



Exploring the Potential of Digital Games for Climate Education: A Review of Policy-Focused Climate Action Games

André Czauderna

Cologne Game Lab, TH Köln, Cologne, 50678, Germany

5 *Correspondence to:* André Czauderna (andre.czauderna@th-koeln.de)

Abstract. Communicating the complexities of climate change and the challenges of climate policy decision-making remains a persistent challenge in geoscience and climate education. This review offers a focused examination of policy-oriented digital games addressing climate action, encompassing both mitigation and adaptation, and considers their potential as educational tools for fostering systems thinking and enhancing understanding of climate governance. It concentrates on digital games that combine engaging gameplay with substantive representations of climate action and meaningful learning opportunities, typically situated between large entertainment titles and specialized academic simulations. The review examines how these games frame climate policy dilemmas, articulate causal relationships, and represent trade-offs across scientific, social, and political domains. In particular, the review analyses key game design choices – such as how conflict is framed, decisions are structured, feedback is delivered, and time is compressed – which shape players’ understanding of climate action and its environmental, social, and political consequences. The review furthermore offers a critical evaluation of how these games represent and simplify complex systems – especially how they portray climate action, climate models, and political decision-making processes. In addition to the main review, a separate section illustratively underscores the importance of debriefing – such as reflective practices in informal online discussions and formal education – in shaping learning outcomes. Overall, the review suggests that, for pedagogical practice, climate action games are most effective when combined with debriefing to support critical engagement with trade-offs and underlying model assumptions. For educational game design, the review highlights the importance of transparent feedback systems, meaningful temporal dynamics, and explicit representation of political and ideological dimensions. For future research, the review calls above all for empirical studies on players’ learning processes and outcomes across different age groups, demographics, and levels of prior knowledge and literacy, including how structured reflection and debriefing shape these processes and outcomes.

25 1 Introduction

Climate change represents one of the most urgent problems facing humanity as well as one of the most complex challenges within the geosciences, encompassing atmospheric, oceanic, and socio-economic dimensions. For geoscientists and educators, effectively communicating the vastness and complexity of climate change remains a central priority, if not a responsibility (Corner et al., 2018; Knudsen and de Bolsée, 2019). As studies have shown that public audiences often have a



30 limited understanding of the science of climate change, sometimes extending to climate denial (Kutney, 2025), geoscience
education must promote greater awareness and understanding of climate change (Lewandowsky, 2021). Equally important,
however, is articulating how scientific insights translate into effective climate policies (Oreskes, 2004; Coyle and Kenny,
2025). Decisions about climate action, i.e., mitigation and adaptation, rely on geoscientific evidence, yet policy processes
often operate on political or economic timescales that differ sharply from those of climate systems. Bridging this gap
35 requires not only clear communication of scientific evidence but also an emphasis on why policy matters: it determines
emissions trajectories, shapes land-use practices, guides hazard preparedness, and ultimately influences the extent of future
climate impacts. By highlighting the role of science-informed policymaking, geoscientists can help stakeholders and the
public to understand that climate policy is not an abstract political debate but a practical extension of geoscience – one that
determines how societies respond to the risks and realities of a changing planet. In this context, creative approaches, such as
40 games, may promote the expansion of geosciences into diverse areas and encourage broader interest in the field’s research
and impacts (Illingworth, 2023).

Over the past decades, digital games, i.e., games playable on digital devices such as personal computers, video game
consoles, smart phones, tablets, etc., have emerged as a compelling tool for climate education. Building on principles of
45 effective learning identified in learning theory (e.g., Dewey, 1916; Schön, 1983; Kolb, 1984; Boud et al., 1985; Gee, 2003),
digital games offer interactive representations of Earth-system dynamics, feedback loops, and temporal processes (Wu and
Lee, 2015; Abraham and Jayemanne, 2017).

Focusing on digital games does not diminish the value of non-digital formats: board games, card-based simulations, and
50 role-playing scenarios remain vital tools in climate and sustainability education, especially for fostering deliberation,
collaboration, and dialogue. However, digital games offer distinctive affordances for representing system complexity,
integrating large datasets, and allowing players to rapidly iterate through alternative policy pathways. This review, therefore,
focuses specifically on these digital formats.

55 According to Ouariachi et al. (2019), digital games on climate change can support affective, cognitive, and behavioural
dimensions of engagement and learning by allowing players to slip into the roles of decision-makers, manipulate variables,
witness consequences, and explore complex systems in ways that static media cannot. Crucially, digital games do not merely
depict scientific models – they also articulate positions about human agency, technological solutions, and governance
through their rule systems and mechanics (Bogost, 2007). As such, they are both scientific and argumentative media: they
60 model climate processes while encoding assumptions about what constitutes meaningful or desirable climate action.

In recent years, an increasing number of digital games have addressed the challenges of climate change from a policy
perspective, including diverse titles such as *Half-Earth Socialism* (2022), *The Climate Game* (2022), and *Beecarbonize*



(2023), which, for brevity, may be referred to as climate action games in this paper. In the game *Half-Earth Socialism*,
65 adapted from a book by Vettese and Pendergrass (2022), players take on the role of leading the Global Planning
Commission, which is tasked with halting climate change after a worldwide socialist revolution in 2022. While time still
permits, players must keep global warming below 1 degree Celsius, extinction rates below 20, and emissions at zero –
ambitious targets that highlight the game’s role in simulating extreme climate-management challenges rather than realistic
policy goals. At the same time, players must maintain population satisfaction and parliamentary approval. Players could
70 begin by investing in public transportation, funding research into meat alternatives, and implementing an environmental
protection curriculum in schools. Other games focus on more pragmatic strategies, such as *The Climate Game*, which is
grounded in the three emissions-reduction pathways outlined in the International Energy Agency’s World Energy Outlook
report: the stated policies scenario, the announced pledges scenario, and the net zero scenario (IEA, 2024). The present
review focuses specifically on this subset of digital games for climate education: policy-oriented games that emphasize
75 decision-making around mitigation and adaptation, highlighting the socio-environmental trade-offs involved.

Research on climate-focused games spans multiple disciplines – from education to game studies to geosciences – each
emphasizing different analytical questions. Much of the literature focuses on conceptual discussions (e.g., Wu and Lee,
2015; Abraham and Jayemanne, 2017), individual game design and development efforts (e.g., Hügel and Davies, 2022), or
80 empirical assessments of learning outcomes and attitude change (e.g., Rooney-Varga et al., 2018; Meya and Eisenack, 2018;
van Beek et al., 2022). Studies typically examine elements such as game design (Hügel and Davies, 2022), player
engagement (Ouariachi et al., 2019; Rooney-Varga et al., 2018), knowledge acquisition (Rooney-Varga et al., 2018), or
shifts in perceptions following gameplay (van Beek et al., 2022; Meya and Eisenack, 2018).

85 Broader reviews exist (e.g., Reckien and Eisenack, 2013; Flood et al. 2018; Douglas and Brauer, 2021; Fernández Galeote et
al., 2021; Gerber et al., 2021b), but these often adopt very wide scopes, covering heterogeneous formats such as board
games, card games, classroom role-play, digital simulations, and digital games. While some reviews provide field-mapping
and/or taxonomies (e.g., Reckien and Eisenack, 2013; Douglas and Brauer, 2021; Gerber et al., 2021b), others offer
systematic reviews of empirical research (e.g., Flood et al., 2018; Fernández Galeote et al., 2021). Rarely, reviews focus on a
90 subset of games, such as on serious games for climate change adaptation (e.g., Flood et al., 2018). Additionally, several
literature reviews examine games for sustainability education in general; these usually include climate change games but are
typically much broader in scope (e.g., Stanitsas, 2019; Tan and Nurul-Asna, 2023). Most reviews also tend to focus heavily
on academic or research-oriented games, largely because these are documented in peer-reviewed literature. As a result, they
pay comparatively little attention to the “middle segment” of climate policy-focused digital games designed for wider
95 audiences but not discussed extensively in academic publications. During analysis, a quantitative, bird’s-eye perspective is
typically favoured over a qualitative analysis of reviewed games. Although climate education increasingly incorporates



interactive media, the unique affordances of digital games compared to other media for fostering systems thinking and reflection remain insufficiently theorized.

100 The unique contribution of the present review is fourfold.

1. It provides a focused examination of policy-oriented digital games about climate action (i.e., climate action games), a genre that has received little qualitative attention in existing studies and reviews, despite its prevalence and direct relevance to understanding real-world climate governance.
- 105 2. It focuses on games that provide engaging gameplay alongside substantive representations of climate action and meaningful learning opportunities, typically situated between large entertainment titles and specialized academic simulations.
3. It analyses how specific game design elements shape understanding of the relationship between climate change, political decision-making processes, and climate action.
- 110 4. It offers a critical evaluation of how these games simplify and represent complex systems – particularly how they portray climate policies, climate models, and political decision-making.

Additionally, this review highlights the importance of reflective practices beyond gameplay, i.e., debriefing, in both informal online communities and formal classroom situations, as these contexts significantly influence what players take away from their interactions with climate policy games. The review concludes by offering recommendations for educators, designers, 115 and researchers.

Overall, this review aims to illustrate what makes these games particularly well suited to fostering deeper understanding and critical reflection on climate action, including both mitigation and adaptation. At the same time, it addresses their limitations, highlighting challenges such as constrained decision spaces, tensions between scientific accuracy and engaging gameplay, 120 and ideological framing. Ultimately, the review examines how digital climate action games can contribute to geoscience and climate education.

2 Review Approach: Focus, Game Selection, Data Analysis

The present section elaborates on the focus of the review (2.1), specifies the criteria for game selection (2.2), and outlines the analytical approach, including the categories used in the analysis (2.3).

125 2.1 Focus

This review presents a structured synthesis of contemporary digital climate action games released primarily between 2020 and 2025. In the context of this paper, climate action is understood as the suite of interventions aimed at mitigating



130 greenhouse gas emissions and adapting to the observed and anticipated impacts of climate change. These actions, which span local to global governance levels, are grounded in geoscientific assessments of Earth-system processes and the risks associated with climate change. The review is based on a broad categorial analysis of all selected games, drawing on similarities as well as differences.

135 The analysis adopts a learning-theory perspective while drawing on insights from geography education, game studies, and game design, focusing specifically on the mechanisms through which games facilitate learning about climate action. It integrates perspectives from geoscience and political science, examining the extent to which digital games adequately depict climate models as well as governance and political processes. This consideration of geoscience and political science is crucial, as it is hypothesized that many climate-related games continue to exhibit persistent gaps – such as varying levels of scientific fidelity, weak representation of ocean-climate interactions, deliberate yet reductive portrayals of political processes, and limited engagement with global climate justice – as well as an ideological position. These omissions and positions shape players’ understanding of climate systems and the constraints of policy-making, rendering them central to any educational assessment.

