Available Online: 5 November 2026 DOI: 10.54254/2753-7102/2026.38784

From real-world governance to playable action: translating three environmental cases into game mechanics in Eco Stewards

Guangyu Chen

Shanghai World Foreign Language Academy, Shanghai, China

guangyuchen413@gmail.com

Abstract. Environmental problems often take a long time to deal with, but a turn in a board game is short. When real problems are put into a game, some details have to be left out. Can players still understand why the actions are needed? This paper discusses this question through three cases in Eco Stewards: the Great Pacific Garbage Patch, methylmercury pollution in Minamata Bay, and soil erosion on China's Loess Plateau. I compare environmental sources with the nine action stages, interface, and upgrade rules in the SDG v2 version. The game text keeps some important reasons. After removing rubbish, we still need to reduce new rubbish. After stopping discharge, we still need to deal with pollution left behind. When restoring vegetation, we need to check whether there is enough water locally. However, the three cases have very similar upgrades. Players pay and immediately receive fixed positive rewards. Some difficulties mentioned in the text do not affect the upgrade. I suggest adding a short question before some choices so that players explain the reason for the action. The game should also explain that reaching the last level does not mean the real problem is solved. These ideas have not been tested with players, and this paper cannot show that the game has already produced learning results.

Keywords: environmental communication, serious games, game mechanics, environmental governance, case comparison

1. Introduction

Removing an abandoned fishing net can reduce the danger it causes, but new plastic may keep entering the sea. Minamata Bay has a different problem. After a factory stops discharging waste, pollutants may still remain on the seabed. The Loess Plateau needs vegetation restoration, but the new plants also need water. Eco Stewards puts these real cases into a digital board game so that people without specialist environmental knowledge can learn about them. Players encounter projects on the board, buy them, and then spend money on

Copyright: © 2026 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

actions at different stages[1].

Players cannot read a long history in every turn. Yet the problem behind one space may last for decades and involve more than one country. Rubbish in the North Pacific is spread out, and its area changes. In Minamata Bay, pollution left behind still needed treatment after industrial discharge stopped[2]. If a game only changes a space from polluted to clean, these details disappear. When making a game, we therefore need to think about which parts can be simplified and which reasons must remain.

This paper mainly looks at how Eco Stewards turns real cases into actions that players can take. I chose the Great Pacific Garbage Patch, Minamata Bay, and the Loess Plateau because their difficulties are different. Marine waste keeps entering the environment. Industrial pollution may remain for a long time. Land damage is also related to people's production activities. All three cases use three upgrade levels. I want to know whether this arrangement can explain their differences, or whether it makes environmental work seem like much the same few steps.

The comparison shows that the differences between the cases are mainly written in the explanations. The explanations cover current damage, problems that may appear later, and why continued observation is needed. In an actual upgrade, players usually just choose a project and pay to get fixed progress. I discuss where these two parts fit together and where they do not yet connect. This is an analysis of how the game presents problems. It does not prove that players have already learned environmental knowledge through it.

2. Approach and materials

2.1. Putting real problems into game actions

Translation in the title means turning relationships in a real problem into things that can be read or done in the game. These include why an action is needed, how much it costs, and what happens afterward. Shortening the background introduction alone cannot do this. Bogost [1] calls the way games express ideas through rules and actions procedural rhetoric. This idea helps explain Eco Stewards. Giving a reward for buying a project and giving a reward only after environmental work is done do not express the same thing.

But having rules does not mean players will understand them as the designer intends. Hunicke et al. [2] distinguish game rules, what happens during play, and the player's experience. Sicart [3] also points out that players bring their own ideas and purposes. Some may skip the explanations. Others may only choose upgrades that make winning easier. So, looking at the code of Eco Stewards cannot tell us what players actually learn. This requires observing real play.

In their review of sustainable-development games, Katsaliaki and Mustafee [4] discuss game goals, player roles, evaluation methods, and the learning results reported in studies. These points remind me that how a game is designed and whether players learn are both questions that need attention. This paper only deals with the first part. The second part needs research involving players.

---

[1] Eco Stewards Project (2026), SDG v2 case data, configuration, and interaction rules. Unpublished software and data; revision 099a975ca6993605a685487407acbf973f4b5dcb, inspected 9 September 2026. Files: data/locations.json; data/game_config.json; src/game/domain/demoGame.ts; src/app/components/Inspector.tsx; AGENTS.md.

