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SERIOUS GAMES FOR SUSTAINABLE BUSINESS TRANSFORMATION: EVIDENCE AND PRACTICE GAPS

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Purpose: This paper aims to examine how serious games are used to support sustainable business transformation and to identify gaps between academic evidence and practice-oriented simulation tools.
Design/methodology/approach: The study adopts a two-stage review design. First, a structured literature review of English-language journal articles indexed in Scopus and Web of Science and published between 2015 and 2024 was conducted at the intersection of sustainability, serious games, and business transformation. Second, the academic review was complemented by an exploratory scan of publicly documented practitioner-oriented SDG-related business games and simulations. The analysis focused on game purpose, structure, target audience, facilitation context, evaluation evidence, and transfer to practice.
Findings: The structured review identified four peer-reviewed studies describing serious games relevant to sustainable business or organizational transformation. The available evidence was concentrated on cognitive and relational outcomes, including awareness-building, systems thinking, collaborative problem framing, stakeholder dialogue, and reflective learning, although the strength and design of the evaluations varied substantially.
Research limitations/implications: The academic review was limited to English-language journal articles indexed in Scopus and Web of Science. The exploratory scan depended on the availability and quality of publicly available documentation. Future research should use broader search strategies, include grey literature, and develop longitudinal evaluation designs capable of assessing cognitive, relational, normative, behavioral, and organizational outcomes.
Practical implications: Serious games can serve as useful entry points for corporate sustainability training, SDG awareness, strategic conversation, and experimentation with sustainability trade-offs. They should be embedded in broader change programs, including preparation, facilitated gameplay, structured debriefing, action planning, managerial sponsorship, and follow-up measurement.
Social implications: By supporting dialogue on sustainability trade-offs and stakeholder responsibilities, serious games may foster more reflective and participatory approaches to corporate sustainability and SDG implementation.

Originality/value: The paper integrates academic evidence with an exploratory assessment of practitioner tools, clarifying an emerging field and identifying priorities for serious game design, evaluation and application in sustainable business transformation.
Keywords: serious games; sustainable business transformation; SDGs; business simulations; organizational change.
Category of the paper: Literature review.

1. Introduction

Sustainable development has become a central strategic concern for contemporary organizations. Since the adoption of the Sustainable Development Goals (SDGs) in 2015, companies have been increasingly expected to contribute to economic, social, and environmental objectives through their strategies, operations, partnerships, and reporting practices (Jiménez et al., 2021; de Almeida et al., 2023). This expectation reflects the growing recognition that businesses are not only affected by sustainability challenges but also play an important role in addressing them. At the same time, translating broad global goals into concrete organizational priorities, investment decisions, operational practices, and performance measures remains difficult.

The complexity of the SDGs creates several challenges for organizations. The goals are interconnected, long-term, and often require decisions that involve trade-offs among financial, environmental, and social outcomes. Companies may therefore struggle to identify which goals are most relevant to their activities, how to incorporate them into business models and strategies, and how to balance competing stakeholder expectations (Sullivan et al., 2018; Montiel et al., 2021). Sustainable business transformation also requires more than formal commitments or reporting. It may involve changes in organizational culture, managerial routines, employee behavior, stakeholder relationships, and resource allocation. Such changes frequently generate uncertainty and resistance, particularly when sustainability objectives appear to conflict with short-term commercial priorities (De Matos, Clegg, 2013; van der Waal, Thijssens, 2020).

These conditions create a need for approaches that enable managers and other organizational stakeholders to explore sustainability challenges, discuss alternative courses of action, and examine the potential consequences of their decisions. Conventional training methods may be useful for communicating concepts and frameworks, but they are often less suited to representing the interdependencies, uncertainties, and competing interests that characterize sustainable business transformation. Serious games and gaming simulations offer a potentially valuable response to this problem because they allow participants to engage with simplified representations of complex systems, assume organizational roles, negotiate trade-offs, receive feedback, and reflect on the consequences of their choices in a controlled environment (Rumeser, 2018; Kikkawa et al., 2022).

In this paper, serious games are understood as structured game-based artifacts designed for purposes beyond entertainment. They combine rules, roles, resources, decisions, feedback, facilitation, and reflection to support learning, inquiry, dialogue, and decision-making (Meijer et al., 2025). They are distinct from gamification, which refers to the use of selected game elements in non-game contexts. This distinction is important because sustainable business transformation typically requires participants to engage with open-ended situations rather than solve problems with a single correct answer. Serious games may therefore provide a space in which participants can test assumptions, explore stakeholder perspectives, and examine the interaction between economic, social, and environmental consequences without exposing real organizations to direct operational risk.

Previous research has shown that game-based interventions can support knowledge acquisition, engagement, systems thinking, collaborative problem-solving, and attitude change in sustainability-related contexts (Janakiraman et al., 2018; Jääskä et al., 2021; Boncu et al., 2022). However, the evidence base remains fragmented. Much of the literature focuses on education, environmental awareness, or short-term learning outcomes, while relatively few studies examine whether serious games contribute to sustained behavioral, strategic, or organizational change in business settings. Meanwhile, practitioner-oriented sustainability simulations are increasingly used by consultancies, universities, foundations, and training providers, although their claimed effects are not always independently evaluated or reported in peer-reviewed publications.

This creates a gap between the apparent availability of practice-oriented tools and the strength of the evidence concerning their contribution to sustainable business transformation. The problem is not only whether such games exist, but also what purposes they serve, how they are designed and facilitated, what kinds of outcomes have been documented, and whether the effects extend beyond awareness and learning to changes in organizational practice. A clearer synthesis is therefore needed to distinguish established evidence from plausible but insufficiently validated claims.

The purpose of this paper is to examine how serious games are used to support sustainable business transformation and to identify the principal gaps between academic evidence and practice-oriented simulation tools. The study addresses the following research question:

What types of serious games currently exist that aim to support sustainable business transformation, and what gaps remain for future development?

The study adopts an exploratory, two-stage review design. It does not test a formal hypothesis. First, a structured review of peer-reviewed studies indexed in Scopus and Web of Science is conducted. Second, the academic evidence is complemented by an exploratory scan of publicly documented practitioner-oriented games and simulations. The two strands are analyzed separately to avoid treating developer descriptions as equivalent to independently evaluated research evidence.

The paper makes three contributions. First, it synthesizes the limited academic evidence on serious games explicitly connected with sustainable business transformation. Second, it compares this evidence with the broader landscape of practitioner-oriented tools. Third, it identifies an evidence–practice gap by showing that serious games appear to be better established as instruments for sustainability learning, dialogue, and reflection than as independently validated mechanisms for sustained organizational transformation.

The remainder of the paper is structured as follows. Section 2 reviews the literature on sustainable business transformation and the use of serious games in sustainability-related learning and change processes, concluding with the research gap and analytical perspective. Section 3 explains the review design, database selection, search strategy, eligibility criteria, exploratory practice scan, and synthesis procedure. Section 4 presents the results of the academic review and the practice-oriented scan, including a comparative analysis of the identified games. Section 5 discusses the findings in relation to previous research and develops their theoretical and practical implications. Section 6 summarizes the main conclusions, limitations, and directions for future research.

2. Literature review

2.1. SDGS and sustainable business transformation

The Sustainable Development Goals provide organizations with a common framework for addressing interconnected economic, social, and environmental challenges. Although the SDGs were originally formulated as global policy objectives, they have increasingly become reference points for corporate strategy, reporting, innovation, stakeholder engagement, and partnership development (Jiménez et al., 2021; Ordonez-Ponce et al., 2021). Companies may contribute to sustainable development by reducing negative impacts, creating positive social and environmental value, and aligning their core activities with selected goals and targets. The SDGs can therefore support strategic positioning, risk identification, opportunity recognition, and communication with stakeholders (WBCSD, 2015; Jones et al., 2016; Ordonez-Ponce, Khare, 2020).

However, integrating the SDGs into business practice is not a straightforward process. The framework includes 17 goals, 169 targets, and numerous indicators, creating a level of complexity that may be difficult to translate into organizational priorities and operational decisions. The goals are also interdependent, meaning that progress in one area may support, constrain, or conflict with progress in another (Nilsson et al., 2018). Organizations must therefore decide which goals are materially relevant, how they relate to the company's value chain and stakeholders, and how to allocate limited resources among competing sustainability priorities (Sullivan et al., 2018; Montiel et al., 2021).

A further challenge arises from the gap between the macro-level formulation of the SDGs and the micro-level realities of individual organizations. The SDGs were designed primarily as global and national development objectives, whereas companies operate within specific industries, markets, regulatory environments, and organizational cultures. Translating broad goals into measurable corporate objectives requires interpretation, prioritization, and adaptation (van Zanten, van Tulder, 2018). This translation process may introduce ambiguity because organizations often lack a shared understanding of what constitutes meaningful SDG implementation and how progress should be assessed.

Corporate engagement with the SDGs may also vary considerably in depth. Some organizations integrate sustainability into their business models, strategic decision-making, investment criteria, and performance systems. Others adopt the language of the SDGs mainly in response to external pressures or reputational expectations, without substantially changing established practices. This creates the risk of symbolic engagement or "SDG-washing", in which organizations communicate alignment with sustainable development while avoiding more demanding operational or strategic changes (Saizarbitoria et al., 2021). Genuine integration, therefore, requires more than mapping existing activities against selected goals. It involves reconsidering how value is created, how impacts are assessed, and how organizational priorities are negotiated.

Sustainable business transformation may include changes to business models, products, technologies, supply chains, procurement practices, managerial routines, and stakeholder relationships. It can also require redefining performance beyond short-term financial results. Companies often face tensions between immediate profitability and longer-term environmental and social objectives, particularly when sustainability investments generate uncertain returns or require changes in established operating models (van der Waal, Thijssens, 2020). These tensions make sustainability transformation a strategic and organizational challenge rather than merely a technical or reporting exercise.

Organizational culture is a critical condition for the successful integration of sustainability goals. Sustainability initiatives are less likely to become embedded when they remain peripheral to managerial decision-making or are assigned to a single department. A supportive culture requires shared understanding, consistent leadership, cross-functional cooperation, and the inclusion of sustainability considerations in everyday routines and decisions (Camelo, Nogueira, 2024). Organizational learning and knowledge management are also important because employees and managers must be able to interpret sustainability challenges, exchange knowledge across functional boundaries, and adapt existing practices (Iqbal, Ahmad, 2020).

Resource allocation constitutes another important barrier. Sustainability initiatives compete with other organizational priorities for financial, human, and managerial resources. Smaller organizations may experience particular difficulties because they often lack specialized sustainability functions, formal measurement systems, and extensive implementation capacity. The integration of sustainability into procurement and supply chain management, for example,

requires coordination across organizational boundaries and cooperation with suppliers whose objectives and capabilities may differ (Cooper, 2024). Effective implementation therefore depends not only on internal commitment but also on the ability to influence and collaborate with external partners.

Stakeholder engagement further increases the complexity of transformation. Organizations must consider the expectations of employees, customers, investors, suppliers, regulators, communities, and other stakeholders. These groups may differ in their understanding of sustainability, their priorities, and their willingness to accept short-term costs in exchange for long-term benefits. As a result, sustainable transformation frequently involves negotiation, conflict resolution, and the reconciliation of competing interests. It also requires transparent communication and credible evidence that organizational commitments are being translated into action.

These challenges suggest that sustainable business transformation should be understood as a process of organizational change rather than as the simple adoption of a set of external goals. Organizational change may generate uncertainty, resistance, and conflicts over resources, responsibilities, and strategic direction (De Matos, Clegg, 2013). Employees may question the necessity of proposed changes, perceive sustainability initiatives as additional workload, or doubt whether senior management is genuinely committed. Sustainable transformation therefore depends on the organization's capacity to build shared meaning, support participation, and connect global sustainability objectives with the practical concerns of organizational members.

Training and learning interventions can contribute to this process by helping managers and employees understand the relevance of the SDGs, recognize interdependencies, and explore the consequences of alternative decisions. Sustainability-related learning may strengthen awareness, engagement, collaboration, and the ability to incorporate environmental and social considerations into business practice (Bilderback, 2023; Teixeira et al., 2022). Nevertheless, the complexity of sustainability transformation limits the effectiveness of approaches based primarily on information transfer. Organizations need learning formats that allow participants to examine trade-offs, confront different stakeholder perspectives, and experiment with possible courses of action.

This creates a potential role for experiential and participatory interventions. Unlike conventional instructional approaches, such interventions can represent sustainability as a dynamic system of interacting decisions, consequences, and stakeholder interests. Serious games and simulation-based methods are particularly relevant in this context because they can provide a structured environment for exploring complexity, testing assumptions, and reflecting on organizational choices. The next section, therefore, examines serious games as learning and change interventions and considers the mechanisms through which they may support sustainability-related transformation.

2.2. Serious games as learning and change interventions

Serious games are designed for purposes that extend beyond entertainment. They use rules, roles, goals, resources, feedback, and decision structures to create environments in which participants can explore problems, test assumptions, and experience the consequences of their actions (Zyda, 2005; Djaouti, 2011). In management and organizational contexts, serious games are often used to support learning, decision-making, collaboration, and reflection. Business simulations represent a related category in which participants manage simplified representations of organizations, markets, projects, or value chains and make decisions under conditions of uncertainty (Feinberg, Johnson, 1988; Klabi, Klabi, 2012).

The terminology used in this field is not always consistent. Serious games, simulation games, business simulations, game-based learning, and gamification are sometimes treated as interchangeable, although they refer to different forms of intervention. Serious games and simulation games are complete systems with defined rules, participant roles, decision spaces, and consequences. Gamification, by contrast, involves adding selected game elements, such as points, badges, rankings, or challenges, to activities that are not games in themselves. This distinction is important because the present study focuses on complete game or simulation artifacts that allow participants to engage with a problem environment rather than on isolated motivational mechanisms.

From a game science perspective, a serious game should not be understood solely as a teaching tool or a digital product. It is better viewed as a structured social and cognitive system in which meaning emerges from the interaction between rules, roles, resources, participants, facilitation, and reflection (Meijer et al., 2025). The educational or organizational value of a game, therefore, does not reside only in its content. It also depends on how participants interpret the situation, how they interact with one another, what feedback they receive, and how the experience is connected to real-world practice.

Serious games are closely associated with experiential learning. Participants learn by acting within a simulated environment, observing the consequences of their decisions, and reflecting on the results. This sequence is consistent with experiential learning approaches in which concrete experience is followed by reflection, conceptualization, and further experimentation (Kolb, 1984). Games can therefore provide opportunities to move beyond passive knowledge acquisition and engage learners in repeated cycles of action and feedback.

