

Trilha 1 - Teorias e Desenvolvimento
Knowledge Before Carbon (KBC): Reinterpretando a Transformação
Sustentável por Meio das Capacidades de Conhecimento

Knowledge Before Carbon (KBC): Reframing Sustainable Transformation
Through Knowledge Capabilities

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RESUMO

Objetivo: Este estudo propõe o framework Knowledge Before Carbon (KBC) como uma teoria integradora de alcance intermediário para explicar como capacidades organizacionais de conhecimento habilitam a transformação sustentável. **Originalidade/Valor:** A contribuição não está em afirmar isoladamente que conhecimento, aprendizagem, governança ou capacidades dinâmicas importam, mas em integrá-los em uma arquitetura de conversão que conecta conhecimento distribuído, ação coordenada e continuidade ao longo do tempo. **Metodologia:** O estudo adota abordagem teórico-conceitual baseada em revisão integrativa intencional, orientada por teoria e não sistemática. Obras fundacionais e complementares foram selecionadas por centralidade teórica, relevância para conhecimento e transformação e contribuição à lógica explicativa do KBC. **Resultados:** O KBC introduz o Modelo AAA (Augmentation, Alignment e Anchoring), cinco proposições teóricas e cinco construtos conceituais. O framework posiciona capacidades de conhecimento como condições antecedentes e habilitadoras, e não como causas suficientes dos resultados de sustentabilidade. **Implicações Práticas:** O KBC oferece uma lente orientada por capacidades para diagnosticar infraestrutura de conhecimento, velocidade de aprendizagem, alinhamento, continuidade de governança e prontidão para transformação que sustentam iniciativas de sustentabilidade.

PALAVRAS-CHAVE: Gestão do Conhecimento, Transformação Sustentável, Capacidades de Conhecimento, Aprendizagem Organizacional, Capacidades Dinâmicas.

ABSTRACT

Objective: This study proposes the Knowledge Before Carbon (KBC) framework as an integrative mid-range theory to explain how organizational knowledge capabilities enable sustainable transformation. **Originality/Value:** The contribution is not the isolated claim that knowledge, learning, governance, or dynamic capabilities matter, but their integration into a conversion architecture that links distributed knowledge to coordinated action and continuity over time. **Methodology:** This study adopts a theoretical-conceptual approach based on a purposive, theory-driven, integrative literature review. Foundational and complementary works were selected for theoretical centrality, relevance to knowledge and transformation, and contribution to the explanatory logic of the KBC. **Results:** KBC introduces the AAA Model (Augmentation, Alignment, and Anchoring), five theoretical propositions, and five conceptual constructs. The framework positions knowledge capabilities as antecedents and enabling conditions rather than sufficient causes of sustainability outcomes. **Practical Implications:** KBC offers a capability-oriented lens for diagnosing whether organizations possess the

knowledge infrastructure, learning velocity, alignment, governance continuity, and transformation readiness required to support sustainability initiatives.

KEYWORDS: Knowledge Management, Sustainable Transformation, Knowledge Capabilities, Organizational Learning, Dynamic Capabilities.

1. INTRODUCTION

Sustainability has become a strategic transformation challenge in which firms must respond simultaneously to environmental pressures, technological changes, institutional expectations, and the need to reconfigure organizational capabilities. Hart's (1995) natural-resource-based view roots environmental performance in distinctive organizational capabilities rather than in external pressure or technology alone, and the transitions literature (GEELS, 2002; LOORBACH, 2010) adds that firms must navigate complex socio-technical change to get there.

However, organizational outcomes remain heterogeneous. The knowledge-based view argues that firms differ in their ability to integrate specialized knowledge (GRANT, 1996), while dynamic capabilities research explains how organizations differ in sensing, seizing, and transforming under change (TEECE; PISANO; SHUEN, 1997; TEECE, 2007). Organizational learning further suggests that the interpretation and institutionalization of knowledge vary across levels and time (CROSSAN; LANE; WHITE, 1999). These perspectives make it plausible that organizations exposed to comparable external conditions can develop different transformation capabilities.

This phenomenon raises an important theoretical and managerial question: Why do organizations facing similar sustainability challenges produce different transformation outcomes? The existing literature offers several explanations for this. Technology-oriented perspectives emphasize the role of innovation and technical solutions in enabling sustainable performance. Governance-oriented approaches focus on the structures, policies, and accountability mechanisms. Regulatory perspectives highlight the influence of institutional pressure and compliance requirements. Similarly, performance-oriented approaches rely heavily on environmental indicators, reporting standards, and sustainability metrics to evaluate the progress of organizations.

These perspectives explain less than they appear to. A technology performs only once someone knows how to select, install, and operate it. A governance structure coordinates nothing until people actually run it, and a reporting requirement records an outcome without

creating the capability behind it. Each account leaves out the same thing: the organizational knowledge that turns a resource into a result.

Therefore, an important part of this heterogeneity may reside in organizational knowledge capabilities. Prior research shows that firms integrate distributed expertise (GRANT, 1996), create and convert tacit and explicit knowledge (NONAKA, 1994; NONAKA; TAKEUCHI, 1995), learn across individual, group, and organizational levels (CROSSAN; LANE; WHITE, 1999), and preserve knowledge through organizational memory and governance mechanisms (WALSH; UNGSON, 1991; FOSS, 2007). KBC integrates these mechanisms into a common sustainability-oriented explanatory architecture.

This study defines organizational knowledge capabilities as the organizational ability to create, share, align, preserve, and apply knowledge in support of transformation objectives. These capabilities extend beyond information management and technological infrastructure. They encompass the organizational processes through which knowledge is generated, coordinated, institutionalized, and transformed into actions.