145 The review focuses on games that occupy a middle ground between large entertainment titles and specialized academic simulations. While mainstream entertainment games offer broad appeal, complex systemic environments, and well-established learning principles, they generally lack scientific accuracy, impose a high entry threshold through genre-specific game literacy, and require substantial time investment, limiting their applicability in formal educational contexts. At the opposite end of the spectrum, research-driven climate simulations achieve high modelling fidelity but tend to have limited reach due to constrained resources, narrowly defined academic or educational audiences, low gameplay appeal, and modest production values.

150 This intermediate category appears to offer particular promise for climate education. These games balance scientific credibility and policy relevance with engaging mechanics, compelling narratives, and accessible interfaces in ways that neither mainstream entertainment titles nor expert-focused simulations typically achieve

155 The review concentrates on games published between 2020 and 2025, providing a relevant timeframe for examining developments in digital climate action games. The period 2020 to 2025 reflects a combination of factors: the early 2020s saw intensified focus on net-zero pathways, resilience-building, and climate justice, shaping game themes and decision structures; advances in interactive visualization, data-driven modelling, and accessible game development tools lowered the threshold for creating sophisticated climate simulations within digital games; and the consolidation of digital distribution platforms enabled a broader range of actors – including independent creators, NGOs, and research institutions – to reach global audiences. Focusing on this recent timeframe also accounts for the short “half-life” of digital climate games (titles



published before 2020 are often less relevant for contemporary practice or even not available anymore, see e.g. Gerber et al. 2021a), while earlier periods have already been covered by existing reviews.

2.2 Game Selection

165 The game selection process began with a search of major distribution platforms, including Steam and the App Store, as well
as media coverage of climate-related games, complemented by prior mapping reviews and scholarly overviews. The
selection criteria targeted titles that focus on policy-relevant climate issues, centre on structured decision-making about
climate action – specifically mitigation or adaptation measures – as a core gameplay element, combine engaging gameplay
with substantive representations of climate action and meaningful learning opportunities, are well-received and/or widely
170 played, and were published between 2020 and 2025.

As the review required climate action to be the primary focus of gameplay, none mainstream entertainment titles were
suitable for inclusion, and the selection consequently centred on the middle-ground category outlined above: games with a
significant appeal and high production value, designed primarily for entertainment, while still intending scientific accuracy
and educational opportunities, likely correlating with both strong game and learning design (*Beecarbonize*, *Fate of the*
175 *World*, *Green New Deal Simulator*, *Half-Earth Socialism*). Although the review focuses on titles published between 2020
and 2025, it includes one notable earlier game, *Fate of the World* (2011), widely regarded as a landmark in the genre and
considerably more complex than most other games.

180 To balance the selection of games from the core middle-ground category, a number of academically developed games
primarily oriented toward education or science communication were included. Even though their dissemination is more
limited and they may exhibit lower production values and polish, they remain broadly comparable in overall appeal. These
games offer particularly robust representations of climate science and policy dilemmas and have been evaluated in peer-
reviewed studies. Accordingly, four games led by academic institutions (not merely as project partners) were selected
185 (*ClimarisQ*, *Ensured Energy*, *Klim:S21*, *Climate Adaptation Game* – with the last game, released in 2019, slightly outside
the 2020-2025 timeframe). For comparative purposes, the selection also includes one game developed and published by an
NGO (*Werde Klimakanzler:in*) and another by a newspaper (*The Climate Game*), both of which largely align with the
characteristics of the middle-ground category.

190 It is important to note that many of the middle-ground games designed primarily for entertainment, although not explicitly
labelled as educational and/or scientific, have collaborated with (or were even initiated by) climate experts, draw on
scientific evidence, or have received funding or been developed as part of public-private partnerships. Equally, all selected
games with a main purpose beyond entertainment are generally comparable in appeal. As a result, the boundaries between
entertainment and education are increasingly blurred – much as they are in other mature media forms such as filmmaking.



195 For pragmatic reasons, games were included only if they were available in English – the dominant language of the field – or German, which is the author’s native language and also appears to be an important language in this domain (e.g., due to public funding structures and as noted in prior reviews).

200 Ultimately, the review considers only ten games because it concentrates on a narrow genre of recent digital games with significant appeal and reach, in which climate action is the primary focus of gameplay. Non-digital games, purely digital simulations lacking game elements, and broader gamified tools are excluded to maintain this focus. Moreover, the analytical approach is qualitative rather than quantitative: the aim is to interpret and compare game and learning design as well as the representation of climate policies, climate models, and political processes in a small number of games (see 2.3).

205 Table 1 provides an overview of all analysed climate action games, including their publication year, developer type, and platform.

Table 1: Overview of selected climate action games, including title and release year, developer type, and platform (ordered by year of publication).

Title / Year	Type of Developer / Cooperation	Platform
Fate of the World (2011)	Indie Studio (Red Redemption) advised by climate scientists (Myles Allen from the University of Oxford)	PC / Mac
Climate Adaptation Game (2019)	Swedish National Knowledge Center for Climate Change Adaptation at SMHI (Swedish Meteorological and Hydrological Institute) together with Linköping University and high school teachers	Browser
Werde Klimakanzler:in (2021)	NGO (GermanZero)	Browser
Half-Earth Socialism (2022) adapted from Vettese & Pendergrass (2022)	Cooperation of scientists / book authors (Drew Pendergrass and Troy Vettese) with indie developers (Francis Tseng and Son La Pham) for a book to game adaptation, published by Trust	PC / Mac / Browser
Klim:S21 (2022) publication: Wankmüller et al. (2025)	Partnership of academia (Research Group for Earth Observation at Pädagogische Hochschule Heidelberg) and a serious game studio (Gentle Troll Entertainment)	Browser
The Climate Game (2022)	Cooperation in the area of data journalism, created by The Financial Times in partnership with Infosys	Browser
Beecarbonize (2023)	Partnership of an indie game studio (Charles Games) and NGOs with climate experts (receiving EU funding)	PC / Mac / Mobile
Green New Deal Simulator (2023)	Indie game studio with an activist reputation (Molleindustria)	PC / Mac / Browser / Mobile
ClimarisQ (2025) publication: Faranda et al. (2026)	Partnership of academia / climate scientists (led by Davide Faranda at the French National Center for Scientific Research – CNRS) and an indie game studio (Opal Games)	Browser / Mobile
Ensured Energy (2025) publication: Simpson et al. (2026)	Academic cooperation between political science (Universität Bern – Institute of Political Science) and informatics (Università della Svizzera Italiana – Faculty of Informatics)	Browser



2.3 Data Analysis

The literature review is structured around a set of analytical categories applied consistently across all selected climate action games. In the research process leading to this review paper, category-based game analyses in the form of short vignettes were written for all games across all categories and compiled in an analysis table. In the next step, a comparative, category-based analysis was conducted across the games, following an approach similar to qualitative methods commonly used in thematic analysis (Braun and Clarke, 2006) or qualitative content analysis (Mayring, 2019).

The analytical categories were developed in the early stages of the review process, guided by the review’s focus. Notably, the categories related to game and learning design draw on Czauderna and Budke’s (2020) decision-making framework for digital games in geography education. Table 2 provides an overview of all data analysis categories and their definitions, along with one anchor example per game (i.e., the vignettes written during analysis).

Table 2: Overview of analytical categories, definitions, and sample data (vignettes per game).

Category of Analysis	Definition	Game Review Anchor Example (Vignettes)
Conflict of Objectives		In <i>ClimarisQ</i> , the core conflict emerges from the necessity to balance climate action with social and economic stability in a system shaped by uncertainty, delay, and escalating risk. Players must keep the three main parameters – Ecology, Popularity, and Finance – above zero at all times; the collapse of any one of them immediately ends the game. At the same time, atmospheric CO ₂ concentration continues to evolve, influencing the frequency and intensity of extreme climate events.
	The core tension or trade-off the player must resolve (e.g., economy vs. emissions, biodiversity vs. extraction, scientific adequacy vs. political feasibility). Shows how the game operationalizes climate dilemmas.	A central trade-off lies between ambitious climate mitigation and short-term political or economic costs. Measures that effectively slow CO ₂ growth and reduce long-term climate risk often strain financial resources or public popularity. In contrast, decisions that prioritize economic growth or social acceptance may preserve stability in the short term but accelerate CO ₂ accumulation, increasing the likelihood of extreme events later in the game.
		A second major tension concerns mitigation versus adaptation. Mitigation actions target the causes of climate change and shape long-term trajectories, but their effects are frequently delayed. Adaptation measures – such as seasonal protections against heatwaves, floods, or droughts – reduce immediate damage and parameter loss, yet leave underlying emission trends untouched. Players must therefore decide how to allocate limited resources between preventing future risks and managing present impacts, knowing that neglecting either can be fatal.
		Temporal trade-offs further intensify these conflicts. Each decision advances the game by one season, and many effects unfold only after several turns. This emphasizes policy lag, delayed feedback,



and rebound effects, where seemingly successful short-term decisions generate adverse long-term consequences. Players must act without full foresight, mirroring real-world climate governance under uncertainty.

Finally, *ClimarisQ* highlights a scale-related trade-off between local and global action. Extreme events are experienced locally and affect regional parameters, while CO₂ concentration operates at a global level. Players are thus forced to balance investments in local resilience with actions aimed at global emissions reduction, emphasizing the structural tension between immediate regional needs and long-term planetary stability.

Overall, *ClimarisQ* frames climate decision-making as a continuous negotiation between incompatible objectives rather than a problem with a single optimal solution. The game's main conflict lies in managing unavoidable trade-offs across time, sectors, and scales – demonstrating that climate action is defined less by perfect choices than by navigating persistent dilemmas under constraint.

ClimarisQ curates player decisions in a highly structured and pedagogically scaffolded way, emphasizing informed choice rather than free-form experimentation. Core decisions are presented through blue decision cards, each requiring the player to swipe left or right – borrowing the familiar interaction logic from games like *Reigns*. This binary choice format simplifies interaction while still embedding complex trade-offs, ensuring accessibility without removing cognitive challenge.

Decision-making is strongly supported by contextual scientific guidance. Before taking an action, players are informed of its impact level as well as any delayed effects, if applicable. In many cases, the Scientific Council provides additional explanations of climate processes related to specific topics. This design choice stresses evidence-based reasoning and reflects the game's roots in scientific mediation. Rather than asking players to guess outcomes, *ClimarisQ* encourages them to interpret scientific advice and weigh it against social, ecological, and financial constraints.