The capacity to experiment is one of the principal advantages of serious games. In organizational settings, many strategic and managerial decisions involve uncertainty, interdependence, and potentially significant consequences. Testing alternative approaches in real organizations may be costly, risky, or impractical. A simulation allows participants to examine possible courses of action in a controlled environment, where failure becomes a source of learning rather than an operational threat (Kikkawa et al., 2022). Participants can compare strategies, observe delayed effects, and reconsider assumptions without exposing an actual organization to direct harm.

Serious games can also support systems thinking. A single factor rarely causes organizational problems, and decisions taken in one functional area may produce consequences elsewhere. By representing relationships between variables, actors, and outcomes, games can help participants recognize feedback loops, unintended consequences, and competing objectives. Even relatively simple simulations can make causal relationships more visible by reducing the complexity of reality to a manageable set of decisions and indicators (Endress et al., 2023).

Another important mechanism is role-based learning. Participants may be asked to represent managers, employees, customers, suppliers, regulators, or other stakeholders. Assuming a role can expose them to perspectives different from their own and help them understand why actors interpret the same problem differently. In business simulations, participants often make decisions from the perspective of specific organizational functions, such as operations, finance, marketing, or procurement. This structure can reveal conflicts between local objectives and overall organizational performance.

The social dimension of gameplay is equally important. Many serious games require participants to cooperate, negotiate, exchange information, and coordinate decisions. These activities can develop communication skills, shared understanding, and collective problem-solving capacity. Business simulations may also expose differences in assumptions and priorities that remain hidden in conventional discussions. In this sense, games can act as boundary objects that provide participants from different functions or professional backgrounds with a common situation and language for examining complex problems.

However, interaction alone does not guarantee learning. The outcomes of serious games depend substantially on facilitation and debriefing. Facilitation helps participants understand the rules, remain engaged, and connect the simulated situation with the purpose of the intervention. Debriefing enables them to reconstruct what occurred, explain their decisions, examine unexpected results, and relate the experience to broader concepts or organizational challenges (Kriz, 2010). Without structured reflection, participants may focus on winning, operational details, or entertaining aspects of the game while overlooking the intended learning outcomes.

Debriefing is particularly important when games address open-ended problems. In such settings, there may be no single optimal strategy or correct answer. The value of the intervention lies instead in comparing interpretations, examining trade-offs, and understanding the assumptions behind different decisions. A skilled facilitator can help participants move from observations about the game to conclusions about real organizational systems. This transfer from simulated experience to practice is essential if the intervention is intended to influence managerial behavior or organizational change.

Research has generally shown that serious games can improve engagement, motivation, knowledge acquisition, and selected cognitive outcomes (Wouters, 2013). Business simulations have also been associated with the development of decision-making skills, entrepreneurial

attitudes, and understanding of cross-functional relationships (Blakely et al., 2018; Nkhoma et al., 2014). Nevertheless, the evidence is not uniform. Outcomes differ depending on game design, participant characteristics, duration, facilitation quality, assessment methods, and the organizational or educational context in which the game is used.

A further limitation concerns the transfer and persistence of effects. Immediate reactions, satisfaction, or knowledge gains are easier to measure than changes in behavior or organizational practice. Participants may perform well in a simulation without applying the same reasoning in their workplace. Organizational routines, incentive systems, managerial support, resource constraints, and cultural norms can prevent the application of insights generated during gameplay. Consequently, serious games should not automatically be treated as stand-alone change mechanisms.

Their contribution is more likely to be significant when they are embedded in broader learning or organizational development processes. Such processes may include preparation before the game, facilitated reflection, action planning, managerial sponsorship, opportunities to test new practices, and follow-up evaluation. The game can create a shared experience and stimulate reflection, but sustained change usually requires additional organizational conditions and reinforcement.

These characteristics make serious games potentially relevant to sustainable business transformation. Sustainability problems involve interdependent systems, long-term consequences, conflicting stakeholder interests, and uncertainty regarding the effects of managerial decisions. Games can represent these conditions in an accessible form and allow participants to explore them through action and dialogue. The following section examines how serious games have been applied in sustainability education and sustainable development contexts, and what outcomes have been reported.

2.3. Serious games for sustainability

Serious games have increasingly been used to support sustainability-related learning, awareness, and decision-making. Sustainability challenges are particularly well-suited to game-based interventions because they involve complex systems, long-term consequences, competing stakeholder interests, and uncertainty about the effects of individual and collective actions. Games can make these relationships more visible by transforming abstract sustainability concepts into concrete decisions, roles, and consequences.

In educational settings, game-based learning has been associated with higher engagement and a deeper understanding of sustainability issues. Interactive scenarios allow participants to explore how environmental, social, and economic factors interact and to observe how decisions made in one area may generate consequences elsewhere (Jääskä et al., 2021). Learner-centered game design can also support knowledge transfer by encouraging participants to apply sustainability concepts rather than merely reproduce them (Oliveira et al., 2021).

Role-playing and simulation formats are particularly relevant because they expose participants to multiple perspectives. Sustainability problems rarely involve only one decision-maker or one objective. Participants may need to represent businesses, public authorities, consumers, communities, or other stakeholders with differing priorities. By negotiating these perspectives, players can better understand the conflicts and interdependencies that shape sustainability decisions. Blanchard and Buchs (2015), for example, showed that role-play can clarify sustainable development concepts while also supporting interpersonal and collaborative skills.

Games can also foster a sense of agency. Sustainability issues are often perceived as distant, highly technical, or beyond the influence of individuals and organizations. Simulation-based activities can reduce this distance by allowing participants to experience how specific choices affect environmental and social outcomes. Studies in sustainability education indicate that hands-on and participatory approaches can strengthen responsibility, engagement, and willingness to address sustainability challenges (Nascimento et al., 2023).

A further advantage of serious games is their potential to support systems thinking. Feedback loops, delays, trade-offs, and unintended consequences characterize sustainability problems. Conventional teaching methods may describe these relationships, but games enable participants to experience them in a dynamic way. By observing how decisions accumulate over time, players can develop a better understanding of the systemic nature of sustainability challenges and the limitations of isolated interventions.

Existing research also suggests that serious games can contribute to environmental knowledge and awareness. Boncu et al. (2022), in a systematic review of serious games and gamified applications, found generally positive effects on pro-environmental knowledge, attitudes, and selected behaviors. Similarly, Ivens et al. (2020) reported that a digital simulation game addressing sustainable agriculture supported participants' knowledge and self-efficacy. These findings indicate that games can make sustainability concepts more accessible and provide learners with opportunities to practice decision-making in a low-risk environment.

Attitudinal change is another frequently reported outcome. Janakiraman et al. (2018) found that game-based learning can influence attitudes towards environmental sustainability by enabling participants to experiment with alternative behaviors without fear of real-world failure. This safe environment may reduce resistance to unfamiliar ideas and encourage reflection on the consequences of established practices. However, changes in attitudes do not necessarily translate into sustained behavioral change, particularly when participants return to organizational or social contexts that do not support new practices.

The use of competitive and cooperative mechanics can further influence engagement. Competition may increase attention and motivation, while cooperation can encourage information sharing and collective problem-solving. In sustainability contexts, cooperative structures are often especially valuable because many problems require coordinated action across organizational and institutional boundaries. Games that combine competition and

collaboration can help participants experience the tension between individual or organizational interests and collective sustainability outcomes.

Technology has expanded the range of sustainability games and how they can be delivered. Digital simulations, online platforms, and augmented reality applications can increase accessibility, provide immediate feedback, and enable visualization of complex environmental processes. Wang et al. (2021), for example, showed that augmented reality games can increase environmental awareness and support pro-environmental learning through interactive experiences. Nevertheless, technological sophistication alone does not guarantee educational or organizational effectiveness. The quality of the scenario, decision structure, feedback, facilitation, and debriefing remains critical.

Several studies have examined serious games in environmental and climate-related contexts. Douglas and Bräuer (2021) identified gamification and game-based applications as potentially useful tools for raising climate awareness and encouraging sustainable action. Madani et al. (2017) similarly argued that serious games can support environmental management by enabling participants to explore complex resource-allocation and policy problems. The Climate Adaptation Game, discussed by Neset et al. (2020), illustrates how game-based formats can integrate systems thinking, stakeholder dialogue, and action-oriented learning to address climate risks.

Board games and facilitated workshop formats have also been used to explore the Sustainable Development Goals. Chen and Ho (2022) demonstrated that a board game can support discussion and understanding of the SDGs by making the relationships among goals more tangible. Such formats can be particularly effective in group settings because they create a common reference point for discussion and allow participants to compare interpretations and priorities.

Despite these promising findings, the existing literature is dominated by educational and short-term outcomes. Most studies focus on knowledge acquisition, engagement, awareness, self-efficacy, or attitudes. These outcomes are important, but they provide limited evidence of sustained behavioral change, strategic reorientation, or organizational transformation. Even when participants report positive learning experiences, it is often unclear whether these effects persist or influence subsequent decisions in real organizational settings.

The sustainability games literature also covers a wide range of contexts, including schools, universities, environmental education, agriculture, urban planning, and climate adaptation. Although this diversity demonstrates the flexibility of game-based approaches, it makes it difficult to draw specific conclusions about business transformation. Findings from educational settings cannot be automatically transferred to corporate environments, where organizational structures, incentives, leadership, resource constraints, and commercial priorities shape implementation.

Another limitation concerns evaluation. Many studies rely on self-reported reactions, post-game surveys, or short-term measures collected immediately after gameplay. Fewer studies use comparison groups, repeated measures, behavioral indicators, or longitudinal follow-up. Consequently, the available evidence is stronger for immediate learning and engagement than for long-term behavioral or organizational outcomes.

Overall, serious games appear to offer considerable potential for supporting sustainability-related learning, systems thinking, stakeholder dialogue, and reflective decision-making. However, the extent to which they contribute to sustainable business transformation remains uncertain. The next section therefore identifies the specific research gap this study addresses and explains the analytical perspective used to compare academic evidence with practice-oriented sustainability simulations.

2.4. Research gap and analytical perspective

The literature reviewed above indicates that serious games can support sustainability-related knowledge, engagement, systems thinking, stakeholder dialogue, and selected attitudinal outcomes. Existing studies also show that games can create safe environments in which participants explore complex problems, test alternative decisions, and reflect on their consequences (Janakiraman et al., 2018; Jääskä et al., 2021; Boncu et al., 2022). However, the available evidence does not yet provide a sufficiently clear account of how serious games contribute specifically to sustainable business transformation.

The first gap concerns the dominant context of previous research. Much of the literature addresses sustainability education, environmental awareness, climate communication, or learning in schools and universities. These studies provide useful evidence on engagement and knowledge acquisition, but their findings cannot be directly applied to organizational transformation. Corporate settings introduce additional conditions, including formal authority structures, functional specialization, strategic priorities, incentive systems, resource constraints, and accountability for commercial performance. A game that improves understanding in an educational setting may not necessarily influence managerial decisions, organizational routines, or investment priorities.

The second gap concerns the types of outcomes that are evaluated. Existing studies predominantly measure immediate or short-term effects, such as participant satisfaction, perceived engagement, knowledge, awareness, self-efficacy, or attitudes. These outcomes are relevant because they may constitute early stages of a broader change process. Nevertheless, they do not demonstrate that participants subsequently alter their behavior or that organizations change their strategies and practices. Evidence becomes substantially more limited when the expected outcome shifts from cognitive and relational learning towards behavioral, strategic, or organizational transformation.

This distinction is particularly important because sustainable business transformation requires more than awareness of sustainability problems. It may involve changes to business models, procurement criteria, resource allocation, cross-functional cooperation, performance measures, and stakeholder relationships. Such changes occur over longer periods and depend on organizational conditions that extend beyond the game session. Consequently, positive post-game reactions should not be interpreted automatically as evidence of sustained transformation.

The third gap relates to the reporting and evaluation of game interventions. Studies differ considerably in the extent to which they describe game rules, participant roles, decision structures, feedback mechanisms, facilitation, debriefing, and implementation context. They also use heterogeneous evaluation methods and outcome measures. This variation makes it difficult to compare interventions and identify which design characteristics are associated with particular outcomes. In some cases, the game itself is described in detail while the evaluation is limited. In others, outcome measures are reported without sufficient information about the intervention that produced them.

The fourth gap concerns the relationship between academic research and professional practice. Consultancies, universities, foundations, and specialist training providers offer a growing number of sustainability-oriented games and business simulations. These tools suggest that game-based approaches are already being applied in corporate sustainability training and strategic workshops. However, publicly available descriptions are often promotional and provide limited information about evaluation procedures, participant samples, or sustained outcomes. Developer materials and user testimonials may indicate perceived usefulness, but they cannot be treated as equivalent to independently reviewed empirical evidence.

The emerging field therefore displays an evidence–practice gap. Practice-oriented tools appear to be more numerous than the peer-reviewed literature suggests, yet their contribution to behavioral and organizational change is rarely assessed independently. At the same time, academically documented games are relatively few and are often evaluated primarily in terms of learning-related outcomes. A review restricted to peer-reviewed studies would therefore provide an incomplete picture of the available tools, whereas an assessment based only on practitioner documentation would risk overstating their effectiveness.

This study addresses that problem through a two-stage design. The first stage examines peer-reviewed academic studies that explicitly connect serious games to sustainability and to business, management, organizational, or strategic transformation. The second stage maps publicly documented practitioner-oriented tools separately. This distinction is maintained throughout the analysis to prevent conflation of evidence from academic studies with claims in developer documentation. The exploratory scan is used to identify practice trends, design patterns, and research opportunities rather than to establish effectiveness.

To structure the comparison, the study applies four analytical dimensions. The first is purpose and transformation logic, which concerns the problem the game addresses, the type of change it is intended to support, and the relationship between gameplay and the expected transformation outcome. This dimension distinguishes, for example, between games designed mainly to raise awareness and those intended to support strategy development, business model innovation, or organizational adaptation.

The second dimension is game structure and action space. It includes participant roles, decision variables, interaction patterns, feedback, competition or cooperation, scenario development, and the extent to which players can influence the simulated system. his dimension is relevant because games may present sustainability either as a set of predefined choices or as an open-ended problem requiring negotiation and collective interpretation.

The third dimension is the target audience and facilitation context. It considers who participates, whether the game is designed for students, managers, professionals, mixed stakeholder groups, or organizational teams, and how facilitation and debriefing support the intervention. This dimension also captures the duration, delivery format, and degree of adaptation to a specific organizational or sectoral context.

The fourth dimension is evidence of outcomes and transfer to practice. It distinguishes among cognitive, relational, normative, behavioral, and organizational outcomes. It also considers the evaluation design, the timing of measurement, the use of comparison groups, and whether the reported effects extend beyond the game session. This distinction enables the separation of documented learning outcomes from claims of sustained business transformation.