Despite their individual contributions, the existing literature on knowledge and sustainability remains relatively fragmented. They provide valuable explanations regarding specific dimensions of knowledge and transformation; however, they offer limited integration of how knowledge capabilities collectively influence sustainable transformation. Consequently, an important theoretical gap remains: the absence of a coherent explanatory framework capable of connecting organizational knowledge capabilities to sustainability outcomes.

This study addresses this gap by proposing the Knowledge Before Carbon (KBC) framework as an integrative mid-range theoretical architecture connecting organizational knowledge capabilities and sustainable transformation. KBC does not claim that knowledge is sufficient for sustainability or that it replaces capital, technology, regulation, strategic intent, or established theories. It proposes that knowledge capabilities constitute antecedent and enabling conditions through which organizations interpret, coordinate, learn, preserve continuity and mobilize transformation.

The central argument of the KBC framework is that sustainable transformation depends on an organization's ability to create, share, align, preserve, and consistently apply knowledge over time. From this perspective, sustainability is not solely a technological, regulatory, or financial challenge. This is fundamentally a knowledge challenge.

To explain how knowledge capabilities influence sustainable transformation, the framework introduces three interconnected mechanisms: Augmentation, Alignment, and

Anchoring (AAA). These mechanisms collectively describe how organizations convert knowledge into transformative capabilities. They are supported by five theoretical propositions and five organizational constructs designed to provide a foundation for future empirical investigations and practical applications.

The primary novelty claim is architectural: KBC theorizes how distributed organizational knowledge can be converted into a coordinated and persistent transformation capability. Its complementary contributions are to connect knowledge management more explicitly to sustainability transformation and to formulate propositions and conceptual constructs that can be subjected to future empirical and rival model testing.

The remainder of this paper is organized as follows. Section 2 reviews the theoretical foundations and positions of KBC relative to adjacent theories. Section 3 details the methodology of the integrative review. Section 4 presents the KBC framework, Hourglass, AAA Model, and the propositions. Section 5 defines the conceptual framework. Sections 6 and 7 discuss the proposed framework and its contributions. Section 8 establishes the scope, limitations, boundary conditions, and research agenda. Section 9 concludes the study.

2. THEORETICAL FOUNDATIONS

The KBC framework is built on the integration of theoretical streams that explain different aspects of knowledge, learning, coordination, transformation and sustainability. Rather than treating these streams as independent bodies of literature, this study interprets them as complementary explanations of a broader phenomenon: the conversion of organizational knowledge capabilities into sustainable transformation.

2.1 Knowledge-Based View

The Knowledge-Based View (KBV) provides the foundational logic for understanding knowledge as a strategic organizational resource. Emerging as an extension of the Resource-Based View (BARNEY, 1991), the KBV argues that knowledge is among the most important resources of a firm because it is difficult to imitate, context-dependent, and deeply embedded in organizational routines and practices.

Grant (1996) argues that the firm's central role is to integrate specialized knowledge distributed among individuals. Kogut and Zander (1992) suggest that firms exist because they are effective social communities for creating, transferring, and applying knowledge. Spender (1996) reinforces this perspective by positioning knowledge as the basis for a dynamic theory of the firm.

From this perspective, competitive advantage does not arise merely from possessing tangible assets or formal organizational structures. It depends on the organization's ability to combine dispersed knowledge and mobilize it for problem solving, innovation, and adaptation. Knowledge is not simply information stored in systems; it is an organizational capability that shapes actions.

This interpretation is highly relevant to sustainable transformation. If knowledge is a primary strategic resource, the ability to address environmental and social challenges also depends on the maturity of organizational knowledge capabilities. Technologies, investments, and policies generate sustainable outcomes only when organizations possess the knowledge required to select, implement, coordinate, and sustain them. This logic is consistent with the natural-resource-based view of the firm, which roots environmental performance in distinctive organizational capabilities (HART, 1995). Therefore, KBV supports the first proposition of KBC: knowledge precedes sustainable performance.

2.2 Organizational Knowledge Creation

If the KBV establishes that knowledge matters, the Organizational Knowledge Creation Theory explains how knowledge is created, shared, and transformed within organizations. Nonaka (1994) and Nonaka and Takeuchi (1995) built their account of knowledge creation on the dynamic interaction between tacit and explicit knowledge.

Tacit knowledge refers to experience, intuition, skills, and mental models that are difficult to formalize in writing. In contrast, explicit knowledge can be codified, documented, and transmitted through reports, procedures, databases, and systems. The SECI model describes knowledge creation as a continuous process involving socialization, externalization, combination, and internalization.

Socialization enables tacit knowledge to be shared through interactions and shared experiences. Externalization transforms tacit insights into explicit concepts, models and documents. Combination integrates different forms of explicit knowledge into new configurations. Internalization occurs when individuals incorporate explicit knowledge into their practices and routines. Nonaka, Toyama, and Konno (2000) further emphasize the importance of Ba, a shared context in which knowledge is created and exchanged.

In sustainability contexts, knowledge is often distributed across multiple departments, disciplines, and hierarchies. Environmental, operational, financial, technological, and regulatory knowledge must be integrated to support effective transformation. When

knowledge creation and sharing are weak, organizations experience fragmented interpretations, duplicated efforts, and difficulties in implementation.

Therefore, the SECI perspective supports the second proposition of KBC: sustainability is a knowledge coordination problem. Sustainable transformation requires not only knowledge but also the capacity to convert individual and departmental knowledge into collective organizational capability.

