

SYSTEMS THINKING AND COMPLEXITY THEORY FOR SUSTAINABLE AND RESILIENT MANAGEMENT: AN INTEGRATIVE CONCEPTUAL FRAMEWORK

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Abstract

Sustainability and resilience have both moved to the centre of management scholarship, yet they are usually theorised apart and studied with analytical tools that assume linearity, equilibrium and clean organisational boundaries. This article develops an integrative conceptual framework that reads sustainable and resilient management through two related but distinct traditions of systemic reasoning: systems thinking and complexity theory. Following a theory synthesis design and a transparent, purposive literature protocol, we first separate the two traditions along their intellectual lineages, ontological commitments, characteristic questions and methodological repertoires, and we show where their conflation has weakened management theorising. We then reconstruct sustainability as a cross-scale system property rather than a firm attribute, and resilience as a normatively loaded capacity that must always be specified as resilience of what, to what, and for whom. On that basis we propose five systemic design principles - boundary and scale framing, feedback and delay literacy, threshold and regime sensitivity, diversity with modularity and slack, and polycentric reflexive governance - and articulate seven propositions that connect these principles to sustainable and resilient organisational outcomes. The framework makes explicit a tension that is often assumed away: the capacities that make an organisation resilient in the short run can entrench the very system structures that make it unsustainable in the long run. We close with a methodological agenda that matches systemic constructs to simulation, participatory modelling, longitudinal process and configurational designs, and with implications for managers, accountants and policymakers working in contested resource frontiers.

Keywords: systems thinking; complexity theory; corporate sustainability; organisational resilience; complex adaptive systems; cross-scale governance

1. Introduction

Management has entered a period in which the disturbances that matter most to organisations no longer originate inside them. Six of the nine planetary boundaries that describe a safe operating space for humanity are now assessed as transgressed, among them climate change, biosphere integrity, land system change and freshwater use (Richardson et al., 2023; Rockström et al., 2009; Steffen et al., 2015). Around that biophysical drift, firms have absorbed a pandemic, energy price shocks, contested mineral supply chains and a widening set of climate related physical and transition risks. Managers are therefore being asked to do two things at once: to reduce the ecological and social burden their organisations place on the

systems that host them, and to keep those organisations functioning while the same systems become less predictable. The first demand is normally filed under sustainability, the second under resilience. Both have become large and productive research programmes. Neither, on its own, tells a manager what to do when the two demands pull in opposite directions.

The difficulty is not a shortage of research but the analytical apparatus most of that research still relies on. Mainstream management inquiry remains largely variance based and reductionist: it isolates a small number of variables, assumes that relationships are stable, linear and separable, and treats the organisation as a bounded unit whose performance can be optimised against an environment held analytically at arm's length (Grewatsch et al., 2023). That apparatus has been extraordinarily useful for problems that behave in an ordered way. It fits poorly with problems whose defining features are interdependence, delay, accumulation, feedback and threshold behaviour, the class of problems long characterised as wicked because their formulation and their solution cannot be separated (Rittel & Webber, 1973). Sustainability and resilience are both problems of that second kind. When they are forced into the first frame, sustainability collapses into a set of firm level scores and disclosures that can improve while the underlying system degrades (Bansal & Song, 2017; Whiteman et al., 2013), and resilience collapses into a capacity to bounce back to a prior state whose desirability is never examined (Hillmann & Guenther, 2021; Wieland & Durach, 2021).

Two traditions of systemic reasoning have been advanced as correctives. Systems thinking, running from industrial and system dynamics through soft and critical systems methodologies, directs attention to structure: to stocks and flows, feedback loops, delays, and above all to where the analyst draws the boundary of the system under study (Checkland, 2000; Meadows, 2008; Mingers & White, 2010; Sterman, 2000). Complexity theory, developed around the idea of the complex adaptive system, directs attention to dynamics: to emergence, nonlinearity, self-organisation, path dependence and the possibility that a system reorganises around a different attractor altogether (Anderson, 1999; Levin, 1998; Preiser et al., 2018). Both have been imported into sustainability management, and the import is accelerating. A review of the field found ninety six articles published between 1990 and 2015, growing rapidly after 2011, with more than half concentrated in two transdisciplinary journals rather than in mainstream management outlets (A. Williams et al., 2017). Strategy scholars have since been urged to widen their lens towards co-evolutionary dynamics, processual explanation and tipping points (Grewatsch et al., 2023), and systems thinking has been positioned as the paradigm shift the Sustainable Development Goals require (Voulvoulis et al., 2022). Each major disruption has renewed the call, most recently in the argument that business sustainability research needs a systems perspective rather than another firm level moderator (Bansal et al., 2021).

Three problems remain unresolved, and together they define the gap this article addresses. First, systems thinking and complexity theory are routinely treated as a single perspective. They share ancestors and vocabulary, but they ask different questions, rest on different assumptions about knowability, and license different methods; collapsing them produces frameworks that borrow the language of complexity while retaining the logic of control (Boisot & McKelvey, 2010; Cilliers, 1998). Second, sustainability and resilience are theorised in parallel literatures that rarely meet. Where they do meet, the relationship is usually asserted to be positive, on evidence that sustainable practices reduce long run volatility and speed recovery from shocks (DesJardine et al., 2019; Ortiz-de-Mandojana & Bansal, 2016). That evidence is real but partial, because it says little about the cases in which an organisation's

resilience is purchased at the expense of the wider system, or in which a system's resilience is precisely what prevents an unsustainable configuration from changing (Folke et al., 2010; Walker et al., 2004). Third, and as a consequence, the field lacks a framework that specifies the mechanisms through which systemic reasoning changes managerial practice and links those mechanisms across scales, from the individual decision to the organisation, the supply network, and the social-ecological system in which all of them sit (Bansal et al., 2018; Starik & Rands, 1995).

This article therefore asks three conceptual questions. How do systems thinking and complexity theory differ, and what does each contribute that the other does not? What happens to the constructs of sustainability and resilience when they are reconstructed as properties of nested systems rather than attributes of firms? And what design principles follow for management, given that sustainability and resilience can reinforce or undermine each other depending on the level and time horizon at which they are pursued? We answer these questions through a theory synthesis conceptual article, a design whose purpose is to integrate concepts from previously disconnected literatures into a higher order framework rather than to test relationships or to inventory a field exhaustively (Cronin & George, 2023; Jaakkola, 2020). The literature was assembled through a transparent purposive protocol, described in Section 2, that combines seed works from each tradition with forward and backward tracing and a set of explicit inclusion criteria. The result is a framework of five systemic design principles and seven propositions, together with a methodological agenda that matches each construct to research designs capable of representing it.

