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Game Over for Climate Change? Communicating and Visualising Global Warming in Digital Games

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Abstract Digital games are increasingly used as innovative tools for climate change communication. Our study uses the example of *Eco* to analyse, with the help of a validated set of criteria, how commercial games communicate climate change and the science behind it, which options for action are suggested to the player and how the interplay of the three pillars of sustainability (environmental, social, and economic) is presented in the game. The paper's conclusions underline the potential for commercial, multiplayer survival games like *Eco* to act as educational tools for communicating complex environmental issues, bridging diverse player demographics, and fostering a deeper understanding of the challenges and solutions in addressing climate change and ecological sustainability. Our findings help test and advance existing concepts in environmental communication studies and sustainability studies.

Keywords Climate change. Digital games. Sustainability. Climate change communication. Audience engagement.

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1 Introduction

The days when climate change could be dismissed as a dystopian scenario from a distant future seem long gone, as extreme weather events are increasingly becoming part of our daily lives – either as personally experienced phenomena or through their media coverage. Climate, however, defined as the average weather over a specific period, cannot be experienced, felt, perceived, and remembered by humans (Grothmann 2018). Thus, the perception of global climate change is necessarily an indirect one: knowledge about its validity, significance and consequences is mediated through representatives from science, politics, and media.

The inherent abstractness of the climate change phenomenon presents researchers, activists, and policymakers with an immense communications challenge. The question arises as to how the invisible can be made visible, how the highly complex stock of knowledge from the climate sciences can be communicated to a lay audience, and which media are best suited to communicating climate change and fostering public engagement. Communicators have, for a long time, assumed that a lack of information explains the lack of public engagement (the so-called information deficit model; Bak 2001; Sturgis, Allum 2004) – an assumption challenged by more recent studies, which attest that it is not necessarily because of too little available information that climate change communication has often been ineffective (Cooper 2011; Moser, Dilling 2011). Moreover, in the media, "dramatic, sensational, fearful, shocking, and other climate change representations" (O'Neill, Nicholson-Cole 2009, 375) have been dominant, even though numerous studies have documented that fear is often not what empowers action (O'Neill, Nicholson-Cole 2009, 375; Moser 2007). Due to this "perfect storm" of climate change communication, it may not come as a surprise that the communication of climate change has become a lively field of research (Schäfer, Ivanova, Schmidt 2011; Doyle 2011). In particular, the one-sided transmission of information in linear media, which turns the audience into passive recipients of information, the alarmist tone adopted, the lack of contextual information and a lack of understanding of who the target audience is have been found to be detrimental to effective climate change communication (O'Neill, Nicholson-Cole 2009; Moser 2010; Owens, Driffill 2008). Media types using multidimensional, serial storytelling have been identified as well-suited for complex, interactive and effective climate change communication (Krauß 2013). Thus, it is not surprising that video games, characterised by their high immersion and interactivity, are considered ideal for conveying the science behind climate change and engaging the audience in a meaningful manner.

For about 15 years, climate researchers, environmental activists and game development studios have recognised the potential of

digital games for Education for Sustainable Development (ESD). In the virtual realm, individual and collective actions can be tested in a safe space, making them well-suited for the playful experience of the most pressing problems of the twenty-first century.[1] With regard to climate change, digital games can serve as "a kind of intellectual and spatiotemporal prosthesis" (Chang 2013, 31), simulating experiences that overcome the abstractness of climate change and thus making anthropogenic climate change and the related risks "playable".

This paper explores the visualisation and communication of climate change in digital games. It uses the game *Eco* to demonstrate that a reduced representation of the scientific models behind climate change can effectively communicate climate science and the interplay of the three pillars of sustainability (environmental, social, and economic) in gameplay. The case of *Eco* shows that a highly complex educational sustainability game can appeal to larger audiences and succeed in the gaming market. Notably, the game garnered significant support receiving a 1.05-million-dollar grant from the U.S. Department of Education (IES 2015), attracting over 4,000 backers on Kickstarter (2016), something that Hayduk (2021) and Cha (2017) have shown to be difficult for games, and gained popularity among YouTube's Let's Play community.

However, perhaps due to the privileged treatment of free, educational browser games in previous studies (see, for example, Neset et al. 2020; Ouariachi, Olvera-Lobo, Gutiérrez-Pérez 2017; Reckien, Eisenack 2013), *Eco* has received little attention in environmental communication studies so far. There is, however, a small qualitative study by Fjællingsdal and Klöckner (2019) which examines the educational potential of *Eco*. The study's findings are promising: playing *Eco* can raise awareness about what actions can protect or upset an ecosystem's balance and thus promote environmental consciousness. However, since the focus of the authors' evaluation of the game is on the potential learning outcomes, the study says little about how communicative features and strategies, simulation techniques and game mechanics are employed to communicate climate change and to make complex information about climate and sustainability science more accessible to a lay audience. Furthermore, the authors touch upon the visual framing of climate change and the options for action recommended in the game. Those issues will be discussed in detail in our paper.

1 Despite these opportunities offered by digital games, it must also be mentioned here that their production, transport, and consumption have a substantial environmental impact. The extraction of mining materials necessary to produce physical games and gaming consoles is extremely harmful to the environment, as this process emits billions of kilograms of CO_2 into the atmosphere. Moreover, games played online require a lot of data usage contributing to "internet pollution", which accounts for 4% of all global greenhouse gases.

