www.sci-cult.com

SCIENTIFIC CULTURE, Vol. 12, No. 4, (2026), pp. 328-340
Open Access. Online & Print

DOI: 10.5281/zenodo. 12426128

SUSTAINABLE ORGANIZATIONAL RESILIENCE PRECEDENTS IN HEALTHCARE ORGANIZATIONS: PIVOTAL ROLES OF CIRCULAR INTELLIGENCE AND KNOWLEDGE INTEGRATION

Ibrahim A. Alibrahim[1], Islam Elgammal[2*], Kareem M. Selem[3]

[1] *Assistant Professor, College of Media and Communication, Imam Mohammad Ibn Saud Islamic University (IMSIU), Riyadh, Saudi Arabia..*
[2] *College of Business Administration, University of Business and Technology, Jeddah, Saudi Arabia.*
[3] *Hotel Management Department, Faculty of Tourism and Hotels, Suez Canal University, 41522, Egypt.*

Received: 01/09/2025
Accepted: 02/12/2025

Corresponding author: Islam Elgammal
(I.elgammal@ubt.edu.sa)

ABSTRACT

This paper evaluates a new model connecting regenerative strategy orientation and digital eco-innovation capability to sustainable organizational resilience of healthcare organizations. This paper builds on regenerative systems thinking and circular economy by introducing two mediators (e.g., green knowledge integration and circular intelligence) to demonstrate the synergistic effect of strategic and technological determinants on adaptive sustainability. This paper collected data from 372 respondents who hold managerial positions (sustainability officers or digital transformation specialists) within Egyptian public and private healthcare organizations. Findings are anticipated to show that regenerative strategies and eco-innovation positively correlate with resilience via enhanced knowledge integration and circular intelligence. This paper adds to the sustainability literature by providing a cohesive analysis that aligns with Egypt Vision 2030 in healthcare contexts.

KEYWORDS: Regenerative strategy orientation; healthcare; circular intelligence; sustainable organizational resilience; digital eco-innovation capability

1. INTRODUCTION

The global healthcare industry is adapting to rapid changes in technology, sustainability, and society (Bevere and Faccilongo, 2024). Organizations are under pressure to adopt more sustainable practices due to growing environmental concerns, energy needs, and resource depletion (Abdelwahed, 2025). The Egyptian healthcare industry has become a high priority for pioneering sustainable reforms, as outlined in the Vision 2030 national strategic framework. Hence, this emphasizes circular value chains, green creativity, and digitization (Bevere and Faccilongo, 2024). In such transformations, combining regenerative practices with advanced digital capabilities will become a strategic imperative to build enduring core adaptability and value (Yadav and Yadav, 2024).

Prior research focused on compliance and efficiency (e.g., integrated environmental management, green supply chains, and corporate sustainability within healthcare (Al Masri and Wimanda, 2024; Jum'a et al., 2024). Environmental literature focuses on harm and incremental improvement, ignoring the lack of restorative and regenerative capacity frameworks and regenerative ecologies (Bevere and Faccilongo, 2024). This lack of understanding pertains to how to employ transformative, systems-level configurations that transcend integrated sustainability to regenerative outcomes. Additionally, Paul et al. (2024) examined healthcare digital transformation and sustainability, while empirical relationships between digital eco-innovation and sustaining organizational resilience remain unexplored (Bevere and Faccilongo, 2024). Thus, this has created a theoretical gap that needs to be addressed through a cohesive framework to illustrate the interaction between regenerative pathways and digital strategies, and their impact on organizational sustainability outcomes.

Many unexplored areas remain concerning mediating mechanisms between strategic and technological forces to develop sustainability-oriented resilience. Previous researchers have focused on leadership styles or green innovation as mediators (Abdelwahed, 2025; Saleem et al., 2025), overlooking the mediating roles of knowledge integration and intelligence-based systems in sustainability shifts. Though research studies have highlighted the importance of digital capabilities for improving sustainability performance (Shin et al., 2023; Trần et al., 2025), few have examined how combining knowledge and circular intelligence links green strategy with resilience (Ul-Durar et al., 2023). The healthcare literature on regions undergoing digital transformation and sustainability initiatives has yet to examine the pivotal role of mediating constructs. In addition, there is a gap between regenerative aspects of resilience and the reactive view (Abdelwahed, 2025). Therefore, this constrains understanding how strategic digital synergies allow healthcare organizations to develop systemic renewal and long-term adaptability (Jum'a et al., 2024). Consequently, the lack of certain concepts calls for empirical and theoretical examinations of cognitive enablers, regenerative strategies, and digital eco-innovation.

Theoretically, this paper draws on regenerative systems thinking theory (RSTT) (Chuah et al, 2025) and circular economy theory (De Angelis, 2021) to capture how organizations might shift to more adaptable and regenerative futures. RSTT takes a holistic approach, treating organizations as living systems within larger social and natural networks (Abdelwahed, 2025). It points out interdependence and renewal as the core features of transformative sustainability. CET adds to this perspective by offering functional frameworks for resource and knowledge circulation and closed-loop systems (Kosolapova et al., 2023). Thus, this enables powerful reuse, waste reduction, and innovative redesign. With this integration, this paper seeks to shift the literature's discourse from linear approaches to regenerative sustainability perspectives and to define resilient sustainability as the ability to thrive through disruptions and to be renewed and reconfigured.

Egypt's sustainable development goals prioritize digital and environmental transformations in the healthcare sector. Although there have been considerable investments in digital infrastructure and green innovations (Nie et al., 2023), empirical evidence remains limited on how healthcare organizations implement regenerative and circular principles (Alfina et al., 2025; Sepetis and Parlavantzas, 2025). This paper addresses this gap by analyzing the interconnections among the core components that form sustainable organizational resilience. These objectives are as follows: 1) analyzing the direct impact of strategic and technological drivers on sustainable resilience; 2) examining the mediating roles of knowledge integration and circular intelligence; and 3) providing empirical support to a regenerative-circular framework for healthcare systems. Our findings will help policymakers, healthcare administrators, and sustainability strategists in building more resilient, data-driven, and sustainable healthcare systems in a resource-constrained, technology-driven future.