Decisions are also curated temporally. Each blue card advances the game by one season, reinforcing the idea that climate action unfolds incrementally and accumulates over time. Some decisions trigger immediate effects, while others generate delayed consequences, represented later through green cards. This separation between action and outcome mirrors real-world climate governance, where policies often produce indirect or postponed impacts.

The decision space is further constrained by hard systemic boundaries: none of the three core parameters – Ecology, Popularity, and Finance – can fall to zero without triggering game over. This forces players to remain within a narrow corridor of viability, discouraging extreme or single-minded strategies and highlighting the necessity of balance. Extreme events, communicated through brown notification cards, can abruptly

Curation of Decisions (Czuderna and Budke, 2020)

How decisions are structured, grouped, visualized, and scaffolded to support learning. Includes interface design, indicators, thematic clustering of policy tools, and sequencing that encourages reflection.



disrupt carefully planned strategies, underscoring the limits of control even when decisions are scientifically informed.

Overall, *ClimarisQ*'s curation of decisions prioritizes guided agency over open-ended freedom. Choices are deliberately framed, scientifically contextualized, and systemically constrained, reflecting the game's educational aim to model climate decision-making as a process shaped by knowledge, uncertainty, delayed effects, and unavoidable trade-offs rather than by unlimited player autonomy.

Feedback in *Beecarbonize* occurs on multiple levels, combining continuous visual indicators, event-driven interruptions, and end-of-game assessment.

Immediate feedback: The emissions bar is always visible, showing the cumulative impact of the player's actions in real time. Similarly, the bars for the three essential resources – money, people, and ideas – allow players to monitor resource availability and anticipate whether planned actions are feasible.

Event feedback: When players approach climate tipping points, marked as yellow triangles on the emissions scale, event cards are triggered (e.g., heatwaves, floods, sea-level rise). Each event specifies the required resource combination and sequence of actions, as well as the consequences if it is not successfully managed, adding urgency and a risk-management dimension to gameplay. Failing to resolve an event marked with a skull icon ends the game.

Systemic feedback: The interplay between sectors (Industry, Ecosystems, People, Science) generates indirect consequences, reinforcing the cause-and-effect relationships in the game world. Poor resource balance or overemphasis on one sector can propagate negative effects elsewhere, visible via the continuous updates to bars and event occurrences.

End-of-game feedback: Upon achieving one of five golden goals or failing, players receive a summary of the decisive factors that determined the game's outcome.

In addition to feedback after actions, players may consult the in-game Encyclopedia even before a decision is made, providing detailed textual explanations of the effects, synergies, and trade-offs of individual cards.

Overall, the feedback design in *Beecarbonize* effectively combines a variety forms of feedback (e.g., visual and textual) at different stages of gameplay (e.g., immediate and end-of game) to make system dynamics transparent, support strategic planning, and enhance understanding of climate decision-making in a complex, interconnected system.

Feedback
(Czuderna and
Budke, 2020)

The type, immediacy, and clarity of feedback – such as continuously visible quantitative metrics, end-of-turn statistics, or narrative consequences.



Time Manipulation (Czuderna and Budke, 2020)	How time is discretized, compressed, and accelerated to illustrate delayed consequences of climate policies (e.g., multi-year turns, projections to 2050/2100, accelerated climate responses).	<p>In <i>The Climate Game</i>, time is highly discretized and compressed into three planning rounds (2022–2025, 2026–2030, 2030–2050). Each round aggregates several years of climate and policy development, allowing players to experience long-term consequences within a short play session.</p> <p>Delayed effects are emphasized through round-based summaries, where earlier decisions shape later emissions trajectories, tipping points, and final temperature outcomes. This structure highlights the path dependency and irreversibility of climate policy while keeping the game accessible and fast-paced.</p>
Representation of Climate Action (within Gameplay)	How climate action is implemented within gameplay, including: mitigation measures, adaptation measures, and the interplay, balance, or imbalance between mitigation and adaptation; whether outcomes are symbolic, simplified, or based on detailed modelling. Assesses how the game conceptualizes pathways for addressing climate change.	<p>The <i>Climate Adaptation Game</i> focuses on climate adaptation rather than mitigation, distinguishing it from many other climate-focused games that primarily deal with emission reductions. Players take on the role of the climate adaptation coordinator for the fictional city of Weatherton, i.e., on a local level, tasked with preparing the city for future climate-related hazards while balancing economic and societal considerations.</p> <p>The game presents seven climate adaptation missions successively over the course of the timeline (2020–2100). Each mission represents a tangible adaptation challenge, such as densifying urban areas, adapting agriculture to drought, saving the hospital from flooding, securing drinking water, or protecting new housing areas in forests. For each mission, the player chooses among multiple alternatives that vary in adaptation effectiveness, cost, and sustainability impacts, or can opt to do nothing.</p> <p>Decisions influence a combination of outcomes: the number of lives saved, the city’s economic state, and progress toward five selected UN Sustainable Development Goals (health, water and sanitation, sustainable built environment, energy, and biodiversity). The game illustrates that adaptation measures often involve trade-offs and require long-term planning, as different actions may affect multiple aspects of city resilience and sustainability.</p> <p>By simulating extreme climate events (heatwaves, droughts, floods) and their stochastic occurrence based on selected climate scenarios (RCP 2.6, 4.5, 8.5), the game emphasizes the uncertainty inherent in adaptation planning. Players can explore how adaptation strategies mitigate risks, revealing the consequences of their decisions over decades. Through this, the game provides an experiential understanding of adaptation as a complex, long-term societal challenge, highlighting both synergies and conflicts between climate adaptation, urban planning, and sustainability goals.</p>
Representation of Climate Science and Models	The degree of modelling sophistication (qualitative narratives vs. quantitative models), inclusion of emissions pathways, sector interactions, transparency of	<p><i>The Climate Game</i> is explicitly grounded in real-world climate and energy modelling. Emissions pathways are based on bespoke calculations by the International Energy Agency (IEA), drawing on scenarios from its Net Zero by 2050 report. These pathways are coupled with the MAGICC v7+ climate model (Model for the</p>



	<p>assumptions, and fidelity to real scientific models.</p> <p>Assessment of Greenhouse Gas Induced Climate Change) to estimate temperature outcomes.</p> <p>Scientific complexity is strongly simplified for accessibility: players interact with high-level policy choices rather than model parameters, and results are communicated through aggregated indicators, sectoral emissions graphs, tipping-point narratives, and round-based summaries. Methane and land-use effects are included, reflecting major climate drivers, while other dynamics such as oceanic processes, permafrost feedbacks, or regional climate variability are largely absent.</p> <p>The game may overrepresent energy-related CO₂ emissions, as mitigation in electricity, transport, buildings, and industry dominates gameplay, while other greenhouse gases and adaptation impacts receive less focus. Time is compressed into three discrete planning rounds, emphasizing long-term consequences but simplifying real-world temporal dynamics.</p> <p>Overall, the game effectively translates credible climate science into an interactive, pedagogically accessible format, but necessarily omits detailed modelling of ocean systems, fine-grained regional interactions, and adaptation measures, prioritizing the most policy-relevant, high-impact sectors and gases.</p>
<p>Representation of Political Processes</p>	<p><i>Half-Earth Socialism</i> places political processes more centrally than most climate policy games by embedding decision-making within a parliamentary system composed of nine distinct factions: Malthusians, Utopians, Consumerists, Fanonists, Ecofeminists, Authoritarians, Accelerationists, Environmentalists, Animal Liberationists. These factions articulate competing perspectives on growth, consumption, equality, technology, and ecological protection, creating ongoing political pressure on the player's actions.</p> <p>Political feasibility is operationalized through political capital and factional approval, which constrain which projects can be pursued and in what sequence. Climate and ecological policies thus require democratic legitimacy, forcing players to negotiate, balance, or strategically alienate parts of the political spectrum. Compared to many climate games that abstract politics away or reduce it to a single constraint, <i>Half-Earth Socialism</i> emphasizes ideological conflict and pluralism as a core component of planetary governance.</p> <p>At the same time, political processes are necessarily simplified and abbreviated. Parliamentary dynamics do not include detailed negotiation, coalition-building, or institutional inertia beyond approval thresholds. Ultimately, the game prioritizes climate and ecological modelling over fine-grained political simulation, using politics as a framing and constraint mechanism rather than as an independently complex system.</p>



Ideological Framing	The normative or ideological assumptions embedded in the game (e.g., technocratic optimism, market liberalism, Green New Deal progressivism, eco-socialist planning). Identifies how the game frames societal change and climate action.	<p><i>Half-Earth Socialism</i> is explicitly grounded in a normative ideological framework derived from the book “Half-Earth Socialism: A Plan to Save the Future from Extinction, Climate Change and Pandemics” by Troy Vettese and Drew Pendergrass (2022). The game advances a post-capitalist, eco-socialist vision in which planetary crises are framed as systemic failures of growth-oriented capitalism rather than as coordination problems within existing economic structures.</p> <p>Climate action is presented as inseparable from collective planning, democratic governance, and large-scale public intervention. The presence of a pluralistic parliament does not neutralize this framing but situates it within internal ideological tensions, allowing competing perspectives – such as consumerism, accelerationism, authoritarianism, or radical ecological ethics – to contest the dominant planning paradigm. Unlike technocratic or market-centric climate games, <i>Half-Earth Socialism</i> does not present technological innovation alone as sufficient, but embeds it within broader social and political transformation.</p> <p>At the same time, the game avoids didactic certainty through the inclusion of competing perspectives, the exposure of trade-offs, and the availability of multiple viable pathways to success. While its ideological orientation is clear, it functions less as propaganda than as a speculative, argumentative simulation, inviting players to test the internal coherence and limits of an eco-socialist approach to planetary governance.</p>
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3 Review

225 This section presents the review itself, providing a comparative overview of the ten selected digital climate action games, framed according to the thematic focuses outlined above. The qualitative analysis in this section is organized around a predefined set of categories corresponding to two aspects – game design (3.1) and representation (3.2) – to enable a structured, category-based comparison.

230 The approach follows the logic of thematic and qualitative content analysis (e.g., Braun and Clarke, 2006; Mayring, 2019) rather than quantitative surveys. The emphasis is on interpretive comparison, highlighting patterns, contrasts, and insights across a deliberately curated corpus.

In the following section (4), the discussion turns to reflective practices (in informal online discussions and formal education),
235 emphasizing that deeper climate learning requires both gameplay and debriefing. This part of the paper connects to learning and debriefing theory and incorporates illustrative examples from online discourse surrounding *Half-Earth Socialism*.