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Therefore, the objective of this paper is to provide answers to the following research questions: How does *Eco* communicate climate change? How are climate change and the science behind it simulated and visualised, and how do the game mechanics and images frame global warming? What mitigation and adaptation strategies are offered in the gameplay? How can the interplay of the three pillars of sustainability (environmental, social, and economic) be experienced in *Eco*?

Our analysis approaches *Eco* with a distinct lens informed by environmental communication studies and sustainability science, aiming to test and advance existing research in these two fields, in which in-depth analyses of commercially available games targeting a wide demographic are still rare.

2 Climate Simulations and Visualisations in Digital Games

Accurately modelling and predicting the earth's climate and weather has been challenging for decades for climate scientists and game designers. The IPCC report defines climate as "the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years" (Intergovernmental Panel on Climate Change 2012, 557). Weather, however, describes a short-term state of the air and atmosphere at a particular time in a specific place. It is described as variable and measurable conditions such as temperature, humidity, precipitation, air pressure and wind strength. Unlike weather, climate cannot be measured directly. It is a statistic that consists of many measurements over a long period of time. Thus, the visibility of global climate change is not simply given but must be constructed and mediated. Both climate scientists and game designers use, albeit different, computer programs to simulate and model the (virtual) planet's climate.

At their most basic level, models in climate science use equations to represent the processes and interactions that drive the earth's climate. The program comprises different modules, for example, an ocean module, a soil module, and an atmospheric module. Like all models, climate models are simplified representations of reality. Therefore, they cannot fully represent the climate system and its changes but still provide valuable insights into the consequences of natural and human influences. Moreover, the models simulate only certain aspects of the real or imagined system under study, depending on the underlying hypotheses. This selection results in a particular view of the simulated world – a fact pointed out by the American simulation researcher Michael R. Lackner as early as 1962: "A Weltansicht (German for 'world view'; Authors' transl.) must be at least

implicitly established to permit the construction of a simulation language" (3). In digital games, the underlying rules and mechanics of the game shape the player's experience and influence their perceptions. In other words, the interactions and choices offered in a game can lead players to adopt specific viewpoints or understandings without relying solely on explicit written or spoken language. Video games, therefore, make claims about "how something does, should, or could work" (Bogost 2007, 58) and are steeped in operations of power. Unlike climate representations in digital games, however, the data produced by climate models are under a high degree of legitimacy pressure, as these future projections influence international, national, and local political decision-making.

In the games market, the pursuit of more realism, especially of more realistic 3D virtual environments, is not new, especially since photorealistic environments have become a major selling point (Roberts, Patterson 2017). As a dynamic weather system is one key component of these virtual environments, game designers constantly push for better simulation techniques that allow them to model the weather and its behaviour more realistically. In newer games, weather phenomena are not only an aesthetic backdrop but also affect gameplay and mechanics. The rain mechanics[2] in the top-rated game *The Legend of Zelda: Breath of the Wild* (2017), for example, make the manoeuvring of the avatar increasingly more challenging, as he can no longer climb in the rain due to the 'slippery' virtual surfaces. In this case, the weather becomes an actor in Latour's sense and shapes the gameplay experience. Detailed weather systems have been shown to enhance the player's immersion (Roberts, Patterson 2017) and improve learning outcomes in virtual spaces (Hsiao et al. 2016).

As digital games simulate ever larger worlds and thus ever more complex ecosystems, not only the weather but also different climate zones and their different biomes are now emulated. Commercially successful games, such as *Horizon Zero Dawn* (2017), *No Man's Sky* (2016) and *Red Dead Redemption II* (2018), simulate regions and even planets with different climates where plants and animal species adapted to that climate 'live', thus imitating our real world to a high degree. However, digital games are not limited to the simulation and visualisation of weather phenomena and different flora and fauna. They also integrate complex data from climate science into their gameplay and thus translate scientific knowledge into playable experiences. An illustrative example is the video game *SimEarth*,

2 Game mechanics refer to the rules, procedures, and interactions that define how a game is played. In the context of rain mechanics, this could involve rules governing how rain affects the in-game environment, such as altering visibility, influencing character movement, or impacting other in-game elements.

released by Maxis in 1990. The game was a pioneering title in the simulation game genre, enabling players to explore the consequences of their actions on a virtual planet's climate, geology, and ecosystems. Players had access to graphical representations of climate data, ecosystem health, population trends, and more. These graphs offered a dynamic way to monitor and interpret the state of the planet's systems, enabling players to make informed decisions as virtual stewards of the Earth. *SimEarth*'s user interface elements bridged the gap between climate science and popular culture, helping players grasp the intricate dynamics of our planet's systems by making them visible through graphs and images.

By simulating the different systems (weather, climate, ecosystem) at play and their mutual effect on each other, climate change games have enhanced players' systems thinking (Waddington, Fennewald 2018). This capability enables players to perceive interrelationships rather than static snapshots, a crucial skill when analysing complex systems such as the evolving global climate. It is now common practice to use systems thinking and system dynamics concepts in teaching and improving comprehension of intricate, global environmental and sustainability issues (Berry et al. 2018; Sanneh 2018; Gregory, Miller 2014; Davis, Sumara 2006). In digital games, a system's behaviour is simulated so that it can be actively experienced.

