Research Article

The Spinning Top Model of Sustainability

A systems-theoretic interpretation as dynamic coherence

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Abstract. *Sustainability remains one of the most contested concepts in contemporary scholarship, with definitional proliferation impeding cumulative theory-building and policy coherence. This study employs Conceptual Framework Analysis (CFA) to systematically examine 161 sustainability definitions drawn from a multi-source corpus, extracting 712 sustainability-related concepts subsequently synthesized into 30 Integrated Concepts (ICs). Thematic distribution analysis reveals that ethical and social domains dominate sustainability discourse, appearing in 107 and 103 definitions respectively, while political, cultural, and legal dimensions remain critically underrepresented. Epistemic deconstruction identifies a pronounced asymmetry, 521 epistemological concepts against 107 ontological and 84 methodological, reflecting a field preoccupied with evaluative criteria at the expense of systemic understanding and operational pathways. Concept integration produces the Triadic Negotiation Framework for Sustainability (TNFS), a three-layer epistemic architecture comprising an ontological condition space, an epistemological value space, and a methodological negotiation space, connected through recursive inter-layer feedback and six irreducible structural tensions. Building on the TNFS, the study proposes the Spinning Top Model of Sustainability (STMS), which interprets sustainability as dynamic coherence, the emergent property of a self-generating system whose vertical axis (normative orientation), spinning body (material conditions), and contact point (methodological negotiation) interact through recursive feedback to sustain coherent motion against socio-ecological resistance. The STMS reframes sustainability assessment from output measurement to functional evaluation of axial alignment, body momentum, and contact point recalibration capacity, offering a diagnostic vocabulary for identifying systemic failure modes invisible to conventional indicator frameworks.*

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1. Introduction

Sustainability is a touchstone across policy debates, academic discussions, and practical interventions. Yet, as Connell (2023) notes, the term often functions more as a persuasive label than a clearly delimited concept. Scholars have attempted to clarify its meaning for several decades, but the field continues to grapple with a proliferation of definitions that seldom align in scope or intent (Johnston et al., 2007; Mensah, 2019). Waas et al. (2011) similarly argue that this definitional plurality has created conceptual clutter, making it difficult to build cumulative theory or develop common indicators. In practice, such inconsistencies divert attention from the substantive issues that sustainability is meant to address. Notably, the rapid institutionalisation of sustainability science has not resolved its underlying conceptual indeterminacy (Del Río Castro et al., 2021; Novicka & Volkova, 2024). Instead, sustainability continues to be interpreted divergently across academic and applied domains despite the growth of sustainability science as a distinct field (Kajikawa et al., 2014; Messerli et al., 2019).

Tracing back, the term "sustainability" originates from the Latin *sustinēre*, meaning "to hold up," and entered the English lexicon through legal and ecological usage in the early 17th to 19th centuries (Oxford English Dictionary, 2025a, 2025b, 2025c). Initially implying endurance or continuity, its modern ecological and systemic meanings emerged in the late 20th century. The conception of *sustainable yield* was formalized by Hans Carl von Carlowitz in 1713, advocating forest management practices that would ensure long-term resource regeneration (Grober & Cunningham, 2012; Wiersum, 1995). This concept later informed natural resource economics, with 19th-century thinkers like Ricardo and Mill speculating on a "stationary state" to counteract growth-driven environmental depletion (Barber, 2009).

The widely acclaimed definition of sustainable development, "meeting the needs of the present without compromising the ability of future generations to meet their own needs", from the Brundtland Report, has brought sustainability into a global concern (Connell, 2023; WCED, 1987). Even though this foundational conception of sustainability incorporates multiple dimensions, the interrelatedness of the dimensions remains underexplored (Lawrence et al., 2025). Other definitions, such as Ehrenfeld's (2005) ideal that "all forms of life should flourish forever" or Costanza and Patten's (1995) characterization of a sustainable system as one that "persists," offer ethical or systemic metaphors they often lead to operational difficulties because they lack measurable, manageable objectives. As White (2013) argues, these conceptualizations are difficult to define 'intelligibly' for businesses and organizations that require clear metrics for progress .

In economic discourse, sustainability has often been defined in terms of non-declining utility, capital preservation, or intergenerational equity (Pearce et al., 2012; Solow, 1991). While useful in formal modelling, these approaches tend to detach from ecological realities or social justice concerns. Meanwhile, ecological definitions emphasize carrying capacity, resource thresholds, or planetary boundaries (Reijnders, 2022; Rockström et al., 2009), yet they too face critique for downplaying cultural agency or political context (Griebler et al., 2025). Social scientists and philosophers have proposed more inclusive formulations grounded in justice, participation, and well-being (Gilman, 2013; UNESCO, 2017), but these often remain aspirational and difficult to operationalize.

Rather than coalescing towards a common conceptual foundation, sustainability definitions continue to proliferate, often reflecting the epistemologies and normative priorities of specific disciplines (Connell, 2023; Purvis et al., 2019). This results in definitional fragmentation, where different domains emphasize competing principles such as efficiency, justice, resilience, or responsibility, without offering integrative coherence (Johnston et al., 2007; Mensah, 2019). Although systems thinking is increasingly referenced in sustainability discourse, few definitions explicitly articulate how sustainability might emerge from dynamic interactions (Li & Guo, 2024; Voinov & Farley, 2007). The semantic flexibility of the term, while enabling interdisciplinary dialogue, also creates ambiguity in measurement, hinders policy coordination, and complicates curricular integration in education for sustainable development (Alexander et al., 2022; Weisser, 2017). This definitional diversity suggests the need for a structured meta-analysis of conceptual patterns, an approach this study pursues through Conceptual Framework Analysis (Jabareen, 2009). These limitations underscore the need for a structured re-examination of sustainability definitions and for conceptual approaches capable of synthesizing core dimensions without collapsing their contextual richness.

At the same time, numerous models were also developed to formalize principles, guide interventions, and enable measurement of sustainability. The most widely adopted model has been the "three pillars" model, which conceptualizes sustainability as the intersection of environmental, social, and economic dimensions (WCED, 1987). Although this structure globalized the concept, it oversimplifies interdependencies and treats sustainability as a static rather than a dynamic condition (Brinkmann, 2023; Purvis et al., 2019). To incorporate sustainability into business and organizational contexts, Elkington's (1997) Triple Bottom Line (TBL), "People, Planet, Profit", was introduced. While this model shaped environmental-social-governance (ESG) frameworks and reporting, it is criticized for shallow compliance and neglecting cultural and institutional dimensions (Abdul-Rashid et al., 2017; Sridhar & Jones, 2013).

One of the most visually engaging frameworks, Doughnut Economics (Raworth, 2012), defines sustainability as a safe space between ecological ceilings and social foundations. While this approach gained attention in urban governance and post-growth discourse, it has been critiqued for its analytical vagueness, static visual metaphor, and cultural blind spots (Hutchison et al., 2021; Nieuwland, 2024; Wahlund & Hansen, 2022). This limits its systemic applicability across diverse contexts.

The Sustainable Development Goals (SDGs), a well employed framework by the United Nations in 2015, attempt to integrate a wide array of global challenges, from poverty to climate change, through 17 interlinked goals (UN General Assembly, 2015). However, the SDGs have been criticized for normative incoherence, difficulty managing trade-offs, and an overreliance on technocratic metrics that often sidestep structural and historical roots of unsustainability (Del Río Castro et al., 2021; Spaiser et al., 2017).

In parallel, ecological economics introduced the dichotomy of Weak and Strong Sustainability. It distinguishes forms of capital that are substitutable from those that are not (Neumayer, 2013; Solow, 1991). While useful for clarifying theoretical boundaries, this binary framing has been faulted for either legitimizing unsustainable practices under weak formulations or being overly rigid in strong versions, which often lack flexibility to accommodate socio-political complexity (Biely et al., 2018; Oliveira Neto et al., 2018). Most existing models fail to represent sustainability as a systemic and dynamic phenomenon, often reducing it to static pillars or technocratic indicators (Costanza & Patten, 1995; Romero & Linares, 2014; Schultz et al., 2013).