3.1 Game Design

The first part of the review employs a conceptual framework introduced in earlier research, which explores how digital strategy and management games originally designed for entertainment can support the practice of dynamic decision-making in geography education. The framework by Czauderna and Budke (2020) is grounded in a comparative qualitative analysis of 17 digital games (selected from an initial sample of 109 games) and emphasizes “decisions that come in a sequence” (Dörner and Funke, 2017, p. 2) in the areas of city planning, climate change, migration, and resource usage. It conceptualizes digital games as structured decision-making environments, in which players navigate sequences of interdependent choices, interpret feedback, and adapt strategies over time. According to the framework, the analysed entertainment games immerse players in complex, often polytelic problems, challenging the players with multiple, sometimes conflicting goals (Betsch et al., 2011, p. 143). These challenges drive a continuous decision-making process, motivating players to engage in iterative problem-solving (Dörner and Funke, 2017). This process takes the form of a cycle – understood in game design as a gameplay loop (Salen and Zimmerman, 2003, p. 316) – which consists of decisions, actions, and feedback. It is central to both the enjoyment and educational value of these games. Simultaneously, such games also simplify and reshape complex issues through didactic mediation, which make problems manageable and enjoyable – and thus support learning. Three core mechanisms underpin their educational potential:

- Structured choices highlight trade-offs while remaining cognitively manageable.
- Feedback systems communicate how player actions affect the underlying system, illustrating causal relationships.
- Temporal manipulation compresses timescales, making delayed consequences more visible.

Applied to climate action games analysed in the present review, these mechanisms can communicate key features of Earth-system behaviour – interconnection, feedback, and delay – and stimulate reflection on human roles within these systems. All surveyed games represent climate action challenges through their decision-making structures, feedback mechanisms, and manipulation of temporal scales. Each game invites players to act as a decision-maker balancing environmental and socio-economic objectives, thereby transforming abstract climate models into interactive experiences. Consistent with the applied framework, these digital games emphasize iterative decision sequences and feedback processes. Players test policy measures, observe quantitative outcomes (e.g., temperature rise, GDP, public support), and adjust strategies accordingly. By condensing decades into minutes, the games reveal temporal dynamics that mirror the lagged effects typical of geoscientific systems – an advantage for communicating cause-effect relationships and the urgency of early action.

The remainder of this subsection offers a closer examination of the learning mechanisms embedded in policy-oriented climate games. Specifically, the section illustrates

- a. how these games promote learning by centring on conflicting goals and trade-offs (3.1.1); and



- 270 b. how players' learning is mediated through specific design strategies, namely the curation of decisions (3.1.2),
feedback (3.1.3), and time manipulation (3.1.4).

3.1.1 Conflict of Objectives

275 Across all games, the central tension revolves around balancing competing objectives under constraints, reflecting the inherent dilemmas of climate governance, which refers to the processes, institutions, and policies through which societies manage and coordinate responses to climate change.

280 Players consistently face trade-offs between environmental, social, and economic goals, and must make decisions knowing that every action carries costs and delayed consequences. The games provide continuous feedback on players' decisions and actions. These feedback loops evaluate, on the one hand, players' in-game success. On the other hand, they allow players to draw tentative conclusions about the potential (side) effects of analogous actions in real-world contexts. In this way, the games create a space for testing and experimenting with climate mitigation and adaptation strategies situated within the tension between political pragmatism and more utopian visions of climate futures.

285 In *Green New Deal Simulator*, for example, the goal is to reduce CO₂ emissions to zero by the year 2050. The specific conflict of objectives requires players, in line with the Green New Deal (e.g., Klein, 2019), to achieve the transformation of the United States of America into a post-carbon economy while simultaneously maintaining full employment (see Fig. 1).



290 **Figure 1: Conflicting goals in *Green New Deal Simulator*: Transformation of the USA into a post-carbon economy vs. maintaining full employment (screenshot), © Molleindustria, 2023.**



Implemented as a deck-building game and excluding specific numbers, players must expand renewable energies, end the use of fossil fuels, capture CO₂ in the atmosphere, modernize the energy grid, and research new green technologies. A significant aspect of this game is the geographical dimension, as the game cards must be distributed to individual states or regions with different social, cultural, economic, and topographic conditions.

295

After only a few minutes of gameplay, players are confronted with the effects of their policies – a process that would take years in the real world. The feedback from the game in turn influences player actions, as it is assumed that players will align their decisions with in-game success. With additional challenges in the game such as passing time and a limited budget, players are constantly under pressure during the relatively short gameplay – a game typically lasts about 40 minutes – leaving little time and space within a single playthrough to experiment with different solutions or strategies. Consequently, multiple playthroughs are required to thoroughly experiment with different approaches.

300

When considering the complete sample of climate action games, the conflict between mitigation policies and economic or social aspects (as described above) emerges as a common and recurring pattern. Most games require players to reduce emissions while maintaining economic performance, political legitimacy, or public approval. Ambitious climate measures often strain resources or popularity, forcing prioritization between immediate gains and long-term sustainability.

305

Another recurring conflict is mitigation versus adaptation. In adaptation-focused games like *Klim:S21* and the *Climate Adaptation Game*, players balance reducing immediate climate risks with longer-term objectives, such as economic stability or progress toward sustainability goals. Hybrid games like *ClimarisQ* combine both dimensions, requiring players to manage global emission trajectories while protecting local systems from extreme events.

310

Some games stress trade-offs that arise from interactions across multiple societal and environmental sectors. *Beecarbonize* and *ClimarisQ*, in particular, emphasize the need for coordination across sectors – such as industry, people, ecosystems, and science, or ecology, finance, and popularity – where decisions generate cascading effects and may trigger tipping points. Rather than optimizing individual sectors in isolation, these games highlight systemic complexity and interdependence as central features of climate decision-making.

315

Temporal and scale-related trade-offs further intensify the dilemmas. Effects often unfold over multiple turns or decades, highlighting delays in policy impact and reinforcing uncertainty. Players must weigh short-term relief against long-term risk, and local versus global priorities, as seen in *ClimarisQ* and *Fate of the World*.

320

In general, analysed games differ markedly in the scale at which trade-offs are presented. Some titles, including *Half-Earth Socialism*, *Fate of the World*, and *The Climate Game*, frame decision-making at a planetary or multi-regional scale, where



- 325 aggregate indicators and global consequences dominate players' attention. Others, such as *Green New Deal Simulator*,
Werde Klimakanzler:in, *Klim:S21*, and *Climate Adaptation Game*, situate trade-offs at national or local levels. These games
highlight country-specific or city-level contexts, emphasizing localized impacts, place-based constraints, and context-
specific priorities.
- 330 The political dimension of climate action games varies considerably across the corpus. In politically explicit games such as
Werde Klimakanzler:in and *Half-Earth Socialism*, trade-offs are strongly shaped by institutional constraints, governance
structures, and electoral pressures, foregrounding the political realities of decision-making. By contrast, more abstracted
games, including *Beecarbonize*, *ClimarisQ*, and *Klim:S21*, frame conflicts primarily in terms of systemic dynamics or
resource-management challenges. In doing so, they deliberately minimize political realism in order to focus players'
335 attention on understanding interactions, causal relationships, and consequences within the climate system.

In summary, while all games operationalize trade-offs to reflect climate dilemmas, differences lie in the nature of competing
objectives, temporal horizon, the scale of impact, and degree of political embedding, shaping how players experience and
prioritize climate action. Finally, all games frame these conflicts as continuous, systemic dilemmas rather than problems
340 with a single solution. Success depends on navigating tensions across sectors, objectives, and time, rather than finding
perfect choices. Whether managing emissions, biodiversity, economic growth, or political stability, players are consistently
confronted with multi-dimensional trade-offs that mirror the complexity of real-world climate action.

3.1.2 Curation of Decisions

Across the reviewed games, decision-making is deliberately curated to support learning, rather than left open-ended. All
345 games structure, visualize, and scaffold choices in ways that reduce cognitive overload while demonstrating key climate-
policy trade-offs.

In practice, this entails, among other things, selecting decision options; presenting them, including their categorization and
visualization; and providing prior explanations and commentary, for instance regarding their effectiveness (see an example
350 from *Half-Earth Socialism* in Fig. 2).

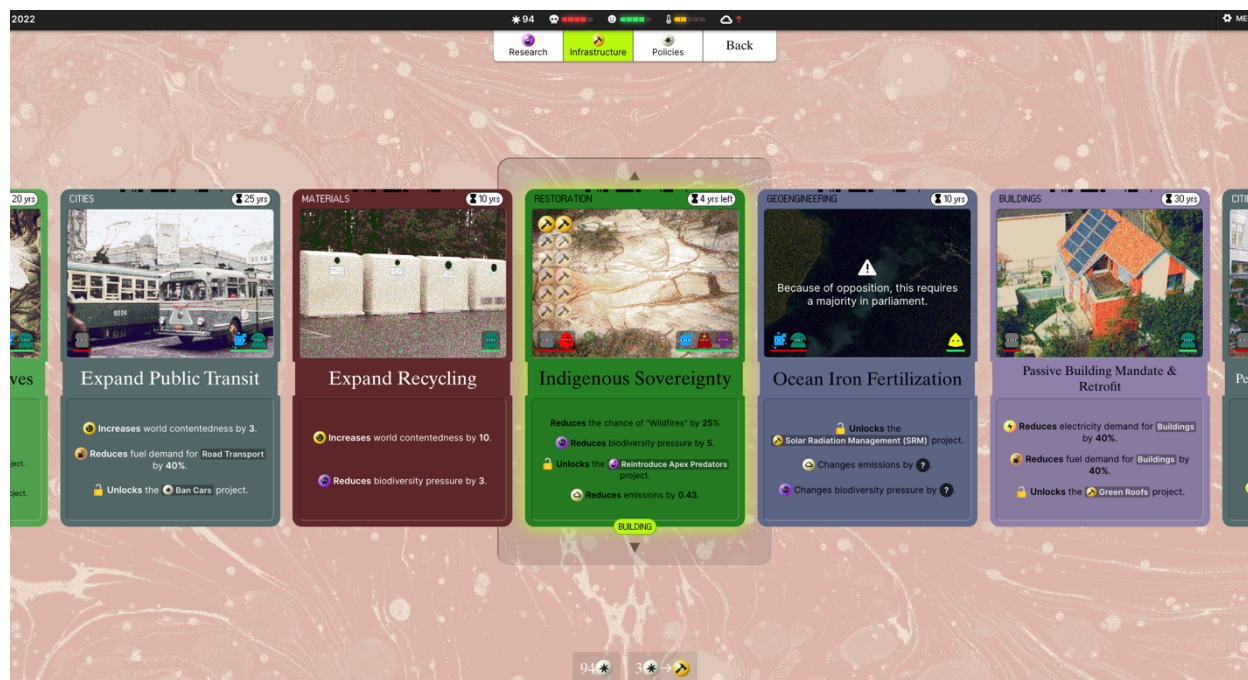


Figure 2: Excerpt from the selection of infrastructure measures in *Half-Earth Socialism* (screenshot), © Francis Tseng and Son La Pham, 2022.