Moreover, as the gaming population has become more diverse over the past two decades, collaborative games like *Eco* are increasingly seen as powerful tools to communicate climate change across diverse age groups, genders, and nationalities. According to a survey conducted in 2022, 36% of US video game players fall within the 18-34 age range, while an additional 6% are 65 years and older (The Entertainment Software Association 2022). Women have also become a significant part of the gaming community. In 2023, women accounted for 46% of gamers in the United States (The Entertainment Software Association 2023). Therefore, the varied composition of the gaming community and the unique affordances of digital games may offer an opportunity to foster a better understanding of complex systemic challenges, such as those linked with climate change.

3 Methodology

Ouariachi, Olvera-Lobo and Gutiérrez-Pérez proposed a set of criteria to describe and analyse the narrative content and ludology of online climate change games. To develop useful criteria which achieve consensus among experts from communication, education and climate change science as well as from game studies, they conducted a Delphi study (2017, 16-19), a systematic, multi-staged and interactive process to arrive at a group opinion or decision by surveying a panel of experts (Scapolo, Miles 2006). Thirteen experts from the United States, Spain and the Netherlands were asked to respond to several rounds of questionnaires. In this process, they were requested to review and modify a proposed set of criteria by Ouariachi et al. or make suggestions for new criteria. Three rounds were sufficient to reach a consensus among the experts, and the criteria thus obtained were tested through the analysis of fifteen games developed in Spain. The framework not only proved to be a valuable tool for comparing and systematising a larger sample of games but was also successfully used to analyse the communicative features of a single game (Ouariachi, Elving, Pierie 2018), which is why we identified it as a suitable method for answering our research questions.

Ouariachi, Elving and Pierie divided the validated criteria into four dimensions (18):

1. Identification: features that help identify and locate the game
2. Narrative: analysis of the narrative and fictional context elements
3. Contents: analysis of the information and messages transmitted about climate change
4. Gameplay: analysis of the game design and formal structures

Since we aim to shed light on how *Eco* communicates climate change and its science, we will devote special attention to the third dimension of the scheme developed by Ouariachi, Elving and Pierie. Here, we are specifically concerned with whether and how scientific concepts from climate and sustainability science are conveyed in the games, how climate change is visualised, and which courses of action are recommended in the game.

In doing so, the following criteria are decisive:

Table 1 Criteria for content analysis according to Ouariachi, Elving and Pierie (2017, 21-2, tab. 1)

Criteria	Description
(1) Term used	The terminology used to describe the phenomenon being studied
(2) Existence of false concepts and misconceptions	Erroneous beliefs that are widely held in relation to climate change (e.g., ozone depletion as a cause)
(3) Explicit use of scientific concepts	Definition of climate change terms (e.g., greenhouse effect)
(4) Explicit use of information sources	Sources of information cited (e.g., source: NASA)
(5) Convergence with social networks	Links to social networks included (e.g., Facebook, Twitter)
(6) Message frame/climate change focus	Main approach to respond to climate change
(7) Message frame/main theme	The main topic being addressed
(8) Message frame/promotion of actions	Activities promoted in the game
(9) Message frame/causes	Attribution to the origins of climate change
(10) Message frame/consequences	Effects of climate change (e.g., glacial melting, desertification, etc.)
(11) Message frame/tone	Values and emotions given to the topic (e.g., alarmist, informative, etc.)
(12) Images	Visual representations

4 Game Analysis: *Eco*

Since early 2018, *Eco* has been commercially available as an early-access version on Steam, one of the most prominent digital game distribution platforms. The game has received 11,046 user reviews on Steam, with 82% being positive, reflecting the game's reception and significance within the gaming community.

Eco[3] is a survival game that can be played either alone or as an online multiplayer game. A shared game experience is recommended, however, as it is a "community-based game" (Steam 2023), in which players must collaborate to build a civilisation by developing laws, government, and an economy to determine the success of their world. Everything the players do affects the environment. Therefore, players must always be aware of the impact of their actions on the virtual ecosystem. As their virtual world is threatened by a meteor strike that would cause global destruction, players must build advanced

3 *Eco* is an actively developed game, and its content and features undergo regular updates. As such, the game's mechanics and content may evolve and change over time.

technologies within 30 in-game days[4] without destroying their planet in the process. They experience the challenges of conflicting goals while playfully finding a balanced strategy for survival.

Thus, *Eco* simulates not only the earth's ecosystem but also other systems, such as our real-world economic and political systems, integrating the ecosystem into a much bigger picture (criterion 7). Sustainable resource management, which is the careful extraction of resources and their use for various purposes, is one of the central game mechanics. The resources in *Eco* are finite, unlike in most of the so-called 4X games (e**x**plore, e**x**pand, e**x**ploit, e**x**terminate). Hence, if a player hoards resources for themselves, other players cannot carry out important tasks, such as building a house or a solar generator. Due to the principle of a shared resource system, players can learn about and experience the tragedy of the commons in virtual space. According to the ecologist Garrett Hardin (1968), as soon as a resource is available to all people without restriction, everyone will try to gain as much profit for themselves as possible. However, this individualistic, egocentric approach eventually leads to the overexploitation of common resources. If a player overexploits on the server, does not share the resources with their fellow players and does not replant or renew them, the sense of community of the virtual community is damaged, as is the sensitive ecosystem, which will eventually collapse (criterion 9). The balance of the ecosystem is also significantly related to the global warming of the virtual planet. In *Eco*, however, global warming or climate change is never explicitly mentioned (criterion 1). Despite this linguistic omission, the game comprehensively simulates climate change (criterion 6). In *Eco*, the climate is influenced by the players' decisions, who can cause, intensify, or mitigate virtual climate change through their actions. The main cause of anthropogenic climate change is direct greenhouse gas emissions from using fossil fuels for industrial machinery and vehicles (criteria 3, 9). The smog produced is dispersed through the air and thus pollutes the surrounding region, negatively impacting the diversity of flora and fauna in the area. The subsequent loss of woodland has an additional negative effect on the CO_2 concentration in the atmosphere.