Scholars are increasingly pointing out that sustainability cannot be understood within narrow disciplinary boundaries. Instead, they advocate for a perspective that integrates diverse forms of knowledge and acknowledges the normative, dynamic, and context-dependent nature of the concept itself (Ben-Eli, 2018; Del

Río Castro et al., 2021). Many of the theories that once guided sustainability research now appear too fragmented or limited, prompting calls for new approaches that place sustainability at the heart of organisational and societal decision-making (Bocken et al., 2014; Patala et al., 2016). Alongside this shift, a growing body of work reminds us that sustainability is not only a technical or environmental question but also a profoundly ethical one, encompassing concerns about justice, cultural continuity, and our responsibilities to future generations (Besong & Holland, 2015; Capasso et al., 2019; Hawkes, 2004). This ethical lens invites deeper reflection on the values and worldviews that shape how societies choose to act (Basiago, 1995; Kuhlman & Farrington, 2010).

Despite advancements in measurement and indicator frameworks, many of these tools still lean heavily toward technocratic solutions (Jia, 2023), which are expert-led, data-driven fixes that prioritize industrial efficiency and standardized technology over local knowledge or social complexity . As a result, they often overlook the cultural and symbolic foundations that influence how communities interpret and pursue sustainability (Alexander et al., 2022; Romero & Linares, 2014). Several authors argue that sustainability is also a cultural project, one rooted in shared meanings, identities, and collective aspirations (Caradonna, 2014; Hawkes, 2004). Yet these cultural dimensions remain marginal in most mainstream frameworks, even though they play a crucial role in shaping community resilience and social well-being (Eilks, 2015).

To address these conceptual gaps, recent scholarship has shifted its focus to viewing sustainability as an emergent property of complex systems, systems that evolve, adapt, and interact across multiple scales (Costanza & Patten, 1995; Roostaie et al., 2019). The Planetary Boundaries framework is one prominent attempt to outline ecological conditions that must be respected to maintain global stability (Rockström et al., 2009). Systems-theoretic perspectives, including Luhmann's Social Systems Theory, further highlight the difficulties that arise when autonomous social subsystems attempt to coordinate around sustainability goals (Li & Guo, 2024). These approaches draw attention to relationships, feedback processes, and multi-level interactions, positioning sustainability as an ongoing and relational process rather than a fixed target (Gould et al., 2023; Lejano, 2019; Schultz et al., 2013; Vossoughi et al., 2023; Wals, 2017; West et al., 2020).

Considering the longstanding conceptual tensions and the diverse ways sustainability has been defined, this study undertakes a systematic reconsideration of the concept. Using Jabareen's (2009) Conceptual Framework Analysis, the study systematically examines 161 sustainability definitions and proposes the Spinning Top Model of Sustainability (STMS). And reframes sustainability not as a state to be achieved but as dynamic coherence, the emergent property of a system continuously sustaining its own motion through the structured interaction of normative orientation, material conditions, and methodological negotiation.

This theoretical inquiry is guided by the following research questions:

RQ1. How are sustainability definitions distributed across the thematic domains of sustainability (economic, social, environmental, cultural, political, legal, and ethical)?

RQ2. What core concepts are articulated in explicit definitions of sustainability, and how are these concepts classified across epistemic roles—ontological, epistemological, and methodological?

RQ3. What integrated concepts emerge from the synthesis of the categorized sustainability concepts?

RQ4. What structural patterns and relationships among the integrated concepts the conceptual architecture of sustainability in the literature?

Through a critical synthesis of 161 definitions and associated conceptual terms, this study contributes to a more coherent, integrative, and actionable understanding of sustainability, one that foregrounds the systemic, historical, and ethical complexities embedded in real-world sustainability challenges.

2. Materials and Methods

This study adopted qualitative interpretive paradigm that utilizes the grounded theory method as its core procedure, Conceptual Framework Analysis (CFA), as proposed by Jabareen (2009) to investigate how sustainability is defined across disciplinary, institutional, and philosophical contexts. CFA is particularly used to examoine abstract and multidimensional constructs, aiming to uncover the underlying epistemic architecture of complex concepts (Edlmann & Grobbelaar, 2021). It proceeds through iterative phases of concept identification, deconstruction, and synthesis, allowing the emergence of a theoretically integrated framework (Figure 1) (Stroebele-Benschop et al., 2025).

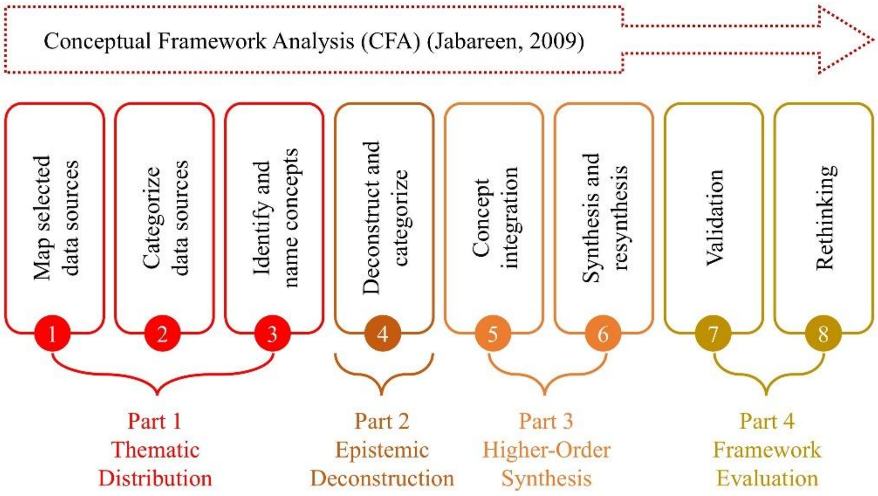

Figure 1. The eight-stage Conceptual Framework Analysis (CFA) Protocol. Adapted from Jabareen (2009)

The goal of the study was not to catalogue every occurrence of the term sustainability but to construct a conceptually rich corpus that captures its core meanings and structural patterns. A purposive, theoretically informed sampling strategy was applied to compile 178 sustainability definitions, of which 161 unique definitions were retained after removing overlaps. Inclusion criteria required that each definition (1) explicitly articulate the meaning or conceptual logic of sustainability or sustainable development, and (2) originate from academically credible or institutionally authoritative sources.

Definitions were gathered through a three-pronged sourcing process. First, 100 definitions were taken from González et al. (2021), a comprehensive synthesis study based on reproducible inclusion procedures. Second, an independent Scopus search (n = 393) identified 18 conceptually rich studies, yielding 42 high-quality definitions after full-text screening. Third, 36 additional definitions were located through backward and forward citation tracing. This multi-source strategy ensured balanced coverage of foundational, contemporary, and cross-disciplinary perspectives (Booth et al., 2016; Greenhalgh & Peacock, 2005). Removing duplication yielded finally 161 unique definitions.

Each definition was treated as a discrete unit of meaning. Following Jabareen's (2009) eight-phase CFA protocol, extensive close reading produced 845 sustainability-related concepts. Before concept extraction, all definitions were categorized into one or more thematic areas according to their dominant conceptual emphasis. The seven thematic areas, economic, social, environmental, cultural, political, legal, and ethical, were adopted from González et al. (2021), who derived and validated this dimensional taxonomy through systematic analysis of 100 sustainability definitions, building on prior sustainability and corporate social responsibility literature (Torugsa et al., 2013; Visser, 2006). To ensure inter-coder reliability (ICR), each definition was evaluated for substantive claims across the seven thematic areas, with a second independent coder verifying a random sample to maintain interpretive consistency (O'Connor & Joffe, 2020). This thematic categorization served as an organizational frame prior to concept extraction, ensuring systematic coverage across all domains of sustainability discourse before final analysis began.