355 Across the sample of climate action games, a shared feature is the use of bounded decision sets. Players never design policies
 from scratch; instead, they choose among predefined actions, cards, or missions that represent plausible interventions.
 Whether through card decks (*Green New Deal Simulator*, *Beecarbonize*, *Fate of the World*), sectoral menus (*The Climate
 Game*, *Ensured Energy*), or mission-based options (*Klim:S21*, *Climate Adaptation Game*), the decision space is intentionally
 limited. This curation communicates what counts as “relevant” climate action within the game’s framing and directs
 360 attention toward systemic levers rather than marginal details.

Second, decisions are thematically grouped and visually organized, which supports orientation and comparison. Most games
 cluster options by sector (e.g., energy, transport, land use), function (e.g., research, infrastructure, policy), or spatial context
 (e.g., regions, cities, ecosystems). Persistent indicators – such as emissions bars, temperature trajectories, budgets,
 365 popularity, or sustainability goals – remain visible while decisions are made. This design encourages players to reason
 relationally, linking individual choices to broader system dynamics.

Third, all games provide anticipatory information that helps players reflect before acting. Effects are previewed through
 icons, short texts, advisor comments, or indicator changes, rather than revealed only after the fact. While the depth of
 370 information varies, this pre-decision guidance consistently frames decision-making as informed judgment rather than trial-
 and-error. Several games (*Beecarbonize*, *ClimarisQ*, *Werde Klimakanzler:in*) further support learning through encyclopedic



entries, short articles, or external references that players can consult voluntarily (see an example from *Beecarbonize* in Fig. 3).



375

Figure 3: Entry for “Carbon Tax” in the in-game encyclopedia of *Beecarbonize*, including pre-turn information on costs and effects (screenshot from the developer’s press kit), © Charles Games, 2023.

380

Fourth, decision curation is closely tied to sequencing and pacing. Options become available gradually, are constrained by prerequisites, or unfold over time, encouraging incremental learning. Delayed effects – common across the sample – separate action from outcome and reinforce reflection on long-term consequences.

385

Overall, despite differences in interface and depth, the games converge on a shared learning logic: decisions are simplified, contextualized, and sequenced to make complex climate governance cognitively accessible without removing its dilemmas. Through careful curation, players are guided to explore trade-offs, anticipate consequences, and connect individual actions to systemic change – central goals of climate-related learning through games.



3.1.3 Feedback

In all games, feedback is a core learning mechanism that makes climate action visible as a dynamic, model-driven process rather than a set of isolated choices. Across the corpus, games provide vivid feedback – in different forms and timing – on players’ decisions and actions (see examples from *The Climate Game* in Fig. 4).

390

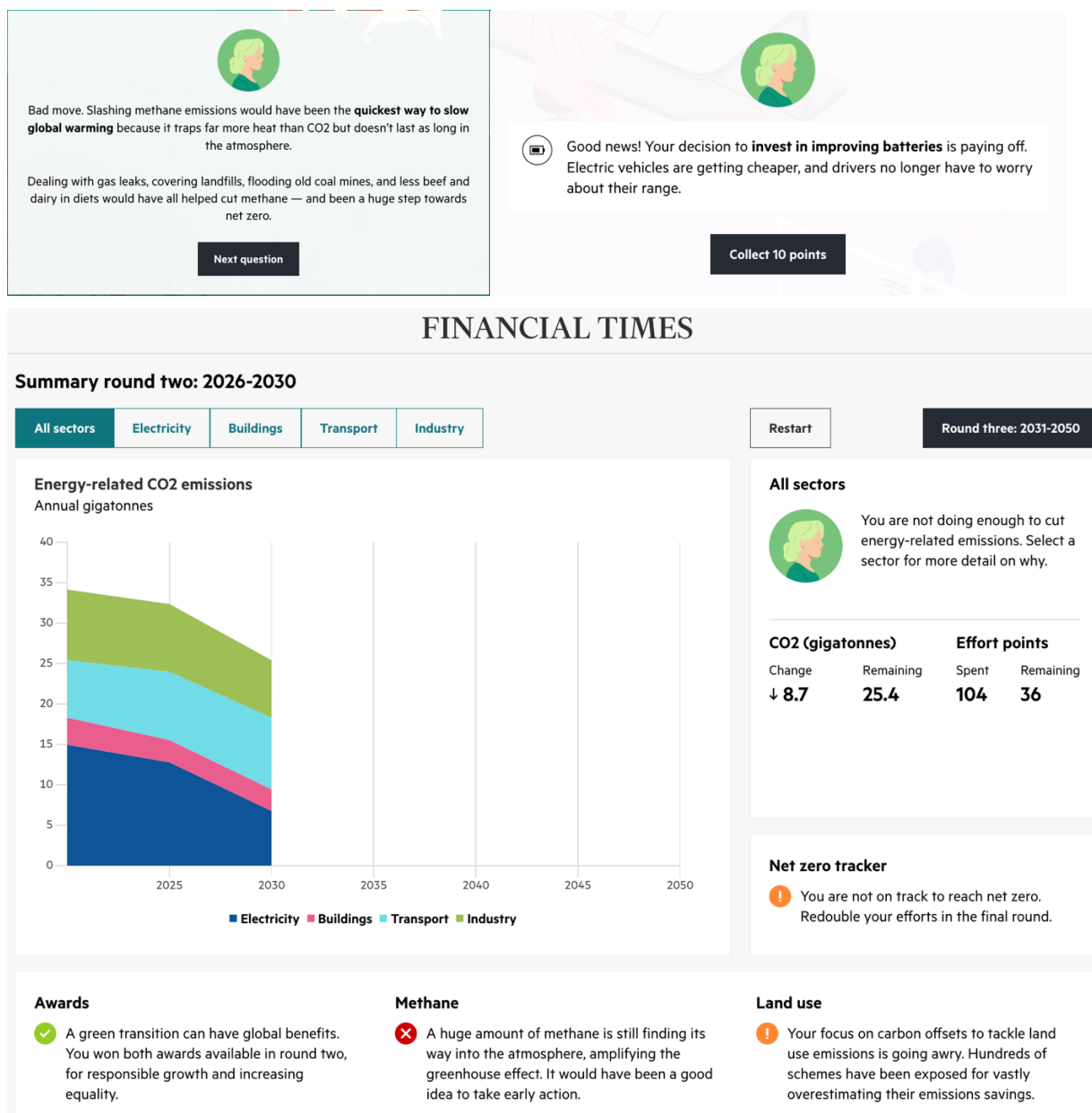


Figure 4: Forms of feedback in *The Climate Game*: as immediate feedback after a single game action (above) and as more extensive feedback after each game round (below) (screenshots), © Financial Times, 2022.



395 A central commonality across all games is the use of persistent quantitative indicators – such as emissions, temperature, budgets, popularity, risk levels, or system stability – that remain visible throughout play. These indicators function as a constant reference point, enabling players to continuously monitor system states and recognize climate action as a matter of steering trajectories rather than triggering single outcomes.

400 In addition to this always-visible layer, most games provide action-linked feedback, where individual decisions are followed by immediate responses. This feedback is often visual (e.g., changes in bars or meters) and sometimes narrated or contextualized through short textual explanations, advisor comments, or news items. Even when simplified, this layer helps players associate specific policy choices with short-term effects, reinforcing causal reasoning.

405 A third shared feature is cumulative, turn- or round-based feedback. Across the sample, consequences are regularly summarized after turns, rounds, or time steps – often spanning multiple years or decades. These summaries aggregate prior decisions into emissions trajectories, disaster reports, political shifts, or sustainability outcomes. Together, these three layers – persistent indicators, immediate action feedback, and cumulative turn or round-based feedback – support learning by linking moment-to-moment decisions with long-term climate dynamics.

410 Some games stress immediate, continuous feedback (*Green New Deal Simulator*, *Beecarbonize*, *ClimarisQ*), where indicators update instantly after each decision, supporting tight action-reaction learning loops. Others emphasize delayed or periodic feedback (*Half-Earth Socialism*, *Fate of the World*, *Climate Adaptation Game*), with consequences emerging only after multi-year turns or summary phases. This shifts learning toward reflection on long-term causality rather than short-term optimization.

415 Feedback ranges from simple, highly legible indicators (bars, thermometers, smileys in *The Climate Game*, *Werde Klimakanzler:in*, *ClimarisQ*) to dense analytical dashboards and graphs (*Fate of the World*, *Ensured Energy*). The former prioritizes accessibility and intuitive sense-making; the latter supports deeper systems analysis but raises cognitive demands.

420 Some games rely primarily on quantitative system feedback (emissions curves, temperature trajectories, budgets), while others integrate narrative or contextual feedback – such as media reactions, disaster descriptions, or stakeholder commentary (*Half-Earth Socialism*, *Werde Klimakanzler:in*, *Klim:S21*). Narrative feedback tends to humanize consequences and highlight political or social dimensions beyond numerical targets.

425 Games like *Beecarbonize*, *ClimarisQ*, and *Fate of the World* explicitly use events, tipping points, and stochastic shocks as feedback, signalling that outcomes are probabilistic and partially uncontrollable (see Fig. 5). In contrast, more linear designs



(*Green New Deal Simulator*, *Climate Game*) present feedback as clearer cause-effect relationships, supporting introductory understanding.

430



Figure 5: Tipping point example (“Antarctic Collapse”) from *Beecarbonize* (screenshot from the developer’s press kit), © Charles Games, 2023.

Finally, nearly all games provide summative feedback at the end of play, whether in the form of scores (*Climate Adaptation*
435 *Game*), comparisons to scientific targets (*ClimarisQ*, *The Climate Game*), or narrative and political outcomes (*Half-Earth*
Socialism, *Werde Klimakanzler:in*). These endings frame what “success” in climate action means – scientifically, politically,
or socially. And encourage reflection, replay, and discussion, particularly in educational settings.

In sum, while all games use feedback to link decisions to consequences, they differ markedly in timing, form, and
440 pedagogical emphasis.