On this basis, the study addresses the following research question:

What types of serious games currently exist that aim to support sustainable business transformation, and what gaps remain for future development?

The study is exploratory and does not test a formal hypothesis. Its objective is to clarify the current state of evidence, compare the main characteristics of identified games, and determine where claims of transformational potential exceed the available empirical support. By combining a structured academic review with a separate exploratory scan of practitioner tools, the paper seeks to provide a more balanced account of both the field's development and its principal methodological and practical limitations.

3. Methodology

3.1. Review design

This study adopted a two-stage review design combining a structured review of peer-reviewed academic literature with a separate exploratory scan of practitioner-oriented serious games and business simulations. The design was selected to capture both the state of research evidence and the broader landscape of tools used in professional practice.

The first stage consisted of a structured literature review. Its purpose was to identify peer-reviewed studies examining serious games or simulation-based interventions at the intersection of sustainability and business, management, organizational change, or strategic transformation. The review followed a transparent sequence of database selection, search, screening, eligibility assessment, data extraction, and comparative synthesis. This approach was intended to improve the study's reproducibility and reduce the risk of selecting cases solely based on their visibility or perceived relevance.

The academic review focused on studies published between 2015 and 2024. The beginning of this period coincides with the adoption of the United Nations Sustainable Development Goals. It reflects the emergence of the SDGs as an important framework for business strategy, management education, and organizational sustainability. The review was limited to English-language peer-reviewed journal articles to maintain a consistent minimum standard of scholarly reporting and enable comparison across studies.

The second stage consisted of an exploratory scan of publicly documented practitioner-oriented games and simulations. This stage was added because sustainability-related tools used in corporate training, strategic workshops, and organizational development are frequently developed by consultancies, universities, foundations, or specialist training providers and may not be described in peer-reviewed publications. Restricting the study to academic databases would therefore have provided only a partial view of the field.

The exploratory scan was designed as a mapping exercise rather than as a systematic review of effectiveness. Its purpose was to identify publicly available tools, describe their intended users and design characteristics, and examine the extent to which their claimed outcomes were supported by accessible evidence. Developer websites, training descriptions, game repositories, professional portals, award databases, and expert contacts were used to identify candidate tools.

The two stages were analyzed separately. Peer-reviewed studies were treated as sources of academic evidence, whereas practitioner documentation was treated as descriptive material concerning the availability, positioning, and design of practice-oriented tools. Claims reported by developers, training providers, or users were not interpreted as equivalent to independently evaluated outcomes.

The two-stage design therefore served two complementary purposes. The academic review established what has been examined and documented in scholarly research. The exploratory scan showed what appears to be available and used in practice. Comparing the two strands made it possible to identify differences in the development of the market for sustainability-oriented serious games and in the strength of the empirical evidence regarding their outcomes. Because the study was exploratory, no formal hypothesis was tested. The analysis was intended to identify recurring patterns, differences, and evidence gaps across the games and simulations identified. Both stages were examined using the analytical dimensions introduced in Section 2.4: purpose and transformation logic; game structure and action space; target audience and facilitation context; and evidence of outcomes and transfer to practice.

3.2. Database selection and search strategy

The academic search was conducted in Scopus and Web of Science. These databases were selected because they provide broad and partly complementary coverage of peer-reviewed research in business and management, environmental science, education, engineering, computer science, economics, and the social sciences. This multidisciplinary coverage was necessary because research on serious games for sustainable business transformation is dispersed across several disciplinary fields rather than concentrated in a single publication stream.

Scopus and Web of Science also support transparent and reproducible search procedures. Both databases allow structured Boolean queries and the application of filters for publication period, language, document type, and subject area. Searching both databases reduced the risk of omitting relevant studies because their journal coverage overlaps but is not identical.

The search was conducted from November 2023 to March 2025 and was limited to English-language, peer-reviewed journal articles published between 2015 and 2024. The year 2015 was selected as the starting point because it marks the adoption of the United Nations Sustainable Development Goals and the subsequent growth of interest in their application to corporate strategy, management education, and organizational transformation.

The search strategy combined three conceptual blocks derived from the research question:

1. sustainability and the Sustainable Development Goals,
2. serious games and related game-based interventions, and
3. business transformation, organizational change, and strategic management.

The first block included terms referring to the SDGs, corporate sustainability, corporate social responsibility, and sustainable business practices. The second covered serious games, simulation games, game-based learning, training games, and related interventions. The third included business transformation, organizational change, business strategy, and strategic planning.

The term gamification was included in the search stage to improve sensitivity, as the terminology used in the literature is not always consistent. However, publications that addressed only isolated game elements, such as points, badges, rankings, or rewards, were excluded during screening unless they described a complete game or simulation artifact. This procedure maintained consistency with the conceptual distinction introduced in Section 2.2.

Subject-area filters were applied to improve the search's relevance while retaining its interdisciplinary scope. The filters extended beyond business and management, as sustainability-oriented games may be reported in environmental science, education, engineering, computer science, or social science journals, even when their application concerns organizational decision-making or business transformation. The complete search formula and database-specific filters are provided in Appendix A.

The search generated 102 records in Web of Science and 97 in Scopus, for a total of 199 records before duplicate removal. The subsequent duplicate removal, title and abstract screening, and full-text eligibility assessment are described in Section 3.3.

The strategy prioritized precision by requiring publications to address all three conceptual domains. This reduced the number of records concerning general environmental education or game-based learning that lacked a recognizable business or organizational context. At the same time, the strategy may have omitted relevant studies that use adjacent terminology, including sustainability transitions, circular economy, climate resilience, responsible innovation, transition management, regenerative business, or organizational learning. This limitation is addressed in Section 5.5 and informs the future research agenda presented in Section 5.6.

3.3. Eligibility and screening

The database searches produced 199 records: 102 from Web of Science and 97 from Scopus. The records were combined into a single dataset, after which duplicates and multiple records referring to the same study were removed. The remaining records were assessed through two consecutive stages: title and abstract screening, followed by full-text eligibility assessment.

Studies were eligible for inclusion when they met all of the following criteria:

- they were peer-reviewed journal articles published in English between 2015 and 2024,
- they described or evaluated a complete serious game, simulation game, business simulation, or closely related game-based intervention,
- the intervention addressed sustainability, sustainable development, or the Sustainable Development Goals,
- the study was situated in a business, management, organizational, strategic, or professional context relevant to sustainable business transformation, and
- the publication provided sufficient information to assess the purpose of the intervention, its target group, its principal design characteristics, and the evidence concerning its outcomes.

Eligibility required explicit relevance to all three substantive domains of the review: a game or simulation intervention, a sustainability-related purpose, and a business or organizational transformation context. This intersection was deliberately applied to distinguish the review from broader bodies of research on environmental education, general sustainability awareness, or game-based learning that lack managerial or organizational application.

Studies were excluded when they:

- focused solely on children's or school-level education,
- addressed general environmental awareness without a clear business, management, organizational, or strategic context,
- examined gamification through isolated elements such as points, badges, rankings, or rewards without describing a complete game or simulation artifact,
- concerned games designed primarily for entertainment without a documented serious purpose,
- discussed sustainability or serious games only conceptually without presenting an identifiable intervention,
- did not provide sufficient information to determine whether the intervention met the inclusion criteria, or
- fell outside the defined publication period, language, document type, or peer-review requirements.

During the first screening stage, titles and abstracts were examined to determine whether the publication appeared to address all three domains. Records clearly unrelated to the research question were excluded at this stage. When relevance could not be determined from the title and abstract alone, the publication was retained for full-text assessment.

During the second stage, the full texts of potentially relevant publications were assessed against the complete eligibility criteria. Particular attention was given to whether the publication described a complete game or simulation, whether sustainability was an explicit purpose rather than a peripheral theme, and whether the intervention was connected with business, management, organizational change, strategic planning, or professional practice.

Where several publications or database records referred to the same study or game intervention, they were treated as a single case for the synthesis. Publications were retained only when they provided sufficiently direct evidence concerning the intervention and its application. Studies dealing exclusively with gamification or general sustainability education were not included in the academic synthesis, even when they were used elsewhere in the paper to contextualize the broader literature.

Following duplicate removal, title and abstract screening, and full-text eligibility assessment, four academic studies met all inclusion criteria and were retained for analysis. These studies concerned MainKassandra (Fischer et al., 2024), the Theory of Change Game (Tribaldos, Schneider, 2021), the Sustainability Futures Game (Ampatzidou et al., 2022), and The Road to Flourishing (Niessen et al., 2024).

The limited final number of studies reflects the deliberately narrow intersection defined by the research question. A publication had to address not only sustainability and a game-based intervention but also a recognizable business, management, organizational, or strategic transformation context. The implications of this narrow yield for the review's interpretation and completeness are considered in the Discussion.

3.4. Exploratory practice scan

The exploratory practice scan was conducted to complement the academic review by providing information on sustainability-oriented games and simulations available in professional practice. This additional stage was necessary because tools used in corporate training, strategic workshops, management education, and organizational development are not always described in peer-reviewed publications. Many are developed and distributed by consultancies, universities, foundations, specialist training providers, or serious-game designers and are documented primarily through websites, brochures, demonstration materials, or facilitator descriptions.

The scan was conducted between November 2023 and March 2025. Candidate tools were identified through Google searches, serious-gaming portals, game repositories, international gaming award databases, developer and provider websites, and expert contacts. Searches combined terms related to serious games, business simulations, sustainability, the Sustainable Development Goals, corporate responsibility, management training, and organizational transformation.

The practice scan was exploratory rather than systematic. Its purpose was to identify visible examples of tools used or promoted in professional contexts, describe their main characteristics, and examine the extent to which publicly available documentation supported claims about their outcomes. It was not designed to provide a comprehensive inventory of all existing sustainability games or to establish their effectiveness.

A tool was eligible for inclusion when it met the following criteria:

- it was publicly identifiable as a complete game, simulation, or facilitated game-based intervention,
- it addressed sustainability, sustainable development, the SDGs, or related environmental and social business challenges,
- it was intended for business, management, professional, organizational, or higher-education audiences,
- it involved decision-making, strategy development, stakeholder interaction, or the exploration of organizational sustainability trade-offs, and
- sufficient public documentation was available to assess its purpose, target group, delivery format, principal gameplay characteristics, and sustainability scope.

Tools were excluded when they were designed primarily for entertainment, focused exclusively on children or the general public for awareness without a clear business or management context, consisted solely of isolated gamification elements, or lacked sufficient documentation for meaningful assessment. Tools whose websites or promotional materials provided only a name or a general sustainability claim, without information about gameplay or intended application, were also excluded.

For each eligible tool, publicly available information was collected on its developer or provider, target audience, intended purpose, physical or digital format, participant roles, decision structure, sustainability themes, SDG coverage, delivery mode, facilitation requirements, and reported outcomes. Information about evaluation was recorded separately, with particular attention to whether independent studies, internal assessments, participant testimonials, or developer descriptions supported claims.

The scan identified fourteen publicly documented SDG-related business games and simulations. These tools are listed in Appendix B. They varied in their thematic focus, complexity, delivery format, and level of available documentation. Some addressed broad corporate sustainability and the triple bottom line, while others focused on climate change, supply chains, circular economy, stakeholder management, or the integration of the SDGs into strategic decision-making.

Two tools—Green Business Lab and Triple Connection—were selected for closer discussion in the main text. They were chosen because they were explicitly positioned for business training or strategic management, provided sufficient public information to assess their design and intended application, and addressed a broad range of sustainability or SDG-related issues. Their inclusion was intended to illustrate recurring features of practitioner-oriented simulations rather than to identify the most effective tools.

The documentation available for the identified games varied considerably. In many cases, information was limited to provider websites, marketing materials, workshop descriptions, demonstrations, or user testimonials. Such materials were considered useful for describing the availability, positioning, and design of the tools, but they were not treated as independent evidence of behavioural or organisational effectiveness. Statements about learning or transformation outcomes were therefore reported as developer or provider claims unless supported by peer-reviewed or independently conducted evaluation.

The results of the practice scan were analyzed separately from those of the academic review. This separation was maintained to avoid equating commercial or promotional descriptions with empirical research evidence. The scan was used to identify design trends, professional applications, and areas where widely available tools have not yet undergone transparent evaluation.

The exploratory nature of the scan creates several limitations. Search results depended on online visibility, search-engine indexing, language, access to documentation, and the continued availability of websites. Commercial tools with restricted documentation may have been

overlooked, while highly visible tools may be overrepresented. Consequently, the fourteen identified games should be interpreted as an indicative sample of publicly documented practice rather than as a complete representation of the market.

3.5. Data extraction and synthesis

Data from the included academic studies were extracted using a standardized coding template. The purpose of the template was to ensure that each serious game was analyzed according to the same criteria and to reduce the risk of presenting the identified interventions as unrelated descriptive cases. The extraction process focused on both the characteristics of the games and the strength of the evidence concerning their outcomes.

For each academic study, the following information was recorded:

- bibliographic information and country or context of origin,
- name and purpose of the game,
- sustainability problem or transformation challenge addressed,
- target audience and participant characteristics,
- physical, digital, or hybrid delivery format,
- duration and facilitation context,
- participant roles and gameplay structure,
- decision variables, interaction patterns, and feedback mechanisms,
- sustainability concepts, SDGs, or theoretical frameworks incorporated into the intervention,
- intended learning or transformation outcomes,
- evaluation design and data-collection methods,
- observed outcomes,
- reported limitations, and
- implications for future development, evaluation, and transfer to practice.

The extraction distinguished between intended and documented outcomes. Intended outcomes referred to the objectives stated by game designers or study authors, whereas documented outcomes referred to effects supported by data reported in the publication. This distinction was necessary because a game's transformational ambitions may be broader than the outcomes that can be assessed empirically.

Evaluation evidence was coded descriptively according to the research design used in each study. The analysis considered whether the evidence was based on participant reactions, qualitative observations, self-reported learning, pre- and post-intervention measurements, comparison groups, behavioral indicators, or longer-term follow-up. No formal risk-of-bias score was assigned because the small number of included studies and the heterogeneity of their designs would have made a standardized quantitative appraisal of limited interpretive value. Instead, the strengths and limitations of the evidence were examined by evaluating the evaluation design, outcome measures, sample characteristics, and measurement timing.

Reported outcomes were organized into five categories:

1. cognitive outcomes, including knowledge, conceptual understanding, awareness, and systems thinking,
2. relational outcomes, including communication, collaboration, stakeholder dialogue, shared understanding, and trust,
3. normative outcomes, including changes in values, attitudes, perceived responsibilities, and social norms,
4. behavioral outcomes, including intentions, individual decisions, and reported changes in practice, and
5. organizational outcomes, including changes in strategies, routines, policies, investments, business models, or implemented sustainability initiatives.