[2] NOAA Ocean Service, What is the Great Pacific Garbage Patch? Updated 23 September 2026. https://oceanservice.noaa.gov/facts/garbagepatch.html. Accessed 9 October 2026. Ministry of the Environment, Japan (2002), Minamata disease: The history and measures, Chapter 4, Measures against Minamata disease. https://www.env.go.jp/en/chemi/hs/minamata2002/ch4.html. Accessed 9 October 2026.

I look at each case in the same order. First, I check how environmental sources explain the problem. Then I look at how the game names and explains its actions. Finally, I check what players can actually do. I ask whether the actions have support and whether the explanations conflict with the sources. Another question is whether players need to understand the reason when making a choice. If they can make exactly the same choice without reading the explanation, the explanation may be correct but still have little effect on play.

2.2. Materials and method

This paper examines the local SDG v2 version checked on 9 September 2026, at Git revision 099a975. Other saved versions or the public version may be different. The older version in the root directory has only one Eco score and is not the version studied here. SDG v2 records seven personal In-game SDG Progress values for each player. These are all numbers set for the game. They cannot be treated as measurements of real environmental improvement or as the percentage of a United Nations target completed[3].

I checked the three cases in the locations dataset, the balance settings in use, the buying and upgrading code, and the Inspector explanation interface. These cases have nine action stages, 27 claim records, and 24 source records containing 21 different URLs. These are just counts of records in the project. They do not mean that each claim is supported by that many independent studies. The nine action names in Table 1 are translated from the game's Chinese fields[4]. The case identifiers in the data are blue-great-pacific-garbage-patch, purple-minamata, and red-loess-plateau.

I chose these cases because none can be solved by one apparently direct response. I first looked at causes and effects in the sources. I then compared them with the game's action order and checked which details affect a choice or an upgrade result. I also recorded what the game leaves out and what people might misunderstand because of this. For example, restoring vegetation is usually seen as a good thing, but whether there is enough local water also needs attention.

For past environmental work and policy goals, I mainly used official sources. For environmental processes and their limits, I used research papers. Both kinds of sources have a limited scope. A project completion report can tell us what work was done, but it cannot establish that everyone affected received the same benefits. This paper has no interviews, field measurements, or experiments with players. Software test reports are only used to understand the program, not to prove its teaching effect.

3. Three cases and their game actions

Table 1 lists the actions in the game. The costs come from the balance settings in use and are in game currency. The progress column shows the additions assigned to each upgrade before the limits on a player's SDG progress are applied. A larger reward in the table does not mean that the action must be more useful in the real world[5].

---

[3] Eco Stewards Project, SDG v2 case data, configuration, and interaction rules, revision 099a975.

[4] Eco Stewards Project, SDG v2 case data, configuration, and interaction rules, revision 099a975.

[5] Eco Stewards Project, SDG v2 case data, configuration, and interaction rules, revision 099a975.

Table 1. Environmental actions, costs, and progress rewards in the three cases

Case and stage	Governance action translated from the game	Cost	Named progress
Pacific patch Lv1	Locate and remove high-risk fishing gear	210	SDG 14 +4
Pacific patch Lv2	Prevent fishing gear and plastic from entering the sea	290	SDG 12 +714 +4
Pacific patch Lv3	Reduce material use across its life cycle and monitor across jurisdictions	290	SDG 12 +714 +7
Minamata Lv1	Stop mercury discharges and control exposure	130	SDG 3 +412 +414 +2
Minamata Lv2	Remove and safely contain mercury-contaminated sediment	290	SDG 3 +712 +414 +2
Minamata Lv3	Manage mercury across its life cycle and monitor over time	210	SDG 12 +73 +414 +2
Loess Plateau Lv1	Protect steep slopes and stabilize erosion gullies	130	SDG 15 +46 +2
Loess Plateau Lv2	Build terraces and change slope-based livelihoods	210	SDG 15 +76 +4
Loess Plateau Lv3	Restore vegetation suited to local conditions and monitor water	210	SDG 15 +76 +4

3.1. The Great Pacific Garbage Patch

The name Great Pacific Garbage Patch can make people imagine a large pile of rubbish that can be collected in one place. NOAA's description is different. The rubbish is spread out, much of it is hard to see, and its area changes with winds and currents[6]. Lebreton et al. [5] used observations from 2015 and 2016 together with a model of debris movement. They estimated that fishing nets made up at least 46% of the floating plastic mass in the study area. This is the mass of plastic in a particular area, not 46% of all pollution in the Pacific. It is also not a measurement of the situation today.