3.1.4 Time Manipulation

Across all titles, time can be seen as an important design strategy and another learning mechanism. In all instances, time is
deliberately compressed and structured to make long-term climate processes playable and intelligible within short sessions.
Rather than mirroring real-time progression, games consistently use abstracted temporal units – turns, rounds, seasons,



445 terms, or multi-year steps – to connect present-day decisions with distant future consequences (see Fig. 6 and Fig. 4 second part). Ultimately, this compression allows players to experience outcomes projected to 2050, 2100, or beyond within minutes or hours of play – a central pedagogical strategy for climate education.



450 **Figure 6: End-of-round report from *Half-Earth Socialism*, illustrating changes in key variables over time (screenshot), © Francis Tseng and Son La Pham, 2022.**

In general, analysed climate action games emphasize delayed consequences and path dependency. In all games, the full effects of decisions are not immediate but unfold over subsequent turns, rounds, or phases. Time therefore functions as a learning device that highlights inertia, policy lag, and the difficulty of reversing trajectories once certain thresholds are crossed.

455

Time manipulation is furthermore closely tied to reflection and planning. Most games separate decision phases from evaluation phases: players act, time advances, and outcomes are revealed in aggregated form. This sequencing encourages players to think prospectively (anticipating future states) and retrospectively (interpreting how earlier choices shaped later outcomes), reinforcing systems thinking rather than reactive play.

460

Games differ substantially in how finely time is segmented. Some use coarse-grained intervals – five-year turns (*Fate of the World*), decade-long steps (*Climate Adaptation Game*), or aggregated planning phases (*The Climate Game*) – which highlight long-term structural change but reduce immediacy. Others adopt fine-grained temporal units, such as seasons (*ClimarisQ*) or continuous progression (*Werde Klimakanzler:in*), making temporal pressure and sequencing more palpable.

465



In several games, time is explicitly represented through timelines, year labels, or turn counters (*The Climate Game*, *Half-Earth Socialism*, *Ensured Energy*, *Fate of the World*). In contrast, games like *Beecarbonize* treat time more implicitly, encoding it through escalating risks, cumulative emissions, and event frequency rather than calendar years. This shifts attention from chronology to system dynamics.

470

In addition, some games give players direct or indirect control over temporal pacing, for example through pause functions (*Werde Klimakanzler:in*, *Climate Adaptation Game*) or by tying time advancement directly to individual decisions (*ClimarisQ*). Others enforce a stricter rhythm, where time advances only after all decisions for a turn are locked in (*Fate of the World*, *Ensured Energy*), emphasizing commitment and irreversibility. Furthermore, all games allow players to rewind
475 time by starting a new attempt, as games function as spaces for experimentation without real-world consequences.

Temporal design also varies in how it communicates urgency. In *Beecarbonize* and *ClimarisQ*, the passage of time is linked to risk escalation: tipping points, countdowns, or increasing probabilities of extreme events create pressure to act early. By contrast, games with longer turns and aggregated feedback (*The Climate Game*, *Half-Earth Socialism*) emphasize strategic
480 foresight and long-term planning over moment-to-moment urgency. Finally, some games explicitly manipulate starting points to teach lessons about delay. *ClimarisQ* allows players to begin in later decades, immediately constraining options and increasing risk.

Taken together, all games use time manipulation to bridge short gameplay sessions and long climate horizons, but they differ
485 in the visibility, controllability, and urgency of time. These differences shape whether players primarily learn about climate change as a problem of delayed feedback, escalating risk, strategic planning, or missed opportunities – highlighting time not just as pacing, but as a central object of learning in climate action games.

3.2 Representation

Representation in climate action games shapes how players understand and engage with climate change, influencing both the
490 strategies they pursue and the assumptions they internalize about the world. The present review analyses representation across four interconnected dimensions: climate action, climate science and models, political processes, and ideological framing.

Representation of climate action examines how mitigation and adaptation measures are implemented, the balance or tension
495 between them, and whether actions are symbolic, simplified, mechanistic, or model-driven. This dimension assesses how games conceptualize pathways for addressing climate change, from straightforward emissions reductions or carbon budgeting to complex, interactive strategies (see 3.2.1).



500 *Representation of climate science and models* considers the sophistication of the underlying modelling, from qualitative narratives to quantitative system-based models. It includes the extent to which games incorporate emissions pathways, sector interactions, transparency of assumptions, and fidelity to real scientific models (see 3.2.2).

505 *Representation of political processes* focuses on the depiction of governance structures, political actors, institutional constraints, and the feasibility of implementation pathways. Games vary in scale, from local to global, and in the degree of contestation and institutional realism they portray, highlighting either technocratic efficiency or the complex negotiation, compromise, and conflict inherent in democratic decision-making (see 3.2.3).

510 *Ideological framing* addresses the normative assumptions and values embedded in the games. Through the narrative, goals, and available actions, games communicate positions such as technocratic optimism, market liberalism, Green New Deal progressivism, or eco-socialist planning. This dimension identifies how the games frame societal change and climate action (see results in 3.2.4).

3.2.1 Climate Action

515 In all games, players select from curated sets of measures that stand in for real-world policy, technological, or planning options. These measures are almost always simplified and abstracted, yet linked to quantitative system variables (e.g., emissions, temperature, risk, budgets, popularity), allowing players to observe causal relationships without engaging with full scientific or institutional complexity.

520 Climate action is moreover framed as constraint-driven decision-making: actions are limited by resources, political feasibility, time, or system thresholds. This reinforces the idea that climate pathways are not chosen freely but emerge from trade-offs, sequencing, and cumulative effects – as a result of dynamic decision-making over time rather than single decisive actions.

525 Most games of the sample place a strong emphasis on mitigation as the default mode of climate action. These games conceptualize climate action primarily as emissions reduction through energy transition, efficiency, land-use change, or technological innovation. Adaptation, when present, is often secondary, implicit, or framed as damage control rather than as an equally strategic pathway.

530 *Half-Earth Socialism*, *Beecarbonize*, and *Fate of the World* represent climate action as a system-wide transformation problem. Mitigation is deeply entangled with land use, biodiversity, social organization, and political legitimacy. Adaptation appears indirectly, for example through ecosystem protection, infrastructure resilience, or human development measures.



These games emphasize interdependencies and feedback loops, portraying climate action as inseparable from broader socio-ecological systems rather than as a single policy domain.

- 535 *Klim:S21* and *Climate Adaptation Game* stand out by placing adaptation at the core of gameplay. Climate action is represented through concrete, locally grounded measures such as flood protection, urban greening, drought-resistant agriculture, or early-warning systems. Mitigation is largely absent. Actions are context-specific and place-based, highlighting vulnerability, uncertainty, and trade-offs between social, ecological, and economic goals. These games conceptualize climate action as ongoing risk management rather than trajectory steering.
- 540 *ClimarisQ* offers the most explicit mechanical balance between mitigation and adaptation. Players must simultaneously manage long-term CO₂ reduction and short-term protection against extreme events. Adaptation does not eliminate risk but reduces losses, while mitigation shapes future probabilities. This dual structure makes the tension between preventing future harm and coping with present impacts a central gameplay experience.
- 545 Games also differ in how model-driven their representations are. Titles like *The Climate Game*, *Ensured Energy*, *ClimarisQ*, and *Fate of the World* explicitly reference scientific models, scenarios, or sectoral pathways, lending epistemic authority to player actions. Others, such as *Green New Deal Simulator* or *Beecarbonize*, rely more on symbolic simplification and systemic metaphors to convey core dynamics without claiming scientific precision.
- 550 Overall, these differences show that climate action in those games is not a single representational strategy but a spectrum: from mitigation-focused policy levers, through integrated socio-ecological system management, to local adaptation and resilience planning. How a game balances mitigation and adaptation – and how concretely or abstractly it models them – strongly shapes the pathways of climate action that players are invited to imagine as plausible, effective, or inevitable.

3.2.2 Climate Science and Models

- 555 Across the sample, climate science is translated into gameplay through layered abstraction rather than direct exposure to scientific models. Even when sophisticated simulations operate in the background, players interact primarily with aggregated indicators (e.g., emissions, temperature, CO₂ concentration, risks, impacts) instead of equations or model parameters. This design choice reflects a common pedagogical logic: scientific credibility is maintained, but cognitive load is reduced to support decision-making and learning.

560

Games also emphasize simplified cause-effect relationships rather than predictive accuracy. While all games aim to communicate that policy choices shape emissions pathways and climate outcomes, none explicitly project plausible ranges of futures or provide uncertainty estimates, as academic models do.



565 Finally, most games prioritize policy-relevant climate knowledge. Energy systems, emissions trajectories, and sectoral interactions are foregrounded, while highly complex Earth-system components, such as ocean circulation, regional climate differentiation, or nonlinear tipping cascades, are either simplified or omitted. This reflects a shared orientation toward making climate science actionable and intelligible within limited playtime.

570 Within the corpus, observable differences appear in how climate science and models are applied. Games such as *Green New Deal Simulator*, *Beecarbonize*, and *Werde Klimakanzler:in* rely primarily on qualitative or semi-quantitative models. Climate dynamics are condensed into a small number of macro-indicators that communicate directionality and trade-offs rather than scientific precision. These games emphasize intuitive understanding of climate-policy relationships, often sacrificing transparency about underlying assumptions or calculations in favour of accessibility.

575 At the other end of the spectrum, *Half-Earth Socialism*, *The Climate Game*, *ClimarisQ*, *Ensured Energy*, and *Fate of the World* integrate formal climate or energy models into their simulations. These games translate player decisions into emissions pathways and temperature outcomes using established scientific tools (e.g., Hector, MAGICC, IPCC-aligned scenarios). While still simplified at the interface level, their outcomes are grounded in peer-reviewed modelling frameworks, lending epistemic authority to gameplay results.

580 Furthermore, games differ markedly in how transparent they are about their scientific foundations. *ClimarisQ* and *The Climate Game* explicitly reference IPCC scenarios, emissions pathways, and probabilistic logic, highlighting uncertainty and nonlinearity as core features of climate science. In contrast, games like *Klim:S21* and *Climate Adaptation Game* embed science through scenario-based storytelling and applied risk assessment, prioritizing experiential plausibility over model disclosure.

590 Another difference lies in the scope of Earth-system representation. Some games focus narrowly on emissions-temperature relationships (*The Climate Game*, *Green New Deal Simulator*), while others adopt a more integrated socio-ecological perspective (*Half-Earth Socialism*, *Fate of the World*), linking climate dynamics to land use, biodiversity, food systems, and human development. Adaptation-focused games (*Klim:S21*, *Climate Adaptation Game*) emphasize climate impacts and risks rather than global climate dynamics, translating science into localized hazard probabilities and vulnerability reduction.