2. LITERATURE REVIEW

2.1. Underpinned Theories

This paper is supported by RSTT and CET, which complement and expand the traditional view of sustainability boundaries. RSTT asserts that organizations should remedy and contribute to system renewal and restoration (Chuah et al., 2025). It prioritizes creating business strategies that mimic the cyclical processes of nature to achieve the ongoing regeneration of resources, communities, and ecosystems as and when required (Abdelwahed, 2025). A regenerative strategy orientation will act as a responsive pivot, encouraging an innovative, collaborative, and system-renewing model of restoration (Hahn and Tampe, 2021). RSTT correlates with the comprehensive goals of EgyptVision 2030, advocating for circular growth in healthcare with sustainable wellness and social regeneration. This perspective encourages organizations to view themselves as renewing ecosystems. From this perspective, CET has also sought to define concrete, measurable approaches to operationalize regenerative intentions on structural and operational levels (De Angelis, 2021).

CET promotes the ideology of closed-loop systems, in which the interactions among materials, energy, and information flow in and out of systems via design and digital technologies (Kosolapova et al., 2023). In this paper, digital eco-innovation capability and circular intelligence serve as CET principle proxies to demonstrate the potential of digital technologies to optimize circular pathways and minimize waste in healthcare systems. CET also validates the pivotal role of green knowledge integration as a mediator, emphasizing that collaborative knowledge transfer and digital intelligence are vital in realizing circular economy. Consequently, CET is the bridge that connects advancing technology and ecological sustainability, allowing a paradigm of value generation from the reuse of resources and intelligent systems (De Angelis, 2021). RSTT and CET together provide a robust theoretical foundation that connects regenerative approaches and digital innovation to strengthen organizational sustainability (see Figure 1). Therefore, this outlines the strategic and technological sophistication that Egyptian healthcare organizations require to operate within a circular, regenerative future.

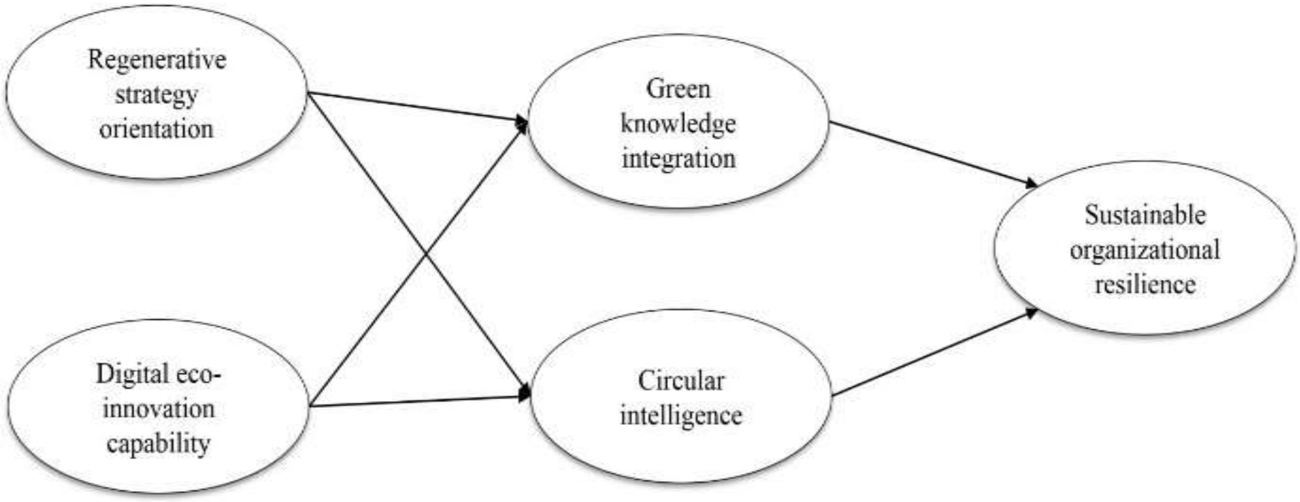

Figure 1: Research model
Source: Author preparation

2.2. Regenerative strategy orientation and green knowledge integration

Regenerative strategies incorporate systemic renewal and circular growth, surpassing traditional forms of sustainability (Horn and Proksch, 2022). Using RSTT, regenerative strategy orientation facilitates synergistic learning and the internalization of ecological intelligence (Gee, 2025). However, prior research overlooks the circulation of sustainability-regenerative strategies structured flow across the organizational levels (Caldera et al., 2022; Hahn and Tampe, 2021). However, such integration is required to implement environmental goals of healthcare settings (Simion Ludușanu et al., 2025). Hence, a regenerative strategy orientation provides the basis for green knowledge integration through cross-functional collaboration, environmental learning, and the operationalization of regenerative ideals within values deconstruction. Healthcare organizations are expected to transform a conceptual sustainability vision through a regenerative strategic orientation into operational practices embedded with knowledge (Gee, 2025; Zhou et al., 2024). In turn, this closes the gap between practical execution and strategic intent. Consequently, this paper hypothesizes that:

H1: Regenerative strategy orientation positively affects green knowledge integration.

2.3. Digital eco-innovation capability and green knowledge integration

Most prior research separates digitalization from the understanding and management of the environment (Chansanguan et al., 2025). Digital transformation enables a new configuration of sustainability practices. CET posits that when knowledge is stored and shared within organizations, technological ecosystems permit resource flows (Rossi and Srai, 2025). In healthcare, digital eco-innovation can bridge data silos and enhance collaborative learning (Bevere and Faccilongo, 2024). Still, empirical research linking digital innovation to the integration of sustainability knowledge remains scarce (Erbey et al., 2025; Kosolapova et al., 2023). This paper seeks to fill this gap by suggesting that integrating eco-innovation strategies improves the consolidation of eco-sustainable knowledge, driven by sophisticated data analytics, AI decision-making tools, and collaboration across different units. Organizations build living knowledge systems that respond to environmental cues when they embed ecological principles in digital infrastructure (Nie et al., 2023). CET demonstrates how digital resources function as cognitive facilitators of circular thinking (Kosolapova et al., 2023). Consequently, digital eco-innovation capabilities are expected to deepen the integration of eco-sustainable knowledge in health organizations (Cheng et al., 2024). Therefore, this transforms healthcare systems into digitally intelligent, self-sustaining learning networks (Chansanguan et al., 2025). Hence, this paper proposes that:

H2: Digital eco-innovation capability positively affects green knowledge integration.