After refining the extracted concepts to remove overlaps and retain unique entries, the initial set of 845 concepts was reduced to 712. These concepts were then classified according to their epistemic role manually: ontological (what sustainability is, including its structure or state), epistemological (how sustainability is understood, including values and interpretive orientations), and methodological (how sustainability is enacted through strategies and actions) (Jabareen, 2009). Validated the categorization of 712 sustainability concepts using a four-step framework. The categorisation of the 712 sustainability concepts was validated using a structured procedure based on the trustworthiness framework of Yvonna Lincoln & Guba, (1985). Each concept was assigned a unique identifier to maintain an audit trail. Inter-coder reliability was assessed on a random subset of 50 concepts using Cohen's Kappa, with a minimum acceptable threshold of $\varkappa \geq 0.60$. The coding scheme was further refined through peer review with the research group and supervisor. A detailed codebook defining all categories and boundaries was developed to ensure transparency and replicability.

After epistemic coding, the categorized dataset of 712 concept instances was subjected to concept integration and synthesis following the procedures of conceptual framework analysis. Concepts within each epistemic category were first examined for semantic similarity and theoretical affinity and grouped into concept clusters representing recurring areas of emphasis within the sustainability literature.

These clusters were then analyzed to identify higher-order conceptual equivalences. Concepts were integrated when they referred to the same structural feature of sustainability, performed the same evaluative function, or specified similar operational mechanisms. Through iterative comparison, concept clusters were progressively consolidated into higher-order integrated concepts.

The preliminary integrated set was subsequently subjected to resynthesis, in which concept boundaries were re-examined to ensure that necessary distinctions were preserved and that no structural elements of the original conceptual corpus were lost. This iterative process resulted in a final set of 30 Integrated Concepts representing the higher-order conceptual structure underlying the 712 extracted sustainability concepts.

Following epistemic coding, the dataset of 712 concept instances was analyzed to identify patterns of conceptual distribution and thematic concentration within each category. Concepts within the same epistemic role were compared for semantic similarity and grouped into thematic clusters representing recurring areas of emphasis in the sustainability literature. This inductive clustering process provided the basis for identifying the dominant conceptual patterns in the dataset and informed the synthesis of higher-order conceptual dimensions presented in the results section.

The framework was evaluated for clarity and cross-disciplinary relevance through internal expert feedback, which refined its conceptual boundaries. The framework is now being presented to the scientific community through peer-reviewed publication to enable broader scholarly evaluation, scholarly critique and iterative improvement (Stroebele-Benschop et al., 2025), aligning with Jabareen's (2009) call for communal validation. While representing a stable synthesis, the model remains open, adaptive, and continuously evolving with new insights.

3. Results

This section presents the study's results, corresponding to the research questions. Includes the results of the thematic distribution of definitions and 4-stage analytical process applied to explicit definitions of sustainability identified in the literature: (1) identification of concepts embedded in definitions, (2) deconstruction and epistemic classification of those concepts, (3) integration of similar concepts into broader consolidated categories, and (4) synthesis of the integrated concepts into a higher-order conceptual framework. Each stage is reported in sequence to reflect the forward-moving logic of the analysis.

3.1 Thematic distribution of sustainability definitions

In the initial mapping phase, 161 definitional sources of sustainability were examined, yielding a comprehensive, multidisciplinary foundation for analysis (Figure 2). The frequency distribution shows that the ethical domain appears in 107 definitions, the social domain in 103, the environmental domain in 96, and the economic domain in 86. The political domain appears in 25 definitions, the cultural domain in 14, and the legal domain in 6. Definitions could be assigned to more than one domain depending on the thematic elements explicitly present in the text.

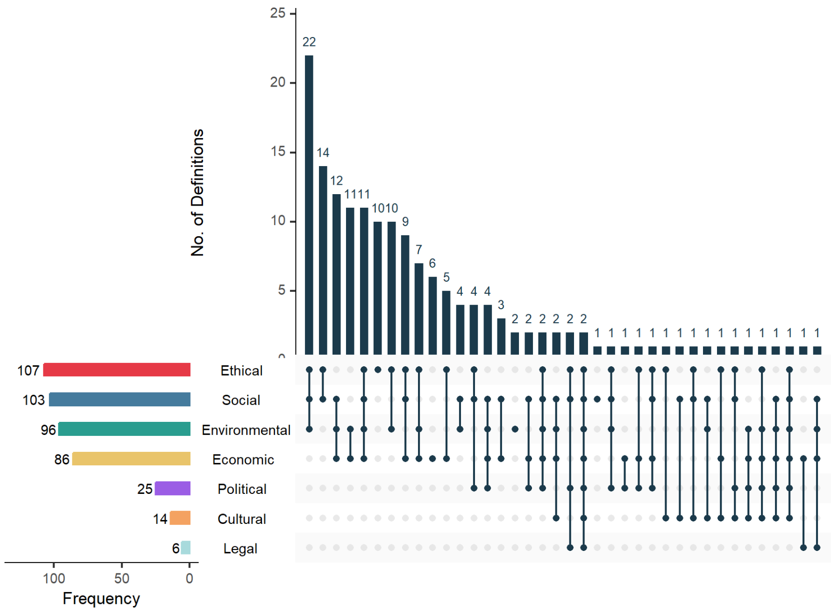

Figure 2. Upset plot showing the frequency and intersection pattern of seven thematic domains across 161 sustainability definitions

The breadth of domain coverage within individual definitions was also examined. Across the dataset, nineteen definitions are confined to a single domain, 111 definitions address two or three domains, and 31 definitions span four or more domains. Within the single-domain category, ten definitions are classified as ethical-only, six as economic-only, two as environmental-only, and one as social-only.

Domain co-occurrence patterns were analysed to identify the most frequent pairings of domains within the definitions. The pairing Ethical–Social occurs in 71 definitions. Environmental–Social appears in 64 definitions, and Environmental–Ethical in 57 definitions. The pairing Economic–Environmental occurs in 56 definitions, Economic–Social in 51 definitions, and Economic–Ethical in 41 definitions. Additional pairings include Political–Social in 21 definitions, Economic–Political in 17 definitions, Ethical–Political in 16 definitions, Environmental–Political in 13 definitions, and Cultural–Social in 10 definitions.

The analysis of complete domain combinations shows recurring definitional configurations. The combination Environmental-Ethical-Social occurs in 22 definitions. Ethical-Social appears in 14 definitions. Economic-Environmental-Social occurs in 12 definitions. Economic-Environmental-Ethical-Social appears in 11 definitions. The combination Economic-Environmental also occurs in 11 definitions, while Environmental-Ethical appears in 10 definitions. Other combinations include Ethical only in 10 definitions, Economic-Ethical-Social in 9 definitions, Economic-Environmental-Ethical in 7 definitions, and Economic only in 6 definitions. These ten domain configurations together represent 97 definitions in the dataset.

3.2 Epistemic deconstruction of the concepts

Epistemic deconstruction of concepts that is three analytical categories used for classification were ontological, epistemological, and methodological. Ontological concepts describe the structural nature of sustainability systems, referring to entities, conditions, and systemic relationships that constitute the domain in which sustainability exists. In total, 107 concepts were coded as ontological. Epistemological concepts define the evaluative standards through which sustainability is judged, specifying the criteria, principles, or conditions that must be satisfied for a system to be considered sustainable. This category accounted for 521 concepts, representing the largest portion of the conceptual corpus.

Methodological concepts refer to the operational mechanisms through which sustainability may be pursued, including practices, strategies, governance arrangements, and institutional interventions. A total of 84 concepts were classified in this category. Coding decisions were based on the functional role each concept performs within its definitional context, rather than on the disciplinary origin of the source (Table 1).