595 Differences are also evident in how uncertainty is represented. Many games encode uncertainty indirectly, through random events or thresholds, whereas *ClimarisQ* and *Climate Adaptation Game* explicitly operationalize probabilistic risk, reinforcing a core insight of climate science: futures cannot be predicted deterministically, only explored statistically.



Taken together, these games form a continuum from symbolic, qualitative representations of climate science to model-driven, scenario-based simulations. Their design choices reflect different priorities – accessibility, scientific fidelity, policy relevance, or experiential learning – demonstrating that climate science in games is not simply “simplified,” but selectively translated to serve distinct educational and epistemic goals.

3.2.3 Political Processes

In the games examined, political processes are generally abstracted rather than fully simulated. Governance is rarely represented through detailed legislative procedures, negotiations, or institutional workflows. Instead, politics enters gameplay primarily as a set of constraints on action – such as budgets, approval levels, effort points, public support, or feasibility thresholds – that limit what players can implement and when.

Games furthermore emphasize trade-offs over deliberation. Players are typically positioned as decision-makers with agenda-setting power, while political complexity is conveyed through competing objectives (e.g., climate effectiveness vs. popularity) rather than through explicit political actors debating or resisting policies. This approach stresses outcomes and consequences rather than procedural realism.

Finally, most games simplify political scale and agency. Players usually operate at a single, clearly defined level (local, national, continental, or global), and multi-level governance, jurisdictional conflict, or international bargaining are rarely modelled explicitly. Political realism is thus selectively reduced to preserve clarity and playability, so that governance mechanics illustrate constraints in climate action rather than replicate real political processes.

Half-Earth Socialism stands out by incorporating political contestation. Ideological factions with competing values actively constrain policy choices, making political feasibility an explicit and persistent challenge. While still simplified, politics functions as a core system rather than a background constraint, emphasizing pluralism, legitimacy, and ideological conflict in climate governance.

Games such as *Werde Klimakanzler:in* and *Ensured Energy* model politics through popularity, acceptance probabilities, lobbying, or campaigns. Here, governance is experienced as a balancing act between effective climate action and maintaining support, reflecting democratic pressures without reproducing formal parliamentary procedures.

In other games, such as *The Climate Game*, *ClimarisQ*, and *Beecarbonize*, political processes are highly simplified. Players assume the roles of powerful planners or ministers with limited opposition, and politics is condensed into constraints on actions – such as effort points, resources, or other parameters. These games prioritize scientific modelling and system dynamics over political realism, implicitly granting players high executive capacity.



630 *Klim:S21* and *Climate Adaptation Game* represent politics implicitly at the municipal level. Rather than elections or parties, political processes emerge through resource scarcity, stakeholder perspectives, competing goals, and long-term planning horizons, reflecting the everyday pragmatics of local climate governance and adaptation.

635 *Fate of the World* abstracts politics into a fictional global authority, replacing democratic processes with indicators such as stability and human development index. This creates a stylized representation of global governance focused on policy consequences across regions, rather than on political legitimacy or negotiation.

In sum, the games form a spectrum from politics as a central arena of conflict and legitimacy to politics as a simplified feasibility filter. While none offer fully realistic political simulations, their differing abstractions reflect distinct assumptions about what players/learners should understand: ideological struggle, democratic compromise, pragmatic planning, or the systemic consequences of policy choices.

640

3.2.4 Ideological Framing

Across the sample, most games embed normative assumptions about climate action. Climate change is almost universally framed as manageable through informed decision-making, whether via policy coordination, technological deployment, or strategic planning. Explicit climate denial or deep political scepticism toward climate science is absent. Instead, games differ mainly in how societal change is imagined: incremental reform versus structural transformation, technocratic management versus ideological contestation, and mitigation-centred versus adaptation-oriented approaches.

645

In all games, agency is centralized. Players typically act as planners, ministers, or coordinators with broad authority, which implicitly endorses a belief in rational governance and expert-led intervention. Even games that stress uncertainty or trade-offs tend to assume that better information and better planning lead to better outcomes, reflecting a broadly modernist and problem-solving orientation.

650

Despite these similarities, games can be clustered according to their ideological framing, with two broad categories: explicitly ideological games and games with a pragmatic, technocratic, problem-solving framing. The first category of explicitly ideological games, including *Green New Deal Simulator*, *Werde Klimakanzler:in*, and *Half-Earth Socialism*, articulates clear normative positions. *Green New Deal Simulator* advances a progressive, techno-optimistic vision in which decarbonization, public investment, and social justice are mutually reinforcing. *Werde Klimakanzler:in* aligns with the GermanZero initiative, normatively committing to the 1.5 °C target while combining ambition with political feasibility. *Half-Earth Socialism* is the most ideologically explicit, framing climate and biodiversity crises as systemic failures of capitalism and advocating eco-socialist planning, collective governance, and post-growth transformation.

660



The second category comprises games with a pragmatic, technocratic, problem-solving framing. Games such as *The Climate Game*, *Beecarbonize*, *Ensured Energy*, *Climate Adaptation Game*, and *ClimarisQ* adopt a more technocratic ideology. *The Climate Game* reflects a market-friendly, pro-growth, mitigation-centred worldview, emphasizing efficiency, innovation, and early intervention within existing economic structures. *Beecarbonize* and *Ensured Energy* frame climate action as a system-optimization challenge, privileging strategic coordination and technological solutions over political or ethical debate. The *Climate Adaptation Game* frames adaptation as a pragmatic policy challenge, emphasizing rational trade-offs and risk management rather than activism or systemic critique. *ClimarisQ* positions itself as science-centred, implicitly endorsing evidence-based rationalism and long-term planning as the appropriate response to climate risk.

As a whole, the games span a continuum from explicit ideological advocacy – such as Green New Deal or eco-socialist framings – to technocratic optimism and policy realism. Even the most “neutral” titles embed assumptions about governance, expertise, and societal change, demonstrating that climate games rarely function as value-free representations. Instead, they offer distinct imaginaries of how climate action should be understood, organized, and justified.

4 Supplementary Considerations and Analysis: The Role of Reflection and Debriefing

A long tradition of research and practice in gaming and simulation emphasizes the importance of player reflection and debriefing for deeper learning. Studies have shown that reflective practices during or beyond gameplay – such as informal online community discussions or formal classroom debriefings – significantly shape what players take away from their interactions with digital games. Consequently, simulation games are often implemented in workshop settings that follow a structured sequence: introduction, gameplay, and debriefing. It is during the debriefing phase that reflection occurs, facilitating deeper learning processes (e.g., Kolb and Kolb, 2009; Crookall, 2010; Kriz, 2010; Crookall, 2023; de Wijse-van Heeswijk, 2025).

Research on player forums highlights their role as sites of informal learning, where participants reflect on both the content and design of games (Gee, 2005). These forums may also foster scientific habits of mind (Steinkuehler and Duncan, 2008). More specifically, discussions among players on platforms such as Steam – an online gaming distribution and communication platform – provide insight into how climate action games are experienced “in the wild” and the educational potential they offer. Common patterns in these discussions include critiques of scientific validity, concerns about the realism of policy scenarios, and debates over perceived ideological biases. Such exchanges illustrate broader challenges in climate communication and education, particularly regarding public trust, interpretation of scientific information, and the negotiation of complex socio-political trade-offs. These insights underscore the importance of reflective practices and debriefing in supporting meaningful engagement with climate action games.



695 A brief review of publicly accessible discussions on Steam concerning *Half-Earth Socialism* illustrates how players engage
with the discourses of such games. Posts and comment threads debate the realism of the game’s global planning model, its
assumptions about renewable energy limits, and its representation of social equity. These conversations demonstrate that
players critically reflect on both scientific plausibility and political ideology, highlighting the potential of what Gee (2005)
calls “affinity spaces” – in this context, online sites of informal learning where participants negotiate the scientific, political,
700 social, and ethical dimensions of climate action. Discussions on Steam often highlight *Half-Earth Socialism*’s limitations as
a representation of real-world phenomena, alongside heated debates about the game’s biases. This is apparent in threads such
as “Thoughts on beating the game” (<https://steamcommunity.com/app/2071530/discussions/0/3428948355359271628/>) and
“‘Evil’ Victory?” (<https://steamcommunity.com/app/2071530/discussions/0/5267542371383445853/>). Similar concerns
about perceived bias recur in user reviews of the game.

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The user fanzhuyifan, for instance, criticizes in a review: “There is not much diversity in winning strategies -- the game is
pretty heavily skewed towards adopting veganism.” Another user, Goose, also notes that the path to success in the game is
heavily constrained, but interprets this as a realistic reflection of real-world conditions:

710 “If you veer outside of the narrow lane that takes you to a liveable world, you won’t ‘win’ the game, just as you won’t ‘win’ at protecting
the planet for real. Of course there is a bias in the game, because the bias is towards minimal harm, maximum equality and complete
sustainability. Why would anyone think that they have a choice in how best to approach achieving success in preventing the planet from
reaching a state of catastrophe if you don’t choose the most equitable and ecological path, including veganism and renewable energy and
massively reduced consumption levels. Sure, technology plays its part but providing necessities to all and protecting the biosphere is the
715 ultimate goal. Capitalism is never going to be the solution. Never was, never will be. Stop kidding yourselves.”

And yet other players find themselves capable of resisting the game’s pressure and report successful playthroughs with less
far-reaching measures than those proposed by the authors of the adapted book. For example, in the thread titled “To anyone
saying they’re forced to do things,” a user shared the following: “I got a victory while maintaining a niche industrial and
720 organic meat production, no banning of any kind, still producing petrol, natural gas, and 15% biofuel Power was mainly
nuclear (50-60%) with some solar and offshore wind, and 10% natural gas power.”

Interestingly, the game is criticized not only by conservative and liberal players but also by players who feel the game is not
utopian enough. One user writes:

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“For a game about revolutionary socialist planning, Half Earth Socialism comes off as arch-conservative. Economic Growth means the rest
of the world looking more like the USA and Europe; human population will go out of control unless THINGS ARE DONE. The Search for
Extraterrestrial Intelligence is not some new project; it was stripped of US funding in 1995 and continues as a citizen effort.



730 As a learning tool, Half Earth Socialism pushes heavily for a few social policies and R&D projects. But I think a game like this one really needs to follow its heart to a logical conclusion: DREAM BIG. Fifty years is not 20 minutes into the future; hempcrete is not the omega material.”