2.4. Regenerative strategy orientation and circular intelligence

Regenerative strategies focus on long-term renewal and transformative potential. Exploring how such strategies translate into adaptive intelligence is still a theoretical gap (Gee, 2025). RSTT and RSTT (Chuah et al., 2025) mention systemic feedback and learning loops, while the literature still falls short in connecting strategic regeneration with the formation of circular, adaptive, intelligent systems (Caldera et al., 2022; Hahn and Tampe, 2021). Hence, this paper argues that a regenerative strategy orientation enables organizations to develop circular intelligence. Organizations can sense and avoid strategic inefficiencies, simulate and eliminate regenerative scenarios, and adapt organizational processes (Gee, 2025). In healthcare, circular intelligence is vital in balancing resource optimization with patient-centered, sustained sustainability (Bevere and Faccilongo, 2024). Thus, this is a theoretical gap to be addressed. Circular intelligence presupposes systems-thinking logics, while digital and organizational cognition (Bag and Rahman, 2024) is organized around. Hence, this paper proposes that:

H3: Regenerative strategy orientation positively affects circular intelligence.

2.5. Digital eco-innovation capability and circular intelligence

Despite rapid digitalization, little research has examined how digital eco-innovation fosters higher-order intelligence in circular systems (Cheng et al., 2024). CET lays the groundwork for linking circular eco-technology with higher-order intelligence systems, in which innovative technologies (e.g., IoT and data analytics) create feedback loops that replicate natural self-sustaining cycles (Bevere and Faccilongo, 2024). Still, research on sustainability has focused on digital tools as operational enablers (Erbey et al., 2025; Kosolapova et al., 2023). This paper addresses this once-overlooked aspect by arguing that digital eco-innovation capability expands organizational circular intelligence, enabling organizations to gather, analyze, and stream circular data for dynamic recirculation. In healthcare systems, where digital eco-innovative capabilities are focused on advanced predictive analytics to streamline processes (e.g., waste and energy for adaptive systems), the impact of intelligent analytics on eco-innovation and digital sustainability is profound (Bevere and Faccilongo, 2024). Within the CET framework, we define digital eco-innovation capability as the strategic enabler of intelligence-driven circular adaptation in healthcare ecosystems. Therefore, this paper proposes that:

H4: Digital eco-innovation capability positively affects circular intelligence.

2.6. Green knowledge integration and sustainable organizational resilience

The relationship between resilience and green knowledge systems in healthcare is still emerging (Vishwakarma et al., 2025). Most literature on resilience in health systems focuses on consolidating reactive mechanisms (Abdelwahed, 2025; Saleem et al., 2025; Ul-Durar et al., 2023). In contrast, the RSTT framework views knowledge flows as drivers of system renewal and revitalization (Chuah et al., 2025). Consequently, this paper argues that integrating green knowledge promotes the sustainability dimension of organizational resilience. As knowledge flows, organizations build adaptive routines, foresight, and environmental agility (Gee, 2025). However, the literature still lacks an understanding of how green knowledge integration can boost organizational resilience and regenerative capacities. In healthcare institutions, green knowledge integration promotes cross-disciplinary teams to anticipate and plan for disruptions, align with circular economy, and sustain performance continuity (Erbey et al., 2025). As described in the RSTT framework, this relationship reminds us that resilience involves redundancy and learning, enabling organizations to adapt and flourish in shifting environmental systems (Saleem et al., 2025). Thus, this paper proposes that:

H5: Green knowledge integration positively affects sustainable organizational resilience.

2.7. Circular Intelligence and sustainable organizational resilience

Most recent resilience research does not consider how cognitive intelligence systems drive adaptability toward sustainability (Vishwakarma et al., 2025). Circular intelligence is an advanced capability that enables organizations to predict, model, and optimize responses to environmental disruptions (Kristoffersen et al., 2020). Much of the literature concentrates on technological resilience or the management of green organizational systems (Abdelwahed, 2025; Saleem et al., 2025; Ul-Durar et al., 2023). Hence, this has left a theoretical gap in how circular cognition and mental frameworks influence and enact sustainable renewal. Based on CET, this paper posits that circular intelligence enables organizations to see sustainability through the lens of a compliance endpoint and an evolving cognitive process. Through integrating feedback loops, predictive analyses, and real-time digital monitoring, circular intelligence shifts the resilience framework into an advanced regenerative system that learns from disruptions (Kristoffersen et al., 2020). In the healthcare sector, this form of intelligence facilitates adaptive resource utilization, waste management, and system recovery during uncertain conditions (Dohmen et al., 2023). Thus, circular intelligence is likely to bolster the dimensions of organizational resilience by providing foresight-driven circular learning loops across organizational ecosystems. Thus, this paper proposes that:

H6: Circular Intelligence positively affects sustainable organizational resilience.

2.8. The mediating role of green knowledge integration

A regenerative strategy orientation, layered with digital eco-innovation capabilities, leads to environmental adaptability for organizations (Ul-Durar et al., 2023). This adaptability, however, profoundly influences sustainable organizational resilience when coupled with the integration of green knowledge (Trần et al., 2025). Fragments of knowledge systems in the literature on sustainability have underscored the weak connective mechanisms between innovation and resilience (Vishwakarma et al., 2025). Consequently, green knowledge integration becomes pivotal as a capability that reformulates dispersed environmental knowledge to develop dynamic adaptive and absorptive capacities (Makhloufi, 2024). Grounded in CET, organizations that have developed mechanisms for integrating knowledge can reorganize and adapt their routine strategies and operations to address ecological turbulence (Shin et al., 2023). In addition, integrating digital eco-innovations codifies and diffuses green knowledge, creating a self-supporting system for long-term resilience (Bevere and Faccilongo, 2024). As a result, green knowledge integration is a means and ability that incorporates rehabilitative thinking with systemic learning (Makhloufi, 2024). Consequently, this synchronizes knowledge streams with eco-intelligence to promote long-lasting organizational resilience and sustainability. Hence, this paper suggests that:

H7: Green knowledge integration mediates the relationship between sustainable organizational resilience and a) regenerative strategy orientation and b) digital eco-innovation capability.

