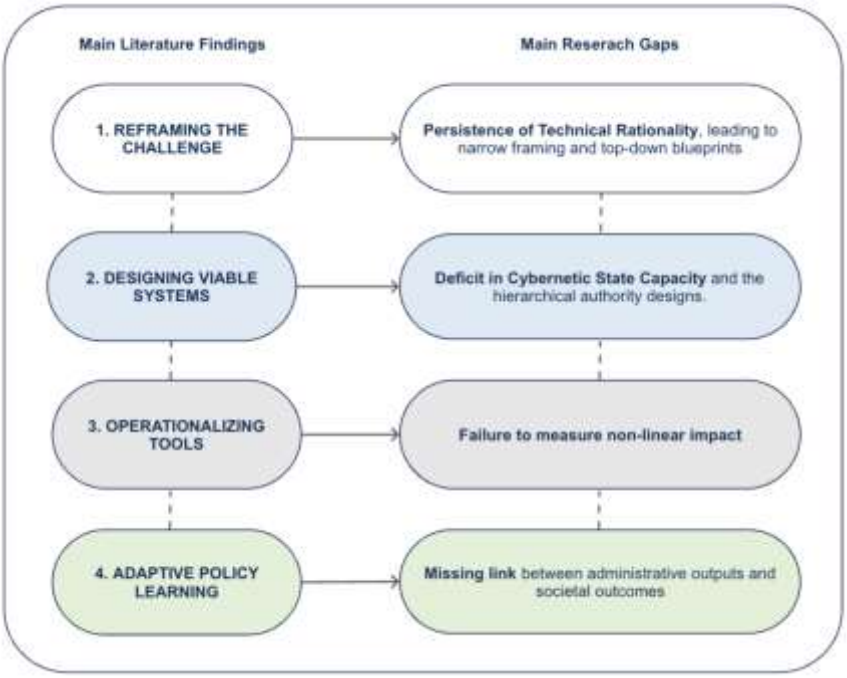


Exhibit 5 deepens this synthesis through detailed analysis. Building on the visual groupings of Exhibit 4, it maps each of the four governance functions against the main literature findings and the consolidated research gaps identified across the 48 reviewed documents.

Exhibit 5. Systemic governance synthesis: main literature findings and consolidated research gaps.

1. Reframing the Challenge	
Main Literature Findings	**Consolidated Research Gaps**
ST reframes governance to recognize complexity in wicked problems (Head & Alford, 2015; Ison et al., 2015), where linear tools fail to grasp emergent consequences (Crowley et al., 2020). Mapping system pathologies (Troncale, 2013; Rasmussen, 2024) reveals structural mismatches between traditional governance and complex policy systems (Sterman, 2002; Mueller, 2020).	Technical rationality drives institutional failure through poor situational framing and blueprinting instead of co-design (Ison et al., 2015, 2018). Furthermore, wicked-problem insights are rarely integrated into actual governance practices or institutional innovations (Ison et al., 2015).
2. Designing Viable Structures	
Main Literature Findings	**Consolidated Research Gaps**
ST reconceptualizes governance as cyber-systemic steering through feedback and distributed arrangements (Ison et al., 2018; Wiener, 1948). The VSM offers a recursive architecture to manage variety gradients (Beer, 1989; Espejo, 2015), although hierarchical fixations and simplistic conceptions of power often persist (Calida et al., 2016).	Primary gaps include the absence of cyber-systemic antidotes to command-and-control, missing Anthropocene design principles, and mismatched institutional practices (Ison et al., 2018). Secondary gaps highlight insufficient analysis of state variety management and the notable absence of a VSM-based cybernetic state capacity framework.
3. Operationalizing Tools and Guides	
Main Literature Findings	**Consolidated Research Gaps**
ST is operationalized through methodologies such as VSM, CSH, SSM, Causal Mapping, and SoSM to map boundaries and select appropriate interventions. Key practical frameworks include the Policy Process Framework (Burian, 1989), the 5 Intervention Level Framework (Durham et al., 2018; Meadows, 2015), and the Systemic Design Practice Wheel (Blomkamp, 2022). SoSM categorizes problem contexts to guide methodology selection.	A primary gap is that policy evaluation has not kept pace with systemic design; methods to analyze non-linear interactions and emergent outcomes are absent. Furthermore, no rigorous means exist to distinguish simple expenditure from real policy impact. Secondary gaps highlight the systematic underuse of soft-science tools intended to capture negotiation and dynamic interaction.
4. Adaptive Policy Learning	
Main Literature Findings	**Consolidated Research Gaps**
Learning is a conversational process that expands institutional variety through shared mental models (Espinosa, 2022), although defensive routines often impede adaptive progress (Argyris, 1995). Because real-world feedback is frequently too slow, simulation-based environments are vital for effective learning (Sterman, 2006). Five structural pathologies, including non-linearity and decentralized control, combined with recurring system archetypes, explain predictable patterns of policy failure (Mueller, 2020; Carvalho et al., 2019).	Primary gaps stem from flawed governance foundations and a weak link between policy analysis and actual decision-making (Ison et al., 2018; Walker, 2000). Institutions often confuse administrative outputs with societal outcomes while making reform commitments that exceed their actual capacity (Robichau & Lynn, 2009; Cairney et al., 2024). Implementation remains siloed, systemic innovation is rare, and there is little empirical evidence on how policymakers learn in complex settings.