The article makes three contributions. Theoretically, it separates two traditions that management research has fused, and it uses that separation to reframe sustainability as a cross-scale system property and resilience as a normatively specified capacity, which allows the sustainability-resilience relationship to be stated as conditional rather than assumed to be positive; the resulting propositions identify boundary framing, feedback structure, threshold proximity, buffering capacity and governance polycentricity as the mechanisms that set the sign of that relationship. Methodologically, it argues that systemic constructs have been imported into management faster than the research designs able to carry them, and it specifies a matched agenda in which feedback and delay call for simulation and participatory model building, emergence and self-organisation call for agent based and network designs, regime behaviour calls for longitudinal and configurational designs, and boundary framing calls for reflexive and participatory inquiry, with corresponding implications for how these constructs are measured. Practically, it translates the five principles into decision heuristics for managers, control and reporting designers, supply chain managers and policymakers, with particular attention to organisations operating in contested extractive and transition frontiers, where the gap between firm level performance and system level outcomes is widest.

2. Designing the conceptual inquiry

The remainder of the article proceeds as follows. Section 2 sets out the conceptual method and the literature protocol. Section 3 reconstructs the two traditions and specifies their convergence and divergence. Section 4 rethinks sustainability and resilience as systemic constructs and develops the tension between them. Section 5 presents the integrative framework and its five design principles. Section 6 states the propositions. Section 7 develops

theoretical, methodological and practical implications. Section 8 sets out boundary conditions and limitations, and Section 9 concludes.

2.1 Type of conceptual contribution

Conceptual articles are not a single genre, and the choice among them carries consequences for what counts as a good argument. Jaakkola (2020) distinguishes theory synthesis, theory adaptation, typology and model building. This article is a theory synthesis. Its purpose is to bring together two bodies of systemic reasoning and two normative constructs that have developed in separate conversations, and to produce from them an integrated account with more explanatory reach than any of the four possesses alone. Cronin and George (2023) describe the same ambition as integrative review work: the value lies in reconciling constructs, exposing hidden assumptions and generating a shared vocabulary, not in cataloguing what has been published.

This design choice imposes obligations. A theory synthesis must state the conceptual problem it solves, show that the literatures it joins are genuinely disconnected, make its selection of sources auditable, and end with claims that could in principle be wrong. It must also avoid a common failure mode in this genre, which is to present a narrative review under the vocabulary of a systematic one. We make no claim of exhaustive coverage, no claim that the corpus is representative of any defined population of studies, and no claim that our synthesis is the only defensible one. What we do claim is that the protocol below is transparent enough for a reader to reconstruct how the argument was built and to locate where a different selection would have produced a different framework.

2.2 Literature protocol

The corpus was assembled in three stages. In the seeding stage we identified anchor works in four streams: systems thinking and systems methodology; complexity theory and complex adaptive systems; social-ecological resilience; and corporate sustainability and organisational resilience. Seeds were chosen for their role in defining the vocabulary of a stream rather than for citation counts alone, and each stream was seeded independently so that the framing of one literature would not determine the entry points into another.

In the tracing stage we followed citations forward and backward from each seed, using Crossref metadata and a multi-database academic search interface covering Semantic Scholar, Scopus, PubMed and arXiv records, supplemented by publisher databases for full text. Tracing continued within a stream until new items ceased to introduce new constructs, which is a saturation criterion rather than a coverage criterion. In the screening stage each candidate was assessed against the inclusion criteria in Table 1. Every item retained was checked against its publisher record for authorship, year, outlet and pagination, and items whose bibliographic details could not be confirmed were removed regardless of their apparent relevance.

Two features of the protocol deserve comment. First, the temporal design is deliberately asymmetric. Foundational works were admitted without date restriction, because the conceptual content of this article depends on formulations from the 1950s to the 1990s that have not been superseded, while applied and empirical work was concentrated on the last decade so that the framework engages the current state of the field. Second, the protocol privileges conceptual distinctiveness over topical proximity. A paper that applies systems

vocabulary decoratively, without a feedback structure, a boundary judgement or a mechanism of emergence, contributes nothing to a synthesis of this kind, however closely its title matches our own.

Table 1

Protocol for the purposive literature review

Protocol element	Specification
Conceptual design	Theory synthesis conceptual article (Jaakkola, 2020), following integrative review logic (Cronin & George, 2023)
Streams seeded	(a) systems thinking and systems methodology; (b) complexity theory and complex adaptive systems; (c) social-ecological resilience; (d) corporate sustainability and organisational resilience
Sources	Crossref bibliographic records; a multi-database academic search interface covering Semantic Scholar, Scopus, PubMed and arXiv; publisher platforms for full text
Search terms	Combinations of systems thinking, system dynamics, soft systems, critical systems, complexity theory, complex adaptive system, emergence, resilience, social-ecological system, planetary boundaries, corporate sustainability, organisational resilience, wicked problems, grand challenges
Period	No lower limit for foundational works; applied and empirical work concentrated on 2015 to 2026
Inclusion criteria	(a) develops or applies a systemic construct with a specified mechanism; (b) addresses sustainability or resilience at organisational, network or system level; (c) peer-reviewed article or scholarly book; (d) bibliographic record verifiable at the publisher or in Crossref
Exclusion criteria	Decorative use of systems vocabulary without a mechanism; technical single-sector applications without conceptual contribution; records that could not be verified; non-English items
Stopping rule	Conceptual saturation within each stream, that is, no further items introducing new constructs
Corpus retained	59 works cited in the synthesis
Verification	Authorship, year, outlet, volume and pagination confirmed against publisher or Crossref records for every retained item
Claims not made	No exhaustiveness, no representativeness, and no equivalence to a systematic review

2.3 Analytical procedure

Synthesis proceeded through three passes over the retained corpus. The first pass coded each work for its ontological commitments: whether the system under study was treated as knowable in principle, whether structure was held to determine behaviour, whether boundaries were treated as given or as chosen, and whether change was modelled as incremental or as potentially discontinuous. The second pass coded for the mechanism the work invoked to explain outcomes, using an open list that converged on feedback, delay, accumulation, threshold, emergence, self-organisation, path dependence, requisite variety and boundary judgement. The third pass mapped mechanisms against the level at which they

operate, from cognition through organisation and network to social-ecological system, which is what produced the cross-scale structure of the framework in Section 5. Disagreements in coding were resolved by returning to the source text and, where a work could be read in more than one way, by recording both readings rather than forcing a single classification.