2.3 Organizational Learning

Knowledge creation and sharing are necessary but insufficient for transformation. Knowledge must be assimilated, interpreted, and incorporated into the organizational practices. This is the central concern of the Organizational Learning literature.

Argyris and Schon (1978) defined organizational learning as a process through which individuals and organizations detect and correct errors. Their distinction between single- and double-loop learning is particularly relevant. Single-loop learning involves corrective actions without questioning the underlying assumptions. In contrast, double-loop learning involves revising the assumptions, beliefs, and mental models that guide actions.

In sustainability initiatives, organizations often begin with single-loop learning, such as improving efficiency, reducing waste, and complying with reporting requirements. These improvements are valuable but may be incremental. A deeper sustainable transformation frequently requires double-loop learning, including questioning how value is created, how risks are interpreted, and how long-term impacts are incorporated into decisions.

Senge (1990) further developed the idea of a learning organization by emphasizing systems thinking, shared vision, team learning, personal mastery, and mental models. Crossan, Lane, and White (1999) proposed a multilevel learning framework that connects individual intuition, group interpretation, organizational integration, and institutionalization.

Together, these contributions suggest that transformation depends on the speed and depth of the learning process. In dynamic environments characterized by regulatory changes, technological acceleration, and shifting stakeholder expectations, organizations that learn faster are better positioned to adapt. This capacity to recognize, assimilate, and apply new external knowledge is captured by the notion of absorptive capacity (COHEN & LEVINTHAL, 1990). This supports the third proposition of KBC: the speed of transformation depends on the speed of learning.

2.4 Knowledge Governance and Organizational Memory

Creating, sharing, and learning knowledge is insufficient if critical knowledge is lost over time. Organizations frequently experience knowledge loss due to turnover, restructuring, leadership changes, mergers, technological shifts, and changes in strategic priorities. This problem is especially relevant to sustainability, where transformation often requires long time horizons and continuity across management cycles.

Knowledge Governance addresses how organizational structures, incentives, coordination mechanisms, and decision processes influence knowledge creation and use. Foss (2007) argues that knowledge governance focuses on the mechanisms that shape knowledge-related behaviors. Grandori (2001) similarly emphasized the role of governance mechanisms in coordinating knowledge-intensive activities.

Organizational Memory complements this perspective by explaining how knowledge is stored and retrieved over time. Walsh and Ungson (1991) described organizational memory as knowledge retained by individuals, culture, structures, procedures, physical settings, and external archives. Stein and Zwass (1995) further discuss how information systems can actualize an organizational memory.

The KBC framework integrates these perspectives by interpreting governance not only as a mechanism of control or compliance but also as a mechanism of memory. Governance can stabilize critical knowledge, preserve lessons learned, institutionalize routines, and enable continuity in the transformation processes.

This interpretation supports the fourth proposition of the KBC: governance is organizational memory. In sustainability contexts, governance mechanisms help ensure that knowledge survives leadership changes, organizational restructuring, and the passage of time.

2.5 Dynamic Capabilities

While the preceding mechanisms explain how knowledge is created, shared, learned, and preserved, Dynamic Capabilities explain how knowledge is converted into action. Teece, Pisano, and Shuen (1997) defined dynamic capabilities as a firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments. Teece (2007) later refined this view by distinguishing between sensing, seizing, and transforming capabilities.

Sensing refers to the ability to identify opportunities and threats. Seizing refers to the ability to mobilize resources and make decisions that capitalize on opportunities. Transforming refers to the ability to reconfigure structures, processes, and competencies, over

time. Eisenhardt and Martin (2000) complement this discussion by emphasizing dynamic capabilities as identifiable and learnable, organizational processes. Zollo and Winter (2002) argue that dynamic capabilities emerge from deliberate learning mechanisms, reinforcing the connection between knowledge and adaptive capacity.

The relevance of dynamic capabilities for sustainability is thus evident. Organizations must sense regulatory shifts, technological innovations, climate risks, market expectations and stakeholder demands. They must seize opportunities through investments, process redesign, and strategic choices. They must transform their organizational routines, structures, and capabilities to sustain change over time.

However, these processes fundamentally depend on knowledge. Organizations cannot sense what they do not know. They cannot seize opportunities without the interpretive capacity. They cannot transform without learning and coordination. From the KBC perspective, knowledge is a condition that is antecedent to dynamic capability. This supports P5 while preserving an important qualification: knowledge is proposed as an antecedent enabling condition of transformation, not as a sufficient or empirically demonstrated cause of carbon outcomes.

2.6 Sustainability Transition

The sustainability Transition literature provides the application context for the KBC framework. Sustainable transformation is not limited to incremental environmental improvements; it often requires changes in technology, processes, business models, institutions, behaviors, and decision-making structures.

Geels (2002) proposed the Multi-Level Perspective (MLP) to explain socio-technical transitions through the interaction of niches, regimes, and landscapes. Niches are spaces for experimentation in which new practices and technologies emerge. Regimes represent dominant structures, norms and routines. Landscapes include broader external pressures such as regulations, macroeconomic forces, social expectations, and global environmental change.

Geels and Schot (2007) further explain that transitions occur through different pathways, depending on the interaction between landscape pressures, regime stability, and niche development. Loorbach (2010) introduced transition management as a governance approach for steering sustainable development in complex systems.

Although the Sustainability Transition literature provides a strong understanding of systemic change, it often pays less explicit attention to the organizational knowledge capabilities required to support such transitions. Sustainable transformation requires

organizations to interpret complex signals, integrate distributed knowledge, coordinate internal actors, learn continuously and preserve strategic memory.