However, the consequences of global warming on the virtual planet are represented in far greater detail than the cause of climate change (criterion 10). Excessive greenhouse gas emissions result in a rise in the average global temperature, ultimately leading to rising sea levels. Virtual climate change also influences the biodiversity of the planet. If pollution levels rise, the diversity and growth of flora and fauna is negatively affected. Moreover, *Eco* simulates different

4 This is the default setting of the game. However, the specific time frame can be adjusted by the server administrator when setting up the game.

climate zones in detail, each with its own vegetation zones. The animal and plant world serves as food for the player. A player who does not eat enough calories can still roam the virtual planet but cannot do any physical labour. It is possible to feed the avatar on a vegan diet; however, the rules of the game determine that the consumption of animal products leads to a faster calorie intake and, thus, to more efficient, faster progress in the game. At first, this may seem surprising for a game like *Eco*. However, sustainability issues such as overfishing, loss of biodiversity, and abnormal changes in marine life can be simulated through hunting and fishing, which might remain hidden. Players can irrevocably wipe out entire animal species through excessive hunting and must also care for reseed plants. Foresight is key here, as trees take time to regrow in *Eco*, so players must be wise about their wood consumption and the timing of reforestation. Early in the game, as soon as the players melt down iron, heaps of slag are produced that contaminate the surrounding soil, forcing the players to deal with and reflect on the undesirable and environmentally harmful side effects of their production. Lag must be buried deep in the ground to avoid impending environmental damage. However, the land is limited, so underground dumps, houses, and factories must be built carefully. In addition, mining tailings and waste pollute the water. Due to this scarcity of resources, resource conflicts with other players can occur.

Such conflicts can only be prevented by skilful cooperation (criterion 8). The players must form groups in which everyone plays a different, equally important role. In *Eco*, there are different areas of expertise, called professions, in which the players can specialise so that the work can be divided among everyone. Each profession brings with it different skills that are essential for progress in the game. Since no player can fill all roles equally, everyone depends on the other players' skills. The hunter provides the meat the cook needs for a nutritious, balanced meal. The calories consumed in this way are essential for the performance of all in-game actions, which is why the meals benefit everyone. The blacksmith can thus produce iron ingots, which the engineer needs for new technologies, and so on. The rules and game mechanics programmed by the development team thus clearly favour cooperative actions over selfish individualism. According to *Eco*, an important key to overcoming sustainability issues lies in cooperation and the conscious use of resources. Should the players fail at both, virtual global warming is set in motion. However, the players are not helpless. Climate change can be slowed down in the game – for example, by limiting individual traffic, reducing industrial activity, reforestation, and even passing climate-friendly laws by the player-run government.

Furthermore, greater emphasis can be placed on expanding renewable energies and alternative vehicle drives. This creates conflicts

of objectives between economic upswing and mobility, on the one hand, and reduction of industry and traffic for the benefit of the climate, on the other. Due to the time constraint of 30 in-game days and the impending disaster of a meteor strike, players are compelled to swiftly traverse the tech tree,[5] as the development of advanced lasers is the only option to stop the meteor. In this context, technology emerges as a saviour, which may downplay the importance of holistic and systemic approaches to addressing environmental disasters – approaches that encompass policy and economic changes, behavioural shifts, global cooperation, and climate education. Therefore, *Eco* figures technology and industrialisation as a double-edged sword, emphasising their capacity to both trigger pollution and offer solutions to environmental disasters, mirroring our 'real-world' climate change discourse.

Due to the complexity of *Eco*, a Wiki page and a Discord chat help the players to find out in advance about the resources they need for a given product and, to some extent, about the effects of their actions on the environment (criterion 5). No external sources of information are mentioned in the game (criterion 4).

However, the status of their virtual planet is also visibly displayed to the players directly on their screens, in the sense of "eco-visualisation" (criterion 12), i.e., "the dynamic means of revealing the consequences of resource use, in order to promote sustainable behaviour, attitudes and decision making" (Löfström, Svanæs 2017, 939). The player encounters the nuanced dynamics of climate change through two distinct perspectives. The first-person viewpoint immerses the player in the immediate experience of environmental changes, providing a subjective lens through the eyes of the in-game character. This perspective allows players to witness, in real-time, the direct impact of their actions on the virtual ecosystem. When high temperatures are reached, for example, soil and plants visibly dry up, and dead animals lie on the barren ground. Polluted water takes on an abnormal, almost pink colour. This visual feedback makes it unmistakably clear to the player that the planet's pollution levels are high. But *Eco* also introduces a second, more analytical viewpoint. Through an in-game geo-information system and line diagrams, players can track even the smallest changes in air and soil pollution. They can also relate this data to other data, such as the amount of player action per hour, to visualise more complex interrelationships.