This study helps explain why the game puts dangerous fishing gear in Lv1. The description gives priority to large items that may trap organisms or break into small pieces. It does not say that one cleanup can empty the patch[7]. The player is dealing with one part of the whole problem. The board space only represents this case. Its edges are not the real boundaries of the garbage patch.

Lv2 starts to consider how to reduce new waste, including managing fishing gear and stopping waste from entering the sea. Lv3 adds reducing material use, reuse, shared responsibility, and monitoring. The United Nations Environment Programme describes dealing with the problem along the path that waste takes from its source to the sea[8]. This also explains why the case involves both SDG 14 and SDG 12. Target 14.1 concerns marine pollution, while 12.5 concerns waste reduction[9]. Reducing waste entering the sea is part of protecting the sea.

6 NOAA Ocean Service, What is the Great Pacific Garbage Patch?

7 Eco Stewards Project, SDG v2 case data, configuration, and interaction rules, revision 099a975.

8 United Nations Environment Programme (2021), From pollution to solution: A global assessment of marine litter and plastic pollution. https://www.unep.org/resources/pollution-solution-global-assessment-marine-litter-and-plastic-pollution. Accessed 9 October 2026.

9 United Nations (2015), Transforming our world: The 2030 Agenda for Sustainable Development. https://sdgs.un.org/2030agenda. Accessed 9 October 2026.

However, the player's main choice is still whether to stay at Lv1 or keep paying for upgrades. The game does not ask players to compare fishing gear policies or negotiate who is responsible. It does not calculate the rate at which new pollution enters the sea, so players cannot change such a value through their actions. Progress increases immediately after an upgrade. Players do not have to return later to check whether rubbish has really decreased[10]. They can therefore pay for pollution prevention, but why prevention works is still mainly explained through text.

The upgrade order also needs explanation. In the game, players clear dangerous waste before they can unlock the later prevention actions. This helps arrange the game, but it does not mean that real work must follow the same order. The sources do not say that pollution prevention has to wait until the ocean is cleaned. I think a sentence could be added to explain that the levels represent different kinds of work. In reality, this work does not have to happen in a strict sequence.

3.2. Minamata Bay

The Minamata Bay case first needs to explain how pollution harmed people. Harada [6] describes methylmercury poisoning after residents ate fish and shellfish polluted by wastewater from a chemical factory. Minamata disease was officially reported in 1956. The Japanese government formally announced its cause in 1968[11]. So this case cannot only be about dirty seawater. How people come into contact with pollution, and how to reduce this contact, are also part of the response.

Lv1 in the game requires both stopping mercury discharge and controlling exposure through polluted seafood. The first reduces new pollution. The second protects people who may come into contact with pollution already there. Lv2 deals with contaminated sediment. The official historical account records dredging and landfill work from 1974 to 1990, after discharges had stopped[12]. Giving sediment a separate stage helps explain that old pollution can remain. Closing a discharge outlet does not mean the bay is immediately safe.

Lv3 expands the work to mercury use and handling, including products, production processes, releases, waste, and contaminated sites. The US Environmental Protection Agency lists these areas, together with research and monitoring, in its introduction to the Minamata Convention[13]. This stage applies the lessons of Minamata to wider mercury management. It does not say that the historical response happened in exactly three steps. The game mainly links this case to SDG 3, which concerns health, and also to chemical management under SDG 12[14]. Targets 3.9 and 12.4 support these links, but cannot be used to calculate how much progress the game should award[15].

The costs in the Minamata case do not simply rise with each level. Sediment treatment costs 290, compared with 130 for Lv1 and 210 for Lv3. The middle stage, which involves extensive cleanup, is the most expensive. This gives the three actions different costs in the game, but it is not a comparison of real project budgets. The

[10] Eco Stewards Project, SDG v2 case data, configuration, and interaction rules, revision 099a975.

[11] Ministry of the Environment, Japan (2002), Minamata disease: The history and measures, Chapter 2, Outbreak of Minamata disease. https://www.env.go.jp/en/chemi/hs/minamata2002/ch2.html. Accessed 9 October 2026.

[12] Ministry of the Environment, Japan, Minamata disease: The history and measures, Chapter 4 (2002).

[13] US Environmental Protection Agency, Minamata Convention on Mercury. https://www.epa.gov/international-cooperation/minamata-convention-mercury. Accessed 9 October 2026.

[14] Eco Stewards Project, SDG v2 case data, configuration, and interaction rules, revision 099a975.