Therefore, Sustainability Transition provides the context in which KBC operates, while knowledge management, learning, dynamic capabilities, and governance provide the mechanisms through which transformation becomes possible. Collectively, these theoretical foundations suggest that sustainable outcomes emerge from knowledge capabilities that enable transformation.

Quadro 1 - Literature Review Matrix and Theoretical Foundations of the KBC Framework

Theoretical Stream	Key Authors	Core Concepts	Contribution to KBC
Knowledge-Based View	Grant (1996); Kogut & Zander (1992); Spender (1996)	Knowledge as strategic resource; knowledge integration	Foundation for P1. Position knowledge as the primary organizational resource and antecedent of sustainable performance.
Organizational Knowledge Creation	Nonaka (1994); Nonaka & Takeuchi (1995); Nonaka et al. (2000)	Tacit knowledge; explicit knowledge; SECI; Ba	Foundation for P2. It explains how knowledge circulates and becomes a collective capability.
Organizational Learning	Argyris & Schon (1978); Senge (1990); Crossan et al. (1999)	Single-loop learning; double-loop learning; learning organization	Foundation for P3. This supports the argument that transformation speed depends on learning speed.
Dynamic Capabilities	Teece et al. (1997); Teece (2007); Eisenhardt & Martin (2000)	Sensing; seizing; transforming	Foundation for P5. It explains how knowledge is translated into adaptive and transformational capabilities.
Knowledge Governance	Foss (2007); Grandori (2001)	Governance mechanisms; coordination structures	Foundation for Alignment, and P4. It explains the organizational coordination of knowledge resources.
Organizational Memory	Walsh & Ungson (1991); Stein & Zwass (1995)	Memory repositories; knowledge retention	Foundation for Anchoring and Governance (C4).
Sustainability Transition	Geels (2002); Geels & Schot (2007); Loorbach (2010)	Multi-Level Perspective; socio-technical transitions	Defines the application context of the framework.
Human-AI Augmentation	Davenport & Kirby (2016); Brynjolfsson & McAfee (2014); Wilson & Daugherty (2018)	Augmentation; collaborative intelligence	Foundation for the Augmentation dimension of the AAA Model.

Source: Prepared by the author.

2.7 Theoretical Gap and Positioning of the KBC Framework

The literature reviewed in the previous sections provides important contributions to understanding knowledge and organizational transformation. The Knowledge-Based View explains why knowledge is a strategic resource. Organizational Knowledge Creation Theory explains how knowledge is generated and shared within organizations. Organizational Learning explains how organizations assimilate and institutionalize new knowledge. Dynamic Capabilities explain how organizations adapt to and transform in changing environments.

Knowledge Governance and Organizational Memory explain how knowledge is coordinated and preserved over time. The sustainability Transition literature explains the broader processes of systemic transformation.

Despite these contributions, an important theoretical gap remains at the intersection of these research streams. KBV emphasizes the integration of specialized knowledge (GRANT, 1996), Absorptive Capacity emphasizes recognition, assimilation, and application of external knowledge (COHEN; LEVINTHAL, 1990), and Dynamic Capabilities emphasizes sensing, seizing, and transforming (TEECE, 2007). KBC does not treat these perspectives as absent; it asks whether an explicit architecture of knowledge creation, coordination, and continuity can add explanatory value for sustainable transformation beyond what each stream explains separately.

Recent studies reinforce the relevance of this intersection. Gupta and Agarwal (2023) identify individual, technological, and organizational enablers of knowledge sharing for organizational sustainability, while Feroz et al. (2023) show that sustainable digital transformation depends on identifiable organizational capabilities for sensing, seizing, and transforming. These contributions strengthen the contemporary basis for examining knowledge-related capabilities while also sharpening the KBC question: whether an explicit architecture of knowledge creation, coordination, continuity, and transformation readiness adds explanatory value beyond adjacent capability models.

This study argues that such variations can be partially explained by differences in organizational knowledge capabilities. More specifically, sustainable transformation depends on an organization's ability to create, share, align, preserve, and consistently apply knowledge over time. These capabilities influence how organizations interpret sustainability challenges, coordinate actions, learn from experiences, institutionalize knowledge, and convert insights into transformation readiness.

Knowledge Before Carbon (KBC) is defined as an integrative mid-range theory that explains how organizational knowledge capabilities are converted into sustainable transformation through the mechanisms of Augmentation, Alignment, and Anchoring.

Unlike existing theories that focus on the isolated dimensions of the phenomenon, KBC integrates multiple theoretical streams into a unified explanatory architecture. Its contribution is not to replace established theories but to connect them through a common causal logic that positions knowledge as an antecedent of sustainable outcomes.

Quadro 2 summarizes the positioning of the KBC relative to its principal theoretical foundations.

Quadro 2 – Positioning of KBC Relative to Existing Theories

Theoretical Stream	Primary Contribution	Main Limitation	Contribution of KBC
Knowledge-Based View	Knowledge as a strategic resource	Limited explanation of transformation processes	Connects knowledge capabilities to sustainability outcomes

Theoretical Stream	Primary Contribution	Main Limitation	Contribution of KBC
Organizational Knowledge Creation	Knowledge creation and sharing	Limited sustainability perspective	Explains conversion into transformation readiness
Organizational Learning	Learning and adaptation processes	Does not by itself integrate governance continuity and sustainability transformation	Connects learning speed with alignment, anchoring, and transformation readiness
Dynamic Capabilities	Organizational adaptation and transformation	Knowledge mechanisms may remain implicit; strong conceptual overlap with KBC requires rival-model testing	Proposes an explicit knowledge conversion and continuity architecture antecedent to transformation capability; incremental value remains to be tested
Knowledge Governance	Coordination mechanisms	Limited transformation perspective	Explains alignment mechanisms
Organizational Memory	Knowledge retention and continuity	Limited transformation perspective	Explains anchoring mechanisms
Sustainability Transition	Systemic sustainable change	Limited organizational explanation	Explains organizational conversion processes

Therefore, the principal contribution of KBC lies in reframing sustainability through the lens of organizational knowledge capabilities. From this perspective, sustainability indicators and environmental outcomes are not interpreted solely as consequences of technology, capital, or regulation. They are also understood as manifestations of underlying knowledge capabilities that enable transformation over time.