The discussion explores the structural implications of this pattern and its impact on the field's future development.

4 | Discussion

This section discusses the structural implications of the four synthesis groups identified in Exhibit 5. Exhibit 5 surfaces a recurring pattern across all four synthesis groups. The diagnostic vocabulary of ST is more developed than its prescriptive translation into governance design, implementation, and evaluation. Each synthesis group documents a domain in which ST has made significant theoretical progress. Yet, in each case, the corresponding gaps indicate that this progress has been only partially integrated into institutional practice.

In the first group, Reframing the Challenge, ST highlights that governance problems are inherently complex, yet institutional practice remains dominated by the technical-rational mindset that gave rise to the very concept (Ison et al., 2015). The ongoing framing failures, persistent initial conditions, and reliance on blueprints reveal that, even where policymakers recognize complexity, governance efforts rest on incorrect assumptions. This exposes a gap between theory and practice in which understanding of *wicked problems* has not prompted the necessary restructuring.

In the second synthesis group, Designing Viable Structures, ST offers the theoretical scaffolding. Variety, recursion, and algedonic signals form the vocabulary, and the VSM provides the structural model. The lack of cyber-systemic design principles deepens a structural disconnect between declared and practiced governance. Institutions officially committed to integrated governance continue to operate in fragmented ways because their architecture lacks the requisite variety to respond to emergent conditions (Ison et al., 2018). Notably, an explicit VSM-based articulation of cybernetic state capacity, defined as the integrated institutional ability to sense, coordinate, learn, and adapt through feedback, is not yet developed in the reviewed literature. This gap emerges from the present synthesis rather than from any single source, and it is identified as a key unresolved issue in this review.

In the third group, Operationalizing Tools and Guides, ST has advanced governance design more than it has advanced equivalent methods for governance evaluation. Without systemic evaluation tools, institutions struggle to assess whether their interventions produce the adaptive, non-linear effects that ST predicts and, therefore, struggle to improve upon them. The conflation of government expenditure with actual policy impact is especially illustrative, as current frameworks are limited in their ability to determine whether institutions steer their systems towards viability. The underuse of soft-science tools further restricts evaluation to methodologies that best capture learning and adaptation.

In the fourth group, Adaptive Policy Learning, the review identifies two related weaknesses: inadequate state capacity and limited institutional capacity for learning. These are conceptually distinct but practically inseparable. Institutions that cannot learn cannot adapt, and those lacking adaptive capacity cannot develop the mechanisms required for learning, creating a self-perpetuating cycle of failure. The weak link between policy analysis and policymaking, alongside the persistent confusion between outputs and outcomes, suggests that current governance structures lack the feedback channels that connect strategic intent to operational responses (Robichau & Lynn, 2009). The limited empirical evidence on how policymakers learn in complex systems means that the field's aspiration to design adaptive governance currently lacks the micro-level detail it requires.