[15] United Nations, Transforming our world: The 2030 Agenda for Sustainable Development (2015).

project data do not explain how to convert these values into real money. They also do not provide a model for calculating environmental treatment costs[16].

Some important issues are still outside the upgrade process. The official account covers compensation and support for patients as well as pollution control[17]. In the selected stages, affected residents have no separate role. Players can reach the highest level without dealing with recognition of harm, consent, or compensation. Completing Minamata in the game therefore only means completing some environmental actions. It cannot mean that victims have received fair treatment, and it certainly cannot mean that past harm has been removed.

3.3. The Loess Plateau

Unlike the first two cases, the Loess Plateau is not mainly about pollutants. It also requires looking at how people use land. The World Bank's project completion report describes terracing, vegetation restoration, grazing restrictions, and changes in livestock production. Fodder and animal enclosures also helped people reduce unrestricted grazing[18]. This shows that protecting soil is related to local production and daily life. The game keeps this connection through slope and gully protection in Lv1, followed by terraces and livelihood changes in Lv2[19].

Protecting vulnerable land deals with erosion that is already happening. Changing land use reduces activities that may continue causing damage. The Lv2 explanation includes sustainable cultivation, controlled grazing, and alternative livelihoods. Both the game and the project report discuss how people use land, rather than only whether a hillside looks greener[20]. However, a project in the game has only one owner. This player's choice cannot be taken as the common interest of an entire rural community.

At Lv3, there is also the question of water. Feng et al. [7] found that large-scale vegetation restoration increased evapotranspiration. This means water entering the air through evaporation and plant transpiration. It may increase competition between ecosystems and people for water. Ren et al. [8] compared two watersheds. They found that tree planting used more soil moisture than natural revegetation, but the difference was statistically significant only in wet years. Neither approach caused soil desiccation at that study site. The study conditions matter when reading these results. They support checking local water conditions before restoration, but do not show that all restoration projects will cause water shortages.

The game's Lv3 explanation asks for a mix of grasses, shrubs, and trees suited to local conditions. It also calls for monitoring soil water, erosion, and runoff. This stage mainly links to SDG 15 and also to SDG 6, bringing land restoration together with water-related ecosystems[21]. More trees are not necessarily better. If the plants need more water than the area can provide, the restoration plan may not be suitable for that place.

But players do not actually have to choose what to plant during an upgrade. The code reads the project identifier and checks ownership, money, the current level, and whether another upgrade is allowed that turn. It

---

16 Eco Stewards Project, SDG v2 case data, configuration, and interaction rules, revision 099a975.

17 Ministry of the Environment, Japan, Minamata disease: The history and measures, Chapter 4 (2002).

18 World Bank (2003), Implementation completion report: Loess Plateau Watershed Rehabilitation Project, Report No. 25701. https://documents1.worldbank.org/curated/en/820471468769214283/pdf/257011CN1Loess1d0Rehab0Project01ICR.pdf. Accessed 9 October 2026.

19 Eco Stewards Project, SDG v2 case data, configuration, and interaction rules, revision 099a975.

20 Eco Stewards Project, SDG v2 case data, configuration, and interaction rules, revision 099a975. World Bank, Implementation completion report: Loess Plateau Watershed Rehabilitation Project, Report No. 25701 (2003).

21 Eco Stewards Project, SDG v2 case data, configuration, and interaction rules, revision 099a975. United Nations, Transforming our world: The 2030 Agenda for Sustainable Development (2015).

then gives fixed rewards. It does not check vegetation types or actual water availability. Once the Loess Plateau Lv3 meets the upgrade conditions, it is assigned seven progress units for SDG 15 and four for SDG 6[22]. The water conditions discussed in the text do not change these rewards. A question could be added here later, asking players why they need to understand water use first. Still, looking at the code alone cannot show that players will misunderstand this.

4. Comparison and ideas for improvement

4.1. What the three levels keep

All three cases explain why the first action is not enough. After marine rubbish is removed, new waste can still enter. Minamata needs to prevent people's exposure and deal with pollution left behind. Land protection on the Loess Plateau is connected to livelihoods and local water supply. These differences have support in the relevant sources[23] [7]. I think the most useful part of the action explanations is that they describe these relationships. Adding a few more facts to a card does not, by itself, make the reasons for an action clearer.

The shared rules also express some ideas. Buying a project gives no progress. Completing an action does. Each stage costs money, and usually only one upgrade can be completed in a turn[24]. After owning a project, players still have to decide whether to spend their limited money and turns on it. The game does not calculate pollutant concentrations, sediment movement, or community welfare. But it makes buying a project and actually doing work separate steps.