This outcome structure made it possible to distinguish immediate learning effects from evidence of sustained transformation. Cognitive and relational outcomes may constitute important early stages of change, but they do not by themselves demonstrate that a game has influenced subsequent behavior or organizational practice.

Data from the exploratory practice scan were extracted using a related but more limited template adapted to the quality of publicly available documentation. For each practitioner-oriented tool, the analysis recorded the provider, target audience, stated purpose, delivery format, participant roles, decision structure, sustainability themes, reported SDG coverage, facilitation requirements, and claimed outcomes. The source and status of the evidence were also recorded, distinguishing between peer-reviewed evaluation, independent assessment, internal provider evidence, user testimonials, and general promotional claims.

The academic studies and practitioner tools were not combined into a single evidence set. The academic review was used to assess documented research evidence, while the exploratory practice scan was used to map tool availability, design trends, and professional applications. Maintaining this separation reduced the risk of interpreting developer claims as equivalent to independently evaluated outcomes. The synthesis was structured around the four analytical dimensions introduced in Section 2.4:

1. purpose and transformation logic,
2. game structure and action space,
3. target audience and facilitation context, and
4. evidence of outcomes and transfer to practice.

The first dimension examined what type of sustainability problem the game addressed and how gameplay was expected to contribute to change. The second compared roles, decisions, feedback, interaction patterns, and the degree of freedom available to participants. The third considered participant groups, delivery conditions, facilitation, debriefing, and adaptation to organizational contexts. The fourth assessed what outcomes were measured, how they were evaluated, and whether the reported effects extended beyond the game session.

The findings were synthesized through structured comparison rather than statistical aggregation. A meta-analysis was not appropriate because the identified studies differed substantially in intervention design, participant groups, outcome measures, evaluation methods, and reporting practices. The synthesis therefore focused on recurring mechanisms, similarities, differences, and evidence gaps across the cases.

The comparative analysis was used to identify three types of patterns. First, it examined characteristics shared across the identified games, such as the use of stakeholder roles, collaborative decision-making, systems thinking, facilitation, and debriefing. Second, it identified differences in transformation focus, target audience, theoretical foundation, game structure, and evaluation design. Third, it assessed where claims concerning sustainable business transformation were supported by empirical evidence and where they remained primarily conceptual, aspirational, or based on short-term learning outcomes.

The results of this process are presented in Section 4. The academic games are first described using a consistent structure and then compared across the analytical dimensions. The practice-oriented tools are reported separately, followed by a synthesis of the evidence–practice gap between the availability of sustainability simulations and the strength of independent evidence regarding their behavioral and organizational effects.

4. Results

4.1. Review and scan outcomes

The database searches generated 199 records in total: 102 from Web of Science and 97 from Scopus. After combining records from both databases, duplicates and multiple records for the same study were removed. The remaining publications were screened by title and abstract, and potentially relevant articles were assessed in full text against the eligibility criteria described in Section 3.3.

Four peer-reviewed studies met all inclusion criteria. Each study described a distinct serious game addressing sustainability in a business, management, organizational, strategic, or professional context. The included games were:

1. MainKassandra, a simulation addressing corporate climate adaptation (Fischer et al., 2024).
2. The Theory of Change Game, a facilitated intervention supporting collaborative planning for sustainability-related change (Tribaldos, Schneider, 2021).
3. The Sustainability Futures Game, a participatory futures-oriented game involving urban and cross-sector stakeholders (Ampatzidou et al., 2022); and
4. The Road to Flourishing, a game addressing strongly sustainable business models and related behavioral constructs (Niessen et al., 2024).

The four studies differed in their target audiences, delivery formats, theoretical foundations, gameplay structures, and evaluation methods. They also addressed different levels of sustainability-related activity, ranging from individual learning and stakeholder dialogue to business model development and organizational adaptation. Their detailed characteristics are presented in Section 4.2 and Appendix B.

The exploratory practice scan identified fourteen publicly documented sustainability- or SDG-related games and simulations with a business, management, professional, or higher-education application. The identified tools addressed a range of topics, including corporate sustainability, climate change, supply chain management, stakeholder engagement, the triple bottom line, the circular economy, and SDG integration.

The level of publicly available documentation varied across the fourteen tools. For some games, the available materials included descriptions of participant roles, decision structures, sustainability indicators, and workshop formats. For others, the information was limited to general descriptions, promotional materials, demonstrations, or user testimonials. The complete set of identified tools and their principal characteristics is reported in Appendix B.

Two practitioner-oriented simulations were selected for closer presentation in the main text:

- **Green Business Lab**, a configurable business simulation in which management teams make cross-functional decisions and monitor financial, environmental, and social performance; and
- **Triple Connection**, a web-based supply-chain simulation in which participants assume functional management roles and make coordinated decisions across the People–Planet–Prosperity dimensions.

These tools were selected because they were explicitly designed for business or management audiences, addressed multiple sustainability dimensions, and provided sufficient documentation to describe their structure and intended application. Their inclusion did not indicate that they were more effective than the other tools identified in the scan.

Table 1 summarizes the outcomes of the two review stages.

Table 1.
Overview of the academic review and exploratory practice scan

Review component	Sources searched	Initial records or tools identified	Final material included	Role in the study
Structured academic review	Scopus and Web of Science	199 records	4 peer-reviewed studies	Assessment of documented academic evidence
Exploratory practice scan	Search engines, game repositories, professional portals, award databases, provider websites, and expert contacts	14 eligible tools	14 tools mapped; 2 discussed in detail	Mapping of publicly documented professional practice

Source: own elaboration.

The academic review and exploratory practice scan therefore produced two separate datasets. The first comprised four peer-reviewed studies subjected to detailed comparative analysis. The second comprised fourteen publicly documented practitioner tools, two of which were selected as illustrative cases for closer description.

4.2. Academic serious games

The structured review identified four serious games that met all eligibility criteria: MainKassandra, the Theory of Change Game, the Sustainability Futures Game, and The Road to Flourishing. The games address different sustainability challenges and use different formats, target groups, and evaluation approaches. The principal characteristics of each intervention are presented below. A detailed comparison is provided in Appendix B.

4.2.1. Main Kassandra

MainKassandra is a facilitated business simulation designed to support learning about corporate climate adaptation and mitigation (Fischer et al., 2024). Its target audience consists primarily of company employees and managers. The game was developed in Germany through an iterative process involving researchers, climate specialists, and representatives of business practice.

During a workshop lasting approximately four to eight hours, participants work in teams of three or four and manage fictitious companies operating in the MainKassandra region. The scenario exposes the companies to climate-related risks and extreme weather events. In successive rounds, teams select adaptation and mitigation measures from a catalog of approximately 80 options, discuss their managerial implications, and present interim decisions. Their performance is represented by a maturity score indicating the degree to which the company is prepared for climate impacts. The session concludes with a facilitated debriefing linking the simulated decisions to participants' professional contexts.

Fischer et al. (2024) evaluated the didactic and contextual requirements for the development of MainKassandra through expert interviews and focus groups rather than testing its learning effectiveness in completed gameplay. The findings, therefore, concern perceived design requirements, pragmatism, transferability, and implementation conditions rather than demonstrated participant outcomes. The study did not assess whether participation increased climate-risk awareness, changed managerial behavior, or resulted in the implementation of organizational adaptation measures.

4.2.2. Theory of Change Game

The Theory of Change Game is an analog board-and-card game designed to help participants develop a shared theory of change for sustainability-related projects and initiatives (Tribaldos, Schneider, 2021). It is intended for researchers, students, practitioners, and stakeholder groups involved in sustainable development or transdisciplinary projects.

The game is typically played by groups of approximately five or six participants. The board provides a visual template on which players map actors, actions, intermediate outcomes, and intended impacts. Gameplay consists of two principal stages. A preliminary brainstorming round is used to generate relevant ideas, after which color-coded prompt cards guide a more detailed discussion of strategies, contextual conditions, causal assumptions, and stakeholder roles. The process is collaborative rather than competitive and depends on facilitated dialogue.

The game was developed through repeated cycles of conceptualization, prototyping, testing, and refinement. Different versions were tested internally, at academic conferences, and during a stakeholder workshop, involving approximately 90 participants in total. The reported evidence concerned mainly cognitive and relational outcomes, including clearer articulation of assumptions, shared understanding of project pathways, and improved stakeholder dialogue. The study did not evaluate whether the jointly developed theories of change subsequently improved project implementation or produced sustained collaboration among participants.

4.2.3. Sustainability Futures Game

The Sustainability Futures Game is a facilitated participatory intervention designed to help stakeholders imagine desirable sustainable urban futures and identify pathways towards them (Ampatzidou et al., 2022). Its participants include city officials, urban planners, sustainability specialists, business representatives, and students in sustainability- and design-related programs. The game has been delivered in both physical and digital formats.

A typical session lasts approximately three hours. Participants select an actual city and collaboratively construct a vision of its desirable sustainable future, usually using 2030 as the reference horizon. They then work backward to identify the decisions, actions, barriers, and intermediate steps required to achieve the proposed future. The game combines storytelling, futures thinking, the SDGs, and structured group discussion. Facilitation supports the development of a shared narrative and the translation of broad sustainability objectives into proposed pathways.

The game was developed through a participatory and iterative process within the CreaTures research project, in cooperation with the design consultancy Hellon. The development process involved at least five design iterations and seven test sessions with professionals and students. Evaluation evidence was mainly qualitative and design-oriented, drawing on user feedback, facilitator observations, and analysis of the iterative development process. Reported outcomes included generating alternative future visions, reflecting on existing assumptions, identifying possible pathways, and recognizing opportunities for stakeholder collaboration. Direct measures of subsequent behavioral, policy, or organizational effects were not reported.

4.2.4. The Road to Flourishing

The Road to Flourishing is a board game designed to increase knowledge of highly sustainable business models and to examine changes in attitudes, perceived social norms, and behavioral intentions (Niessen et al., 2024). Its target audience includes corporate

professionals, sustainability consultants, entrepreneurs, and business students. The game can be delivered in person or online using a virtual board.

Participants progress through five levels of sustainable business strategy: Efficiency, Net Zero, Circularity, Sufficiency, and Regeneration, before reaching the final stage of Flourishing. Gameplay combines quiz questions, business examples, scenario events, and reflective prompts. Participants may play individually or in teams and are asked to distinguish between incremental sustainability practices and more transformative approaches to value creation.

The game was developed using a Design Science Research approach that combined theory-informed design with iterative testing. Its evaluation involved a pre- and post-game survey completed by 220 participants from academic, business, and consultancy contexts. The results showed significant improvements in participants' understanding of concepts including flourishing, regeneration, and sufficiency. Positive changes were also reported in selected attitudes and perceived social norms concerning sustainable business practices. However, the study did not identify a significant short-term change in participants' stated behavioral intentions.

Among the four included studies, The Road to Flourishing provided the most extensive quantitative evaluation. Nevertheless, its outcome measurement was conducted directly around the intervention, and the study did not assess whether the observed knowledge and attitudinal changes were sustained or translated into subsequent business decisions or organizational practices.

4.3. Comparative synthesis

The four serious academic games differed in their sustainability focus, target audiences, game structures, and evaluation approaches. However, they also shared several recurring characteristics. Across the studies that evaluated gameplay, the strongest documented outcomes were cognitive or relational. Main Kassandra contributed design-oriented evidence rather than participant outcome evidence.

Table 2.
Comparative characteristics of the academic serious games

Game	Sustain-ability and transfor-mation focus	Target audience	Format and duration	Main gameplay mechanism	Facilitation and debriefing	Evaluation design	Main documented outcomes	Behavioral or organizational evidence
Main Kassandra	Corporate climate adaptation and mitigation	Company employees and managers	Facilitated business simulation; approximately 4–8 hours	Team management of fictitious companies, selection of adaptation measures, and response to climate events	Central to the workshop, connects decisions with participants' organizational contexts	Expert interviews and focus groups informed the development of the simulation; no evaluation of completed gameplay outcomes	Design requirements concerning relevance, pragmatism, transferability, and implementation conditions	Participant learning, behavioral change, and organizational outcomes were not assessed

Cont. table 2.

Theory of Change Game	Planning and coordination of sustainability -related projects and initiatives	Researchers, students, practitioners, and stakeholder groups	Analogue board-and-card game; group-based workshop	Collaborative mapping of actors, actions, assumptions, outcomes, and impacts	Required to structure dialogue and develop a shared theory of change	Iterative testing in academic and stakeholder settings; mainly qualitative feedback	Shared under-standing, clarification of assumptions, stakeholder dialogue, and collaborative planning	No evidence of subsequent project performance or sustained collaboration
Sustainability Futures Game	Visioning and pathway development for sustainable urban futures	City officials, planners, sustainability professionals, business representatives, students	Physical or digital facilitated session; approxima-tely 3 hours	Storytelling, future visioning, backcasting, and collaborative pathway development	Central to the creation of shared narratives and action pathways	Iterative design process, facilitator observations, and qualitative participant feedback	Systems thinking, alternative future visions, identification of pathways, and stakeholder interaction	No direct evidence of later policy implementation or organizational change
The Road to Flourishing	Strongly sustainable business models and progression from incremental to regenerative strategies	Corporate professionals, consultants, entrepreneurs, and business students	Physical or virtual board game	Progression through sustainability levels, quizzes, examples, scenarios, and reflective prompts	Supports interpretation of sustainability concepts and comparison of business strategies	Pre- and post-intervention survey; 220 participants	Increased knowledge, improved understanding of flourishing, regeneration, and sufficiency; selected attitudinal and normative changes	No significant short-term change in behavioral intention; no organizational follow-up

Source: own elaboration.

The games addressed sustainability transformation at different levels. Main Kassandra focused most directly on organizational adaptation by placing participants in the role of company decision-makers responding to climate-related risks. The Road to Flourishing addressed business-model transformation by contrasting incremental sustainability practices with sufficiency, regeneration, and flourishing. The Theory of Change Game focused primarily on project planning and stakeholder alignment. At the same time, the Sustainability Futures Game focused on collective visioning and pathway development in an urban, cross-sector context.

The target audiences also varied. Main Kassandra was designed mainly for organizational employees and managers. The Road to Flourishing included corporate professionals but was also tested with students, entrepreneurs, and consultants. The Theory of Change Game and the Sustainability Futures Game involved more heterogeneous groups, including researchers, practitioners, public-sector representatives, students, and other stakeholders; consequently, the four games covered both internal organizational learning and broader multi-stakeholder processes.