2.9. The mediating role of circular intelligence

Sustainability strategies must include regenerative approaches and eco-innovations (Ul-Durar et al., 2023). Companies often lack the cognitive infrastructure to achieve circular, resource-efficient outcomes through regenerative strategies and digital eco-innovations. Alifina et al. (2025) documented that strategic digital eco-innovations incorporate operationalized regenerative strategies. This paper recognizes that sustainability outcomes derive from cognitive technological strategies reliant on the internalization of circular logic. Recent scholars (Chansanguan et al., 2025; Sepetis and Parlavantzas, 2025) noted that circular thinking is crystallizing as the new sustainability paradigm rests on the underexplored role of this thinking as a mediating cognitive mechanism. This paper positions circular intelligence as a mediating construct in the theoretical discourse on how organizational cognition actualizes innovation and resilience. Thus, circular intelligence mediates by reshaping managerial cognitive frameworks toward cyclic regeneration. Hence, this cultivates in organizational resilience the waste reduction, resource regeneration, and adaptive cognitive processes essential in resource scarcity. Therefore, this paper assumes that:

H8: Circular intelligence mediates the relationship between sustainable organizational resilience and a) regenerative strategy orientation and b) digital eco-innovation capability.

3. METHODOLOGY

3.1. Research rationale

Healthcare services are in the midst of a pivot in focus, driven by Vision 2030 and National Transformation Program goals (Awad et al., 2025), emphasizing digitization, sustainability, and resilience. In past years, institutional pressures from the global healthcare community to integrate eco-sustainability into their healthcare service delivery have been researched in the marketplace (Alfina et al., 2025). Sustainability within healthcare institutions includes adopting green hospital-building technologies, reducing waste, and ensuring the sustainability of patient care delivery. Knowledge gaps and poor systemic understanding of building and integrating a sustainable, regenerative healthcare system continue to focus on the environmental and digital gaps within the system (Awad et al., 2025). Understanding how regenerative and digital eco-innovative capabilities can be translated into resilient, sustainable organizations is crucial (Bevere and Faccilongo, 2024). Thus, this is because Egypt is an emerging economy, and its healthcare governance integrates global sustainability standards into its operations. Therefore, this is expected to develop into practical frameworks and contribute to managerial policies.

3.2. Pretest and procedure

Before data collection, we ensured that measurement items underwent field testing and reverse translation procedures to ensure clarity, validity, and cultural appropriateness. The first version of the questionnaire was in English. We used reflective, multi-item scales from leading works on regenerative strategy, eco-innovation, knowledge integration, circular intelligence, and organizational resilience, and each construct comprised five to six items and was rated on a five-point Likert scale. The instrument underwent a forward and backward translation process to achieve linguistic equivalence. The first two bilingual academic experts translated the English version of the questionnaire into Arabic. A pair of professional translators who were blind to the original instrument translated the questionnaire into English. The two English versions of the questionnaire were reconciled, and discrepancies were resolved during a review meeting involving three scholars in sustainability, healthcare management, and organizational behavior. This process iteration ensured conceptual alignment and aimed to reduce potential cultural or semantic prejudice.

After validating translations, a pretest was conducted with a purposive sample of 69 healthcare professionals, including hospital administrators, digital transformation officers, and environmental sustainability coordinators. Respondents assessed the questionnaire considering its readability and the relevance and clarity of its items. Cronbach's alpha for the pilot was over 0.70 for all constructs and confirmed the internal consistency of the constructs. This pretesting phase instrument further refined its psychometric robustness by contextualizing the survey items to be appropriate for the language and to align with healthcare in Egypt.

3.3. Instruments

All constructs were assessed using multi-item reflective scales tailored to the Egyptian healthcare context (see Appendix A). Five items were used to measure regenerative strategy orientation derived from Hahn and Tampe (2021), focusing on regenerative leadership, ecosystem renewal, and restorative strategy emphasis. Six items were used to measure digital eco-innovation capability, following Xu et al. (2023), focusing on AI/IoT integration, eco-digital design, and resource optimization. Green knowledge integration used six items from Lee and Kim (2011), including knowledge acquisition, internal dissemination, and the application of environmental insights. Circular intelligence involved six items based on Kristoffersen et al. (2020), focusing on predictive analytics, system simulation, and adaptive feedback loops. Ten items from Kantur and Say (2015) focused on organizational responses to disruptions were used to assess organizational resilience. A five-point Likert scale was used for all items (1 = strongly disagree to 5 = strongly agree), and to mitigate response bias, a few items were reverse-keyed.

3.4. Data gathering process

This paper focused on healthcare professionals in public and private hospitals, clinics, and healthcare networks throughout Egypt, including Ismailia, Port Said, and Suez. Thus, this included healthcare members, environmental and digital initiatives operational decision-making teams (e.g., hospital administrators, department heads, digital innovation officers, sustainability officers, and clinical managers). Because this paper examined the relationships among regenerative strategy, digital eco-innovation, knowledge integration, circular intelligence, and sustainable organizational resilience, the sample comprised individuals with substantial knowledge of organizational strategy and sustainability. Multiple dimensions of healthcare organizations (e.g., type, size, and operational departments) were stratified and sampled to ensure different levels of abstraction and to provide a comprehensive representation of the spectrum from operational/frontline managers to top executives.

The structured online questionnaire was distributed via professional networks, institutional email lists, and healthcare forums and 700 survey invitations were sent to potential respondents. As part of survey preparation, the instrument was developed in English and translated into Arabic through a comprehensive reverse-translation process to maintain linguistic and conceptual consistency. Before data collection, respondents were informed of the paper's purpose and the confidentiality of their data, and asked to complete the questionnaire voluntarily. Reminder emails were sent two weeks and four weeks after the initial email to improve response rates. To maximize participation, the survey was left open for 6 weeks. 390 of the 700 surveys sent out were returned, giving a 55.7% response rate. Responses were checked for completeness, and consistent patterns were filtered, flagging sloppy responses for removal. Hence, 372 responses were used to perform the final analysis. The respondent profile presents a diverse, representative sample of Egyptian healthcare organizations. Among the 372 valid responses (see Appendix B), there was balanced gender representation: 54% male and 46% female respondents. Regarding organizational roles, 38% of respondents were hospital administrators or senior managers, 32% were department heads or unit managers, and 30% were digital innovation or sustainability officers. Respondents were also diverse in hospital type, with 60% working in public hospitals and 40% in private hospitals and clinics.

The number of years of healthcare experience ranged from 1 to 25, ensuring that all respondents had adequate experience in organizational strategy, sustainability, and digital transformation. This range of experience helps generalize findings and captures from all levels and functions in Egyptian healthcare systems. Regarding respondents and their data, this paper complied with ethical guidelines. Data collection was preceded by obtaining institutional review board approval, and respondents provided electronic informed consent. Respondents were informed of our objectives. They were provided guarantees of respect to confidentiality and anonymity, and the right to disengage from this paper without consequences. Data were collected and stored in secure systems accessible to researchers.