The criticism of another user also targets the book on which the game is based, questioning the specific form of socialism advocated therein and expressing a desire for the game to offer a choice between different forms of socialism:

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“The game is a missed opportunity in favor of promoting a form of degrowth, austerity socialism rather than an eco-modernist socialism. It should allow different socialist perspectives to play out fairly. Instead the creators insist on the vegan anti-nuclear localism common to the petite-bourgeois socialists, which, in the creator’s defense, is in line with their desire to follow in the footsteps of the Utopian fools who were obsessed with creating cookshops of the future. For a better approach to a socialist strategy for dealing with climate change, try Matt Huber’s book ‘Climate Change as Class War: Building Socialism on a Warming Planet’ by the same publisher that put out the book that inspired this game.”

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While informal online discussions illustrate spontaneous reflection and critique, their educational value is constrained by the lack of structured facilitation. In light of the analyses above, it is essential for formal educational approaches to deliberately encourage reflection that extends beyond gameplay. Debriefing practices could not only mitigate the simplifications and biases inherent in the games but also promote deeper learning. Ultimately, the very shortcomings of current climate games – such as constrained decision options, simplified representation of climate models, and embedded ideological biases – can themselves become productive resources for climate education, as they could be used as opportunities for reflection, for example, if recipients of climate education were asked to compare the climate policies possible in games with real policy proposals (on paper and in implementation) or to examine the observed effects of climate policy in games for their scientific plausibility. Furthermore, it seems promising to have recipients justify their position pursued in the games and retrospectively analyze its effects.

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In sum, reflecting on their playful experimentation within the didactically moderated spaces of the games – facilitated through formal debriefings – may help players develop and articulate their own positions. This interplay of gameplay and reflection can foster opinion formation, idea development, and argumentative preparedness, ultimately equipping players to engage more effectively in societal discourse on climate issues.

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5 Conclusions

Overall, this review demonstrates that policy-oriented digital games focused on climate action (i.e., climate action games) occupy a valuable niche within digital approaches to climate and geoscience education. Positioned between entertainment-driven blockbuster titles and narrowly scoped academic simulations, these games combine accessibility with substantive

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representations of climate action, creating opportunities for meaningful learning. Through well-ordered problems, decision-based mechanics, feedback systems, and temporal structuring, they can facilitate understanding of mitigation and adaptation as complex, contested, and long-term processes.

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The review contributes to climate and geoscience education by explaining why such games are especially well suited to fostering deep comprehension and critical reflection on the climate crisis. Across titles, players are repeatedly placed in situations that require weighing competing objectives, anticipating delayed consequences, and interpreting cause-effect relationships. These mechanics enable forms of systems thinking, trade-off reasoning, and temporal awareness that are difficult to achieve through text-based or lecture-driven instruction alone. The review also compares these games with one another in terms of their game and learning design as well as their portrayals of climate action, climate science, and political processes.

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The competencies players develop during gameplay align closely with those emphasized in sustainability education (e.g., UNESCO, 2017; Wiek et al., 2011), climate change education (e.g., Anderson, 2012; Mochizuki and Bryan, 2015), and geoscience education (e.g., Ribeiro and Vasconcelos, 2025). These include systems thinking, strategic visioning, policy assessment, and ethical reasoning, all of which support geoethical engagement and global citizenship in the Anthropocene. The games challenge players to consider the political viability of their decisions as well as their long-term environmental, economic, and social consequences. The structured nature of the game simulations provides clear pedagogical objectives – such as balancing environmental with economic goals – while maintaining a high degree of player/learner agency.

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For geoscience education and communication more broadly, digital games can function as “boundary objects” (Star and Griesemer, 1989): shared artifacts that help different communities – in this case, scientists, policymakers, game developers, educators, students, and the broader public – interact, translate, and coordinate across epistemic and cultural divides. By translating geoscientific data into interactive representations, they make system feedbacks, trade-offs, and uncertainties visible in ways that can complement more traditional instructional approaches.

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From a game-based learning standpoint, the games analysed in this review article model key aspects of situated learning (e.g., Gee, 2003): learners take on meaningful roles, make consequential decisions, and learn from the games’ feedback loops. This feedback – ranging from public opinion shifts to long-term carbon reduction projections – offers valuable insights that guide reflection and learning. It reveals the complexity of climate governance and encourages players to reconsider their assumptions, positions, and priorities.

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At the same time, the educational potential of games is inseparable from their limitations. Games necessarily simplify climate science, politics, and social dynamics, and they do so from particular normative standpoints. Compressed timelines,

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aggregated indicators, or abstract player roles, for example, can obscure political conflict, distributional effects, or scientific uncertainty. Recognizing these simplifications – not as flaws to be eliminated, but as objects of critical reflection – is therefore essential. Moreover, evidence from a long tradition of research on simulation and gaming indicates that learning outcomes do not emerge automatically from gameplay but require structured reflection and debriefing (e.g., Kolb and Kolb, 800 2009; Crookall, 2010; Crookall, 2023).

In this context, research on informal learning around games underscores potential avenues of learning, demonstrating that learning extends beyond the game itself. Online communities – such as player discussions on Steam or explanatory videos on YouTube – serve as informal learning environments that Gee (2005) describes as affinity spaces: settings where players 805 share strategies, debate the realism of the games’ scenarios, and critically engage with the ideological underpinnings of proposed solutions. These reflective practices resonate with both transformative learning theory (Mezirow, 1997) and social constructivist theories of (game-based) learning (e.g., Gee, 2003; Steinkuehler, 2007), offering learners opportunities for metacognitive engagement and critical reflection.

810 As existing literature on games, simulations, and learning consistently emphasizes that post-game reflection is crucial for transforming in-game experiences into transferable understanding (e.g., Kolb and Kolb, 2009; Crookall, 2010; Crookall, 2023), the reviewed games would strongly benefit from:

- guided discussion of why certain strategies succeeded or failed,
- 815 • explicit unpacking of model assumptions and simplifications,
- comparison between in-game logics and real-world climate governance processes,
- reflection on ethical and normative dimensions (e.g., who benefits, who bears costs, which futures are privileged).

In classroom contexts, this can take the form of facilitated debriefings, reflective writing tasks, or comparative analysis 820 across multiple games. Debriefing prompts might include, for example:

- Which components of the Earth system were represented, simplified, or excluded, and how might these choices shape players’ interpretations of climate processes?
- In what ways do the game’s proposed solutions or modelled trajectories correspond to (or diverge from) 825 contemporary geoscientific research and policy assessments?

These prompts help learners bridge the gap between simulated and real-world systems, turning gameplay into an opportunity for deeper geoscientific reasoning.



830 From a design perspective, the review highlights recurring tensions between scientific fidelity, political realism, and
engaging gameplay. The analysed games navigate these tensions in different ways, but several cross-cutting design insights
emerge.

First, feedback design is central. Games that combine always-visible quantitative indicators (e.g., emissions, temperature,
835 budgets) with occasional immediate feedback on players' actions and delayed, cumulative feedback are especially effective
in making climate dynamics legible. Clear signalling of delayed effects helps players grasp temporal lags and path
dependency – core concepts in climate science and policy. Conversely, games that rely solely on end-of-turn or end-of-game
feedback risk obscuring causal links, especially for players with limited prior knowledge.

840 Second, time manipulation functions as a powerful didactic device. Multi-year turns, projections to 2050 or 2100, and
escalating risk profiles translate slow-moving climate processes into experiential form. Yet time compression also entails
normative choices: it can privilege mitigation over adaptation, underplay irreversibility, or suggest levels of control that
exceed real-world governance capacities. Designers should therefore treat temporal structure not merely as pacing, but as an
essential design choice with epistemic and ethical implications.

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Third, the representation of political processes and ideology deserves particular attention. While some games explicitly
emphasize ideological contestation, most embed normative assumptions implicitly – through centralized player authority,
technocratic framings, or constrained decision spaces. These choices shape how players understand climate action: as a
matter of expert optimization, democratic negotiation, or systemic transformation. Designers aiming for educational use
850 should consider making such assumptions transparent and contestable, for example by: offering alternative scenarios or rule
sets, allowing players to compare governance models, explicitly addressing what is left out of the simulation.

Fourth, co-creation between scientists and game developers can help ensure both scientific fidelity and compelling
gameplay, while transparent documentation of model structures and data sources enhances credibility and aligns with open-
855 science principles. The framework applied in this review provides clear design guidance for such collaborations, highlighting
key design elements such as meaningful conflicts of objectives and transparent, data-grounded feedback.

Future research on climate games and education should pursue several directions. Empirical studies should examine how
players interpret game mechanics, narratives, constraints, and representations, and how they negotiate ideological framings
860 in light of their prior beliefs. Most importantly, research is needed to investigate players' learning processes and outcomes
across different age groups, demographics, and levels of prior knowledge and literacy. In this context, studies should also
scrutinize how structured reflection and debriefing influence these learning processes and outcomes. Classroom-based
implementations, longitudinal studies, and analyses of informal player discourse can provide valuable evidence on the



educational effectiveness of climate action games. Design-oriented research may further explore how to balance model
865 complexity with pedagogical clarity, communicate uncertainty transparently, and expand decision spaces without
compromising playability.

In conclusion, this review has examined how contemporary digital games that emphasize climate policy decision-making
represent, structure, and communicate climate action from an educational perspective. By qualitatively analysing ten
870 prominent climate action titles using a set of categories informed by a synthesis of insights from educational game research,
learning theory, sustainability education, climate science, and political science, this review demonstrates how game
mechanics, feedback systems, scientific representations, and narrative framings mediate players' understanding of climate
policy challenges. Overall, the analysis shows that these digital games – through structured decision pathways, diverse forms
of feedback, and compressed temporalities – offer distinctive affordances for engaging learners with the complexities of
875 Earth systems and climate governance.

Simultaneously, the review underscores that climate action games inevitably embed scientific, ideological, and pedagogical
assumptions. These assumptions shape how agency, responsibility, trade-offs, and future pathways are portrayed, thereby
influencing how players interpret both the possibilities and limitations of climate action. The meaningful use of digital games
880 in educational contexts requires recognizing and critically evaluating these framings.

The review also highlights the importance of guided reflection and debriefing. When gameplay is paired with opportunities
to interrogate modelling assumptions, compare simulated outcomes with real-world data, and connect in-game decisions to
actual climate policy debates, digital games can support deeper systems thinking and more informed engagement with
885 uncertainty.

Collectively, these insights point to the growing significance of digital decision-making games as tools for climate and
geoscience education. With careful design and critical pedagogical integration, climate action games can foster nuanced and
reflective engagement with the governance challenges at the heart of the climate crisis.

890 **Code and data availability**

The data used in this study consist of publicly available games reviewed qualitatively by the author. All games analysed are
cited in the paper and can be accessed via their official websites or digital distribution platforms. No proprietary data or
custom code were used.



Competing interests

895 The author declares that he has no conflict of interest.

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