All four games required participants to work with simplified representations of sustainability problems. Main Kassandra used fictitious companies, climate events, and predefined adaptation options. The Theory of Change Game used a visual causal structure to connect actors, activities, assumptions, and expected impacts. The Sustainability Futures Game used future narratives and backcasting to construct pathways from a desirable future to present decisions. The Road to Flourishing organized sustainable business strategies into successive levels and asked participants to distinguish between incremental and transformative approaches.

The degree of structure differed across the interventions. MainKassandra and The Road to Flourishing provided relatively explicit decision environments, predefined options, and visible progress indicators. The Theory of Change Game and the Sustainability Futures Game offered more open action spaces in which participants generated content, negotiated meanings, and constructed shared outcomes. The latter two games depended more strongly on discussion and collective interpretation, whereas the former two placed greater emphasis on making choices within a prepared simulation framework.

None of the games was designed as an individual, self-directed intervention. Interaction among participants was a central feature in all cases. MainKassandra required teams to formulate company responses to climate risks. The Theory of Change Game relied on collaborative planning and the exchange of assumptions. The Sustainability Futures Game used storytelling and group visioning, while The Road to Flourishing combined quiz, scenario, and reflection activities that could be completed in teams. Cooperation was more prominent than competition across the four games.

Facilitation and debriefing were reported as important components of the interventions. In MainKassandra, facilitation supported the interpretation of climate impacts and the connection between game decisions and company practice. In the Theory of Change Game, facilitators guided participants through causal reasoning and stakeholder discussion. In the Sustainability Futures Game, facilitation supported inclusive participation, future visioning, and backcasting. In The Road to Flourishing, reflective prompts and discussion supported the interpretation of sustainability concepts and business strategies.

The studies differed substantially in their evaluation designs. MainKassandra, the Theory of Change Game, and the Sustainability Futures Game were evaluated mainly through qualitative or design-oriented procedures, including iterative testing, focus groups, observations, expert feedback, and participant reflections. The Road to Flourishing used a pre- and post-intervention survey with 220 participants, thereby providing the most extensive quantitative evidence among the four studies.

Among the studies that evaluated participant outcomes, the strongest documented effects were cognitive, including increased sustainability knowledge, improved understanding of sustainable business concepts, greater awareness of interdependencies, and enhanced systems thinking. Relational outcomes were also frequently reported, particularly improved stakeholder dialogue, shared understanding, collaboration, and joint problem framing.

Normative outcomes were assessed less frequently. The Road to Flourishing reported changes in selected attitudes and perceived social norms, whereas the other studies primarily described reflections on values, assumptions, or responsibilities using qualitative evidence. Behavioral outcomes were limited. The Road to Flourishing did not identify a significant short-term change in behavioral intentions, and the other studies did not systematically measure post-game behavior.

None of the four studies provided direct longitudinal evidence of organizational transformation. The evaluations did not establish whether participation led to the implementation of sustainability initiatives, changes in organizational routines, revisions to strategies, new investment decisions, or sustained cross-functional cooperation. Where organizational or policy effects were discussed, they were presented primarily as intended applications or potential consequences rather than empirically documented outcomes.

Overall, the comparison showed a consistent progression in the strength of available evidence. Evidence was strongest for immediate cognitive and relational outcomes, less developed for normative and behavioral outcomes, and absent or highly limited for sustained organizational effects. The evaluated games provided documented support primarily for sustainability learning, dialogue, and collaborative exploration, while MainKassandra contributed evidence concerning design and implementation requirements.

4.4. Practice-oriented simulations

The exploratory practice scan identified fourteen publicly documented sustainability- or SDG-related games and simulations intended for business, management, professional, or higher-education audiences. The identified tools addressed corporate sustainability, climate change, supply chain management, stakeholder engagement, the circular economy, social responsibility, the triple bottom line, and the integration of the SDGs into managerial decision-making. Their detailed characteristics are presented in Appendix B.

The tools differed in their delivery formats and level of complexity. The scan included physical board games, facilitated workshop formats, digital simulations, and web-based business games. Some interventions focused on a single sustainability issue, whereas others represented interactions among financial, environmental, and social performance. The duration of the identified tools ranged from short workshop activities to multi-round simulations delivered over several sessions.

Participant roles were used frequently. Players were commonly assigned managerial, functional, stakeholder, or institutional responsibilities and were required to make decisions from these perspectives. Several games included roles related to operations, procurement, marketing, finance, sustainability, public administration, or community interests. Team-based decision-making and negotiation were more common than individual gameplay.

Cross-functional trade-offs were another recurring feature. The tools typically required participants to balance financial performance with environmental and social considerations. Some simulations used indicators, dashboards, scores, or scenario events to show the consequences of participant decisions. Facilitated discussion and debriefing were also frequently mentioned in provider documentation, although the scope and structure of these activities were not always described in detail.

Public documentation differed substantially in quality. For some tools, the available materials provided information on gameplay, participant roles, decision variables, workshop structure, sustainability indicators, and target audiences. For others, the available evidence consisted mainly of general descriptions, marketing statements, demonstrations, or participant testimonials. Independent evaluation studies were identified for only a limited proportion of the tools.

Two simulations, Green Business Lab and Triple Connection, were selected for closer presentation because they were explicitly intended for business and management audiences, addressed several dimensions of sustainability, and were sufficiently documented to permit an assessment of their principal design features.

4.4.1. Green Business Lab

Green Business Lab is a configurable business simulation designed to help management teams examine the economic, environmental, and social consequences of corporate decisions (The Green Business Lab, 2025). The simulation is based on the triple-bottom-line perspective and is intended for executives, managers, employees, business students, and other participants involved in organizational decision-making.

Participants manage a simulated company and make decisions across strategy, innovation, operations, resources, and stakeholder relations. Decisions are made across a sequence of simulation cycles. Their consequences are presented through financial, environmental, and social performance indicators, which allow teams to compare results and reconsider their strategies.

The simulation can be delivered in different formats, ranging from a single-cycle workshop to a multi-cycle development program. Provider documentation indicates that the tool can be adapted to different learning objectives and organizational contexts. Sessions include facilitated reflection in which participants review their results and discuss the relationships between business performance and sustainability.

Publicly available materials describe Green Business Lab as supporting awareness, strategic thinking, cooperation, and understanding of sustainability trade-offs. The available documentation includes provider descriptions and participant or client statements. No peer-reviewed independent study was identified that examined sustained behavioral, strategic, or organizational outcomes following participation in the simulation.

4.4.2. Triple Connection

Triple Connection is a web-based business simulation focused on a consumer goods supply chain (Inchainge, 2025). It is intended for corporate training, management education, and professional development. The simulation addresses the integration of financial, environmental, and social performance through the People–Planet–Prosperity framework.

Participants work in teams and assume functional executive roles, including Sustainability, Operations, Purchasing, and Marketing. Each role controls a different set of decisions, requiring participants to exchange information and coordinate their actions. Teams make decisions

concerning the supply chain, product strategy, sourcing, operations, and sustainability performance over several simulation rounds.

The simulation uses a "true return on investment" concept to combine conventional financial results with environmental and social outcomes. Performance information is provided between rounds, enabling teams to observe the consequences of their decisions and revise their approach. Structured debriefing is used to review coordination problems, trade-offs, and the alignment of functional decisions.

Provider materials indicate that Triple Connection is used in corporate and higher-education settings and can support cross-functional collaboration, systems thinking, and sustainability-related decision-making. Publicly available documentation describes its gameplay structure, functional roles, and performance framework. However, no independent peer-reviewed evaluation was identified that measured whether participation resulted in sustained changes in managerial behavior, organizational routines, or supply-chain practices.

Table 3 summarizes the principal characteristics of the two simulations.

Table 3.
Comparative characteristics of selected practice-oriented simulations

Simulation	Main focus	Target audience	Format	Participant roles and decisions	Performance feedback	Publicly documented outcomes	Independent evidence
Green Business Lab	Corporate sustainability and triple-bottom-line performance	Executives, managers, employees, and business students	Configurable team-based simulation; single or multiple cycles	Cross-functional decisions concerning strategy, innovation, operations, resources, and stakeholders	Financial, environmental, and social indicators	Awareness, strategic reflection, cooperation, and understanding of sustainability trade-offs	No independent peer-reviewed evaluation of sustained behavioral or organizational outcomes has been identified.
Triple Connection	Sustainable consumer-goods supply chains and People–Planet–Prosperity performance.	Corporate participants, managers, and business students	Web-based, multi-round team simulation	Functional executive roles in Sustainability, Operations, Purchasing, and Marketing	Integrated performance results and "true return on investment"	Cross-functional collaboration, systems thinking, and sustainability decision-making	No independent peer-reviewed evaluation of downstream organizational change has been identified

Source: own elaboration.

The two simulations shared several design features observed across the broader set of practice-oriented tools. Both allocated managerial responsibilities to participants, required coordination across functional areas, represented trade-offs among financial, environmental, and social outcomes, and used performance feedback to inform facilitated debriefing.

The practice scan also showed that the existence of a publicly available tool did not necessarily correspond with the availability of evaluation evidence. The identified materials generally provided more information about intended purposes, delivery formats, and claimed benefits than about research design, participant samples, outcome measurement, or follow-up. Consequently, the scan produced a detailed map of practice-oriented applications but a more limited body of independently documented outcomes.

The comparison of the structured academic review and the exploratory practice scan revealed a clear difference between the availability of sustainability-oriented serious games and the strength of evidence concerning their outcomes.

The academic review identified four peer-reviewed studies that met the full eligibility criteria. These studies provided relatively detailed information on the game's purpose, participant groups, gameplay structure, facilitation, and evaluation. However, the number of qualifying interventions was small, and the reported evidence concerned mainly immediate cognitive and relational outcomes.

The exploratory practice scan identified fourteen publicly documented games and simulations intended for business, management, professional, or higher-education audiences. This broader set of tools demonstrated that sustainability-oriented simulations are more widely available in practice than the peer-reviewed literature alone would suggest. The tools addressed a range of applications, including corporate sustainability, climate adaptation, sustainable supply chains, stakeholder engagement, circular economy, and SDG integration.

The two strands differed substantially in the type and quality of available documentation. Academic publications generally describe the research context, participants, intervention design, data-collection procedures, and observed outcomes. Practitioner documentation was more likely to describe a tool's intended purpose, format, target audience, and claimed benefits. Information concerning sample characteristics, measurement instruments, comparison conditions, and follow-up periods was often unavailable.

Table 4 compares the principal characteristics of the evidence identified in the two strands.

Table 4.
Comparison of academic evidence and practitioner documentation

Dimension	Academic serious games	Practice-oriented simulations
Number identified	4 peer-reviewed studies	14 publicly documented tools
Main source of information	Journal articles	Provider websites, brochures, demonstrations, repositories, testimonials, and training descriptions
Typical level of intervention detail	Purpose, participants, gameplay, facilitation, evaluation procedure, and outcomes	Purpose, target audience, delivery format, roles, indicators, and claimed benefits
Most frequently reported outcomes	Knowledge, awareness, systems thinking, shared understanding, stakeholder dialogue, and selected attitudes.	Awareness, engagement, strategic reflection, collaboration, systems thinking, and decision-making
Evaluation methods	Qualitative observations, focus groups, iterative testing, participant feedback, and one pre–post survey study	Mainly provider descriptions, internal materials, client statements, and testimonials
Behavioral evidence	Limited; one study assessed behavioral intentions without significant short-term change.	Generally not independently assessed
Organizational evidence	No direct longitudinal evidence of changed strategies, routines, investments, or implemented initiatives	No independent peer-reviewed evidence was identified for most tools.
Follow-up beyond the intervention	Rare or absent	Rarely reported
Status of claims	Partly supported by research evidence, mainly for immediate outcomes	Predominantly descriptive or provider-reported

Source: own elaboration.

Across the academic studies, evidence was strongest for outcomes measured during or immediately after gameplay. Knowledge acquisition, conceptual understanding, systems thinking, dialogue, and collaborative problem framing were documented more frequently than behavioral or organizational effects. Only The Road to Flourishing used a quantitative pre- and post-intervention design with a relatively large sample of participants. Even in that study, changes in knowledge and selected attitudes were not accompanied by a significant short-term change in behavioral intentions.

The Theory of Change Game and the Sustainability Futures Game were evaluated primarily through qualitative feedback, observations, participant outputs, and iterative development. MainKassandra contributed design-oriented evidence based on expert interviews and focus groups rather than participant outcome evidence. None of these studies established whether the interventions led to subsequent changes in organizational practice.

The practitioner tools displayed several design characteristics similar to those found in the academic games. These included role allocation, team-based decision-making, sustainability indicators, cross-functional trade-offs, scenario events, performance feedback, and facilitated debriefing. However, the presence of similar game mechanisms was not accompanied by comparable evidence concerning outcomes.

For most practitioner-oriented tools, publicly available materials reported intended benefits rather than independently measured effects. Statements concerning improved awareness, collaboration, strategic thinking, or decision-making were typically based on provider descriptions, workshop summaries, or participant testimonials. Information on research design, baseline measurements, participant selection, or long-term follow-up was generally unavailable.

The identified evidence–practice gap therefore had two components. First, practice-oriented tools were more numerous than the academic literature indicated. Second, the level of empirical validation was substantially lower than the level of market availability and professional application. This pattern is illustrated in Figure 1.

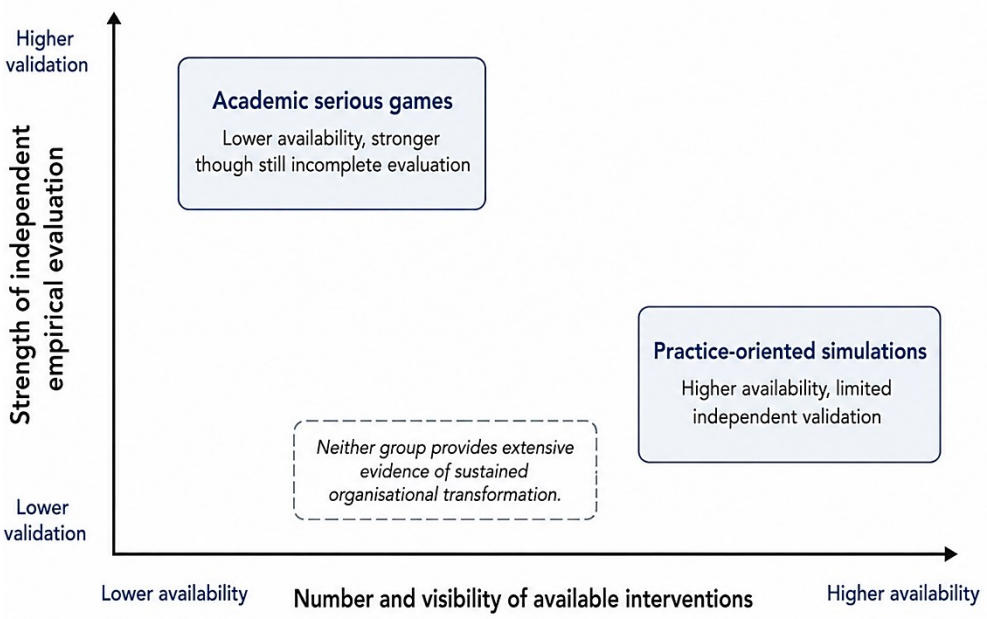

Figure 1. Availability and independent validation of serious games for sustainable business transformation.