Table 1. Distribution of extracted sustainability concepts across epistemic roles

Epistemic role	**Analytical function**	**Coding criterion**	**Example concepts from corpus**	**N**
Ontological	Describes the structural nature of sustainability systems	Concepts referring to entities, states, or systemic relationships that constitute the domain in which sustainability exists	*A characteristic or state; A state; All forms of life; Balanced systems; Balanced conditions; Carrying capacity; Always thriving; Adaptive prevention system*	107
Epistemological	Defines the criteria through which sustainability is evaluated	Concepts specifying principles, standards, or conditions used to judge whether a system is sustainable	*Ability to be maintained; Ability to be sustained; Absorptive capacity; Acceptable level; Actor involvement; Adaptability; Adaptation; Active cultivation*	521
Methodological	Identifies mechanisms through which sustainability is pursued	Concepts referring to actions, strategies, governance arrangements, or operational practices aimed at achieving sustainability	*Acceptable economic process; Appropriate technology; Conservation; Conservation of life forms; Continued cooperation; Continuity of human activity; Benefit production; Autonomous natural processes*	84

3.3 Integrated conceptual synthesis

Following epistemic categorization, the dataset of 712 extracted concepts was subjected to concept integration and resynthesis in order to identify higher-order conceptual units representing recurring structural elements within sustainability definitions. Concept integration involved comparing concepts across the dataset and consolidating those that referred to the same structural property of sustainability, expressed similar evaluative criteria, or described comparable implementation mechanisms. Through this iterative synthesis process, the 712 original concept instances were reduced to 30 Integrated Concepts (ICs).

These Integrated Concepts form the conceptual architecture underlying sustainability definitions and are organized across three epistemic layers: Ontological layer (7 ICs) – describing the structural nature and systemic properties of sustainability systems; Epistemological layer (17 ICs) – specifying the criteria used to evaluate sustainability and Methodological layer (6 ICs) –

identifying mechanisms through which sustainability objectives are pursued in practice (Appendix A).

3.4 The Triadic Negotiation Framework for Sustainability (TNFS)

The Conceptual Framework Analysis of 161 sustainability definitions, yielding 712 original concepts subsequently synthesized into 30 integrated concepts, produced a three-layer epistemic architecture designated the Triadic Negotiation Framework for Sustainability (TNFS) (Figure 3). Following Jabareen's (2009) conceptual framework methodology, the 30 integrated concepts were classified according to their epistemic function, ontological, epistemological, or methodological, resulting in three analytically distinct but structurally interdependent layers. The ontological layer (IC1–IC7) constitutes the condition space of the framework, encompassing the foundational physical and systemic realities within which all human activity occurs. The epistemological layer (IC8–IC24) constitutes the value space, capturing how sustainability is simultaneously known, evaluated, and ethically obligated across five domains of human concern. The methodological layer (IC25–IC30) constitutes the negotiation space, comprising the contact points where human intention meets ontological reality through structured intervention. Taken together, these three layers advance a central theoretical claim that sustainability is not a fixed state to be achieved but a continuous negotiation between what socio-ecological systems are and what human systems value, and the quality of that negotiation, rather than any particular outcome it produces, is what sustainability fundamentally measures.

The ontological layer: condition space

The ontological layer comprises seven integrated concepts organized across four conceptual axes that together define the condition space of the TNFS. The Material Axis encompasses "State Of Being / Characteristic State" (IC1) and "Natural & Human-Made Capital Stocks" (IC4), establishing the physical substrates and asset stocks that constitute the material basis of any sustainability condition. The Drive Axis encompasses "Flourishing & Thriving Of All Life" (IC2) and "Dynamic Systems, Complexity & Change" (IC5), capturing the generative forces and systemic properties that animate socio-ecological systems. The Boundary Axis encompasses "Ecosystem, Biosphere & Planetary Boundaries" (IC3), establishing the non-negotiable ecological limits within which human activity must be contained. The Geometry Axis encompasses "Human–Environment & Society–Nature Relationship" (IC6) and "Resilience, Stability &

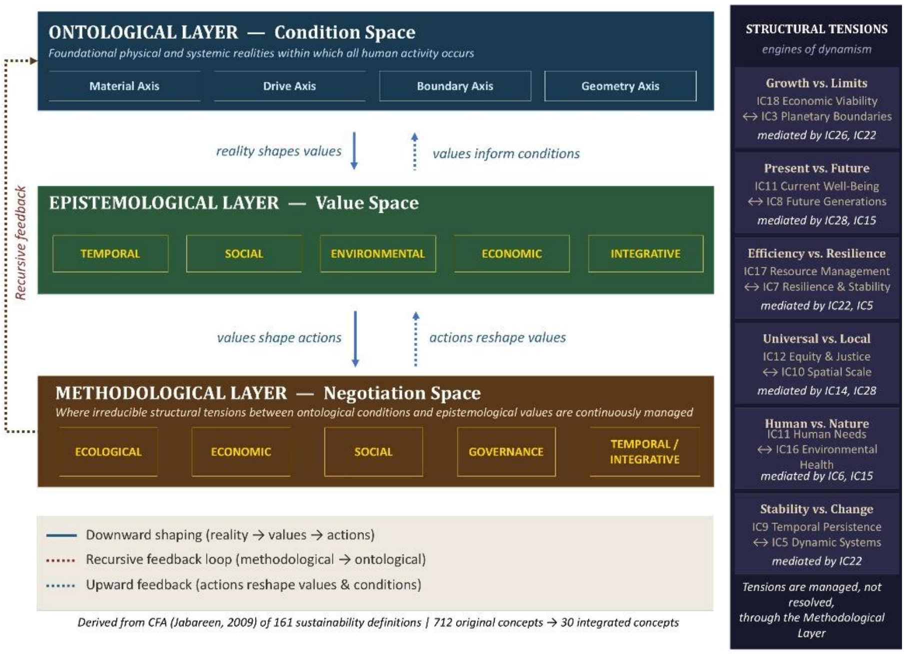

Figure 3. The Triadic Negotiation Framework for Sustainability (TNFS)

Adaptive Systems" (IC7), defining the relational and structural properties that characterize the interface between human and natural systems. Critically, the ontological layer is not treated as a passive or fixed background condition. Methodological actions feed back into ontological conditions, conservation practices can restore planetary boundaries (Gann et al., 2019; Van Vuuren et al., 2025; Zhao et al., 2024), production systems can deplete or regenerate capital stocks (O'Grady et al., 2024; Tenaw, 2025; Zambrano-Monserrate, 2025; Zhao et al., 2024), education can reshape human-environment relationships (Olsson et al., 2004; Pörtner et al., 2023; Sharifi, 2023), and governance can build or erode systemic resilience (Clement et al., 2024; Olsson et al., 2004; Salomon et al., 2019). The ontological layer therefore simultaneously sets the conditions for negotiation and remains subject to the outcomes of that negotiation.

<u>The epistemological layer: value space</u>

The epistemological layer comprises seventeen integrated concepts organized across five thematic clusters that together constitute the value space of the TNFS.

Following Jabareen (2009), the epistemological layer captures not only how sustainability is known but how it is valued and ethically obligated. In sustainability science, this distinction collapses, normative commitments such as equity, well-being, and responsibility are simultaneously knowledge claims and value positions (Basiago, 1995; Besong & Holland, 2015; Drury et al., 2023; Kuhlman & Farrington, 2010), a finding consistent with the empirical dominance of ethical-social domain pairings identified in the thematic distribution analysis. The Temporal Cluster encompasses "Intergenerational Equity & Future Generations" (IC8), "Temporal Persistence & Non-Decline " (IC9), and "Spatial Scale: Local To Global" (IC10), addressing the temporal and scalar dimensions of sustainability obligation. The Social Cluster encompasses "Human Needs, Well-Being & Quality Of Life" (IC11), "Equity, Fairness & Social Justice" (IC12), "Social Fabric, Culture & Community" (IC13), "Civic Participation, Voice & Collective Agency" (IC14), and "Responsibility, Ethics & Value Systems" (IC15), collectively establishing the normative foundations of sustainability as a social and ethical project. The Environmental Cluster encompasses "Environmental Health, Conservation & Biodiversity" (IC16) and "Resource Management, Limits & Efficiency" (IC17), grounding sustainability in ecological realities and resource constraints. The Economic Cluster encompasses "Economic Viability, Growth & Development" (IC18), "Development, Progress & Human Advancement" (IC19), and "Outcomes, Performance & Realization" (IC20), capturing the productive and evaluative dimensions of human economic activity. The Integrative Cluster encompasses, "Holistic Balance & Integration Of Dimensions" (IC21), "Adaptive Capacity, Flexibility & Learning" (IC22), "Non-Compromise, Harm Prevention & Safeguarding" (IC23), and "Epistemological Coherence & Knowledge Integration" (IC24), providing the cross-cutting concepts through which the other four clusters are held in dynamic relation. The five clusters are not discrete silos but structurally coupled domains (Eizenberg & Jabareen, 2017; Jabareen, 2008; Purvis et al., 2019), economic viability without environmental health is conceptually incoherent, and equity without temporal persistence is normatively incomplete.