Taken together, these four synthesis groups and their gaps lead to a key observation. Governance in the Anthropocene would benefit from the cybernetic state capacity needed to manage variety. *Cybernetic state capacity* is here defined as the integrated institutional ability to sense environmental variety, coordinate across recursive levels, learn from feedback, and adapt without losing coherent identity. It operationalizes Ashby's Law of Requisite Variety (Ashby, 1956;

Beer, 1989) at the level of the state. A governance system can only steer what it can represent, and can only represent what its variety-management structures allow. The field has the conceptual language to describe this challenge, namely variety, requisite variety, viability, feedback, and algedonic signals. However, a fully developed institutional articulation, evaluation framework, and empirical base remain to be built. A renewed research focus may complement descriptive analysis with prescriptive design, specifying conditions for building and maintaining viable, adaptive governance structures. More specifically, the review identifies four unresolved gaps: a framing gap, a cybernetic capacity-formation gap, a non-linear evaluation gap, and an adaptive learning and translation gap. Together, these gaps suggest that future research should explain not only what viable governance structures are, but also how they are enacted and transformed over time.

5 | Conclusions

This paper investigates how Systems Thinking is being used in public policy governance structures by performing a systematic review of 48 documents following the PRISMA 2020 guidelines. The review shows that ST has produced a substantial theoretical and methodological apparatus for analyzing and redesigning public policy governance structures, while also revealing that this apparatus is unevenly integrated with mainstream governance theory. Cyber-systemic perspectives, particularly the VSM, CSH, SSM, and SD, provide the conceptual architecture necessary to characterize governance as a viable, feedback-driven, and adaptive process. Their application to public policy institutions, however, remains confined to selected domains and underdeveloped in terms of comparative and longitudinal evidence.

The paper contributes to theory in three main ways. First, the use of ST in public policy governance is mapped along eight analytical dimensions and consolidated into four governance functions, providing a comprehensive overview of how ST has been operationalized. Second, four research gaps are identified, namely a framing gap, a cybernetic capacity-formation gap, a non-linear evaluation gap, and an adaptive learning and translation gap, framing a future research agenda. Third, the paper introduces the concept of *cybernetic state capacity*, defined as the integrated institutional ability to sense environmental variety, coordinate across recursive levels, learn from feedback, and adapt without losing coherent identity. Grounded in Ashby's Law of Requisite Variety (Ashby, 1956), this concept operationalizes at the level of the state the cybernetic principle that a system can only steer what it can represent.

The paper contributes to practice in three main ways, addressing three audiences: 1) policymakers; 2) public sector managers; 3) governance researchers and consultants. First, the methodological resources available when designing governance arrangements for complex policy domains, particularly VSM, CSH, SSM, and SD, are clarified for these audiences. Second, sectors characterized by high complexity and rapidly changing actor landscapes, including New Space ecosystems, the energy transition, and digital governance infrastructures, are identified as promising contexts in which to apply and test these methodologies. Third, a transition is suggested from descriptive analysis towards the prescriptive design of effective, adaptive governance structures, with three priorities: enhancing cybernetic state capacity to handle increasing complexity and sustain organizational viability; designing governance frameworks that transition from linear models to continuous learning and co-creation; and developing systemic evaluation methods that measure impact beyond expenditure tracking.

This research has four limitations. 1) The review is limited to English-language sources retrieved from three databases (Web of Science, Scopus, Elicit) up to 11 October 2025. Relevant work in other languages or in grey literature may not be captured. 2) The review examines public policy governance broadly and does not yet test the proposed cybernetic state capacity concept in a specific empirical setting. 3) The integration of ST with process theory and other governance traditions is here a conceptual proposal that requires further empirical investigation. 4) Future

research should operationalize cybernetic state capacity through comparative methods that combine the diagnostic strength of the VSM with process-oriented sensitivity to temporal dynamics and governance change. In this respect, organizational process theory offers a promising integration with the VSM by examining how viable governance arrangements emerge, stabilize, and change in practice over time.

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