Source: own elaboration.

The comparison therefore identified a progressive reduction in the strength of evidence across outcome levels. Evidence was most frequently available for cognitive and relational outcomes, less frequently for normative and behavioral outcomes, and rarely, if at all, for organizational outcomes. Figure 2 presents this distribution.

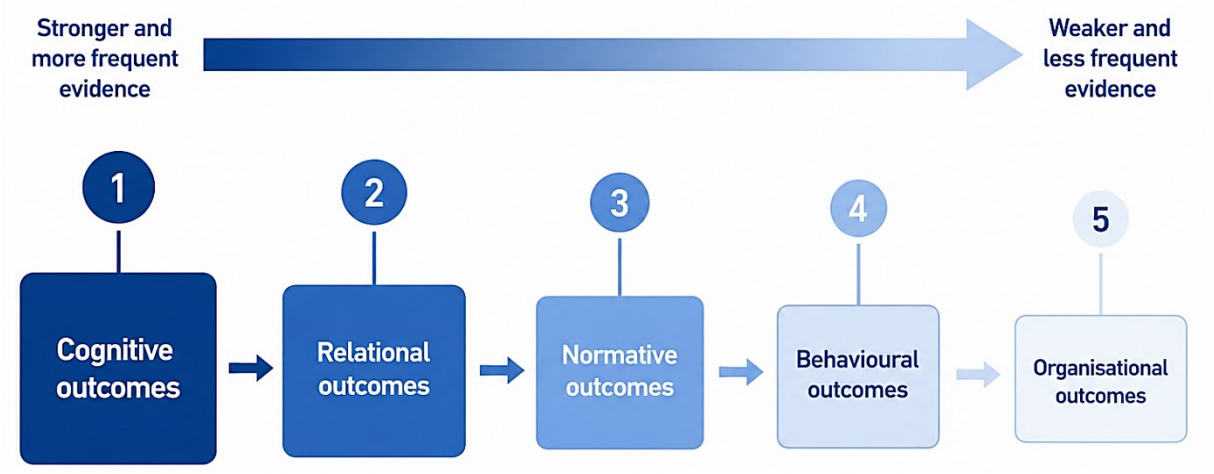

Figure 2. Strength of evidence across outcome levels.

Source: own elaboration.

The available material thus documented a substantial number of sustainability-oriented game applications but a much smaller body of independently evaluated interventions. It also showed that the reported evidence was concentrated at the level of learning, awareness, and interaction rather than sustained changes in managerial behavior, business strategy, or organizational practice.

5. Discussion

5.1. What was known and what this review adds

Previous research has established that serious games can support learning, engagement, and reflection in sustainability-related contexts. Studies conducted in education, environmental management, climate communication, and sustainable development have reported improvements in knowledge, awareness, systems thinking, self-efficacy, stakeholder dialogue, and selected attitudes (Janakiraman et al., 2018; Jääskä et al., 2021; Boncu et al., 2022). These findings are consistent with the broader serious-games literature, which associates game-based interventions with experiential learning, feedback, active participation, and structured reflection (Wouters, 2013; Kikkawa et al., 2022).

The present review confirms this general conclusion but narrows its relevance to sustainable business transformation. This distinction is important because an intervention can be successful as a learning activity without producing organizational change. Participants may understand sustainability trade-offs more clearly after gameplay, but applying these insights in practice depends on decision-making authority, organizational culture, incentives, resources, managerial support, and opportunities for implementation.

The structured review identified only four peer-reviewed studies that met the full intersection of three criteria: a complete game or simulation intervention, an explicit sustainability-related purpose, and a business, management, organizational, strategic, or professional context. This limited number contrasts with the broader literature on sustainability education and environmental awareness. It shows that the evidence base becomes much smaller when the expected application is defined as sustainable business transformation rather than sustainability learning more generally.

The main new finding is the identification of a hierarchy of documented outcomes. Across the reviewed academic games, evidence was strongest for cognitive outcomes, including knowledge, awareness, conceptual understanding, and systems thinking. Relational outcomes, such as dialogue, collaboration, shared framing, and stakeholder understanding, were also frequently reported or qualitatively indicated. Evidence concerning normative change was more limited, while behavioral and organizational outcomes were rarely assessed.

This pattern extends previous research by showing that the strength of evidence decreases as the expected outcome moves further away from the game session. Immediate learning and interaction are relatively visible and measurable. Changes in values, intentions, behavior, organizational routines, strategic decisions, or business models are more difficult to demonstrate and require longer observation periods, different indicators, and access to organizational data. The reviewed studies, therefore, provide stronger support for serious games as instruments of learning and dialogue than as independently validated mechanisms of sustained business transformation.

A second contribution lies in comparing academic evidence with practitioner-oriented tools. The exploratory scan identified fourteen publicly documented sustainability or SDG-related business games and simulations, indicating that practice-oriented tools are more widely available than the peer-reviewed literature alone suggests. These tools frequently use managerial roles, cross-functional decision-making, sustainability indicators, performance dashboards, and facilitated debriefing. At the same time, their public documentation generally provides more information about intended benefits than about independently measured effects.

The review therefore identifies an evidence–practice gap. Practice-oriented tools are relatively visible and numerous, but their behavioral and organizational effects are rarely assessed independently. Academic studies provide more transparent evidence, but they remain few in number and are concentrated mainly on immediate learning-related outcomes. The central conclusion is not that serious games are ineffective. Rather, their current contribution concerns learning, dialogue, and reflection, while their contribution to sustained organizational transformation remains plausible but insufficiently validated.

5.2. Common mechanisms and differences

The comparison indicates that the four academic cases shared a general intervention logic: each translated a complex sustainability problem into a structured setting for exploration, interaction, and reflection. However, the games differed substantially in how this logic was operationalized. The most important differences concerned the openness of the action space, the type of participant contribution, the role of facilitation, the level of transformation addressed, and the design of the evaluation.

The Theory of Change Game and the Sustainability Futures Game created relatively open-ended action spaces. Participants generated causal pathways, future visions, assumptions, stakeholder relationships, and possible actions through facilitated group work. Their central outputs were, therefore, collectively constructed representations of a sustainability problem rather than performance against a predefined solution. These formats were particularly oriented towards collaborative problem framing, clarification of assumptions, and the development of shared interpretations.

The Road to Flourishing used a more structured conceptual progression. Participants moved through predefined levels of sustainable business practice, from efficiency-oriented approaches to regeneration and flourishing. Quizzes, examples, scenarios, and reflective prompts directed attention towards distinctions among different levels of sustainability ambition. The intervention was therefore more strongly oriented towards conceptual learning and the assessment of short-term changes in knowledge, attitudes, perceived social norms, and behavioral intentions.

MainKassandra also represented a comparatively structured design, based on fictitious companies, climate-related events, predefined adaptation options, and a maturity score. However, its position in the comparison requires particular caution. Fischer et al. (2024)

examined the didactic and contextual requirements for developing the simulation through expert interviews and focus groups. The study therefore provides evidence on design requirements, relevance, and conditions for transfer, rather than demonstrating outcomes of completed gameplay.

The cases also differed in the function assigned to participant perspectives. In the Theory of Change Game and the Sustainability Futures Game, heterogeneous stakeholder knowledge formed part of the content generated during the session. Participants contributed different interpretations and jointly constructed pathways or narratives. In The Road to Flourishing, participant engagement was organized more strongly around the interpretation of an existing conceptual framework. MainKassandra was designed to position participants as organizational decision-makers who respond to climate-related risks and consider alternative adaptation measures.

These differences reveal two broad design orientations. The first uses a game to structure collective construction, allowing participants to formulate the problem, identify relationships, and negotiate possible futures. The second uses a game to structure guided exploration, directing participants through predefined concepts, decisions, or sustainability levels. Neither orientation is inherently superior. Their suitability depends on whether the intervention is intended primarily to support shared problem framing or to communicate and apply a particular conceptual model.

Facilitation was relevant across all four cases, but its function varied. In the more open-ended games, facilitators supported dialogue, causal reasoning, inclusion of different perspectives, and the integration of participant-generated contributions. In the more structured games, facilitation helped participants interpret predefined choices and relate them to professional or organizational contexts. This variation indicates that facilitation should be considered part of the intervention design rather than a uniform delivery condition.

The games also addressed different levels of transformation. Main Kassandra is concerned with organizational adaptation to climate risk. The Theory of Change Game supported the planning and coordination of sustainability-related projects. The Sustainability Futures Game focused on collective visioning and the development of urban transition pathways. The Road to Flourishing addressed the understanding of strongly sustainable business models and progression beyond incremental sustainability practices. Consequently, the identified games should not be treated as interchangeable examples of a single intervention category.

Evaluation design created an additional source of difference. The Road to Flourishing provided the clearest quantitative pre- and post-intervention evidence. The Theory of Change Game and the Sustainability Futures Game relied mainly on qualitative feedback, participant outputs, observation, and iterative development. MainKassandra examined expert-informed design requirements rather than gameplay effects. Apparent differences in effectiveness may therefore reflect differences in what was evaluated and how, rather than differences in the inherent quality of the interventions.

Overall, the comparison suggests that the shared value of the games lies in their capacity to structure complex sustainability problems and create conditions for participation and reflection. Their specific contribution, however, depends on the configuration of the action space, participant roles, facilitation, the purpose of transformation, and the evaluation design. More structured formats appear particularly well-suited to guided conceptual exploration, whereas open-ended formats appear better suited to collaborative framing and stakeholder dialogue. Across both orientations, the available evidence remains concentrated on proximal cognitive and relational outcomes rather than sustained behavioral or organizational change.

5.3. Theoretical implications

The findings suggest that serious games should not be conceptualized as self-contained mechanisms of sustainable business transformation. The reviewed studies provide evidence that games can generate cognitive and relational outcomes, including knowledge development, systems thinking, stakeholder dialogue, and shared understanding. However, they do not demonstrate that gameplay alone produces sustained behavioral or organizational change. A more appropriate theoretical interpretation is that serious games create enabling conditions within a broader process of organizational learning and transformation.

This distinction extends experiential learning perspectives. Experiential learning theory explains how participants may develop understanding through action, feedback, reflection, and experimentation (Kolb, 1984). The serious-games literature similarly emphasizes active participation, role-taking, decision-making, and debriefing as mechanisms through which learning occurs (Kriz, 2010; Kikkawa et al., 2022). These mechanisms explain immediate cognitive and relational effects, but they are insufficient to explain whether insights generated during gameplay become embedded in organizational routines, strategies, or decision systems.

Based on the comparative findings, the contribution of a game to sustainable business transformation can be illustrated by the provisional process logic in Figure 3.

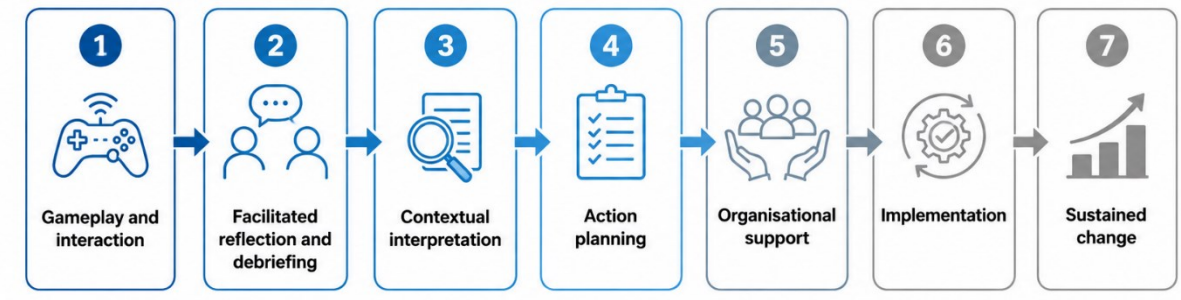

Figure 3. Proposed process linking serious game participation to sustained organizational change.
Source: own elaboration.

This sequence should be understood as an analytical model rather than as a validated causal framework. It identifies the stages through which game-based learning may be transferred into organizational practice and clarifies where this transfer may be interrupted. Gameplay creates

a shared experiential setting; reflection and debriefing transform experience into articulated learning; contextual interpretation relates game-based insights to organizational realities; action planning converts general insights into proposed decisions or initiatives; organizational support determines whether these proposals can be implemented; and implementation and sustained change refer to the adoption and continuation of new practices over time.

The process logic implies that serious-game outcomes should be analyzed at multiple levels. Immediate learning outcomes, behavioral intentions, implemented actions, and organizational transformation are not equivalent indicators of effectiveness. They represent different stages in a possible transformation process and require different methods of assessment. Knowledge acquisition does not demonstrate behavioral change, and behavioral intention does not demonstrate organizational implementation.

The review therefore supports a distinction between proximal and distal outcomes. Proximal outcomes occur during or shortly after the intervention and include knowledge, awareness, dialogue, and shared understanding. Distal outcomes occur later and include behavior change, implementation, strategic reorientation, and organizational transformation. Claims about effectiveness should correspond to the level of outcome actually measured.

The findings also suggest that serious games can be understood both as learning artifacts and as components of organizational change processes. As learning artifacts, games create structured environments for experimentation, feedback, and reflection. As components of change processes, they may help initiate dialogue, align stakeholders, and generate action proposals. Their transformational potential depends on whether these outputs are connected to subsequent organizational processes.

Another theoretical implication concerns the relational character of sustainable business transformation—the reviewed games produced outcomes not only through individual cognition but also through interaction among participants. Shared understanding, stakeholder dialogue, and collective problem framing were among the most consistently reported effects. This suggests that serious games may serve as boundary objects that connect actors across different organizational functions, professional backgrounds, or stakeholder groups.

Finally, the evidence–practice gap has theoretical significance. Practice-oriented simulations are more numerous than the academic evidence base suggests, but their transformational claims are often not independently assessed. This means that game-based practice has advanced faster than theory and evaluation. Future theory development should therefore examine not only whether games work, but through which mechanisms, under what conditions, for which participants, and at which level of outcome.

Overall, the review supports a conditional and process-oriented conceptualization of serious games. Their theoretically plausible contribution lies in generating proximal cognitive and relational conditions that may support subsequent organizational change. The transition from these proximal outcomes to sustained transformation is not inherent in the game itself but depends on transfer mechanisms and organizational conditions operating after gameplay.