The methodological layer: negotiation space

The methodological layer comprises six integrated concepts organized across five contact zones that together constitute the negotiation space of the TNFS. The designation of this layer as a negotiation space represents a theoretical reframing of the methodological function in sustainability frameworks (Jia, 2023; Soulé et al., 2021; Stumm, 2026). Rather than treating methodological concepts merely as tools or instruments for implementing epistemological goals (Jia, 2023; Romero & Linares, 2014), the TNFS positions the methodological layer as the structural site where irreducible tensions between ontological conditions and epistemological values are continuously managed. The Ecological Contact Zone encompasses "Conservation, Preservation & Restoration Methods" (IC25), establishing the direct intervention point between human action and ecological systems. The Economic Contact Zone encompasses "Sustainable Production, Innovation & Technology" (IC26), constituting the productive interface between human economic activity and natural resource systems. The Social Contact Zone encompasses "Education, Behavior Change & Individual Action" (IC27), capturing the transformative pathway through which individual and collective values are cultivated and enacted. The Governance Contact Zone encompasses "Institutional Governance & Organizational Methods" (IC28), providing the institutional mechanisms through which collective decisions are made, enforced, and adapted over time (Mzembe et al., 2025; Patterson et al., 2017). The Temporal Contact Zone encompasses "Continuity Of Programs, Services & Benefits" (IC29), ensuring that sustainability interventions persist across political cycles and institutional transitions (Braams et al., 2024; Kuzemko et al., 2016). The Integrative Contact Zone encompasses "Institutional Memory, Knowledge Transfer & Capacity Building" (IC30), functioning as the bridge between adaptive capacity and temporal persistence by preserving and transmitting the knowledge generated through experience (Berkes et al., 2000; Olsson et al., 2004). Crucially, each contact zone operates simultaneously as a site of intervention and a site of feedback, methodological actions do not merely respond to ontological conditions and epistemological values but actively reshape both through their consequences.

Inter-layer relationships and recursive dynamics

The analytical power of the TNFS derives not from its three layers in isolation but from the structured relationships operating between and across them. Three distinct relationship types characterize the inter-layer architecture of the framework. The first is downward shaping, in which ontological conditions constrain and configure epistemological values, planetary boundaries establish the outer limits of legitimate economic aspiration (Hummels & Argyrou, 2021; Kallis et al., 2025; Rabbi, 2025; Vázquez et al., 2023), dynamic systems complexity demands adaptive rather than static normative frameworks (Abujder Ochoa et al., 2024, 2025; Nelson et al., 2020; Rabbi, 2025), and the human-environment relationship structures the ethical obligations that sustainability discourse articulates (Gulomova, 2024; Keitsch, 2018; Milgin et al., 2020). Epistemological values in turn shape methodological action intergenerational equity generates institutional governance obligations (Santos Campos, 2018; Spijkers, 2018; Taghizadeh, 2025; Weiss, 2021), environmental health demands conservation intervention (Aronson et al., 2020; Balewa et al., 2024; Behera et al., 2024; Breed et al., 2021; Campuzano-Vera et al., 2025; Jones et al., 2018), and adaptive capacity necessitates education and flexible governance arrangements (Akamani, 2023; Didham & Ofei-Manu, 2020; Fazey et al., n.d.; Folke et al., 2005; Koontz et al., 2015). The second relationship type is upward feedback, in which methodological actions reshape epistemological understanding, conservation practices alter assessments of environmental health (Bauch et al., 2015; Husk et al., 2016; Sheehan et al., 2024), governance institutions redefine participation norms (Blakeley, 2010; Blanco et al., 2022; Bussu et al., 2022; Kiss et al., 2022; Milazzo & Goldstein, 2019; Paliokaitė & Sadauskaitė, 2023; Swyngedouw, 2005), and education transforms the ethical values communities bring to sustainability decisions (Giusti et al., n.d.; Jakubowski, 2025; Kondo & Baars, 2025; Misiaszek, 2023; Salmi, 2025; Taylor, 2017). The third and most theoretically significant relationship type is recursive feedback from the methodological layer back to the ontological layer, the relationship that most sharply distinguishes the TNFS from static sustainability frameworks. Conservation can restore or degrade planetary boundaries (Langhammer et al., 2024; Pörtner et al., 2023; Yin et al., 2025), production systems can regenerate or deplete capital stocks , education can fundamentally alter the human-environment relationship at the level of ontological condition rather than merely epistemological perception (Jakubowski, 2025; Kondo & Baars, 2025; Taylor, 2017) and governance can build or systematically erode systemic resilience (Blanchet et al., 2017; Chaffin & Gunderson, 2016). This recursive dynamic means that human action does not merely respond to ontological reality, it constitutes and reconstitutes it. Sustainability governance that fails to account for this recursive dimension risks treating as fixed the very conditions its interventions are altering.

Structural tensions as engines of dynamism

The synthesis phase of Conceptual Framework Analysis requires examination of structural contradictions that emerge from concept interaction (Jabareen, 2009). The inter-layer relationship analysis reveals six such contradictions, designated here as structural tensions, that operate across all three layers simultaneously and function as the primary engines of dynamism within the framework. These tensions are not treated as problems to be solved or failures of coordination but as irreducible contradictions inherent in the relationship between socio-ecological systems and human value systems (Costanza & Patten, 1995; Gould et al., 2023; Voinov & Farley, 2007). Their irreducibility is precisely what prevents sustainability from achieving a fixed equilibrium (Costanza & Patten, 1995; Schultz et al., 2013) and what necessitates the continuous negotiation that the methodological layer is designed to manage. The first tension, Growth versus Limits, operates between IC18 (Economic Viability) and IC3 (Planetary Boundaries), and is managed through IC26 (Sustainable Production) and IC22 (Adaptive Capacity). The second tension, Present versus Future, operates between IC11 (Current Well-Being) and IC8 (Intergenerational Equity), and is managed through IC28 (Institutional Governance) and IC15 (Responsibility and Ethics). The third tension, Efficiency versus Resilience, operates between IC17 (Resource Management) and IC7 (Resilience and Stability), and is managed through IC22 (Adaptive Capacity) and IC5 (Dynamic Systems and Complexity). The fourth tension, Universal versus Local, operates between IC12 (Equity and Justice) and IC10 (Spatial Scale), and is managed through IC14 (Civic Participation) and IC28 (Institutional Governance). The fifth tension, Human versus Nature, operates between IC11 (Human Needs and Well-Being) and IC16 (Environmental Health), and is managed through IC6 (Human–Environment Relationship) and IC15 (Responsibility and Ethics). The sixth tension, Stability versus Change, operates between IC9 (Temporal Persistence) and IC5 (Dynamic Systems and Complexity), and is managed through IC22 (Adaptive Capacity). Each tension has one pole anchored in the ontological layer and one in the epistemological layer, with the methodological layer functioning consistently as the site of management. This structural pattern confirms that the methodological layer is not incidental to the framework but architecturally central (Jia, 2023; Soulé et al., 2021; Stumm, 2026), it is the layer through which the framework remains operational under conditions of irreducible contradiction.

4. The Spinning Top Model of Sustainability (STMS)

Building on the TNFS, the present study proposes the Spinning Top Model of Sustainability (STMS), a dynamic interpretation of the same three-layer architecture rendered in motion (Figure 4). The STMS adopts the metaphor of a living top, a self-generating system that produces its own motion through internal organization rather than externally applied force, directly homologous to the TNFS's recursive dynamic in which methodological actions reshape ontological conditions, which reconfigure epistemological values, which generate new methodological imperatives.