3.5. Analytic strategy and common method bias (CMB)

This paper evaluates the proposed model using PLS-SEM and ADANCO software designed for composite-based structural equation modeling (Sarstedt et al., 2022). ADANCO provides the option to specify reflective and formative models, perform bootstrap resampling, and run extensive diagnostics (Guenther et al., 2023). This software follows a sequence of steps: measurement model assessment, followed by structural model evaluation. ADANCO's graphical modeler helps visualize paths and check confirmed relational hypotheses, fostering strong inference in the presence of non-normal data distributions (Memon et al., 2021). As self-report data are collected for independent, mediator, and dependent variables, CMB is a potential concern. Procedural and statistical approaches are taken to address the potential for CMB.

For procedural approaches, the survey was designed with the following in mind: a) the respondents' anonymity is assured and the absence of correct or socially desirable answers is provided to minimize social desirability bias, b) the questionnaire is designed to include buffer items to separate predictor and outcome constructs, c) items are mixed or counterbalanced, and d) reversed keyed items are provided in order to address acquiescence bias. Harman's single-factor test is used in statistical approaches to CMB analysis to determine whether a single factor accounts for most of the variance. Additionally, a latent method factor of PLS-SEM is included to capture the shared variance due to the measurement method. Moreover, the marker-variable approach can be applied, in which an unrelated construct estimates method variance.

4. RESULTS

4.1. Outer model estimation

Before analyzing the structural relationships, the outer model was assessed to assess the reliability and validity of the latent constructs (Guenther et al., 2023). According to Table 1, indicator loadings were assessed, and all items exceeded the minimum value of 0.70 (Memon et al., 2021). All constructs were deemed valid. Construct consistency and reliability were determined to be satisfactory, as indicated by Cronbach's alpha and Composite Reliability (CR), exceeding 0.70 (Sarstedt et al., 2022). Constructs also satisfied the requirements for convergent validity, with AVEs above 0.50 (Memon et al., 2021). Discriminant validity was verified using the Fornell-Larcker criterion (see Appendix C) and the HTMT ratio, confirming expected outcomes (Sarstedt et al., 2022) and indicating that all values should be below 0.85. The above outcomes demonstrated that the measurement model is valid and reliable; therefore, it is appropriate to proceed with the structural model evaluation and hypothesis testing.

Table 1: Construct reliability and validity

Constructs	Codes	Factor loadings	Alpha	CR	AVE
Regenerative strategy orientation	RSO1	0.821	0.874	0.907	0.660
	RSO2	0.848			
	RSO3	0.791			
	RSO4	0.826			
	RSO5	0.802			
Digital eco-innovation capability	DIC1	0.787	0.911	0.935	0.703
	DIC2	0.855			
	DIC3	0.876			
	DIC4	0.843			
	DIC5	0.830			
	DIC6	0.816			
Green knowledge integration	GKI1	0.822	0.922	0.943	0.737
	GKI2	0.875			
	GKI3	0.867			
	GKI4	0.854			
	GKI5	0.878			
	GKI6	0.856			
Circular intelligence	CRI1	0.841	0.928	0.947	0.719
	CRI2	0.870			
	CRI3	0.865			
	CRI4	0.854			
	CRI5	0.871			
	CRI6	0.830			
Sustainable organizational resilience	SOR1	0.812	0.950	0.958	0.704
	SOR2	0.837			
	SOR3	0.846			
	SOR4	0.858			
	SOR5	0.867			
	SOR6	0.853			
	SOR7	0.821			
	SOR8	0.834			
	SOR9	0.857			
	SOR10	0.841			

4.2. Model fit indices

Within ADANCO-PLS, the Standardized Root Mean Square Residual (SRMR) and the Normed Fit Index (NFI) were used to assess the overall model fit (see Table 2). The SRMR value of 0.048 was lower than the suggested 0.08 threshold, suggesting a high fit between the observed and predicted correlation matrices (Memon et al., 2021). The NFI was 0.912; likewise, the 0.90 threshold was exceeded, indicating that the fit was better than the null model's incremental fit (Guenther et al., 2023). These indices confirm that the proposed measurement and structural models fit the empirical data well, reinforcing the reliability and robustness of the subsequent hypothesis testing. R^2 values further illustrate that the structural model had considerable explanatory power, accounting for 58.7% of the variance in green knowledge integration, 56.1% in circular intelligence, and 66.2% in sustainable organizational resilience (see Table 2).

4.3. Hypothesis testing

According to Table 2, findings proved that regenerative strategy orientation positively affected sustainable organizational resilience ($\beta = 0.342$, $t = 4.127$, $p < 0.001$, $f^2 = 0.102$), indicating a moderate effect size. Similarly, digital eco-innovation capability positively affected sustainable organizational resilience ($\beta = 0.278$, $t = 3.582$, $p < 0.001$, $f^2 = 0.074$). Regenerative strategy orientation also positively influenced green knowledge integration ($\beta = 0.451$, $t = 6.231$, $p < 0.001$, $f^2 = 0.189$) and circular intelligence ($\beta = 0.398$, $t = 5.416$, $p < 0.001$, $f^2 = 0.142$), while digital eco-innovation capability positively affected green knowledge integration ($\beta = 0.329$, $t = 4.908$, $p < 0.001$, $f^2 = 0.084$) and circular intelligence ($\beta = 0.357$, $t = 5.102$, $p < 0.001$, $f^2 = 0.091$). Hence, this confirms substantial direct relationships in line with theoretical expectations.

Next, mediation analyses revealed significant pathways through green knowledge integration and circular intelligence (see Table 2). The indirect effect of regenerative strategy orientation on sustainable organizational resilience via green knowledge integration was positive ($\beta = 0.162$, $t = 3.524$, $p < 0.001$, CIs = [0.092, 0.238]). Likewise, the indirect effect of regenerative strategy orientation on sustainable organizational resilience via circular intelligence was positive (β = 0.158, t = 3.417, p < 0.001, CIs = [0.085, 0.234]). Similarly, digital eco-innovation capability positively affected sustainable organizational resilience through green knowledge integration (β = 0.108, t = 3.108, p < 0.01, CIs = [0.045, 0.179]) and circular intelligence (β = 0.125, t = 3.276, p < 0.01, CIs = [0.058, 0.197]). Results confirm that green knowledge integration and circular intelligence are partially mediated, providing robust empirical support for dual-mediation hypotheses.