3. Two traditions of systemic reasoning

3.1 Systems thinking: structure, boundary and leverage

Systems thinking is best understood not as a theory but as a family of methodologies united by a claim about explanation: that the behaviour of a system arises principally from its structure, and that structure consists of stocks, flows, feedback loops and delays rather than of the attributes of its parts (Forrester, 1961; Meadows, 2008; Sterman, 2000). The practical consequence is a reversal of ordinary managerial reasoning. When an outcome disappoints, the systems thinker does not first ask who failed; the first question is what structure would generate this behaviour even if everyone performed competently. Policy resistance, in which well intentioned interventions produce the opposite of their intended effect, is the signature phenomenon of the tradition, and it is explained by feedback loops that were outside the analyst's boundary and by delays long enough to break the perceived link between action and consequence (Sterman, 2006).

Three lineages within the family matter for management. The hard or quantitative lineage, developed as industrial and then system dynamics, represents structure formally and simulates it, on the argument that human intuition performs poorly in systems with accumulation and delay (Forrester, 1961; Sterman, 2000, 2006). The soft lineage, associated above all with soft systems methodology, abandons the assumption that there is one system out there to be modelled, and treats models as devices for structuring debate among actors who hold incompatible worldviews (Checkland, 2000). The critical lineage insists that every boundary judgement is also an ethical and political judgement, because it determines whose concerns count as relevant and whose are externalised (Jackson, 2019; Midgley, 2000; Ulrich, 1983). Reviews of systems ideas in operational research confirm that all three remain live, and that their combination in mixed interventions is now common (Mingers & White, 2010).

For sustainable and resilient management the critical lineage carries particular weight, because the central analytical move in corporate sustainability is a boundary judgement. Deciding that a firm's carbon accounting stops at its own operations, or that a mining company's responsibility ends at the concession fence, is not a technical convention; it is a decision about which feedbacks will be represented and which affected parties will be silent in the model (Jackson, 2019; Ulrich, 1983). Much of what is criticised as symbolic sustainability management is better diagnosed as a boundary problem: the reporting system is internally coherent and the boundary is drawn where the damage is not.

3.2 Complexity theory: emergence, nonlinearity and adaptation

Complexity theory begins from a different question. Rather than asking what structure produces this behaviour, it asks how order arises and changes in systems composed of many interacting, adapting agents whose aggregate behaviour cannot be derived from the properties of any one of them. Its core object is the complex adaptive system, characterised by a sustained diversity of components, localised interaction, and selection processes that operate on the results of that interaction (Holland, 1995; Levin, 1998). Four features recur.

Emergence means that system level properties are not present in the parts. Nonlinearity means that the size of an effect need not be proportional to the size of its cause. Self-organisation means that coordination can arise without a coordinator. Path dependence means that history is not decorative: small early differences can lock a system onto trajectories that later become expensive to leave (Anderson, 1999; Preiser et al., 2018).

Complexity theory entered organisation science as an argument against the assumption that managers stand outside the systems they direct (Anderson, 1999). Its most developed managerial extensions treat leadership as the practice of enabling adaptive dynamics rather than specifying outcomes, distinguishing an administrative function that maintains order from an adaptive function that generates novelty, and an enabling function that manages the interface between them (Uhl-Bien et al., 2007; Uhl-Bien & Arena, 2018). A parallel line of work asks what kinds of decision the manager faces at all, arguing that ordered contexts admit good practice and analysis while unordered contexts require probing and pattern recognition, and that the most damaging error is applying the methods of one domain in the other (Kurtz & Snowden, 2003). Boisot and McKelvey (2010) supply the connective argument: an actor's capacity to cope with a stimulus depends on holding internal variety commensurate with the variety confronting it, a proposition that traces back to the law of requisite variety (Ashby, 1956).

In sustainability science the same apparatus is used to characterise social-ecological systems, understood as relationally constituted, radically open, context dependent and capable of generating genuine novelty, with methodological consequences that follow from those properties rather than from disciplinary habit (Preiser et al., 2018; Reyers et al., 2018). The most consequential import into management is the possibility of regime change: systems can shift, sometimes abruptly, to a qualitatively different configuration, and near such a shift they display characteristic statistical signatures including slowing recovery from small perturbations (Scheffer et al., 2009).

3.3 Convergence, divergence and the cost of conflation

The two traditions overlap enough to be confused and differ enough that the confusion matters. They converge on interdependence, on the inadequacy of decomposition, on the significance of feedback, and on the claim that intervention changes the system being observed. They diverge on three axes. The first is epistemic ambition. Systems thinking, in its hard lineage, holds that a useful approximation of structure can be built and simulated, and that better models yield better policy. Complexity theory holds that in genuinely complex systems some outcomes are not predictable in principle, so the aim shifts from prediction to the cultivation of conditions under which desirable order can emerge (Cilliers, 1998; Kurtz & Snowden, 2003). The second is the locus of explanation: structure and leverage points in the first tradition, interaction and adaptation among heterogeneous agents in the second. The third is the implied theory of intervention: redesign the structure, against enable, seed, probe and select.

Conflating them has three costs for management research. It licenses a rhetoric of complexity attached to methods that assume the opposite, as when a study invokes emergence and then tests a linear model on cross-sectional data. It obscures the fact that the traditions recommend different things in the same situation, so that a manager told to think systemically receives no guidance on whether to model and redesign or to experiment and select. And it hides the critical question of boundaries, which complexity theory tends to take as given and critical

systems thinking treats as the central object of reflection (Midgley, 2000; Ulrich, 1983). Table 2 sets out the comparison that the rest of the article relies on.

Table 2

Systems thinking and complexity theory compared

Dimension	Systems thinking	Complexity theory
Central question	What structure generates this behaviour?	How does order arise and change among interacting, adapting agents?
Principal lineages	Industrial and system dynamics; soft systems methodology; critical systems thinking	Complex adaptive systems; complexity leadership; complexity-informed social-ecological research
Unit of explanation	Structure: stocks, flows, feedback loops and delays	Interaction and adaptation among heterogeneous agents
Treatment of boundaries	A deliberate and contestable judgement; the central object of reflection in the critical lineage	Usually taken as given; the openness of the system is emphasised instead
Assumption about predictability	Behaviour modes are knowable from structure; a useful approximation is achievable	Some outcomes are unpredictable in principle; pattern recognition replaces forecasting
Characteristic mechanisms	Accumulation, delay, loop dominance, leverage points, policy resistance	Emergence, nonlinearity, self-organisation, path dependence, regime shift
Typical methods	Simulation modelling, causal loop and stock-flow mapping, participatory model building	Agent-based modelling, network analysis, pattern and narrative methods, early-warning diagnostics
Theory of intervention	Represent the structure and redesign it	Enable, seed, probe, amplify and select
Contribution to sustainability	Explains why well-intended interventions displace impact rather than reduce it	Explains why systems can degrade abruptly rather than gradually
Contribution to resilience	Locates the buffers, delays and loops that generate absorption	Locates thresholds, attractors and the conditions for transformation
Characteristic failure mode	Over-confidence in the model; treating boundary choices as technical conventions	Complexity as rhetoric; treating unpredictability as an excuse from analysis

The position taken here is that the traditions are complementary once their division of labour is stated. Systems thinking is strongest where structure is relatively stable and the problem is that decision makers misperceive accumulation, delay and feedback; complexity theory is strongest where the structure itself is in play, where agents adapt to each other faster than any model of them can be updated, and where the relevant question is whether the system is approaching a threshold. Sustainable and resilient management requires both, because it involves stable physical accumulations, such as greenhouse gases, tailings and depleted aquifers, and simultaneously unstable social configurations of expectation, legitimacy and contestation.