The spinning top was selected through the criterion of functional homology, the source domain must share structural properties with the target domain that perform equivalent roles within their respective systems, not merely superficial resemblances (Gentner, 1983; Hesse, 2017). Three properties make it appropriate for the analogy. Axial integrity, the top maintains directional coherence through a normative axis around which all motion organizes, is functionally homologous to the epistemological layer, which provides normative orientation without which sustainability has no directional integrity. Contact-point negotiation, the top maintains stability by continuously negotiating between internal rotational momentum and surface resistance, is functionally homologous to the methodological layer. Motion-dependent persistence, the top persists only while in motion and collapses at stillness, directly encodes the STMS's central claim that sustainability is a continuous process, not a state. The living top generates motion internally rather than requiring external energy input, making it the appropriate analogy for a system whose persistence emerges from internal relationship quality rather than external governance pressure. The analogy has limits, a physical top has fixed mass and a rigid axis, whereas the TNFS's ontological conditions are dynamically reconstituted and its epistemological axis is contested and evolving, but the STMS draws on the spinning top's dynamic structural logic, not its physical determinism. At thresholds of radical socio-ecological transformation, planetary tipping points, civilizational value shifts, or irreversible systemic rupture, the living top metaphor approaches its explanatory boundary, as these conditions involve not precession and recovery but structural transformation of the system itself (Folke et al., 2010; Horn et al., 2023; Walker et al., 2004), a dynamic the STMS captures partially through its recursive feedback logic but does not fully theorize and which represents the primary direction for subsequent theoretical development.

The three anatomical features of the top map directly onto the three TNFS layers. The vertical axis is the epistemological layer, the normative orientation running through the entire system without which rotational coherence collapses into directionless wobble. The spinning body is the ontological layer, the material mass whose constitution determines the boundaries within which motion is possible. The contact point is the methodological layer, the site where the full accumulated force of conditions and values meets environmental resistance and must continuously recalibrate. The surface terrain against which the contact point negotiates, designated here as the socio-ecological operating environment, is constituted by the ontological layer itself, specifically the boundary conditions of "Ecosystem, Biosphere & Planetary Boundaries" (IC3), the dynamic complexity of "Dynamic Systems, Complexity & Change" (IC5), the relational properties of "Human–Environment & Society–Nature Relationship" (IC6), and the systemic resilience of "Resilience, Stability & Adaptive Systems" (IC7).

These three features interact through the physics of spinning, not as adjacent zones. The body spins around the axis, ontological conditions are continuously oriented by the epistemological framework running through them. The body's full momentum bears down on the contact point, the entire force of conditions and values converges at the negotiation space, which translates internal momentum into continuous engagement with external reality. Critically, the contact point transmits environmental resistance back upward through the body to the axis, methodological experience recalibrates ontological conditions and reorients epistemological values as a structural consequence of the system's own dynamic, not as a deliberate governance decision. This is precession, perturbation at the contact point causes the body to shift its rotational pattern and the axis to correct. The six structural tensions are centrifugal forces generated by the system's own spin, originating at the normative axis where competing values coexist, radiating outward through the ontological body where they manifest as competing demands on material conditions, and reaching maximum pressure at the contact point where the system's full internal force meets the resistance of the socio-ecological operating environment. They are not external threats imposed on the system but endogenous dynamics generated by the act of sustaining itself, the signature of a system genuinely engaged with its own irreducible contradictions rather than suppressing them. A living top that can precess and recover is sustaining. One that cannot recalibrate under precessional pressure loses coherent spin and falls.

Self-generating capacity emerges from three mechanisms. Structural differentiation, the axis provides directional orientation without mass, the body provides material momentum without direction, the contact point provides environmental interface without internal substance, creates the internal gradient without which no self-generated motion is possible; it is precisely because they are different kinds of things that their interaction generates dynamic coherence. Recursive feedback, the contact point continuously transmits environmental resistance back through the body to the axis, functions as the system's internal energy source, regenerating through its own circulation rather than drawing on a finite external supply. Negotiation as coherence, the contact point manages precessional pressure from structural tensions, translating destabilizing lateral forces into corrective rotational adjustments that maintain axis alignment and body momentum. Sustainability is not a property systems possess but a capacity they continuously produce through the quality of interaction between fundamentally different structural features.

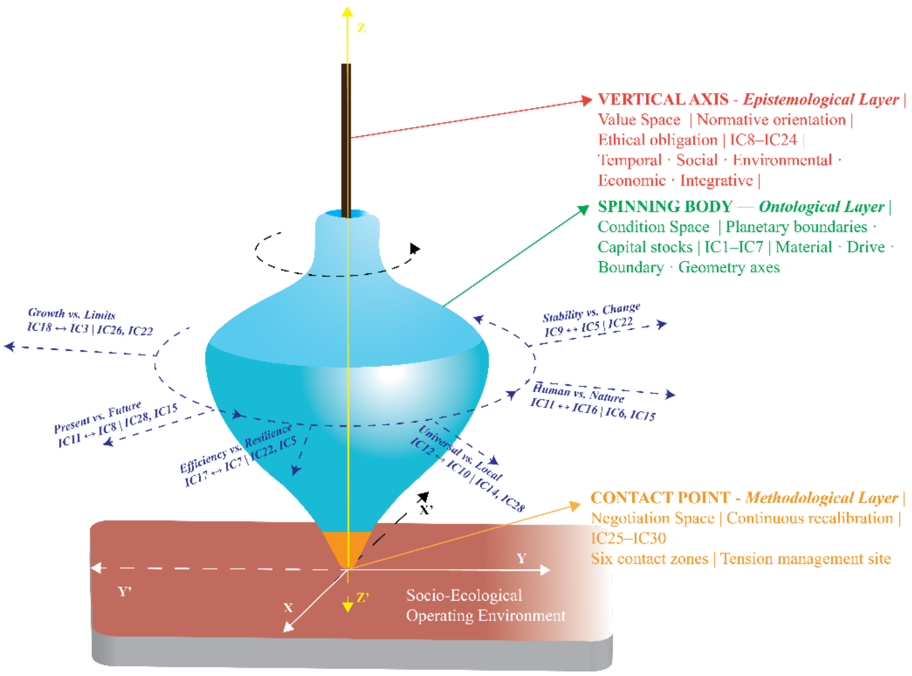

Figure 4. The Spinning Top Model of Sustainability (STMS)

4.1 Persistence and collapse conditions

The STMS identifies three persistence conditions and three corresponding failure modes. Axis alignment requires the epistemological layer to retain genuine normative coherence, when values collapse into technocratic compliance targets the axis is hollowed, producing rotation without direction, activity without normative orientation. Body momentum requires ontological conditions to remain dynamically reconstituted through methodological feedback, when conditions are treated as fixed background the body spins on residual momentum while quietly decelerating, a condition sustainability reporting systems are structurally poorly equipped to detect because they measure outputs rather than momentum. Contact point recalibration capacity requires the methodological layer to actively negotiate environmental resistance and transmit that experience back through the system, when reduced to implementation tools the contact point seizes, transmitting force downward but receiving no feedback upward, severing the recursive loop that sustains self-generation. Each failure mode is gradual and initially invisible, axis misalignment produces misdirected activity, momentum loss produces decelerating activity, contact point seizure produces brittle activity, all generating outputs that resemble sustainability performance until internal deterioration crosses the threshold at which coherent spin can no longer be maintained and the system falls.

4.2 Positioning the STMS against existing frameworks

The three pillars model targets balance, a condition of rest the living top demonstrates is equivalent to collapse, and obscures the epistemic differentiation between conditions, values, and interventions (Purvis et al., 2019). The Triple Bottom Line reduces sustainability to output measurement, enabling diagnostic inversion, a system can exhibit axis misalignment, momentum loss, and contact point seizure while generating favorable outputs (Elkington, 1997). Doughnut Economics identifies the safe space within which systems should operate but not the generative mechanism that keeps them there, the Doughnut identifies the space, the STMS explains what keeps a system coherently within it (Raworth, 2012). The SDGs provide epistemological and methodological contact points without an ontological foundation or theory of inter-domain relationships, functioning as a static checklist rather than a self-generating system (UN General Assembly, 2015). The STMS subsumes rather than replaces these frameworks, each captures a partial view of what the living top is, none explains how it moves.