5.4. Practical implications

The process model presented in Figure 3 has direct implications for the design and implementation of serious-game interventions. Organizations should treat gameplay as one component of a broader sustainability or change program and ensure that the intervention is connected with contextual interpretation, action planning, implementation support, and follow-up. In practice, this requires alignment among the intended outcome, game design, participant group, facilitation approach, organizational context, and evaluation method.

The first practical requirement is to define the intended outcome before selecting a game. Organizations should distinguish among awareness building, knowledge development, stakeholder alignment, strategy formulation, behavioral experimentation, and organizational implementation. A game designed primarily to introduce sustainability concepts may be appropriate for awareness raising but insufficient for business-model redesign or cross-functional decision-making. The objective of the intervention should therefore be matched with the game's structure, target audience, decision space, and evaluation approach.

Participant selection is equally important. When the objective is general sustainability education, the game may be used with broad groups of employees or students. When the objective is organizational change, participants should include individuals with relevant knowledge, decision-making authority, and responsibility for implementation. Cross-functional sustainability challenges may require participation from managers across strategy, operations, procurement, finance, marketing, human resources, and sustainability.

Contextual adaptation should also form part of the intervention design. Generic games can support conceptual learning, but their relevance to organizational practice may be limited when participants cannot relate simulated conditions to their own decisions and responsibilities. Adaptation may involve industry-specific scenarios, organizational terminology, realistic stakeholder roles, company data, relevant sustainability indicators, or current strategic challenges. The aim is not to reproduce reality in full, but to create a credible connection between the game and the organization's actual sustainability challenges.

Facilitation and debriefing should be treated as central elements of the intervention. Effective facilitation involves more than explaining the rules. It includes encouraging balanced participation, questioning assumptions, identifying conflicts, and helping participants connect game experience with organizational practice. Debriefing should address what occurred, why particular decisions were made, which assumptions influenced them, which trade-offs became apparent, and how the simulated experience differs from organizational reality.

Reflection should be followed by action planning. Participants should identify a limited number of concrete actions, responsibilities, resources, and decision points arising from the session. These may include testing a new sustainability criterion, revising a procedure, initiating a cross-functional working group, assessing climate-related risks, or developing a pilot

initiative. Without this transition, positive engagement may remain limited to the workshop experience.

Managerial sponsorship and follow-up are particularly important when proposed actions require resources, authority, or cross-departmental coordination. Senior managers should clarify how game outputs will be reviewed and which recommendations may be developed further. Follow-up mechanisms may include review meetings, progress reports, coaching sessions, repeated gameplay, or the integration of actions into existing project and performance management systems.

Evaluation should correspond to the intended level of change. Satisfaction surveys can indicate whether participants found the game engaging, but they do not demonstrate learning or transformation. Knowledge tests, reflection reports, and pre- and post-session measures can assess cognitive or attitudinal outcomes. Behavioral and organizational claims require additional indicators, such as implemented action plans, revised procedures, new sustainability initiatives, changed investment criteria, or evidence of cross-functional cooperation.

For organizations purchasing or commissioning serious games, the findings provide criteria for selecting providers. Potential users should request information about the target audience, learning objectives, participant roles, decision mechanisms, facilitation requirements, debriefing process, evaluation evidence, and possibilities for adaptation. Claims of behavioral or organizational impact should be examined carefully when they are supported only by testimonials or promotional descriptions.

Overall, serious games are most useful as structured components of broader sustainability and change programs. Their contribution is strongest when organizations define clear objectives, involve relevant decision-makers, adapt the intervention to context, provide skilled facilitation, connect debriefing with action planning, ensure managerial sponsorship, and measure outcomes beyond the game session.

5.5. Alternative interpretations and limitations

The limited evidence of behavioral and organizational outcomes should not be interpreted as proof that serious games are ineffective in supporting sustainable business transformation. The reviewed studies show that games can produce immediate cognitive and relational outcomes. However, they provide insufficient evidence to determine whether these outcomes persist or lead to changes in organizational practice. The distinction between absence of evidence and evidence of absence is therefore essential.

One possible interpretation is that serious games generate useful effects that were not captured by the evaluation designs used in the reviewed studies. Most assessments were conducted during or shortly after the intervention and focused on outcomes that could be measured within a short time frame, such as knowledge, awareness, participant reactions, shared understanding, or attitudes. Organizational transformation, by contrast, may develop over several months or years and may therefore remain invisible in short-term evaluation.

The choice of outcome measures may also have influenced the observed pattern. Cognitive and attitudinal variables can be assessed relatively easily through questionnaires, interviews, or participant feedback. Behavioral and organizational outcomes require access to subsequent decisions, implementation processes, performance data, and organizational records. Researchers may therefore select proximal outcomes not because they are the only relevant effects, but because they are more feasible to observe.

A related interpretation concerns the indirect nature of game-based influence. A serious game may contribute to a later decision or initiative without being identified as its primary cause. Participants may draw on concepts, relationships, or insights developed during gameplay when contributing to sustainability projects, but the intervention's influence may be difficult to isolate from other factors. Multiple interacting influences, including regulation, leadership priorities, market conditions, stakeholder pressure, available technologies, and existing sustainability programs, usually shape organizational change.

The lack of observed behavioral change may also reflect barriers occurring after the game rather than weaknesses in the intervention itself. Participants may develop new knowledge or intentions but lack authority, resources, time, or managerial support to act on them. Established routines, incentive systems, departmental boundaries, and short-term performance pressures may prevent the application of game-based insights. In such cases, the intervention may succeed at the learning level while transfer fails at the organizational level.

Participant characteristics and self-selection create further interpretive uncertainty. Individuals who voluntarily participate in sustainability-related games, research projects, workshops, or training programs may be more motivated and receptive than the wider organizational population. In some cases, prior interest in sustainability may also reduce the potential for measurable attitudinal change. Positive reactions may therefore partly reflect participant predispositions, while the challenge of engaging skeptical or less motivated groups remains underexamined.

The role of facilitation also complicates attribution. The reviewed games depended substantially on discussion, reflection, and debriefing. Consequently, observed outcomes cannot be attributed solely to the game artifact. They may result from the combined influence of game design, facilitator competence, participant composition, group dynamics, and organizational context. The same game may therefore produce different outcomes in different settings.

Several limitations of the present study should also be acknowledged. First, the structured academic review was limited to Scopus and Web of Science. These databases provide broad multidisciplinary coverage, but they do not include all relevant publications. Second, the review included only English-language, peer-reviewed journal articles published between 2015 and 2024. This restriction improved consistency but excluded books, conference proceedings, reports, dissertations, non-English publications, and other forms of grey literature.

Third, the search strategy deliberately required an explicit intersection between sustainability, game-based intervention, and business or organizational transformation. This improved precision but may have reduced recall. Relevant studies using adjacent terminology, such as transition management, circular economy, responsible innovation, organizational learning, climate resilience, or business-model experimentation, may not have been retrieved. The inconsistent use of terms such as “serious games”, “simulation games”, “game-based learning”, and “gamification” may also have affected the search results.

Fourth, the final academic sample consisted of only four studies. This small number limits the generalizability of the conclusions and prevents statistical aggregation. The included studies were also heterogeneous in purpose, participants, duration, game structure, theoretical foundations, and evaluation design. The synthesis was therefore interpretive rather than meta-analytic.

Fifth, no formal risk-of-bias assessment was conducted. Evidence was evaluated descriptively based on study design, outcome measures, sample characteristics, and assessment timing. This approach was appropriate for a small and methodologically diverse sample, but it does not provide a standardized quality score for the included studies.

Sixth, the exploratory practice scan was not designed as a comprehensive market review. The identification of tools depended on online visibility, search-engine indexing, available documentation, expert contacts, and the continued accessibility of provider websites. Commercial tools with limited public information may have been overlooked, while highly visible tools may have been overrepresented. The selection of Green Business Lab and Triple Connection for closer discussion was purposive and should not be interpreted as evidence that they are representative of all practice-oriented simulations.

Finally, the analytical hierarchy of cognitive, relational, normative, behavioral, and organizational outcomes is a useful organizing framework, but the categories are not entirely independent. Improved knowledge may support dialogue, dialogue may influence norms, and normative change may affect behavior. The relationships among these outcomes are likely to be recursive rather than strictly linear. The process model presented in Figure 3 should therefore be treated as a heuristic framework for future research rather than as a confirmed sequence.

Despite these limitations, the study provides a transparent comparison of academic evidence and publicly documented practice. Its conclusions are deliberately cautious: serious games have demonstrated value for sustainability learning and stakeholder interaction, while their contribution to sustained business transformation remains plausible but insufficiently documented.

5.6. Future research agenda

Future research should move beyond documenting participant reactions and short-term learning outcomes towards examining whether, how, and under what conditions serious games contribute to sustained changes in managerial behavior and organizational practice. This requires broader search strategies, more transparent reporting, longitudinal evaluation, stronger attention to transfer mechanisms, and independent assessment of practitioner-oriented tools.

A priority is to broaden the evidence base. Future reviews should include additional databases, specialist repositories, conference proceedings, dissertations, reports, and grey literature. Search terms should also be expanded to include related concepts such as sustainability transitions, climate resilience, circular economy, responsible innovation, organizational learning, business model experimentation, transition management, and regenerative business. This would help determine whether the limited number of included studies reflects a genuinely narrow evidence base or is partly due to disciplinary fragmentation and inconsistent terminology.

A second priority is developing a common reporting framework for serious games in sustainable business transformation. Future studies should describe the purpose and transformation logic of the game, target group, format, duration, delivery conditions, participant roles, rules, resources, interaction patterns, feedback mechanisms, facilitation, debriefing, theoretical basis, organizational context, intended outcomes, measured outcomes, timing of evaluation, and conditions affecting transfer to practice. A standardized reporting framework would make it easier to compare interventions, replicate studies, and identify which design features are associated with particular outcomes.

A third priority is longitudinal and multi-level evaluation. Future studies should distinguish clearly among cognitive, relational, normative, behavioral, and organizational outcomes. These categories represent different levels of change and should not be treated as interchangeable indicators of effectiveness. Immediate post-game evaluation can capture engagement and learning. However, follow-up after several weeks or months is needed to assess whether participants applied the insights, changed decision-making practices, initiated sustainability-related actions, implemented action plans, maintained cross-functional cooperation, or influenced strategies, investments, policies, and routines.

A fourth priority is the analysis of transfer mechanisms. The process model proposed in Figure 3 suggests that gameplay may contribute to transformation through facilitated reflection, contextual interpretation, action planning, organizational support, implementation, and sustained change. Future studies should examine where transfer succeeds or fails. Research should investigate whether debriefing quality, contextual relevance, action planning, managerial sponsorship, decision authority, resource availability, organizational culture, and follow-up support mediate or moderate the relationship between gameplay and later outcomes.

A fifth priority is the independent evaluation of practitioner-oriented simulations. The exploratory scan showed that many tools are already used in professional practice, yet their effects are rarely documented through peer-reviewed research. Collaboration among providers, client organizations, and independent researchers could strengthen the evidence base while preserving practical relevance. Evaluations should document participant characteristics, delivery conditions, game mechanisms, outcome measures, and follow-up procedures. Independent assessment would also reduce the risk of selective reporting and enable more credible comparison between commercial tools and academically developed interventions.

Future studies should also consider stronger comparative and mixed-method designs. Comparative research could examine serious games versus conventional training, one-off gameplay versus gameplay combined with follow-up support, generic versus organization-specific scenarios, facilitated versus minimally facilitated delivery, competitive versus collaborative structures, and individual participants versus intact organizational teams. Mixed methods would be particularly useful because quantitative designs can measure changes in knowledge, attitudes, intentions, behavior, or organizational indicators. In contrast, qualitative methods can explain how participants interpret the game, how group dynamics shape outcomes, and why transfers succeed or fail.

Finally, future research should examine not only intended benefits but also possible limitations and unintended effects. Serious games may oversimplify complex sustainability problems, privilege particular assumptions, create false confidence, reinforce dominant perspectives, or encourage participants to focus on winning rather than reflection. These risks are especially important when simulations are used to support strategic or policy decisions.

Overall, the future research agenda should move the field from descriptive accounts and immediate post-game evaluation towards cumulative, theory-informed, longitudinal, and context-sensitive evidence. The central challenge is no longer only to demonstrate that serious games can engage participants or improve knowledge, but also to establish how game-based learning translates into action and whether it contributes to sustained, sustainable business transformation.

6. Summary

This study addressed the following research question: *What types of serious games currently exist that aim to support sustainable business transformation, and what gaps remain for future development?* The review identified a small group of academically evaluated games and a broader set of practice-oriented simulations designed to support sustainability learning, strategic reflection, stakeholder dialogue, scenario exploration, and business decision-making.

The main finding is that serious games are supported most consistently as instruments for generating cognitive and relational outcomes. They can improve participants' sustainability knowledge, systems thinking, shared understanding, and dialogue. Evidence becomes progressively weaker for normative, behavioral, and organizational outcomes. In particular, the available studies do not provide sufficient longitudinal evidence that game-based interventions produce sustained changes in managerial behavior, organizational routines, strategies, or business models.

The scientific contribution of the study lies in combining a structured review of peer-reviewed research with an exploratory scan of practitioner-oriented tools. This comparison revealed an evidence–practice gap: sustainability-related business games are more widely available in professional practice than the academic literature suggests, but their organizational effects are rarely evaluated independently. The study also distinguishes between proximal learning outcomes and distal transformation outcomes. It proposes a process model that links gameplay to reflection, contextual interpretation, action planning, organizational support, implementation, and sustained change.

From a practical perspective, serious games should be treated as components of broader sustainability and organizational change processes rather than as stand-alone training events. Their potential value increases when the intervention has clearly defined objectives, involves participants with relevant knowledge and decision authority, is adapted to the organizational context, includes skilled facilitation and structured debriefing, and leads to specific action plans supported by management and follow-up mechanisms.

The conclusions should be interpreted in light of several limitations. The academic review covered two databases of English-language peer-reviewed journal articles published between 2015 and 2024, yielding a small, methodologically heterogeneous final sample. The exploratory practice scan was dependent on publicly available online documentation and was not a comprehensive market analysis. Moreover, the practitioner tools differed considerably in the transparency and quality of the evidence provided.

Future research should therefore focus primarily on longitudinal, multilevel evaluation of the transfer of gameplay to organizational practice. Studies should examine not only whether participants learn or engage, but also whether game-generated insights influence later decisions, behaviors, implemented initiatives, organizational routines, and sustainability performance. Particular attention should be given to the mechanisms and contextual conditions that enable or prevent this transfer.