4. Sustainability and resilience as systemic constructs

4.1 Sustainability is a property of systems, not of firms

Corporate sustainability research has for three decades carried a tension between two ways of locating its object. In the dominant formulation, sustainability is an attribute of the organisation, expressed as a portfolio of practices, disclosures and ratings, and studied by relating that portfolio to financial outcomes. In the alternative formulation, sustainability is a property of the system that includes the organisation, and a firm can only be said to be sustainable relative to the state of the ecological and social systems on which it draws (Starik & Rands, 1995; Whiteman et al., 2013). The distinction is not semantic. Under the first formulation, aggregate improvement in firm level scores is evidence of progress. Under the second, it is evidence of nothing until it is related to system state, because scores can rise across a population of firms while the underlying system continues to degrade.

The planetary boundaries programme made the second formulation operational for management by supplying a set of biophysical control variables and thresholds against which corporate activity can be positioned (Rockström et al., 2009; Steffen et al., 2015). Whiteman et al. (2013) argued that corporate sustainability without such foundations is untethered, and that the boundaries framework requires firms to attend to cross-scale ecological dynamics rather than to their own footprint alone. The subsequent assessment that six of nine boundaries have been transgressed sharpens the point rather than changing it (Richardson et al., 2023). The implication for theory is that the unit of analysis for sustainability cannot be the firm by itself; it must be the firm within a specified system, at a specified scale, over a specified horizon.

Two literatures have documented what goes wrong when scale and horizon are left implicit. Bansal et al. (2018) show that organisations attend to issues at scales that match their own operations, which systematically under-weights slow and spatially diffuse processes even when those processes dominate the outcome. Slawinski and Bansal (2015) show that firms facing the same climate problem construct different temporal horizons, and that short horizons produce responses that look rational period by period and irrational when accumulated. These are not failures of will but of representation: the accounting and control systems in use do not carry stocks, delays or cross-scale feedbacks, so those features cannot enter deliberation. Systems thinking names this directly as a boundary and structure problem (Meadows, 2008; Sterman, 2006), and paradox scholarship names the resulting managerial situation as one of persistent, non-resolvable tension rather than of trade-offs to be optimised away (Hahn et al., 2018).

4.2 Resilience: of what, to what, for whom

Resilience entered management from ecology, where Holling (1973) distinguished it from stability: stability is the speed of return to an equilibrium, resilience is the magnitude of disturbance a system can absorb while retaining its relationships and functions. Social-ecological research subsequently decomposed the construct into three capacities: resilience as persistence, adaptability as the capacity of actors to influence the system's trajectory within its current configuration, and transformability as the capacity to create a fundamentally different configuration when the existing one becomes untenable (Folke et al., 2010; Walker et al., 2004). Management research imported the first of these most enthusiastically and the third barely at all. It does possess an established vocabulary for adaptive capacity in the dynamic

capabilities tradition, organised around sensing, seizing and reconfiguring (Teece, 2007), but that vocabulary is firm-centred: it describes the capacity to adjust to an environment without describing the state of the system being adjusted to, which is precisely the information sustainability judgements require.

The result is a construct that reviews have repeatedly found to be overextended. Linnenluecke (2017) traces distinct and largely non-communicating streams, from supply chain resilience to organisational reliability to resilience of individuals, each with its own referents. Hillmann and Guenther (2021) go further, questioning whether organisational resilience is yet a construct in the technical sense, given the instability of its definitions, dimensions and measures. T. A. Williams et al. (2017) diagnose the same fragmentation across crisis management and resilience research and argue for fusing them around process. In supply chain research, the fault line is now explicit: an engineering perspective treats resilience as recovery of performance to a target state, while a social-ecological perspective treats it as the capacity of an interdependent network to persist, adapt or transform, and the two lead to different design recommendations (Wieland, 2021; Wieland & Durach, 2021). Related work on viability extends the frame from surviving a disruption to remaining functional as an intertwined network over the long run (Ivanov & Dolgui, 2020).

The systemic reading forces three specifications that firm level treatments usually leave open. Resilience of what: which system and which functions are to be maintained, the firm's earnings, the network's service capability, or the watershed's regulating services. Resilience to what: which class of disturbance, since capacities that buffer high frequency, low amplitude variation differ from those that matter at a regime boundary. And resilience for whom: since maintaining a configuration protects those who benefit from it, resilience is never normatively neutral, a point sustainability scholarship has pressed with increasing force (Ergene et al., 2021; Reyers et al., 2018). A tailings management regime, an extractive concession or a labour arrangement can be highly resilient and precisely for that reason unsustainable.

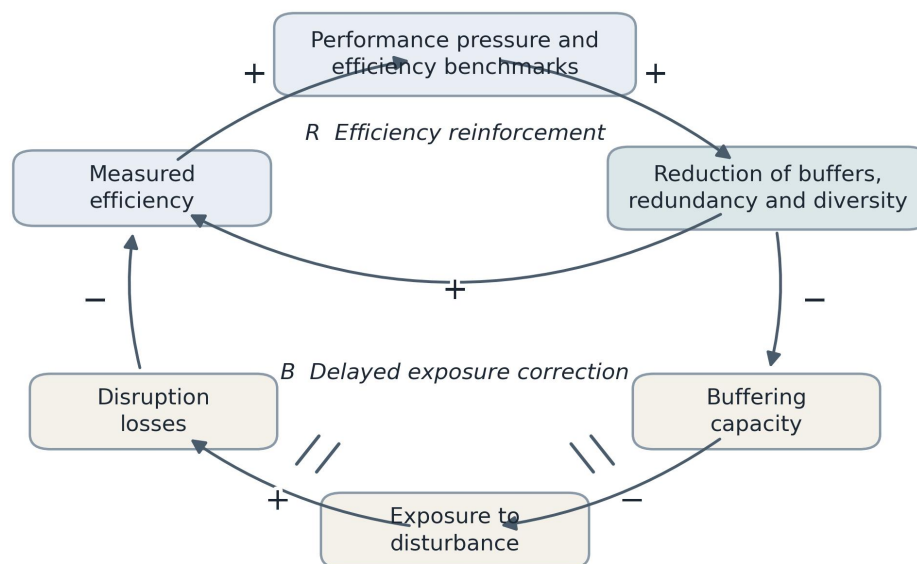
4.3 The conditional relationship between sustainability and resilience