4.3 Central theoretical claim

Sustainability is not a state, a balance, a space, or a set of goals. It is a condition of dynamic coherence, the emergent property of a living system that produces its own motion through the interaction of three fundamentally different structural features, sustains that motion through recursive transmission of environmental experience from contact point through body to axis, and maintains coherent identity under precessional tension through continuous recalibration. The question is not whether a system is sustainable, a binary judgment on a static condition, but whether a system is sustaining, a continuous assessment of the dynamic coherence it is actively producing through the interaction of axis, body, and contact point against the terrain of the socio-ecological operating environment.

5. Discussion

Results of thematic distribution of definitions, frequency distribution reveals that sustainability discourse is more fundamentally rooted in ethical and social reasoning than in environmental or economic considerations, challenging the conventional assumption that sustainability is primarily an environmental concern. This finding supports scholarly critiques of technocratic sustainability frameworks that reduce complex social dynamics to measurable indicators, reinforcing calls for value-laden definitions that foreground intergenerational equity and normative obligation (Arcagni et al., 2021; Drees et al., 2021; Mensah, 2019; Reid & Rout, 2020).

The stark underrepresentation of political (25), cultural (14), and legal (6) domains exposes a critical conceptual gap, as sustainability transitions are structurally dependent on governance configurations (Mzembe et al., 2025), purposeful political coordination (Patterson et al., 2017), pluralistic institutional arrangements (Braams et al., 2024; Massuga et al., 2024), and enforceable policy mixes (Kuzemko et al., 2016).The marginalization of culture is equally consequential, as cultural contexts dictate both the psychological determinants of pro-environmental behavior and how communities conceptualize sustainability (Tam, 2025), with collectivism and long-term orientation specifically translating environmental intentions into actual behavior (Chwialkowska et al., 2020; Mi et al., 2020). Cultural worldviews further prove more powerful than objective conditions in shaping environmental risk perceptions and pro-environmental attitudes (X. Lou & Li, n.d.; Yuan et al., 2023). Without cultural grounding, the social identities, group norms, and self-transcendent values essential for mobilizing collective action and fostering ecocentric orientations toward sustainability are systematically overlooked (Culiberg & Elgaaied-Gambier, 2016; Fielding & Hornsey, 2016; Mosanya & Kwiatkowska, 2023; Shen & Zhang, 2024).

The predominance of multi-domain definitions confirms broad disciplinary convergence on sustainability as an inherently interdisciplinary construct, as the historical integration of economic, social, and environmental dimensions emerged precisely to address the inadequacies of single-discipline thinking (Purvis et al., 2019), with contemporary frameworks further expanding into political and cultural spheres to reflect the complexity of sustainable development (Hariram et al., 2023; Marra, 2022). In contrast, the 19 single-domain definitions concentrated at ethical-only and economic-only poles reflect disciplinary insularity, evidenced by narrow utilitarian policy frameworks that prioritize resource efficiency while abandoning social and environmental integration (Ramcilovic-Suominen & Pülzl, 2018), and by management approaches that sustain single commodities while ignoring broader ecological and social economies (Zanotti et al., 2020). This insularity carries significant methodological consequences, as evaluating sustainability through isolated disciplinary paradigms fails to capture systemic interlinkages, undermines democratic accountability in SDG assessments (Marra, 2022), erodes social-ecological resilience (Zanotti et al., 2020), and allows institutions to make superficial policy commitments without undertaking structural change (Ramcilovic-Suominen & Pülzl, 2018).

Domain co-occurrence analysis challenges the primacy of the economic-environmental pairing in mainstream policy discourse, where global institutions have historically cemented a growth-oriented "win-win" paradigm that positions economic development as the primary mechanism for addressing environmental problems (Purvis et al., 2019), further reinforced by mainstream sustainable development definitions that problematically reproduce neoliberal economic-environmental framings (Drury et al., 2023). The broader definitional literature increasingly rejects this primacy, as utilitarian and growth-based sustainability paradigms are demonstrated to be analytically inconsistent and ultimately unfeasible unless sustainability is treated fundamentally as an ethical issue grounded in intergenerational equity (Zagonari, 2020), with scholarly and societal discourse similarly shifting away from profit maximization toward social and ethical foundations (Rincon-Roldan & Lopez-Cabrales, 2021). The emergence of Ethical–Social (71) as the most frequent pairing reflects the deep inextricability of these two domains, with ethical paradoxes positioned at the heart of sustainable development and intrinsically linked to social equity (Jabareen, 2008), ethical ideologies and personal norms identified as the strongest antecedents of socially responsible behavior (Hosta & Zabkar, 2021), prosocial propensities such as altruism constituting the psychological core of sustainable action (Otto et al., 2021), and sustainability itself increasingly reconceptualized as a normative ethical framework governing social obligations to humans, animals, and the planet (Drury et al., 2023).

The most frequent complete domain combination being Environmental–Ethical–Social (22) rather than the classic triple-bottom-line formulation reinforces a clear reorientation away from economic-centric sustainability thinking. Luque González et al. (2021) empirically demonstrate this shift, finding that the ethical dimension appears in 80% of sustainability definitions while economic considerations appear in only 31%, with social-ethical-environmental combinations carrying greater conceptual weight than economic-centric triads. Eizenberg and Jabareen (2017) further solidify this reorientation by positioning equity, justice, and safety as the ontological foundations of sustainability, explicitly superseding purely economic drivers. These patterns collectively confirm that sustainability lacks not only definitional consensus but domain consensus, as social sustainability alone is characterized as a conceptually chaotic field without universal agreement across academia and practice (Kristoffersen et al., 2024), disciplinary fragmentation persists between environmental sciences and social sciences in addressing ecological versus socio-political dimensions (Schorr et al., 2021), and despite decades of global discourse including the SDGs, an operational definition of sustainability remains elusive (Griebler et al., 2025). This fragmentation carries direct implications for interdisciplinary research and policy translation, suggesting that robust sustainability definitions must deliberately expand beyond traditional pillars to integrate political, legal, and cultural domains alongside economic, social, environmental, and ethical ones (Giojalas et al., 2021; Hariram et al., 2023)s, as Indigenous conceptualizations demonstrate that enforceable customary law and cultural relationality are inseparable from effective environmental governance (Virtanen et al., 2020), and sustainability itself must ultimately be reconceptualized as a fully integrated, place-based construct that dissolves arbitrary disciplinary boundaries to address complex societal and intercultural realities (Boyer et al., 2016).

The epistemic distribution reveals that sustainability discourse is overwhelmingly preoccupied with evaluative criteria, as assessment methods are dominated by goal-oriented evaluation frameworks while property-oriented approaches addressing structural systemic nature remain marginal (Soulé et al., 2021), with a massive proliferation of 346 evaluative indicator criteria further evidencing this preoccupation (Pires et al., 2020), alongside corporate evaluations favoring quantified performance metrics over underlying systemic capabilities (S. Lou et al., 2024). This asymmetry confirms normative standard-setting without proportionate attention to operational pathways, as voluntary sustainability standards reduce complex systems to linear compliance measurements that treat dynamic entities as industrial assembly lines (Jia, 2023), while sustainability policies similarly fail by imposing complexity-reducing targets that ignore non-linear systemic interactions and feedback loops (Stumm, 2026). The ontological underrepresentation partially explains persistent definitional fragmentation, as imprecise formulations that fail to incorporate the physical reality of socio-ecological systems sustain irresolvable conceptual debates (Ruggerio, 2021), producing over 100 different terminological combinations for assessment frameworks precisely because the systemic properties underlying evaluative standards remain poorly defined (Soulé et al., 2021). Most consequentially, the marginalization of methodological concepts directly mirrors the implementation gap, as evaluation frameworks frequently omit valid theories of change explaining how interventions translate into sustainable impacts (Jia, 2023), and while most assessment methods successfully diagnose problems, only a fraction provide actionable guidance for practitioners and policymakers (Soulé et al., 2021). Robust sustainability frameworks therefore require deliberate rebalancing, integrating holistic understanding of system interdependencies alongside human evaluation metrics (Stumm, 2026), incorporating reflexive governance and methodological theories of change beyond rigid standardized metrics (Jia, 2023), and establishing ontological clarity by accounting for the complexity and hierarchical organization of socio-ecological systems (Ruggerio, 2021).