Eco also uses "whole earth images" (Schneider 2016), which bear visual resemblance to the IPCC's scientific images. The IPCC has

5 A tech-tree in video games is a visual representation of available technologies and their dependencies, allowing players to unlock and explore new in-game abilities and advancements as they progress.

used coloured global maps, bar graphs and curves to aggregate the most complex scientific knowledge in the field of climate science since 2001. Schneider (2016) expounds on how the image of a blue planet that has turned red became one of the most widespread icons of climate change. The IPCC's climate report contains visualisations of different climate change scenarios that use false-colour coding to visualise cold, warm, and hot temperatures. The colour scale ranges from light blue for cold temperatures to purple for scorching temperatures. Schneider describes the emotional effect of this colour scale on the viewer:

> Earth does not look like the living planet – Gaia – anymore, which the Blue Marble photograph portrayed so impressively. Instead, we can observe Earth transforming into a planet hostile to life or becoming a 'dead planet'. […] The burning world's image bear [sic!], intentionally or not, elements of horror and shock that, if we like it or not, are attached to the image. (8)

Interestingly, *Eco* uses the same colour scale as the IPCC report but with reversed signs: a low level of soil pollution, for example, is indicated with purple, and a high level of pollution with a yellowish, almost white hue **[fig. 1]**.

Due to this scientific presentation, anthropogenic climate change in *Eco* does not appear as an inevitable dystopian catastrophe but as a measurable and thus controllable scenario that can be prevented or slowed through cooperation as well as resource-saving and climate-friendly actions (criterion 11).

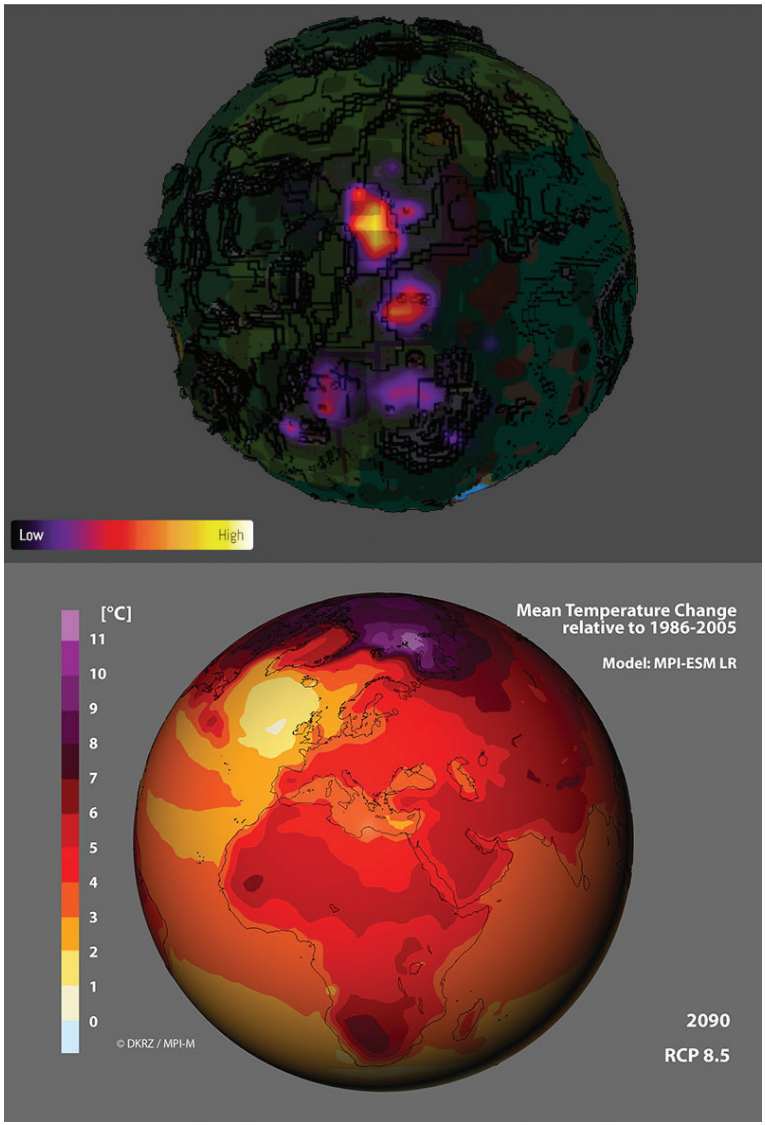

Figure 1 Comparison between the 3D map of the virtual planet in *Eco* (top) and a visualisation of the Earth's climate in 2090 by the German Climate Computing Centre (bottom). The latter is part of the German contribution to the Fifth IPCC Assessment Report of 2013. For more information and a full resolution image, see the website of the DKRZ (German Climate Computing Center): `https://www.dkrz.de/en/communication/climate-simulations/cmip5-ipcc-ar5/ergebnisse/2m-temperatur-en`