Empirical management research has generally found a positive association between the two. Ortiz-de-Mandojana and Bansal (2016) show, in a matched-pair design over fifteen years, that firms adopting sustainable business practices exhibit lower financial volatility, higher sales growth and better long term survival. DesJardine et al. (2019) find that firms with stronger social and environmental practices suffered less severe losses and recovered faster around the 2008 financial crisis. These findings are important and we do not dispute them. They are, however, findings about the firm level, in a period without a regime shift in the underlying system, using outcome measures defined by the firm's own continuity.

A systemic reading identifies at least three conditions under which the relationship reverses. The first is the level mismatch. Capacities that make an organisation resilient can be externalised costs elsewhere: inventory buffers, redundant suppliers, insurance and relocation transfer exposure rather than reducing it, so system level exposure is unchanged while firm level exposure falls. The second is the horizon mismatch. Optimising for rapid recovery to a prior operating state protects a configuration whose long run viability is precisely what is in question, and near a threshold it consumes the slack that transformation would require (Folke et al., 2010; Scheffer et al., 2009). The third is the efficiency trap. Systems that are optimised for performance under expected conditions tend to shed the diversity, modularity and slack that generate resilience under unexpected ones, and because that shedding raises measured

performance in the short run it is rewarded by the same control systems that will later record the failure (Biggs et al., 2012; Wieland & Durach, 2021).

This is the tension the framework in Section 5 is designed to make analysable rather than to assume away. Figure 1 renders it as a feedback structure. A reinforcing loop runs from performance pressure to the removal of buffers to improved measured efficiency and back to intensified pressure; a balancing loop runs from buffer depletion through rising exposure to eventual disruption; and the delay between the two is what allows the reinforcing loop to dominate for long enough to make the eventual disruption severe. Read this way, the frequently observed pairing of high efficiency with brittle failure is not a management pathology in need of exhortation but a predictable consequence of a structure in which the costs of lost buffering are separated in time and space from the benefits of removing them.

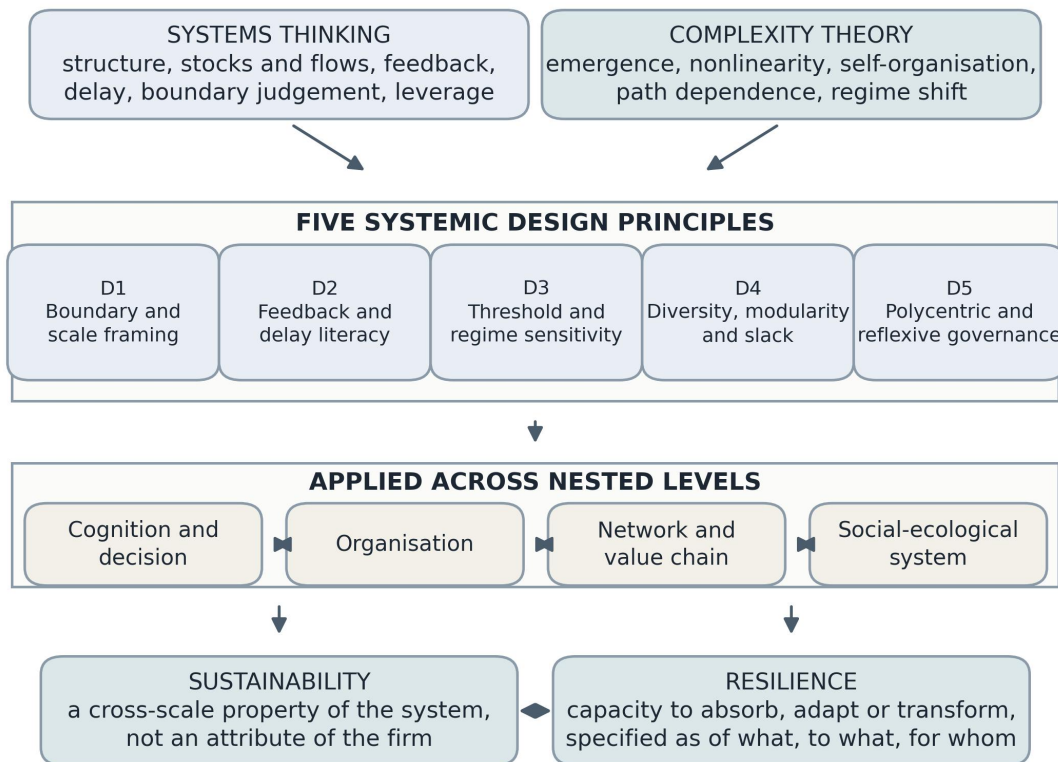


Note. + denotes a same-direction link and – an opposite-direction link; // marks a material delay. R is a reinforcing loop and B a balancing loop. The delays in the balancing loop are what allow the reinforcing loop to dominate long enough for the eventual disruption to be severe.

Figure 1. *The efficiency and buffering feedback structure underlying the sustainability-resilience tension*

5. An integrative framework: five systemic design principles

The framework integrates the two traditions by assigning each a distinct role and by organising their contributions across four nested levels: cognition and decision, organisation, network and value chain, and social-ecological system. Systems thinking supplies the account of structure and of boundary judgement; complexity theory supplies the account of adaptation, emergence and regime behaviour. Sustainability is positioned as the cross-scale property to be achieved and resilience as the set of capacities that determine whether the system can hold or move to a configuration in which that property obtains. Figure 2 presents the framework. Five design principles connect the levels; each is stated below with the mechanism it works through and the managerial practice it implies, and Table 3 summarises the mapping.



Conditional relationship: sign set by the mechanism of capacity creation versus exposure transfer, by level and horizon, and by proximity to a threshold

Figure 2. *An integrative framework for sustainable and resilient management*

5.1 Boundary and scale framing

The first principle is that every sustainability or resilience judgement begins with a boundary decision, and that the decision should be made deliberately, documented and revisited rather than inherited from accounting convention. Critical systems thinking treats boundary judgements as simultaneously empirical and ethical, since they determine which feedbacks are represented and which stakeholders are treated as external (Jackson, 2019; Midgley, 2000; Ulrich, 1983). The managerial practice implied is explicit boundary specification in any assessment, sustainability report, risk register or investment appraisal: a statement of what is inside, what is outside, at what spatial and temporal scale, and what is known to be excluded. The associated mechanism is representational: what is outside the boundary cannot generate a signal, so exclusion produces confident decisions built on structurally incomplete models (Bansal et al., 2018; Sterman, 2006).