Table 2: Structural model assessment

H	Structural paths	β	t-value	p-value	f2	Decision
Direct effects						
H1	Regenerative strategy orientation → Green knowledge integration	0.451***	6.231	0.000	0.189	Supported
H2	Digital eco-innovation capability → Green knowledge integration	0.329***	4.908	0.000	0.084	Supported
H3	Regenerative strategy orientation → Circular intelligence	0.398***	5.416	0.000	0.142	Supported
H4	Digital eco-innovation capability → Circular intelligence	0.357***	5.102	0.000	0.091	Supported
H5	Green knowledge integration → Sustainable organizational resilience	0.368***	4.284	0.000	0.106	Supported
H6	Circular intelligence → Sustainable organizational resilience	0.354***	4.031	0.000	0.095	Supported
Indirect effects						
H	Structural paths	β	t-value	p-value	97.5%CIs	Decision
H7a	Regenerative strategy orientation → Green knowledge integration → Sustainable organizational resilience	0.162***	3.524	0.000	[0.092, 0.238]	Mediation
H7b	Digital eco-innovation capability → Green knowledge integration → Sustainable organizational resilience	0.108**	3.108	0.002	[0.045, 0.179]	Mediation
H8a	Regenerative strategy orientation → Circular intelligence → Sustainable organizational resilience	0.158***	3.417	0.000	[0.085, 0.234]	Mediation
H8b	Digital eco-innovation capability → Circular intelligence → Sustainable organizational resilience	0.125**	3.276	0.001	[0.058, 0.197]	Mediation
Quality indicators						
R2 for Green knowledge integration		0.587	R2 for Circular intelligence			0.561
R2 for Sustainable organizational resilience		0.662	SRMR/NFI			0.048/0.912
Note: 2-tailed test; ***p < 0.001, **p < 0.01						

5. DISCUSSION AND CONCLUSIONS

5.1. General discussion

Our findings underscore the importance of understanding regenerative strategy orientation and digital eco-innovation capability in building sustainable organizational resilience in healthcare organizations. Hence, organizations with adaptive, regenerative, and eco-innovative strategies withstand and adapt to environmental uncertainties and systemic shocks. In sustainability management, healthcare settings remain understudied, although regenerative strategies have been recognized as facilitating holistic resource renewal and sustenance (Caldera et al., 2022; Hahn and Tampe, 2021) and stakeholder well-being (Chuah et al., 2025). Regenerative healthcare organizations achieve resilience by maintaining operational continuity across social and environmental dimensions. (Hahn and Tampe, 2021) A similar contribution to the literature is the positive impact of digital eco-innovation capability, which underscores the pivotal role of digital innovation capabilities in green transitions through data-driven environmental control and efficient resource allocation. Sustainability, digitalization, and regenerative design can be integrated to support hospitals and healthcare facilities under difficult, complex conditions (Yadav and Yadav, 2024).

In addition, green knowledge integration and circular intelligence enhance understanding of how internal cognitive and knowledge components function to strengthen the relationship between strategic orientation and sustainable resilience. Knowledge integration has been viewed as an operational enabler in the recent literature (see Alfina et al., 2025; Sepetis and Parlavantzas, 2025). In healthcare contexts, knowledge integration has more transformative potential. Through green knowledge integration, organizations can incorporate sustainability knowledge into collaborative decision-making processes of administrative units tasked with developing environmental solutions (De Angelis, 2021). Thus, this is consistent with Hahn and Tampe (2021), who recognized that adequate green knowledge promotes adaptive learning and strategic renewal of the organization. The importance of circular intelligence lies in extending knowledge by conceptualizing it as the cognitive ability to identify and act on circular opportunities across value chains (Yadav and Yadav, 2024). Hence, circular thinking entails using dynamic intelligence to identify regenerative loops. Therefore, this also implies that hospitals can use circular intelligence to reduce waste, enhance supply chain sustainability, and align healthcare systems with circular economy principles.

Rationally, RSTT and CET provide a credible foundation for the theory developed from our findings. RSTT argues that organizations must maintain and renew the systems they interconnect with, emphasizing adaptability and self-renewal. The strong links between a regenerative strategy orientation and resilient organizational sustainability confirm this theory. A regenerative strategy orientation motivates resilient healthcare organizations to develop systems that restore social and ecosystem values (Dohmen et al., 2023). Such organizations develop resilience that goes beyond crisis recovery to continual renewal. Conversely, CET augments this argument by describing organizational prowess via inter-system feedback loops and organizational infrastructural resilience (Kolodny-Goetz et al., 2021). Therefore, CET and RSTT explain the regeneration of organizational strategy and the role of circular reasoning in fostering permanent organizational resilience. Thus, this explains the shift in health organizations from entities to proactive systems that evolve and regenerate their ecosystems.

Our results have valuable implications for leaders in healthcare, policy, and sustainability. The evidence for mediation by green knowledge integration and circular intelligence indicates that ecosystems of integrated knowledge and cognitive flexibility should be central to sustainability initiatives. Digital eco-innovation adoption offers the potential for more refined process acceleration through real-time analytical evaluation to reduce waste and carbon, improve tracking, and support green procurement. In addition, the relationships between RSTT and CET suggest that healthcare system sustainability should be approached and regarded as systems-level transformations. Such a transformation will allow healthcare organizations in Egypt to improve their organizational resilience and operationally support their contribution to the country's sustainability and Vision 2030 objectives. This paper shows how circular and regenerative approaches to theory and practice can be synthesized to advance healthcare excellence.

5.2. Theoretical implications

This paper enriches the literature on the theoretical foundations of sustainability and resilience within organizational and healthcare management by proposing a synergistic integration of RSTT and CET. In doing so, this paper develops a first-of-its-kind conceptual framework beyond the one-dimensional sustainability models. Previous literature defined resilience as a recovery-focused, reactive process (Dohmen et al., 2023; Kolodny-Goetz et al., 2021) and failed to conceptualize it within a proactive, regenerative framework. The empirical grounding of regenerative strategy orientation as a critical precursor of sustainable organizational resilience confirms the core proposition of RSTT that entities must function as living systems and regenerate their organizational resources. This paper advances the digital sustainability literature by establishing that digital eco-innovation capability contributes to enhanced regenerative outcomes (Bevere and Faccilongo, 2024). Therefore, new technologies are facilitators and transformative amplifiers of regenerative and circular shifts (Siakas et al., 2023).