5 Discussion and Conclusion

Eco demonstrates the interplay of the three pillars of sustainability (environmental, social, and economic) and how gameplay can help develop mitigation strategies for conflicting goals. The game visualises and simulates the complexity and interconnectivity of several different systems and processes which occur in our real world but whose connections may often be too intricate, chaotic, or opaque to grasp fully. In *Eco*, the players are not only city builders, engineers, blacksmiths, and hunters but also producers of greenhouse gases and, ultimately, the reason for any occurring global warming. They must, therefore, constantly push for a balance in their virtual ecological, economic, and political system, which can lead not only to conflicts between the individual members of the community but also to conflicts of interest between rapid economic growth and environmental protection. Thus, *Eco* offers a virtual playground for developing and applying various strategies and solutions to problems over which players often have little or no decision-making power in everyday life. Especially young people and marginalised groups, who are often excluded from political participation and are therefore rarely perceived as autonomous political agents, may be able to experience themselves as architects of a sustainable future. In *Eco*, they experience a utopian version of our 'real world', in which they are encouraged to participate in environmental discourse and democratic processes. However, this utopian vision also lacks any traces of previous generations. In this virtual environment, the player is not confronted with 'boomer malfeasance', for example a Texas-sized island of floating plastic in the Pacific Ocean. Instead, at the beginning of their gameplay experience, players encounter a breathtaking landscape where nature thrives, lush forests stretch as far as the eye can see, teeming with vibrant flora and fauna, and crystal-clear rivers meander through picturesque valleys. While this may raise concerns about *Eco*'s feasibility and authenticity, the in-game ecotopia can also be seen as an opportunity to stop playing the 'blame game' and foster cooperation across different age groups.

The game also employs an elaborate climate model not only to communicate the scientific principles of, but also to illustrate its associated risks. *Eco* not only simulates a planet with different biomes and climate zones but also a pollution system that consists of air and ground pollution components. Prolonged air and ground pollution leads to sea level rising and an increase in baseline temperature, which has devastating effects on the environment and eventually on the virtual community who need food and drinking water. Players can also learn about the level of pollution, biodiversity and player population through statistics and a 3D map view of their planet.

In addition, *Eco* uses visual signals, such as thick plumes of smoke or discoloured water, to draw attention to environmental damage.

Despite this dense simulation of climate change and its consequences on the environment and humans, *Eco* works with a reduced representation of the climate system (criterion 2). For example, the game assesses the in-game air pollutionby tracking the emission of CO_2. Other direct and indirect greenhouse gases, such as methane or sulphur dioxide, are not integrated into the climate and environment model, nor are nuclear particles from nuclear sources. Moreover, causal chains remain opaque in some places, such as the connection between CO_2 rise and sea-level rise. *Eco* also does not include a representation or game mechanic for melting polar ice caps, despite the rapid loss of polar ice becoming a central aspect of our 'real-world' climate change discourse. And while the game is a comprehensive ecosystem simulator, it falls short in simulating short-term weather effects.[6]

However, this reduction does not necessarily mean that *Eco* communicates ineffectively. On the contrary, excessive scientific framing has been proven to be an unsuitable grounding for effective climate change communication (Moser, Dilling 2011). Instead, *Eco* draws on the representation of the three pillars of sustainability (environmental, social, and economic) and can thus contextualise climate change as a "super wicked problem" (Levin et al. 2012) – a multidimensional, global challenge – without being alarmist. Moreover, *Eco* encourages the development of solutions and ideas through cooperation, creativity, and scientific exploration, thus actively engaging the players with an issue instead of making them passive receivers of information. In their research on effective climate change communication, Moser and Dilling (2011) also emphasise the need to take greater account of the target audience and their values, attitudes, and opinions. A comprehensive knowledge of the target audience leads to more appropriate framings, images, messages, and messengers.

Eco appeals to different types of players and is therefore attractive to a larger group of gamers. Based on the player's focus of attention (world-oriented versus player-oriented) and their approach to the game (action versus interaction), the Bartle taxonomy of player types groups gamers into one of four classifications: achiever, explorer, socialiser, or killer (Bartle 1996). In addition to a specific game goal that must be achieved at a given time (achiever), but which can only be accomplished through joint agreements and cooperation (socialiser), *Eco* also offers a large world to explore (explorer). Furthermore, *Eco* draws on the tried-and-tested game mechanics and graphics of

6 Some weather mechanics (clear sky, light rain, heavy rain) will be included in the upcoming update (version 10), which, as of the current date, has not been released.

the classic game and top-seller *Minecraft* and can thus build on players' previous gaming experience. Both the targeting of different player types and the graphic and ludic reference to already established gaming traditions can explain why *Eco* was able to establish itself in the gaming market despite its serious themes.

Games on sustainability and climate change have grown and diversified exponentially over the last few years. In addition to board games such as *Keep Cool* (2013), serious games such as *The Climate Trail* (2019), climate simulations such as *SCIARA*[7] (2021) and commercial games such as *Civilization VI* (2019) have also taken up the topic. Due to their moderate scientific framing of climate change, the active engagement of the player with sustainability issues through game mechanics, contents, and visualisation without taking the moral high ground and the involvement of different player types, these games can serve as valuable tools for climate change communication. Therefore, it is necessary to focus on the educational potential of computer games in the sense of gaining concrete knowledge and skills. Our paper sought to highlight the importance of incorporating commercially available games into the corpus. This is significant because these popular games play a crucial role in shaping public perceptions and discourse surrounding climate change. Additional research is required in this area, extending beyond individual analyses to encompass historical and discursive contexts, as well as different hardware. Mobile gaming, for example, is underrepresented in the current research despite the many possibilities for new formats that it is opening, such as location-based games or augmented reality games. The same is true for virtual reality. How do these new formats tackle climate-change-related themes? How have climate change mechanics and imagery in digital games changed over the decades? What ideas about and framings of climate change and its consequences can be discerned in them? The answers to these questions may not only reveal our "knowledge about and attitudes toward life" (Geertz 1973, 89) over time but may also provide us with a better understanding of the pitfalls and potentials of digital games to make one of the most pressing problems of our time both visible and playable.