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Appendix A – Review protocol and exploratory scan procedure

This appendix documents the protocol used in the structured literature review and the exploratory scan of practice-oriented serious games. The study does not claim to be an exhaustive systematic review of all sustainability-related games. Instead, it combines a transparent academic review with an exploratory mapping of publicly documented practitioner tools, because many serious games used in corporate sustainability training are developed and disseminated outside peer-reviewed publication channels.

1. Academic database search

Scopus and Web of Science were searched for English-language peer-reviewed journal articles published between 2015 and 2024. The year 2015 was selected because it marks the adoption of the SDGs. The search string combined three conceptual blocks: (a) sustainability and SDGs; (b) serious games, simulation games, game-based learning, gamification, training games, and learning and development; and (c) business transformation, organizational change, business strategy, and strategic planning.

The search formula was: ("Sustainable Development Goal*" OR "SDG*" OR "SDG Integration" OR "Sustainability Initiative*" OR "Corporate Social Responsibility" OR "CSR Initiative*" OR "Sustainable Business Practice*" OR "Corporate Sustainability") AND ("Serious Game*" OR "Gamification" OR "Game-Based Learning" OR "Training Game*" OR "Sustainability Training" OR "Simulation Game*" OR "Impactful Game*" OR "Learning and Development") AND ("Business Transformation" OR "Organizational Change*" OR "Business Strategy*" OR "Strategic Planning").

In Scopus, the search was limited to the following subject areas: Social Sciences; Computer Science; Environmental Science; Business, Management and Accounting; Energy; Engineering; Economics, Econometrics and Finance. In Web of Science, the search was limited to Environmental Sciences and Ecology; Business and Economics; Computer Science; Engineering; Social Sciences - Other Topics; Education and Educational Research; and Science and Technology - Other Topics.

2. Screening procedure

The Web of Science search generated 102 records, and the Scopus search generated 97 records. Duplicates and multiple records referring to the same study were removed. Titles and abstracts were screened for explicit relevance to all three domains: a game or simulation intervention; a sustainability- or SDG-related purpose; and a business, management, organizational, or strategic transformation context. Full texts were then assessed when the title and abstract indicated potential relevance. Four academic studies met the inclusion criteria and were retained for synthesis.

3. Data extraction and coding

A common extraction template was used for all academic games. The following fields were coded: country of origin; game purpose; target audience; physical or digital format; gameplay structure; sustainability concepts addressed; intended and observed learning outcomes; underlying theory or framework; design process, including co-design and iteration; evidence of evaluation; reported limitations; and future development implications. These fields were

selected to support a comparable synthesis across games and to avoid describing each case according to a different set of criteria.

4. Exploratory scan of practice-oriented games

Because the academic search yielded few directly relevant studies, an exploratory scan was conducted to identify publicly documented practice-oriented serious games and simulations. From November 2023 to March 2025, searches were conducted through Google, serious gaming portals, game repositories, international gaming awards, developer websites, and expert contacts. Candidate tools were included in the mapping table when they were publicly identifiable, related to sustainability or the SDGs, relevant to business or management audiences, and sufficiently documented to assess their purpose, target group, format, and SDG coverage. Entertainment-only titles and tools without adequate documentation were excluded.

Fourteen candidate SDG-related business games were identified in the exploratory scan. Two games, Green Business Lab and Triple Connection, were selected for closer discussion in the manuscript because they were explicitly positioned for business training or strategy work, offered public documentation sufficient for assessment, and reported broad SDG coverage. The exploratory scan was treated as a mapping exercise rather than as evidence of effectiveness. Developer claims, testimonials, and website descriptions were therefore interpreted with caution and not treated as equivalent to independent empirical evaluation.

5. Synthesis logic and limitations

The synthesis was organized around four analytical dimensions: purpose and transformation logic; game structure and action space; target audience and facilitation context; and evidence of outcomes. This framework enabled comparison of game purpose, game elements, validation, and transfer to practice. The review is limited by database coverage, language, keyword selection, and public availability of practitioner documentation. The narrow yield indicates that future reviews should test broader keyword strategies, including terms such as transition management, circular economy, climate adaptation, responsible innovation, organizational learning, and sustainability transitions.

Appendix B – Supplementary comparison tables

Table B1.
Comparison of serious games based on the structured literature review.

Category	MainKassandra	Theory of Change Game	Sustainability Futures Game	The Road to Flourishing
Country of origin	Germany	Switzerland and Germany	Finland	Netherlands
Game purpose	Engage corporate teams in learning about climate change adaptation and mitigation by role-playing a fictitious company.	Apply "Theory of Change" (ToC) thinking to sustainable development projects. Help players collaboratively articulate how a project or initiative can achieve its desired impact by mapping out actors, actions, and outcomes.	Enable stakeholders to imagine desirable sustainable futures for an urban context and explore pathways to achieve them.	Raise players' knowledge of sustainable business models and influence their attitudes and intentions to implement more transformative sustainability practices.
Target audience	Employees and managers in companies.	Researchers, students, and practitioners involved in sustainability projects or transdisciplinary initiatives.	Primarily aimed at professionals in urban planning and sustainability, such as city officials, urban planners, business leaders, and sustainability specialists. The game has also been played with master's students in sustainability/design programs.	People working in or with business, including corporate professionals, sustainability consultants, and business students.
Format (physical/digital)	Physical simulation board game with printed materials and some digital supplements.	Purely analog board and card game.	Both physical and digital.	Both physical and digital.
Gameplay structure	A facilitated simulation workshop (~4–8 hours). Players form teams of 3–4, each team managing a fictitious company in the "MainKassandra" region, which faces the impacts of climate change. The game is scenario-based and unfolds in rounds. In	A board-and-card game for ~5–6 players. The board displays a Theory of Change (ToC) template, and players collaboratively fill it in through guided discussion. The game involves two phases: a quick brainstorming round to identify key ideas, followed by a deeper	A facilitated narrative workshop (~3 hours), focused on imagining and planning sustainable urban futures. Participants choose a real city and first co-create a vision of what a desirable, sustainable version of that city might look like in 2030. Then they work backward	A board game (playable in person or online via a virtual board on Miro) that uses quiz questions and scenario "events" to simulate a company's journey toward sustainability. Players (individuals or teams) start at the beginning of a game board and progress through

	each round, teams discuss and select climate adaptation or mitigation measures (from a provided catalog of ~80 options) to protect their companies from extreme weather and climate risks. They must make managerial decisions, role-play discussions, and present interim results after each round, thereby helping to share knowledge. Success is measured by a "maturity" score indicating how well the company is prepared for climate impacts. The final debriefing closes the session, during which all players reflect on what they learned and how it applies to their real work environment.	discussion using color-coded prompt cards. These cards help players reflect on strategies, context, and assumptions, while encouraging participation and structured dialogue. A facilitator typically concludes the session with a debrief to consolidate learning and insights.	to identify the key steps, challenges, and actions needed to reach that future. The game blends storytelling, collaboration, and strategic thinking, often using the UN SDGs as a guide. Sessions end with presentations and reflections. The game can be played as a physical board game or as an online workshop using a digital collaboration platform (e.g., Miro), with facilitators guiding the exercises in either format.	five levels of sustainable business strategy: Efficiency → Net Zero → Circularity → Sufficiency → Regeneration, ultimately reaching "Flourishing" at the end. The board is essentially a path with these stages. On each turn, a player must answer a multiple-choice question about a sustainability concept or a real-world case. A correct answer allows the player/team to move forward to the next step. Along the way, they encounter event and explanation cards that deepen their understanding of each sustainability concept. In the latest version, players also reflect on how each strategy could apply to their own context. A facilitator may guide discussion and debrief at the end to reinforce learning and support real-world application.
Sustainability concepts covered	Climate change adaptation and mitigation in a business context.	Theory of Change and project planning for sustainable development.	Urban sustainability and futures thinking.	Sustainable business models and "strong sustainability."
Learning outcomes (intended and observed)	Intended outcomes include improved understanding of corporate climate adaptation; participant learning outcomes were not empirically evaluated in the reported study.	Qualitative feedback from iterative testing indicated clearer articulation of assumptions, shared understanding of project pathways, and appreciation of diverse perspectives. No long-term behavioral or organizational outcomes were assessed.	Qualitative observations and participant-generated outputs indicated reflection on assumptions, development of alternative visions, identification of possible pathways, and opportunities for stakeholder collaboration. No direct behavioral, policy, or organizational outcomes were measured.	The game was shown to significantly increase players' knowledge of sustainable business concepts, helping them better understand strategies like circularity and sufficiency. Some positive shifts were also observed in attitudes and social norms around sustainability. However, a single session did not lead to significant changes in players' stated intention to act more sustainably in their work. Still, participants found the real-world

				examples engaging and appreciated the quiz-based format, which likely supported retention. The game's updated version includes reflective prompts to help players connect the content to their own context, aiming to strengthen future behavioral impact.
Evidence of evaluation	Expert interviews and focus groups were used to identify didactic, contextual, and implementation requirements. No formal evaluation of completed gameplay outcomes was reported.	Evidence from iterative playtesting and stakeholder workshops. Reported outcomes primarily focus on cognitive and relational learning; long-term behavioral evidence remains limited.	Mainly qualitative, design-oriented evidence from iterative testing, user feedback, and facilitator observations. Limited direct measurement of learning outcomes or behavioral effects.	Strongest evidence among the four cases: pre- and post-game survey with 220 participants, showing significant knowledge gains and some attitudinal/social-norm effects, but no significant short-term change in behavioral intention.
Transfer/validation gap	Unclear whether workshop learning leads to implemented climate adaptation measures, changes in investment decisions, or changes in organizational routines.	Unclear whether shared theories of change improve later project implementation or sustained stakeholder collaboration.	Unclear whether visions and pathways generated in the game are integrated into real planning, policy, or organizational decision-making.	Unclear whether improved knowledge and attitudes translate into actual strategic or behavioral change without repeated use, action planning, and organizational support.
Underlying theory or framework	Climate adaptation theory and serious gaming pedagogy.	Theory of Change (ToC) methodology and social learning concepts.	Transformative design frameworks.	Sustainable business model theory and behavioral theory.
Design process (co-design & iteration)	The game was developed as part of a climate adaptation training project using an iterative, user-informed process. The team reviewed literature and interviewed HR and sustainability experts to identify practical elements for managers, then created a prototype. Feedback from manager focus groups led to key refinements, such as simplifying the structure and adding realistic scenarios. While not fully co-designed, the game was significantly shaped by	The creators followed a systematic process of conceptualization → prototyping → testing → refinement, repeating this over several rounds. Drawing on the Theory of Change literature and earlier serious games, the team built an initial prototype that was tested internally and led to significant changes. Subsequent iterations were tested at academic conferences and a stakeholder workshop, which together involved around 90 participants. Feedback-	The game was developed through a participatory, multi-iteration design process as part of the CreaTures research project. Co-developed with the design consultancy Hellon, the game evolved over at least five design iterations and seven test sessions. Early prototypes focused on refining core mechanics and storytelling prompts to support futures thinking. Later sessions involved target users—including professionals and students—which helped adapt the	The Road to Flourishing was developed using a Design Science Research (DSR) approach, combining theory-driven design with iterative testing. The team identified a gap in sustainability education tools—particularly the dominance of weak sustainability—and proposed a game to foster stronger paradigms. After reviewing existing tools, they created a prototype and tested it in five rounds with sustainability academics, refining the game based

	stakeholder input. Formative evaluations during testing guided further improvements. The current version reflects at least two design cycles, with additional updates planned based on future workshop use.	informed continuous improvements—such as more precise wording, better pacing, and smoother discussion flow. This iterative, feedback-driven approach allowed players to act as co-developers. By the final version, only minor adjustments were needed, and the game effectively supported its intended learning outcomes.	game to different contexts. Feedback from each round informed changes in structure, content, and facilitation. This collaborative, iterative approach ensured the game was both practical and adaptable across settings.	on feedback. Once early feedback stabilized, they launched a larger evaluation phase and introduced Version 2.0, tailored to business audiences. These updates—such as adding reflective steps and adjusting the pacing—were based on user input. The process reflects a structured, evidence-based cycle blending academic design with real-world relevance.

Source: own elaboration.

Table B2.

Practice-oriented sustainability games identified in the exploratory scan

No.	Game	Type		Created by	Target group				Purpose		No. of SDGs	Country	Source of information
		Board game	Web based		Business	Education	Public administration	NGOs	Strategy	Awareness			
1	BUSINESS SIMULATION		X	Edumundo		X			X		3-4 out of 17	Netherlands	https://www.edumundo.com/gamification/business-games/sustainable-business-simulatie
2	Corporate Sustainability Dilemma Game		X	EU-funded "Gamify Project"	X					X	13	European Union	https://www.gamify.site/corporate-sustainability
3	Ecologic	X		Sabirov & Kormakov	X	X	X	X		X	Not publicly reported	Russia	https://www.ecologic4people.ru/en
4	Green Business Lab		X	Realia Group LLC	X				X		10 out of 17	USA	Sustainability Simulation Game Home - The Green Business Lab (gblsim.com)
5	Green&Great		X	Center for Systems Solutions		X				X	Not publicly reported	Poland/ Germany	https://greenandgreat.socialsimulations.org/#main
6	In the Loop ® Game: Board Game	X		In the Loop Games	X	X				X	Not publicly reported	Netherlands	In the Loop Games – Making circular economy fun and understandable
7	MIT CleanStart		X	MIT Management Sloan	X	X	X			X	9	USA	https://mitsloan.mit.edu/teaching-resources-library/cleanstart-simulating-a-clean-energy-startup
8	Save the Future		X	Centre for Systems Solutions	X	X	X	X	X		Not publicly reported	European Union.	https://games4sustainability.org/gamepedia/save-the-future/
9	Sustainability Game Experience		X	Contur	X					X	16	Germany	https://www.contur-online.de/en/sustainability-game-experience/
10	Sustainable Business Model Innovation Game	X		threebility		X			X		Not publicly reported	Germany	https://www.threebility.com/post/playing-games-to-facilitate-sustainable-product-and-business-innovation
11	Teamplay		X	The Sustainability Games		X				X	17	Netherlands	The Sustainability Games - Online employee engagement, learning, and development accelerator to enable a circular economy and achieve the SDGs
12	Sustainable Business		X	Hubro Education		X			X		Not publicly reported	Norway	https://hubro.education/en/hubro-sustainable-business-simulation

13	The Net Zero Game 2050	X		Net Zero Game ApS	X	X	X	X		X	4	Denmark	https://netzerogame.com/
14	Triple Connection		X	Inchainge	X				X		13 out of 17	Netherlands	The Triple Connection: Sustainability Business Game Simulation (inchainge.com)

Source: own elaboration.