Green knowledge integration and circular intelligence as twin mediators deepen the theoretical conversation by bridging the cognitive, informational, and systemic aspects of sustainability. Knowledge integration extends the knowledge-based view by incorporating the environment and regenerative intelligence into organizational learning frameworks. Empirical findings established knowledge integration as a support function and strategic mediator that bridges regenerative intent and long-term resilience outcomes. Further, circular intelligence helps develop the cognitive foundation of circular economy by framing intelligence as dynamic, interpretive capabilities that empower firms to recognize and actualize regenerative prospects across value chains. This cognitive framework addresses circular reasoning and cognitive and decisional frameworks that drive systemic regeneration. This synthesis of RSTT and CET anchors a broader theoretical framework that intertwines strategy, cognition, and digital pathways to sustainability, reframing sustainability as a regenerative system. In organizations operating in high-stakes environments, this presents a more adaptive understanding of resilience. This paper provides a more holistic, adaptive understanding of resilience within organizational ecosystems in high-stakes environments.

5.3. Practical implications

This paper raises several actionable recommendations for healthcare managers, policymakers, and practitioners to enhance regenerative and resilient capacities. First, the importance of regenerative strategy orientation is that healthcare organizations should stop focusing on sustainability and instead adopt systems thinking to address it in a more transformative, holistic way. Thus, organizational planning, procurement, and service delivery must include regeneration principles. Therefore, this can include the formation of cross-functional sustainability committees within each hospital. Thus, this incorporates medical, administrative, and technical spheres to ensure that operational regeneration goals of biodiversity maintenance and social well-being are operationalized. Further, standard performance appraisal systems should be modified by incorporating regenerative performance indicators (e.g., carbon cost per patient service and closed-loop material reuse in patient service streams).

Further, automated resource management through AI systems and waste tracking and recording via advanced blockchain technology can minimize waste and enhance efficiency. These can become digital circular economy-influenced waste management systems. Advanced eco-innovation for standardized medical inventories can be integrated to contain the overuse of disposable medical supplies and minimize operational costs. To accrue and maintain operational digital systems of lowered management eco-innovation capabilities, digital literacy education for managerial operational healthcare levels is imperative. Collaboration with technologists and sustainability entrepreneurs can create co-innovation ecosystems to leverage digital sustainability frameworks. Digital twin systems can simulate environmental impacts of various healthcare operations and interventions to align eco-innovative operational and clinical objectives with real-time capabilities.

Lastly, the mediating roles of green knowledge integration and circular intelligence underscore the need to establish organizational culture centered on collective learning, cognitive flexibility, and sustainability-focused problem-solving. Healthcare organizations could promote knowledge exchange systems and interprofessional learning sites where employees discuss practices linked to innovation, green/sustainable transformation, and environmental performance. In addition, circular reasoning training could foster cognitive skills to spot regenerative possibilities for waste reduction and energy use, and to optimize products and their life cycles. Moreover, environmental accreditation standards could incorporate knowledge-based circular initiatives and encourage hospitals to focus on internal sustainability-related strategic initiatives aligned with their operations. Integrating feedback and adaptive learning embodies regenerative and circular theories, enabling learning health systems. Institutionalizing green knowledge integration and circular intelligence can empower healthcare leaders to reshape their organizations into adaptive, self-sustaining systems that thrive in uncertainty.

6. LIMITATIONS AND FUTURE RESEARCH

This paper has made key contributions to the literature; however, it also has its limitations. First, this paper used a cross-sectional approach; future research should employ longitudinal or experimental designs to examine the temporal order of regenerative and circular capabilities. In addition, datasets were collected from Egyptian healthcare organizations, which may limit the generalizability of our findings to other cultures or institutions. Comparative studies embedded in other sectors or in sustainability-oriented geopolitical regions will enhance the external validity of our proposed framework. Although this paper was focused on self-reported data, including sustainability performance indicators from other data sources and self-reported data from various sources would help address this issue. Future research could improve our framework by incorporating boundary moderators, institutional pressures, or organizational learning climates to exploit organizations' regenerative performance.

7. Acknowledgement:

This work was supported and funded by the Deanship of Scientific Research at Imam Mohammad Ibn Saud Islamic University (IMSIU) (grant number IMSIU-DDRSP2602).

REFERENCES

Abdelwahed, N. A. A. (2025). The predictive power of technology leadership and green HRM toward green innovation, work engagement and environmental performance. International Journal of Productivity and Performance Management, 74(6), 2159-2182.

Al Masri, R., and Wimanda, E. (2024). The role of green supply chain management in corporate sustainability performance. Journal of Energy and Environmental Policy Options, 7(2), 1-9.

Alfina, K. N., Ratnayake, R. C., Wibisono, D., Basri, M. H., and Mulyono, N. B. (2025). Prioritizing performance indicators for the circular economy transition in healthcare supply chains. Circular Economy and Sustainability, 5(1), 231-276.

Awad, I. M., Nuseibeh, H., and Amro, A. A. (2025). Competitiveness in the era of circular economy and digital innovations: An integrative literature review. Sustainability, 17(10), 4599.

Bag, S., and Rahman, M. S. (2024). Navigating circular economy: Unleashing the potential of political and supply chain analytics skills among top supply chain executives for environmental orientation, regenerative supply chain practices, and supply chain viability. Business Strategy and the Environment, 33(2), 504-528.

Bevere, D., and Faccilongo, N. (2024). Shaping the future of healthcare: Integrating ecology and digital innovation. Sustainability, 16(9), 3835.

Caldera, S., Hayes, S., Dawes, L., and Desha, C. (2022). Moving beyond business as usual toward regenerative business practice in small and medium-sized enterprises. Frontiers in Sustainability, 3, 799359.

Chansanguan, S., Rittippant, N., Ueki, Y., and Jeenanunta, C. (2025). Sustainable digital transformation in public hospitals: Strategic enablers for smart healthcare systems. Sustainability, 17(19), 8614.

Cheng, W., Li, Q., Wu, Q., Ye, F., and Jiang, Y. (2024). Digital capability and green innovation: The perspective of green supply chain collaboration and top management's environmental awareness. Heliyon, 10(11), e10921.

Chuah, C., Homer, S. T., and Loo, W. H. (2025). Mapping regenerative business: a conceptual framework building upon systems thinking in Southeast Asia, Asian Journal of Business Ethics, 1-29.