5.1 Theoretical contribution of the TNFS

Taken together, the three layers, inter-layer relationships, recursive feedback loops, and six structural tensions constitute a conceptual architecture that reframes sustainability in three fundamental respects. First, the TNFS reframes sustainability ontologically, not as a condition defined by the balance of three pillars but as a property of dynamic, bounded socio-ecological systems that are simultaneously subject to human valuation and reshaped by human action. Second, the TNFS reframes sustainability epistemologically, as an inherently normative frame in which knowing and valuing are inseparable, consistent with the empirical finding that ethical-social domain pairings dominate sustainability definitional discourse. Third, and most significantly, the TNFS reframes sustainability methodologically, as a continuous negotiation process in which irreducible structural tensions between ontological conditions and epistemological values are managed, never resolved, through governance, education, conservation, production, program continuity, and institutional memory. This triadic reframing generates the framework's central theoretical claim that sustainability is most accurately understood not as a state, a balance, or a target, but as the quality of the negotiation process through which human systems continuously navigate the contradictions between what socio-ecological systems are and what human systems value. A sustainability framework that cannot account for the irreducibility of these contradictions, the recursiveness of human action on ontological conditions, and the inseparability of knowing and valuing will remain analytically incomplete and practically insufficient.

5.2 Implications of the STMS

The STMS generates three direct implications for sustainability research, governance, and practice. Assessment must shift from output measurement to functional evaluation, not what a system produces but whether its axis is aligned, its body is generating momentum, and its contact point is recalibrating. A system that meets all its targets while its normative coherence erodes, its adaptive capacity decelerates, and its governance learning stalls has optimized exploitation at the cost of exploration, rendering it sustaining in appearance only, efficient until the inevitable surprise it can no longer absorb (Duit & Galaz, 2008). Governance must be designed not for equilibrium but to preserve axial coherence, sustain body momentum through active feedback, and protect contact point recalibration capacity across political cycles and institutional transitions. Sustainability governance that locks in assumptions, insulates values from experience, or converts methodological spaces into compliance mechanisms is systematically dismantling the conditions for sustaining (Beunen et al., 2017; Rölfer et al., 2022). Power asymmetries produce precisely these failure signatures, an axis encoding the normative priorities of dominant actors while marginalizing future generations and non-human entities, a body whose momentum is sustained by depleting the conditions of the least powerful, and a contact point whose recalibration loop is selectively closed to challengers while remaining open to incumbents (Patterson et al., 2017; Swyngedouw, 2005). Sustainability science must treat the precessional pressure of structural tensions not as a problem to be resolved but as the generative condition that makes sustainability possible, eliminating that force removes the very dynamic whose management keeps the system alive.

The STMS functions at this stage as a meta-framework, a theoretical architecture for thinking about, designing, and critiquing sustainability systems rather than a fully operationalized measurement protocol. Axis alignment is assessable through participatory value mapping, whether communities can articulate shared normative commitments that genuinely orient decisions rather than merely legitimize predetermined ones. Body momentum is assessable through adaptive capacity indicators, whether systems are generating new responses to emerging conditions or depleting existing capacities without renewal. Contact point recalibration capacity is assessable through governance learning indicators, whether institutions are updating their approaches based on methodological experience or repeating fixed protocols regardless of feedback. These are research directions the framework's architecture makes visible rather than resolved measures, and their development constitutes the primary empirical agenda the STMS generates. Its immediate practical contribution lies in its diagnostic logic, the three failure modes of axis misalignment, momentum loss, and contact point seizure provide an analytical vocabulary for identifying why sustainability systems that appear to perform well in output terms are simultaneously losing their capacity to sustain.

The STMS can be engaged at three levels without requiring full taxonomic deployment, the meta-level through the axis-body-contact point metaphor for diagnostic reflection, the framework level through the TNFS three-layer architecture for research design, and the concept level through the 30 integrated concepts for detailed analytical work, allowing practitioners, researchers, and educators to enter the model at the depth appropriate to their purpose without mastering its full architecture before deriving analytical value from it.

6. Conclusions

This study set out to address the persistent conceptual fragmentation of sustainability by undertaking a systematic analysis of 161 definitions through Conceptual Framework Analysis. The findings reveal that sustainability discourse is more fundamentally grounded in ethical and social reasoning than in environmental or economic considerations, with the Ethical–Social domain pairing appearing in 71 definitions and the Environmental–Ethical–Social combination constituting the most frequent complete domain configuration. Political, cultural, and legal dimensions remain critically underrepresented, exposing a structural gap between the domains most frequently theorized and those most consequential for governance, behavioral change, and institutional legitimacy.

The epistemic deconstruction of 712 extracted concepts reveals a pronounced asymmetry: sustainability scholarship is overwhelmingly preoccupied with evaluative criteria while systematically underinvesting in ontological clarity and methodological theory of change. This asymmetry directly mirrors the implementation gap documented across sustainability governance, assessment, and education, where frameworks successfully diagnose problems but fail to generate actionable pathways.

Concept integration produced the Triadic Negotiation Framework for Sustainability (TNFS), a three-layer epistemic architecture in which ontological conditions, epistemological values, and methodological interventions are structurally interdependent and recursively connected. The TNFS advances a central theoretical claim: sustainability is not a fixed state to be achieved but a continuous negotiation between what socio-ecological systems are and what human systems value, and the quality of that negotiation, rather than any particular outcome it produces, is what sustainability fundamentally measures.

The Spinning Top Model of Sustainability (STMS) renders this architecture in motion. By mapping the TNFS onto the functional homology of a living spinning top, whose axial integrity, body momentum, and contact-point negotiation interact through recursive feedback to sustain coherent motion, the STMS provides both a theoretical reframing and a diagnostic vocabulary. Sustainability is reconceptualized as dynamic coherence: the emergent property of a system that continuously produces its own motion through the structured interaction of normative orientation, material conditions, and methodological negotiation against the resistance of the socio-ecological operating environment.

Three practical implications follow. First, sustainability assessment must shift from output measurement to functional evaluation, examining whether axial alignment is maintained, whether body momentum is being actively regenerated, and whether contact point recalibration capacity is preserved across political cycles. Second, sustainability governance must be designed not for equilibrium but to protect the generative conditions of dynamic coherence, recognizing that power asymmetries produce precisely the failure signatures, axis misalignment, momentum loss, and contact point seizure, that conventional reporting systems are structurally unable to detect. Third, sustainability science must treat the precessional pressure of structural tensions not as problems to be resolved but as the generative condition that makes sustainability possible.

This study carries several limitations. The corpus, while systematically assembled, reflects the availability and accessibility of English-language academic and institutional sources, potentially underrepresenting Indigenous, non-Western, and practitioner-generated conceptualizations. The STMS currently functions as a meta-framework and theoretical architecture rather than a fully operationalized measurement protocol; the development of validated indicators for axial alignment, body momentum, and contact point recalibration constitutes the primary empirical agenda the model generates. Future research should pursue cross-cultural validation of the integrated concept structure, empirical testing of the three failure mode diagnostics across diverse governance contexts, and theoretical extension of the model's recursive feedback logic to conditions of radical socio-ecological transformation where precession gives way to structural rupture.

The STMS does not replace existing frameworks. It subsumes them, each captures a partial view of what the living top is but none explains how it moves. The question sustainability science must now pursue is not whether a system is sustainable, but whether it is sustaining.

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