3. METHODOLOGY

This study adopts a theoretical-conceptual approach based on a purposive, theory-driven integrative literature review. Integrative reviews are appropriate when the objective is to synthesize mature but dispersed bodies of literature and develop a new conceptual or theoretical perspective rather than estimate an effect or provide exhaustive bibliometric coverage (TORRACO, 2005; WHITTEMORE; KNAFL, 2005; SNYDER, 2019). Accordingly, the review is explicitly non-systematic; it does not claim exhaustive retrieval, a PRISMA-type protocol, or reproducible coverage of every publication in the field.

The analytical procedure followed five theory-building stages adapted from Whitemore and Knafl (2005): (1) problem identification, (2) literature search and theoretical discovery, (3) evaluation and purposive selection of sources, (4) cross-stream analysis and concept mapping, and (5) integrative interpretation. The guiding problem was the absence of an integrated explanation connecting organizational knowledge capabilities to sustainable transformation. The search and discovery process focused on the Knowledge-Based View,

organizational knowledge creation, organizational learning, absorptive capacity, dynamic capabilities, knowledge governance, organizational memory, sustainability transition, and, as a contemporary augmentation stream, human-AI collaboration.

Source inclusion was guided by three explicit criteria: theoretical centrality within the relevant stream, direct relevance to knowledge creation, integration, learning, coordination, preservation, adaptation, or sustainable transformation, and explanatory complementarity with the emerging KBC architecture. Foundational works were used to establish construct genealogy, while more recent integrative reviews and capability-oriented studies were used to challenge the framework's positioning. Sources were excluded from the core synthesis if they were peripheral to the research question, duplicated an already represented theoretical mechanism without adding explanatory value, or concerned sustainability outcomes without an organizational knowledge mechanism. Because the selection was purposive and interpretive, the resulting corpus should be understood as a theory-building sample rather than an exhaustive representation of the literature.

The analysis proceeded through theory-to-architecture mapping. For each theoretical stream, this study identified its focal mechanism, explanatory contribution, limitation for the focal problem, and potential relationship with other streams. These mappings were compared iteratively to derive the KBC central thesis, AAA conversion logic, five propositions, and five conceptual constructs. Rival explanations were retained rather than treated as displaced theories: in particular, Dynamic Capabilities and Absorptive Capacity establish important tests of incremental explanatory value. No primary data were collected, and no statistical mediation, causal magnitude, construct validity, or measurement scale validity was claimed. Therefore, the resulting framework is offered as a falsifiable theoretical proposal for future empirical examination.

4. RESULTS AND DISCUSSION

4.1 Central Thesis

The KBC framework begins with a bounded theoretical claim: technologies, regulations, investments, and institutional pressures do not by themselves explain how organizations achieve and sustain transformation. KBC proposes that organizational knowledge capabilities are antecedent and enabling conditions that shape how resources and pressures are interpreted, coordinated, learned from, and converted into action.

This claim does not deny the importance of technology, regulations, financial resources, strategic intent, or institutional feasibility. These factors may independently enable, constrain, or determine particular outcomes. KBC focuses on the organizational knowledge architecture that can make transformation more reliable when problems are uncertain, distributed, and knowledge-intensive.

Therefore, the central thesis of KBC may be summarized as follows: an organization's capacity to pursue sustainable transformation is influenced by its ability to create, share, align, preserve, and apply relevant knowledge consistently over time. The phrase 'knowledge is an outcome; knowledge is the cause' is retained only as an executive heuristic for this knowledge-first orientation; it should not be interpreted as an empirically demonstrated monocausal law.

4.2 KBC Hourglass Framework

The KBC framework is represented by an hourglass model that illustrates how knowledge capabilities are converted into organizational outcomes. The upper part of the hourglass represents knowledge capabilities, including infrastructure, creation, sharing, learning, and knowledge retention. The narrow center represents the critical conversion point through which knowledge becomes coordinated action. The lower part represents organizational outcomes, including decision quality, transformation readiness, adaptive capacity, and sustainability.

The hourglass metaphor is not merely visual. It expresses the logic that knowledge does not automatically produce a transformation. Knowledge must pass through organizational mechanisms that amplify, coordinate, and preserve it. This conversion process is captured by the AAA Model: Augmentation, Alignment, and Anchoring.

The main contribution of the hourglass model is to invert the dominant logic of sustainability analyses. Instead of beginning with carbon metrics and looking backward, KBC begins with knowledge capabilities and explains how they create the conditions for sustainable outcomes.