7 https://sciara.de/.

Bibliography

Aonuma, E. et al. (2017). *The Legend of Zelda: Breath of the Wild*. Japan: Nintendo.

Bak, H.-J. (2001). "Education and Public Attitudes Toward Science: Implications for the 'Deficit Model' of Education and Support for Science and Technology". *Social Science Quarterly*, 82(4), 779-95. https://doi.org/10.1111/0038-4941.00059.

Bartle, R. (1996). "Hearts, Clubs, Diamonds, Spades: Players Who Suit Muds". *Journal of MUD Research*, 1(1). https://mud.co.uk/richard/hcds.htm.

Berry, H.L. et al. (2018). "The Case for Systems Thinking About Climate Change and Mental Health". *Nature Climate Change*, 8(4), 282-90. https://doi.org/10.1038/s41558-018-0102-4.

Bogost, I. (2007). *Persuasive Games: The Expressive Power of Videogames*. Cambridge, MA: MIT Press.

Cha, J. (2017). "Crowdfunding for Video Games: Factors That Influence the Success of and Capital Pledged for Campaigns". *International Journal on Media Management*, 19(3), 240-59. https://doi.org/10.1080/14241277.2017.1331236.

Chang, A.Y. (2013). *Playing Nature: The Virtual Ecology of Game Environments* [PhD Dissertation]. Berkeley: University of California. https://escholarship.org/uc/item/9ch2w332.

Cooper, C.B. (2011). "Media Literacy as a Key Strategy Toward Improving Public Acceptance of Climate Change Science". *BioScience*, 61(3), 231-7. https://doi.org/10.1525/bio.2011.61.3.8.

Davis, B.; Sumara, D.J. (2006). *Complexity and Education: Inquiries into Learning, Teaching, and Research*. Mahwah: Lawrence Erlbaum Associates.

Doyle, J. (2011). *Mediating Climate Change*. Burlington: Ashgate. Environmental Sociology.

Fjællingsdal, K.S.; Klöckner, C.A. (2019). "Gaming Green: The Educational Potential of Eco – a Digital Simulated Ecosystem". *Frontiers in Psychology*, 10, 2846. https://doi.org/10.3389/fpsyg.2019.02846.

Geertz, C. (1973). *The Interpretation of Cultures*. New York: Basic Books.

Gregory, A.; Miller, S. (2014). "Using Systems Thinking to Educate for Sustainability in a Business School". *Systems*, 2(3), 313-27. https://doi.org/10.3390/systems2030313.

Grothmann, T. (2018). *Die Wahrnehmung des Klimawandels und wodurch sie beeinflusst wird*. https://www.klimanavigator.eu/dossier/artikel/038715/index.php.

Hardin, G. (1968). "The Tragedy of the Commons". *Science*, 162, 1243-8.

Hayduk, T.M. (2021). "Kickstart My Market: Exploring an Alternative Method of Raising Capital in a New Media Sector". *Journal of Media Business Studies*, 18(3), 155-78. https://doi.org/10.1080/16522354.2020.1800310.

Hsiao, H.-S. et al. (2016). "Weather Observers: A Manipulative Augmented Reality System for Weather Simulations at Home, in the Classroom, and at a Museum". *Interactive Learning Environments*, 24(1), 205-23. https://doi.org/10.1080/10494820.2013.834829.

IES (2015). *Eco: An Online Virtual World for Middle School Environmental Literacy and Collaborative Problem Solving*. https://ies.ed.gov/funding/grantsearch/details.asp?ID=1600.

Intergovernmental Panel on Climate Change (2012). "Glossary of Terms". Field, C.B. et al. (eds), *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaption*. New York: Cambridge University Press, 555-64.

Krauß, F. (2013). "Klimawandel Kommunizieren: Die Richtigen Framings, Formate Und Zielgruppen". Müller, K.-D. (Hrsg.), *Wissenschaft in der digitalen Revolution*. Wiesbaden: Springer Fachmedien Wiesbaden, 105-34.

Lackner, M.R. (1962). "Toward a General Simulation Capability". Barnard, G.A. (ed.), *Proceedings of the Spring Joint Computer Conference* (San Francisco, 1-3 May 1962). New York: ACM Press, 1-14.

Levin, K. et al. (2012). "Overcoming the Tragedy of Super Wicked Problems: Constraining Our Future Selves to Ameliorate Global Climate Change". *Policy Sciences*, 45(2), 123-52. https://doi.org/10.1007/s11077-012-9151-0.

Löfström, E.; Svanæs, D. (2017). "Eco-Visualisation: An Exploration of the Concept and Its Practical Implications". ECEEE (ed.), *ECEEE 2017 Summer Study on Energy Efficiency. Consumption, Efficiency and Limits = Conference Proceedings* (Toulon; Hyéres, 29 May-3 June 2017). Stockholm: ECEEE, 939-47.

Moser, S.C. (2007). "More Bad News: The Risk of Neglecting Emotional Responses to Climate Change Information". Mose, S.C.; Dilling, L. (eds), *Creating a Climate for Change: Communicating Climate Change and Facilitating Social Change*. Cambridge: Cambridge University Press, 64-80.