De Angelis, R. (2021). Circular economy and paradox theory: A business model perspective. Journal of Cleaner Production, 285, 124823.

Dohmen, A. E., Merrick, J. R., Saunders, L. W., Stank, T. P., and Goldsby, T. J. (2023). When preemptive risk mitigation is insufficient: The effectiveness of continuity and resilience techniques during COVID-19. Production and Operations Management, 32(5), 1529-1549.

Erbey, A., Gündüz, C., and Fidan, Ü. (2025). Digitalization, Sustainability, and Radical Innovation: A Knowledge-Based Approach. Sustainability, 17(7), 2972.

Gee, R. O. W. (2025). Greening the blue ocean: Leading systemic transformation with regenerative intelligence. Earth Environmental Science Research and Review, 8(1), 01-27.

Guenther, P., Guenther, M., Ringle, C. M., Zaefarian, G., and Cartwright, S. (2023). Improving PLS-SEM use for business marketing research. Industrial Marketing Management, 111, 127-142.

Hahn, T., and Tampe, M. (2021). Strategies for regenerative business. Strategic Organization, 19(3), 456-477.

Horn, E., and Proksch, G. (2022). Symbiotic and regenerative sustainability frameworks: Moving towards circular city implementation. Frontiers in Built Environment, 7, 780478.

Jum'a, L., Alkalha, Z., and Alaraj, M. (2024). Towards environmental sustainability: the nexus between green supply chain management, total quality management, and environmental management practices. International Journal of Quality and Reliability Management, 41(5), 1209-1234.

Kantur, D., and Say, A. I. (2015). Measuring organizational resilience: A scale development. Journal of Business Economics and Finance, 4(3), 1-20.

Kolodny-Goetz, J., Hamm, D. W., Cook, B. S., and Wandersman, A. (2021). The readiness, resilience and recovery tool: An emerging approach to enhance readiness amidst disruption. Global Implementation Research and Applications, 1(2), 135-146.

Kosolapova, N., Matveeva, L., Nikitaeva, A., and Chernova, O. (2023). The drivers of the circular economy: Theory vs practice. Terra Economicus, 21(2), 68-83.

Kristoffersen, E., Blomsma, F., Mikalef, P., and Li, J. (2020). The smart circular economy: A digital-enabled circular strategies framework for manufacturing companies. Journal of Business Research, 120, 241-261.

Lee, K. H., and Kim, J. W. (2011). Integrating suppliers into green product innovation development: An empirical case study in the semiconductor industry. Business strategy and the Environment, 20(8), 527-538.

Makhloufi, L. (2024). Do knowledge sharing and big data analytics capabilities matter for green absorptive capacity and green entrepreneurship orientation? Implications for green innovation. Industrial Management and Data Systems, 124(3), 978-1004.

Memon, M. A., Ramayah, T., Cheah, J. H., Ting, H., Chuah, F., and Cham, T. H. (2021). PLS-SEM statistical programs: A review. Journal of Applied Structural Equation Modeling, 5(1), 1-14.

Nie, C., Zhong, Z., and Feng, Y. (2023). Can digital infrastructure induce urban green innovation? New insights from China. Clean Technologies and Environmental Policy, 25(10), 3419-3436.

Paul, J., Ueno, A., Dennis, C., Alamanos, E., Curtis, L., Foroudi, P., ... and Wirtz, J. (2024). Digital transformation: A multidisciplinary perspective and future research agenda. International Journal of Consumer Studies, 48(2), e13015.

Pereira, N., and Fernandes, C. (2025). Knowledge management in health organizations: A systematic literature review. Journal of the Knowledge Economy, 1-73.

Rossi, L. A., and Srai, J. S. (2025). The role of digital technologies in configuring circular ecosystems. International Journal of Operations and Production Management, 45(4), 863-894.

Saleem, F., Sundarasen, S., and Malik, M. I. (2025). Green leadership and environmental performance in hospitals: A multi-mediator study. Sustainability, 17(12), 5376.

Sarstedt, M., Radomir, L., Moisescu, O. I., and Ringle, C. M. (2022). Latent class analysis in PLS-SEM: A review and recommendations for future applications. Journal of Business Research, 138, 398-407.

Sepetis, A., and Parlavantzas, I. (2025). Circular economy behavior and sustainable healthcare. Circular Economy and Sustainability, 1-23.

Shin, J., Mollah, M. A., and Choi, J. (2023). Sustainability and organizational performance in South Korea: The effect of digital leadership on digital culture and employees' digital capabilities. Sustainability, 15(3), 2027.

Siakas, D., Lampropoulos, G., Rahanu, H., Georgiadou, E., and Siakas, K. (2023). Emerging technologies enabling the transition toward a sustainable and circular economy: The 4R sustainability framework. In European conference on software process improvement (pp. 166-181). Cham: Springer Nature Switzerland.

Simion Ludușanu, D. G., Fertu, D. I., Tinică, G., and Gavrilescu, M. (2025). Integrated quality and environmental management in healthcare: Impacts, implementation, and future directions toward sustainability. Sustainability, 17(11), 5156.

Trần, T. H. T., Abu Afifa, M., Tran, N. K., and Dang, D. M. T. (2025). The role of green technology innovation and digital capability in sustainable management and performance: Empirical evidence. Meditari Accountancy Research, 1-20.

Ul-Durar, S., Awan, U., Varma, A., Memon, S., and Mention, A. L. (2023). Integrating knowledge management and orientation dynamics for organization transition from eco-innovation to circular economy. Journal of Knowledge Management, 27(8), 2217-2248.

Vishwakarma, L. P., Singh, R. K., Mishra, R., and Kumari, A. (2025). Application of artificial intelligence for resilient and sustainable healthcare system: Systematic literature review and future research directions. International Journal of Production Research, 63(2), 822-844.

Xu, J., Yu, Y., Zhang, M., and Zhang, J. Z. (2023). Impacts of digital transformation on eco-innovation and sustainable performance: Evidence from Chinese manufacturing companies. Journal of Cleaner Production, 393, 136278.

Yadav, V., and Yadav, N. (2024). Beyond sustainability, toward resilience, and regeneration: An integrative framework for archetypes of regenerative innovation. Global Journal of Flexible Systems Management, 25(4), 849-879.

Zhou, K., Warwick, E., Ucci, M., Davies, M., and Zimmermann, N. (2024). Sustaining attention to sustainability, health, and well-being in urban regeneration. Organization and Environment, 37(1), 57-83.