5.2 Feedback and delay literacy

The second principle is that managers and control systems should be able to identify the feedback loops and delays that govern the outcomes they are accountable for. Misperception of accumulation and delay is a robust and well documented source of dynamic decision error, and it is not corrected by domain expertise or by more data alone (Sterman, 2000, 2006). The practice implied is the routine construction of causal loop or stock and flow representations

before intervention, including in management control and performance measurement design, so that the question of what this indicator will do to the loop it sits in is asked before the indicator is adopted. The mechanism is anticipatory: representing a delay is what makes it possible to attribute a present outcome to a past decision, and thus what makes learning from experience possible in systems where the feedback is slow.

5.3 Threshold and regime sensitivity

The third principle is that management should treat the possibility of nonlinear, regime-changing behaviour as a standing assumption rather than a tail case. Ecological and social-ecological systems exhibit thresholds beyond which reorganisation occurs and return is slow or impossible, and the approach to such thresholds leaves detectable statistical traces, including rising autocorrelation and variance and slowing recovery from small perturbations (Scheffer et al., 2009; Steffen et al., 2015). The practice implied is the identification of the slow variables that condition a system's stability, the specification of indicators that track proximity to a threshold rather than only current performance, and the design of decision rules that trigger on trajectory rather than on level. The mechanism is the substitution of anticipatory action, taken while options remain, for reactive action taken after reorganisation has begun.

5.4 Diversity, modularity and slack

The fourth principle is that resilience is generated by structural properties that reduce short run measured efficiency: a diversity of options and response types, modularity that limits the propagation of failure, and slack in the form of buffers, redundancy and uncommitted resources. Principles for enhancing resilience in social-ecological systems foreground exactly these properties alongside the management of connectivity and slow variables (Biggs et al., 2012), and the requisite variety argument supplies their formal basis: only variety can absorb variety (Ashby, 1956; Boisot & McKelvey, 2010). The practice implied is to treat diversity, modularity and slack as capital assets with an explicit rationale and an explicit cost, rather than as inefficiency awaiting elimination, and to constrain the connectivity of critical subsystems deliberately. The mechanism is absorptive: these properties convert what would be a systemic failure into a local one.

5.5 Polycentric and reflexive governance

The fifth principle is that the governance of systemic problems should be distributed across multiple centres of decision at multiple scales, with overlapping authority and mechanisms for mutual adjustment, and should be reflexive about its own framing. Polycentric arrangements have been shown to sustain the management of shared resources where single-centre arrangements fail, because they combine local knowledge with cross-scale coordination and allow experimentation without system-wide exposure (Ostrom, 2009, 2010). Governance theory reaches the same conclusion by asking how governance systems balance exploration against exploitation under complexity (Duit & Galaz, 2008), and organisational research converges through the argument that leadership in adaptive systems consists of enabling interactions rather than issuing specifications (Uhl-Bien et al., 2007; Uhl-Bien & Arena, 2018). For grand challenges, robust action approaches supply the operational form: participatory architectures, framings that many actors can endorse for different reasons, and distributed experimentation that keeps options open (Dentoni et al., 2018; Ferraro et al., 2015; George et al., 2016). The mechanism is variety generation combined with cross-scale learning.

Table 3

The five systemic design principles: mechanisms, levels, practices and sources

Principle	Core mechanism	Principal levels	Managerial practice	Indicative literature
D1. Boundary and scale framing	Representation: what lies outside the boundary cannot generate a signal	Cognition; organisation	State the system boundary, scale and horizon in every assessment, report and appraisal; record known exclusions and revisit them	Bansal et al. (2018); Jackson (2019); Midgley (2000); Ulrich (1983)
D2. Feedback and delay literacy	Anticipation: representing delay makes present outcomes attributable to past decisions	Cognition; organisation	Build causal loop or stock and flow representations before intervening; test each indicator for the loop it will create	Forrester (1961); Meadows (2008); Sterman (2000, 2006)
D3. Threshold and regime sensitivity	Early action: acting while options remain rather than after reorganisation	Network; social-ecological system	Identify the slow variables; track threshold proximity rather than current performance alone; trigger decisions on trajectory	Folke et al. (2010); Scheffer et al. (2009); Steffen et al. (2015)
D4. Diversity, modularity and slack	Absorption: variety and loose coupling convert systemic failure into local failure	Organisation; network	Treat diversity, redundancy and slack as assets with a stated rationale and cost; limit the connectivity of critical subsystems deliberately	Ashby (1956); Biggs et al. (2012); Boisot & McKelvey (2010); Wieland & Durach (2021)
D5. Polycentric and reflexive governance	Variety generation combined with cross-scale learning	Network; social-ecological system	Distribute decision authority with overlapping mandates; build local decision capacity; run bounded experiments; revisit the framing	Duit & Galaz (2008); Ferraro et al. (2015); Ostrom (2009, 2010); Uhl-Bien & Arena (2018)

6. Propositions

The framework yields seven propositions. They are stated so that each identifies a mechanism, a level and a condition under which it should fail, which is what makes them candidates for empirical work rather than restatements of the framework. Table 4 pairs each with the constructs it invokes and the research designs capable of testing it.

Proposition 1. The wider the system boundary an organisation adopts in representing its sustainability performance, along spatial, temporal and stakeholder dimensions, the smaller the divergence between its firm level sustainability assessments and the state of the systems its activities affect.

Proposition 2. Organisations whose management control and performance measurement systems explicitly represent stocks, delays and feedback loops experience fewer policy-resistant outcomes, understood as sustainability interventions that displace impact across time, space or stakeholder groups rather than reducing it.

Proposition 3. The predictive value of firm level resilience capacities for organisational continuity declines as the host social-ecological system approaches a regime threshold, at

which point transformative capacity, rather than absorptive or adaptive capacity, becomes the binding constraint.

Proposition 4. Diversity, modularity and slack relate to organisational performance conditionally: negatively to measured efficiency under stable conditions and positively to functional continuity under high amplitude disturbance. The sign of the observed sustainability-resilience association therefore depends on the disturbance regime prevailing in the observation window.