Moser, S.C. (2010). "Communicating Climate Change: History, Challenges, Process and Future Directions". *WIREs Climate Change*, 1(1), 31-53. https://doi.org/10.1002/wcc.11.

Moser, S.C.; Dilling, L. (2011). "Communicating Climate Change: Closing the Science-Action Gap". Dryzek, J.S.; Norgaard, R.B.; Schlosberg, D. (eds), *The Oxford Handbook of Climate Change and Society*. Oxford: Oxford University Press, 161-74.

Neset, T.-S. et al. (2020). "Serious Gaming for Climate Adaptation – Assessing the Potential and Challenges of a Digital Serious Game for Urban Climate Adaptation". *Sustainability*, 12(5), 1789. https://doi.org/10.3390/su12051789.

O'Neill, S.; Nicholson-Cole, S. (2009). "'Fear Won't Do It': Promoting Positive Engagement with Climate Change Through Visual and Iconic Representations". *Science Communication*, 30(3), 355-79. https://doi.org/10.1177/1075547008329201.

Ouariachi, T.; Elving, W.; Pierie, F. (2018). "Playing for a Sustainable Future: The Case of We Energy Game as an Educational Practice". *Sustainability*, 10(10), 3639. https://doi.org/10.3390/su10103639.

Ouariachi, T.; Olvera-Lobo, M.D.; Gutiérrez-Pérez, J. (2017). "Analysing Climate Change Communication Through Online Games". *Science Communication*, 39(1), 10-44. https://doi.org/10.1177/1075547016687998.

Owens, S.; Driffill, L. (2008). "How to Change Attitudes and Behaviours in the Context of Energy". *Energy Policy*, 36(12), 4412-18. https://doi.org/10.1016/j.enpol.2008.09.031.

Reckien, D.; Eisenack, K. (2013). "Climate Change Gaming on Board and Screen: A Review". *Simulation & Gaming*, 44(2-3), 253-71. https://doi.org/10.1177/1046878113480867.

Roberts, S.; Patterson, D. (2017). "Virtual Weather Systems: Measuring Impact Within Videogame Environments". *Proceedings of the Australasian*

Computer Science Week Multiconference (Geelong, 30 January-3 February 2017). New York: ACM, 1-7.
Sanneh, E.S. (2018). *Systems Thinking for Sustainable Development: Climate Change and the Environment*. Cham, Switzerland: Springer.
Scapolo, F.; Miles, I. (2006). "Eliciting Experts' Knowledge: A Comparison of Two Methods". *Technological Forecasting and Social Change*, 73(6), 679-704. https://doi.org/10.1016/j.techfore.2006.03.001.
Schäfer, M.S.; Ivanova, A.; Schmidt, A. (2011). "Globaler Klimawandel, Globale Öffentlichkeit?". *Studies in Communication / Media (SCM)*, 1, 131-48.
Schneider, B. (2016). "Burning Worlds of Cartography: A Critical Approach to Climate Cosmograms of the Anthropocene". *Geo: Geography and Environment*, 3(2), e00027. https://doi.org/10.1002/geo2.27.
Sturgis, P.; Allum, N. (2004). "Science in Society: Re-Evaluating the Deficit Model of Public Attitudes". *Public Understanding of Science*, 13(1), 55-74. https://doi.org/10.1177/0963662504042690.
The Entertainment Software Association (2022). "U.S. Video Gamers Age 2022". The Entertainment Software Association (ed.), *2022 Essential Facts About the U.S. Video Game Industry*, vol. 5. Washington, D.C.: ESA. https://www.theesa.com/wp-content/uploads/2022/06/2022-Essential-Facts-About-the-Video-Game-Industry.pdf.
The Entertainment Software Association (2023). "Video Game Players Gender 2023". The Entertainment Software Association (ed.), *2023 Essential Facts About the U.S. Video Game Industry*, vol. 3. Washington, D.C.: ESA. https://www.theesa.com/wp-content/uploads/2023/07/ESA_2023_Essential_Facts_FINAL_07092023.pdf.
Waddington, D.I.; Fennewald, T. (2018). "Grim FATE: Learning About Systems Thinking in an In-Depth Climate Change Simulation". *Simulation & Gaming*, 49(2), 168-94. https://doi.org/10.1177/1046878117753498.

Cited Materials

Eisenack, K.; Petschel-Held, G. (2013). *Keep Cool*. Germany: Spieltrieb.
Firaxis Games (2019). *Civilization VI: Gathering Storm*. USA: 2K Games.
Guerrilla Games (2017). *Horizon Zero Dawn*. Netherlands: Sony Interactive Entertainment.
Hello Games (2016). *No Man's Sky*. UK: Sony Interactive Entertainment.
Kickstarter (2016). *Eco – Global Survival Game by John Krajewski*. https://www.kickstarter.com/projects/1037798999/eco-global-survival-game/description.
Kutscha, S.; Tamberg, D. (2021). SCIARA. Germany.
Maxis; Wright, W. (1990). *SimEarth*. USA: Maxis.
Rockstar Games (2018). *Red Dead Redemption II*. USA: Rockstar Games.
Steam (2023). *Eco*. https://store.steampowered.com/app/382310/Eco/.
Volk, W. (2019). *The Climate Trail*. USA: Deep State Games.