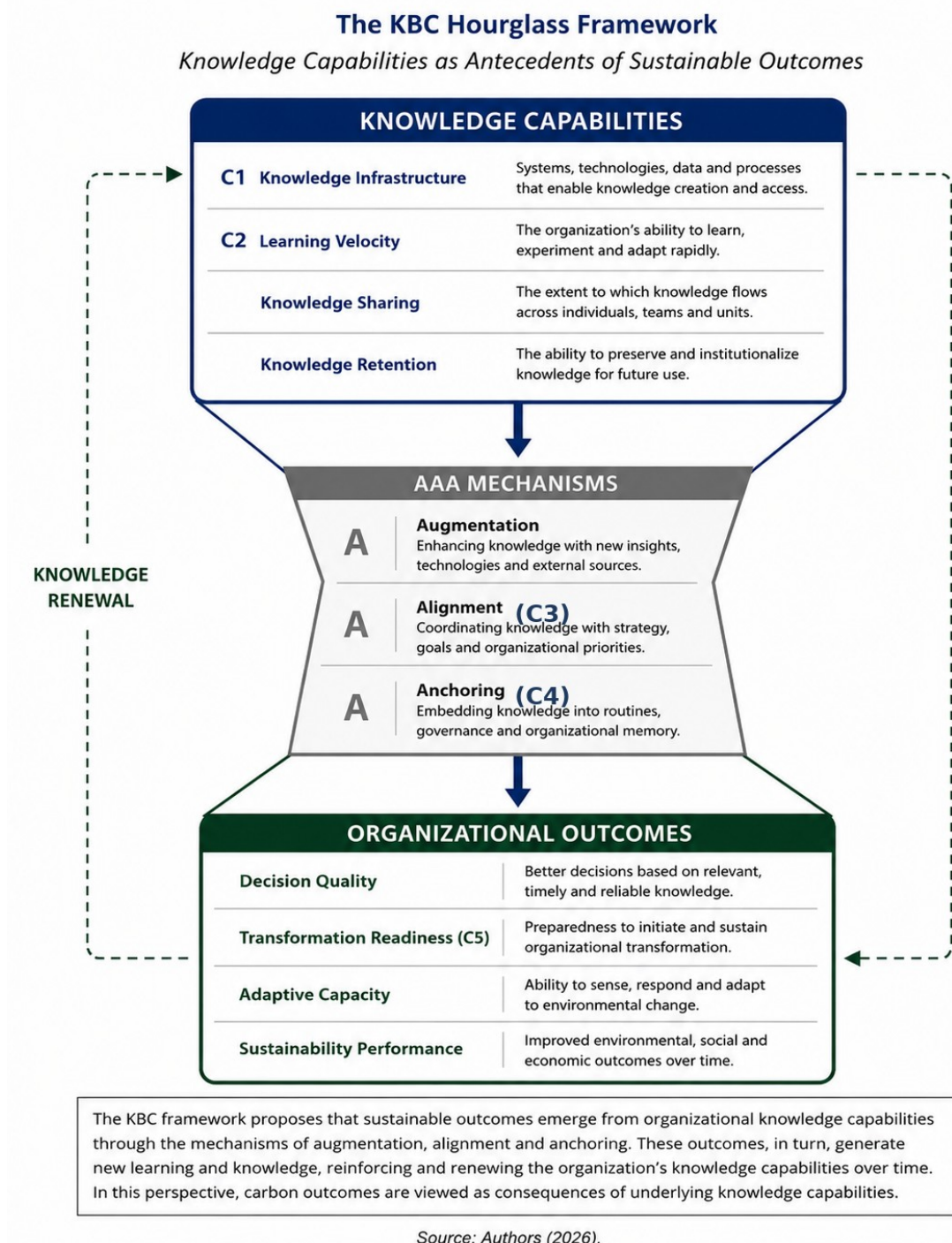


Figure 2: KBC Hourglass Framework: Conversion of Knowledge Capabilities into Sustainable Outcomes.
Source: Prepared by the authors.

4.3 AAA Model

The operational core of the KBC is the AAA Model, which comprises three complementary mechanisms: Augmentation, Alignment, and Anchoring. These mechanisms explain how organizational knowledge capabilities are converted into transformation readiness.

Augmentation refers to the expansion of human and organizational capacity to create, interpret, share, and apply knowledge. It includes training, collective learning, expert networks, decision support systems, digital tools, and artificial intelligence. In the KBC framework, technology does not replace human knowledge. It amplifies the capacity of individuals and organizations to deal with complex issues.

Alignment refers to the coherence between strategies, processes, structures, indicators, decisions, and behaviors. Knowledge that remains fragmented across organizational silos does not lead to transformation. Therefore, alignment is the mechanism that coordinates knowledge toward common objectives. Among the three mechanisms, Alignment occupies a central position because it connects knowledge with organizational action.

Anchoring refers to the preservation of knowledge over time through governance, memories, routines, policies, and institutional mechanisms. Sustainable transformation often requires continuity over long time horizons. Without anchoring, critical knowledge may be lost through turnover, restructuring or changes in leadership. Anchoring ensures that knowledge becomes part of the organizational memory rather than remaining dependent on isolated individuals.

Together, Augmentation expands knowledge capacity, alignment coordinates knowledge application, and anchoring preserves knowledge continuity. These mechanisms constitute the central conversion processes of the KBC framework.

The three mechanisms do not map onto the constructs one-to-one. Alignment and Anchoring operate as specific organizational capabilities and are therefore expressed directly in the constructs Alignment Quality (C3) and Governance Anchoring (C4). In contrast, augmentation functions as a transversal enabler that amplifies other capabilities rather than acting as an isolated dimension. Because human and technological augmentation increases the capacity to create, interpret, share, and preserve knowledge, its effects are distributed across Knowledge Infrastructure (C1) and Learning Velocity (C2) rather than being represented as a separate construct. This interpretation preserves the parsimony of the framework while explaining why the AAA mechanisms and the five constructs are related but not symmetrically mapped to each other.