Proposition 5. Polycentric governance arrangements, with overlapping authority and mechanisms for cross-scale learning, sustain shared resource systems more effectively than single-centre arrangements under high uncertainty, and their relative advantage increases with the heterogeneity of local conditions.

Proposition 6. Organisational resilience is positively associated with system sustainability when it is built through capacity-creating mechanisms, such as diversity, modularity, slack and learning, and is null or negatively associated when it is built through exposure-transferring mechanisms, such as insurance, relocation, supplier substitution and the externalisation of risk.

Proposition 7. Sustained mismatch between the scale and horizon of an organisation's decision rules and the scale and horizon of the processes generating its impacts erodes the buffering capacity of the host system cumulatively, even when each individual decision is locally optimal.

Table 4

Propositions, focal constructs and research designs capable of testing them

Proposition	Focal constructs	Level of analysis	Suggested research design
P1	Boundary breadth; divergence between firm level assessment and system state	Organisation and social-ecological system	Comparative case analysis paired with independent system-state indicators; content analysis of boundary disclosure
P2	Representation of stocks, delays and feedback in control systems; policy resistance	Organisation	Longitudinal case studies of control system change; system dynamics simulation of the control structure
P3	Threshold proximity; absorptive, adaptive and transformative capacity; organisational continuity	Organisation within a social-ecological system	Panel designs with regime-shift diagnostics; historical case analysis of firms in systems that crossed a threshold
P4	Diversity, modularity and slack; measured efficiency; functional continuity; disturbance regime	Organisation and network	Panel analysis with disturbance-regime moderators; set-theoretic configurational analysis; simulation experiments
P5	Polycentricity; heterogeneity of local conditions; resource system outcomes	Network and social-ecological system	Comparative institutional analysis; multi-case designs across governance arrangements; agent-based modelling
P6	Mechanism of resilience production (capacity	Organisation and network	Mechanism-coded longitudinal data; configurational analysis; matched-pair

Proposition	Focal constructs	Level of analysis	Suggested research design
	creation versus exposure transfer); system sustainability outcomes		designs that separate the two mechanisms
P7	Scale and horizon mismatch; cumulative erosion of buffering capacity	Cross-level	System dynamics simulation; long-horizon panel data with cumulative measures; participatory model building

Propositions 1, 2 and 7 concern representation and are the most directly actionable, since they can be addressed through the design of accounting, control and disclosure systems. Propositions 3 and 4 concern conditions and are the most consequential for empirical work, because they imply that studies of the sustainability-resilience relationship are not comparable unless the disturbance regime and threshold proximity of the observation window are specified. Propositions 5 and 6 concern mechanisms and carry the framework's central normative claim, which is that how a capacity is produced determines whether it contributes to or detracts from sustainability at the system level.

7. Implications

7.1 Theoretical implications

The first theoretical implication is that the systemic toolkit should be disaggregated before it is applied. Treating systems thinking and complexity theory as interchangeable has allowed management research to adopt the vocabulary of complexity while retaining the assumptions of variance-based inquiry. Separating them, as in Table 2, makes it possible to ask a prior question in any study: is the problem one of misperceived structure, in which case modelling and redesign are appropriate, or one of adaptive dynamics under irreducible uncertainty, in which case probing, seeding and selection are appropriate. The distinction also clarifies why the same advice can be given by both traditions for opposite reasons, as with decentralisation, which the first tradition may recommend to shorten feedback delays and the second to increase variety.

The second implication concerns dependent variables. If sustainability is a cross-scale property rather than a firm attribute, then studies that regress financial outcomes on sustainability scores are measuring the diffusion of a management practice rather than the sustainability of anything (Bansal & Song, 2017; Whiteman et al., 2013). This does not make such studies worthless, but it does mean their findings cannot be aggregated into claims about system level progress. The framework suggests a class of dependent variables that management research has largely left to other disciplines: the state of specific social-ecological variables in the systems an organisation operates within, measured at scales that match the processes involved.

The third implication concerns resilience theory. By insisting on the three specifications of what, to what and for whom, and by distinguishing capacity-creating from exposure-transferring mechanisms, the framework offers a route out of the construct proliferation that recent reviews have documented (Hillmann & Guenther, 2021; Linnenluecke, 2017). It also connects organisational resilience to the transformability component that management

research has under-theorised, which matters because transformation, not persistence, is what the situation described by the planetary boundaries literature requires (Folke et al., 2010; Richardson et al., 2023). The sustainability transitions literature has developed a detailed account of how such reconfiguration proceeds across niche, regime and landscape levels (Geels, 2011; Loorbach et al., 2017), and connecting organisational transformability to that account is an obvious and largely unexploited opening.

The fourth implication is that the sustainability-resilience relationship should be theorised as conditional. This positions the framework alongside paradox scholarship, which treats tensions in corporate sustainability as persistent rather than resolvable (Hahn et al., 2018), and alongside critical work that questions whether incremental corporate approaches can address the problems they name (Ergene et al., 2021). It also speaks to grand challenge research, where robust action approaches already assume distributed experimentation under irreducible uncertainty (Ferraro et al., 2015; George et al., 2016), and to supply chain scholarship, where the engineering and social-ecological perspectives are now explicitly in tension (Ivanov & Dolgui, 2020; Wieland, 2021; Wieland & Durach, 2021).

7.2 Methodological implications

The framework's methodological claim is that systemic constructs have entered management faster than the designs capable of representing them, and that the resulting mismatch is a substantial source of weak inference. Four correspondences follow.

Feedback, delay and accumulation require designs that can represent state over time. System dynamics simulation is the mature instrument here, and its value lies less in forecasting than in exposing the structural sources of counterintuitive behaviour and in testing policies against structures rather than against point estimates (Forrester, 1961; Sterman, 2000, 2006). Participatory or group model building extends this into contested settings, where the model's function is to surface incompatible worldviews and make boundary judgements explicit rather than to settle them (Checkland, 2000; Midgley, 2000).

Emergence, self-organisation and heterogeneous adaptation require designs in which macro patterns are generated rather than assumed. Agent based modelling is the direct instrument, and network analysis provides the observational counterpart, particularly for connectivity and modularity, which the framework treats as manipulable properties rather than descriptive features (Biggs et al., 2012; Preiser et al., 2018).

Thresholds and regime behaviour require long observation windows and analytical strategies suited to discontinuity. Longitudinal panel designs combined with regime-shift and early-warning diagnostics, such as tests for rising variance, rising autocorrelation and critical slowing down, are appropriate where sufficient time series exist (Scheffer et al., 2009). Where they do not, historical and process case designs remain the strongest available route to identifying the sequence by which a configuration locked in, provided the analysis is genuinely processual rather than a narrative wrapped around a variance model (Grewatsch et al., 2023).

Configurational relationships require configurational methods. Propositions 4 and 6 assert that the same capacity produces opposite outcomes in different combinations and contexts, which is a claim about sufficiency and equifinality rather than about average effects, and set-theoretic methods are designed for exactly that structure. Mixed method designs that integrate a quantitative strand on system state with a qualitative strand on boundary framing and

contestation are especially suited to Propositions 1 and 7, provided integration occurs at the design stage and is displayed rather than asserted.

Two measurement implications follow. First, sustainability measures should be system-referenced wherever possible, that is, expressed relative to a specified ecological or social threshold rather than to a prior period or a peer group. Second, resilience measurement should distinguish the mechanism by which a capacity was produced, since Proposition 6 makes that distinction decisive; a resilience index that scores insurance coverage and supplier diversity identically will confound the two. Finally, boundary specification should be treated as reportable methodological information: studies of corporate sustainability should state the system boundary, scale and horizon they adopt as routinely as they state their sample and estimator.

7.3 Practical implications

For general managers, the framework converts into a small set of questions that can be asked before any significant sustainability or resilience decision. Where have we drawn the boundary, and who is outside it. What loops and delays connect this decision to the outcome we are accountable for. Which slow variables condition our operating environment, and how close are they to a threshold. What diversity, modularity and slack are we removing, and what were they buying. And is the capacity we are building creating something or moving exposure to someone else. These questions are not a substitute for analysis, but they change what analysis is commissioned.

For accounting, control and reporting, the implications are more specific. Boundary disclosure should be explicit and revisited, since the boundary determines what the reporting system can see. Indicators should include at least some that track trajectory and threshold proximity rather than level and period-on-period change, because a system can be well within tolerance on every current indicator while moving quickly towards a limit. Performance measurement should be examined for the loops it creates: an efficiency indicator that rewards the removal of buffers is not a neutral instrument but an active participant in the structure described in Figure 1. And where an organisation's material impacts occur at scales its accounting does not reach, that gap should be stated rather than resolved by narrowing the definition of materiality.

For supply chain and operations management, the framework supports designing for modularity and functional redundancy rather than for recovery speed alone, and it suggests that resilience investments be classified by mechanism, so that capacity creation and exposure transfer are not aggregated into a single score (Ivanov & Dolgui, 2020; Wieland & Durach, 2021).

For policymakers and regulators, the polycentricity principle argues against concentrating authority for systemic problems in a single agency or a single instrument, and in favour of overlapping arrangements with explicit cross-scale learning mechanisms (Duit & Galaz, 2008; Ostrom, 2010). It also argues for building the capacity of local decision centres, since polycentric arrangements depend on local units that can actually decide.

These implications are sharpest in contexts where a single industrial activity dominates a regional social-ecological system and where the gap between firm level performance and system level outcomes is widest (Elliyana, 2025). Extractive and energy transition frontiers are the clearest case: an operation can improve on every reported indicator while the watershed, the fishery or the local economy it is embedded in moves closer to a threshold, and

the reporting boundary is precisely what prevents that movement from registering. In such settings the framework's first and third principles carry most of the practical weight, since they determine whether the relevant dynamics are visible at all.

8. Boundary conditions and limitations

Four boundary conditions delimit the framework's claims. First, it is developed for problems characterised by dynamic complexity: interdependence, delay, accumulation and the possibility of nonlinear change. Where a problem is genuinely ordered, the systemic apparatus adds cost without adding insight, and applying it is the mirror image of the error this article criticises (Kurtz & Snowden, 2003). Second, the framework assumes that an organisation has some capacity to alter its own decision structures; where autonomy is severely constrained, by tight regulatory prescription or by dependence on a single powerful buyer, the principles describe what should be done more accurately than what can be. Third, its treatment of thresholds assumes the existence of identifiable slow variables and some observational access to them, an assumption that holds unevenly across contexts. Fourth, it is developed at a level of generality that will require adaptation to particular institutional settings, and its cross-scale claims presume the availability of at least some system level data.

Three limitations should be stated plainly. The article is conceptual, and the seven propositions are arguments, not findings; nothing here has been tested. The literature protocol is purposive and saturation-based rather than systematic, so a different set of seeds would have produced a somewhat different synthesis, and the corpus is confined to English-language published work, which is a real limitation for a framework that argues for the importance of local knowledge and plural worldviews. And the framework itself is a boundary judgement: in choosing to organise the field around structure, adaptation and scale, it makes other organising axes, particularly those centred on power, political economy and historical injustice, peripheral when critical scholarship suggests they may be central (Ergene et al., 2021). We regard that as the most consequential of the three, and as the most promising direction for the framework's extension.

Future research might proceed along four lines. The first is empirical testing of the propositions, beginning with Propositions 4 and 6, which are the most tractable and the most consequential. The second is the development of system-referenced sustainability measures usable in management research, which is currently the binding constraint on the whole programme. The third is investigation of the conditions under which organisations move from adaptation to transformation, since transformability remains the least theorised component in management applications of resilience. The fourth is the integration of a power-analytic account into the boundary framing principle, which would ask not only where the boundary is drawn but who has the authority to draw it and who bears the consequences.

9. Conclusion

Sustainability and resilience are usually presented to managers as complementary goals and to researchers as separate literatures. This article has argued that both presentations obscure what is at stake. Read through systems thinking and complexity theory, treated as distinct rather than interchangeable traditions, sustainability becomes a property of nested systems that firm level measurement cannot capture on its own, and resilience becomes a capacity whose value depends entirely on what is being sustained, against what, and in whose interest. Once both

are located in the same systemic frame, their relationship turns out to be conditional rather than automatic: the same organisational capacity can support system sustainability or undermine it, depending on whether it creates capacity or transfers exposure, on the level and horizon at which it operates, and on how close the host system is to a threshold.

The framework's contribution is to make that conditionality analysable. Five design principles specify where systemic reasoning enters managerial practice, seven propositions state the relationships in falsifiable form, and a matched methodological agenda identifies the designs capable of carrying constructs that management research has so far imported faster than it can test. For managers, the practical yield is a short set of questions about boundaries, loops, thresholds, buffers and mechanisms that changes what gets analysed before a decision is made. For organisations working in contested resource frontiers, where a single activity can dominate the social-ecological system that hosts it, those questions are not academic. They determine whether the system's condition appears anywhere in the organisation's field of view.

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Declaration of competing interests

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Author contributions

Rismawati: conceptualisation, framework development, writing of the original draft, review and editing, supervision. Anny Widiastara: conceptualisation, literature synthesis, review and editing. Ali M. Abdillah: literature synthesis, framework refinement, review and editing.

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