The mechanisms should not be interpreted as quantities that should be maximized without limits. Insufficient augmentation can restrict the analytical capacity, whereas excessive augmentation may create information overload. Insufficient alignment can fragment actions, whereas excessive alignment may suppress dissent. Insufficient anchoring can cause organizational forgetting, whereas excessive anchoring may preserve obsolete routines. These potential nonlinearities are boundary hypotheses generated by the conceptual architecture and require empirical testing rather than being treated as established effects.

4.4 Theoretical Propositions

The KBC framework is supported by five theoretical propositions that synthesize the integration of the theoretical streams discussed in this article. These propositions offer a basis for future empirical investigations.

Quadro 3 - Theoretical Propositions of the KBC Framework

Code	Proposition	Main Theoretical Foundation
P1	Under conditions of sustainability-oriented strategic intent and feasible action, the maturity of organizational knowledge capabilities is positively associated with sustainable transformation performance.	Knowledge-Based View
P2	The effectiveness of sustainability initiatives is positively associated with an organization's capacity to coordinate relevant distributed knowledge across areas, functions, and hierarchical levels.	Organizational Knowledge Creation / SECI
P3	The speed of sustainable transformation is positively associated with the speed at which relevant and sufficiently validated knowledge is acquired, interpreted, shared and applied.	Organizational Learning
P4	Governance mechanisms that preserve, transmit, update, and make critical knowledge retrievable, support continuity in sustainable transformation over time.	Knowledge Governance and Organizational Memory
P5	Knowledge capabilities contribute to transformation readiness; however, realized sustainability outcomes are also conditioned by strategic intent, resources, institutional feasibility, and external constraints.	Dynamic Capabilities and Sustainability Transition

Source: Prepared by the author.

4.5 Constructs of the KBC Framework

While the propositions provide the explanatory logic of KBC, the five constructs identify the conceptual dimensions through which parts of that logic may later be observed. They are not proposed as a validated scale, nor does the present article assume that all five occupy the same causal level. Knowledge Infrastructure and Learning Velocity can operate as enabling conditions; Alignment Quality and Governance Anchoring represent organizational states/capabilities associated with the conversion process; and Transformation Readiness is

treated as a proximal capability state closer to implementation. This layering is specified to reduce circularity and must be tested empirically.

Knowledge Infrastructure refers to the organizational capacity to store, organize, make available, and retrieve knowledge required to support decisions and transformation processes. It includes procedures, documentation, knowledge bases, information systems, lessons learned, and formal knowledge sharing mechanisms.

Learning Velocity refers to the speed at which individuals and organizations acquire, interpret, share, and apply new knowledge. It captures not only how much learning occurs, but also how quickly new knowledge is incorporated into organizational practices.

Alignment Quality refers to the degree of coherence between strategy, objectives, processes, indicators, structures, and behaviors. This reflects the organizational capacity to coordinate knowledge across functions and convert it into consistent action.

Governance Anchoring refers to the capacity to preserve, stabilize, and transmit critical knowledge over time. It includes governance structures, institutionalized routines, monitoring systems, policies, and mechanisms that support the continuity of the program.

Transformation Readiness refers to the organizational preparedness to mobilize coordinated implementation once relevant knowledge and strategic decisions are available. It is conceptually distinct from sustainability outcomes: an organization may be ready to transform but remain constrained by resources, strategic intent, institutional feasibility, or external conditions.

Quadro 4 - Constructs of the KBC Framework

Code	Construct	Definition	Associated Proposition
C1	Knowledge Infrastructure	Capacity to store, organize, make available, and retrieve knowledge:	P1
C2	Learning Velocity	Speed of acquisition, interpretation, sharing, and application of new knowledge:	P3
C3	Alignment Quality	Coherence among strategies, processes, indicators, decisions, and behaviors.	P2
C4	Governance Anchoring	Capacity to preserve, stabilize, and transmit critical knowledge over time.	P4
C5	Transformation Readiness	Preparedness to mobilize coordinated implementation once relevant knowledge and strategic decisions are available, distinct from the realized sustainability outcome.	P5

Source: Prepared by the author.

4.6 Discussion

The KBC framework contributes to the sustainability debate by shifting the analytical attention from observable outcomes to the organizational capabilities that make such outcomes possible. Much of the contemporary sustainability agenda is organized around metrics, technology, regulatory compliance, and reporting. These elements are essential, but they provide only a partial explanation of the transformation.

Technology-first approaches assume that technical solutions will generate sustainable results once adopted. However, technologies require knowledge for their selection, implementation, operation, adaptation, and scaling. Compliance-first approaches emphasize rules, controls, and reporting obligations; however, compliance does not automatically create learning, alignment, or organizational memory. Carbon-first approaches focus on emissions and environmental indicators, but the indicators describe outcomes more than they explain their causes.

KBC proposes a knowledge-first perspective without asserting a knowledge-only explanation for the phenomenon. From this perspective, sustainable performance is partly conditioned by the capabilities through which organizations create, share, align, preserve, and apply relevant knowledge. Technology, capital, regulation, leadership, culture, and institutional conditions remain alternative or complementary explanations for this phenomenon. The theoretical value of KBC therefore depends on whether its knowledge architecture adds explanatory power beyond these factors and beyond established constructs such as Absorptive Capacity and Dynamic Capabilities.

This reframing does not diminish the relevance of the carbon metrics or sustainability indicators. Instead, it distinguishes outcomes from the organizational conditions that may precede them. KBC is also bounded by the quality of the knowledge being mobilized: a highly capable organization can coordinate and preserve knowledge that is incomplete, obsolete, or incorrect. Therefore, knowledge capability should be distinguished from epistemic validity, a distinction that has become an explicit priority for future research.

The framework also bridges knowledge management and sustainability. Traditionally, the knowledge management literature has focused on knowledge creation, sharing, learning, and retention. The sustainability literature has focused on environmental outcomes, socio-technical change, and governance. KBC connects these domains by proposing that knowledge capabilities are the antecedents of sustainable transformation.

5. FINAL CONSIDERATIONS AND IMPLICATIONS

The contributions of KBC are primarily theoretical and architectural. It does not claim that knowledge, learning, governance, memory, or dynamic capabilities are new individually. Rather, it integrates these established streams to explain a specific problem: how distributed organizational knowledge may be converted into a coordinated and persistent transformation capability. This architecture offers a basis for explaining part of the heterogeneity in sustainability transformation outcomes, while remaining open to rival explanations and empirical falsification.

The AAA Model provides the proposed conversion logic. Augmentation expands human and organizational capacity; alignment coordinates distributed knowledge with collective action; anchoring supports continuity across time. These mechanisms are conceptual and have not been validated as statistically distinct or mediators of these relationships. Their empirical separability, relative importance, and possible nonlinear effects remain unanswered questions.

A further contribution is the connection between governance and organizational memory within the anchoring mechanism. The framework does not equate governance universally with memory; rather, it proposes that selected governance routines can function as memory mechanisms by preserving, transmitting, updating, and making critical knowledge retrievable over time.

Practically, the framework offers a diagnostic lens rather than a prescriptive one. Organizations can examine whether sustainability initiatives are constrained by inaccessible knowledge, slow learning, cross-functional misalignment, loss of critical knowledge, or limited readiness to mobilize and coordinate implementation. Such a diagnosis should complement, not replace, technical, financial, regulatory, and environmental analyses.

Managerially, KBC suggests that leaders examine the knowledge conditions surrounding sustainability investments: how evidence is generated and challenged, how functions coordinate interpretations, how lessons survive turnover, and how obsolete knowledge is revised or retired. This extends the practical implications beyond generic recommendations to invest in knowledge systems and observable organizational questions that can guide future diagnostics and case-based research.

5.1 Scope, Limitations and Future Research

The KBC framework was developed to explain the relationship between organizational knowledge capabilities and sustainable transformation under conditions in which knowledge is distributed, uncertainty is material, and coordinated learning and continuity are important. Its scope and limitations define the conditions under which a theory should be interpreted and tested.

First, this study is both theoretical and conceptual. It contains no primary empirical evidence and does not establish causal magnitude, statistical mediation, predictive validity or validated measurement scales. Propositions are theoretical statements that can be supported, revised, or rejected through future research.

Second, KBC does not replace the Knowledge-Based View, SECI, Organizational Learning, Absorptive Capacity, Dynamic Capabilities, Knowledge Governance, Organizational Memory, or Sustainability Transition. Its incremental contribution remains contingent on demonstrating that the integrated knowledge-to-transformation architecture explains variance or mechanisms not already captured by these established perspectives, especially Dynamic Capabilities and Absorptive Capacity.

Third, KBC is not proposed as a sufficient or universally positive cause of sustainable outcome. Strategic intent, resource sufficiency, institutional feasibility, regulation, leadership, culture, and epistemic validity may moderate, constrain, or redirect this relationship. In addition, AAA mechanisms may exhibit nonlinear failure modes: excessive alignment may become conformational, and excessive anchoring may become rigid. These are theoretical boundary hypotheses and not the findings of the present study.

Future research should be conducted sequentially. The first priority is construct specification: defining domains, exclusions, levels of analysis, and discriminant boundaries among C1-C5 and neighboring constructs. Qualitative critical-incident studies can then be used to assess content validity and identify observable indicators. Only after this stage should scale development and factor validation be considered for future research. Rival-model tests should compare KBC with Dynamic Capabilities, Organizational Learning, and Absorptive Capacity and examine their incremental explanatory value. Longitudinal and multi-source designs should be used to test the temporal precedence between knowledge capabilities, transformation readiness, and outcomes. Further studies should examine boundary conditions, possible non-linearities in Alignment and Anchoring, the distinction between knowledge capability and epistemic validity, and whether KBC predicts transformation reliability and adaptability across repeated decisions rather than isolated project success.

5.2 Conclusions

This study addresses the following central question: How do knowledge capabilities influence an organization's capacity to promote sustainable transformation? To answer this question, the Knowledge Before Carbon framework was proposed as an integrative conceptual architecture connecting knowledge management, organizational learning, dynamic capabilities, governance, organizational memory, and sustainability transition literature.

The main contribution of this study is to position organizational knowledge capabilities as proposed antecedents and enabling conditions of sustainable transformation and to specify an architecture through which this relationship can be examined. The contribution is integrative rather than substitutive: KBC connects established theories while exposing its own claims to future rival model testing.

The framework proposes that sustainable transformation is influenced by an organization's ability to create, share, align, preserve, and consistently apply relevant knowledge over time. The AAA Model describes a conceptual conversion logic through Augmentation, Alignment, and Anchoring while recognizing that strategic intent, resources, institutional feasibility, and knowledge validity can condition realized outcomes.

Although developed in the context of sustainability, the architecture may be relevant to other transformation domains; this possibility is outside the evidence of the present study and should be treated as a future research question rather than a demonstrated generalization.

In summary, sustainability should not be understood only as a technological, regulatory or financial challenge. KBC proposes that this is also a knowledge capability challenge. The value of that proposition will ultimately depend on empirical evidence showing where the framework holds, where it adds to its explanatory power, and where it fails.

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