4.2. What appears in the text but not in the rules

The nine stages have 20 named progress effects. Before the progress limits are applied, every effect is a positive addition. Yet the descriptions mention uncertainty, continued monitoring, and some limits that the upgrade code does not check[25]. Lv3 includes monitoring in all three cases, but players do not have to return later to see the results or adjust their actions to new conditions. Work that needs to continue in reality receives its reward after one upgrade in the game.

The text is still useful. The Inspector interface explains what happened, why the problem is hard to deal with, what each level does, and why the action helps. Players can also open the source information to check the evidence. The game cannot calculate every environmental process, so text can provide further explanation. But having this text does not mean that players have read or understood it. Sicart's [3] discussion of player interpretation also reminds us that the meaning players find in a game may differ from what the designer wants to express.

Source links also need maintenance. During the source check in September 2026, a World Bank feature page cited in the project could no longer be opened. The analysis therefore used the project completion report, which was still accessible, to check the actions[26]. This is only one broken link, but it shows why leaving a URL

[22] Eco Stewards Project, SDG v2 case data, configuration, and interaction rules, revision 099a975.

[23] United Nations Environment Programme, From pollution to solution (2021). Ministry of the Environment, Japan, Minamata disease: The history and measures, Chapter 4 (2002).

[24] Eco Stewards Project, SDG v2 case data, configuration, and interaction rules, revision 099a975.

[25] Eco Stewards Project, SDG v2 case data, configuration, and interaction rules, revision 099a975.

[26] World Bank, Implementation completion report: Loess Plateau Watershed Rehabilitation Project, Report No. 25701 (2003).

is not enough. It is better to include the author, title, and date as well. Even if the address changes, readers have other information to help them find the source again.

4.3. Asking players to think about the reason for an action

One change to try is a short question at an important choice in each of the three projects. The Pacific case could ask what remains unresolved after rubbish is removed. Minamata could ask why sediment still needs treatment after discharge stops. The Loess Plateau could ask what needs to be known before deciding what to plant. These are only suggestions. They are not existing features, and they have not been shown to improve learning. I hope they could make players think about what an action is meant to solve before paying for it.

When Lv3 is completed, the game could also explain that only the game's action sequence is finished. Real monitoring and work by the organizations involved may still need to continue. This sentence could explain the limit of completion, but it would not make players actually take part in monitoring. A next step could be a small playtest. It could compare how players explain the three cases before and after playing and record their choices. If they choose the right action but cannot give a reason, the connection between the explanation and the choice needs another look. However, a small playtest without a control group cannot prove that the game generally causes better learning.

5. Limitations

This paper studies the game, not its players. The three cases were chosen because of their different difficulties and cannot represent all 24 projects. Stage counts and record counts cannot support statistical conclusions either. Although I used the same questions for each case, no other researcher independently repeated this analysis. Translating the Chinese action names into English may also lose some of the original meaning. The case identifiers are therefore kept so that readers can compare the discussion with the original fields.

The external sources are not complete either. Government and funding-agency reports have institutional viewpoints. Research papers cover particular places, periods, and methods. This paper cannot present the experience of every affected community. It also examines only one local version. If the game changes later, it will need to be checked again. What this paper can discuss is the relationship between sources, game explanations, and actual actions. Finding out what players understand still requires observing them. Passing software tests, completing an upgrade, or finishing a game cannot replace this step.

6. Conclusion

Eco Stewards gives a specific reason for each level of action in the three cases. The Pacific case separates removing existing rubbish from preventing new pollution. Minamata separates reducing human exposure from treating remaining contamination. The Loess Plateau connects soil protection with land use and the water needed for vegetation restoration. These points are supported by environmental sources. They are fairly clear in the action names and explanations, but the upgrade rules keep fewer of these details.

Players spend money and turns on environmental work, but do not deal with many of the uncertain results described in the sources. They also do not deal with how work is divided between institutions. This is the main weakness found in the comparison. Improving it does not have to mean simulating every real process. We could first ask players why an action is needed and what remains unresolved afterward, then use a playtest to see whether they can explain it clearly. Such a test has not yet been done. For now, the game can be said to

offer an opportunity to encounter these environmental problems, but not to have already taught players about them.

References

[1] Bogost, I. (2007). *Persuasive games: The expressive power of videogames*. MIT Press. https://doi.org/10.7551/mitpress/5334.001.0001

[2] Hunicke, R., LeBlanc, M., & Zubek, R. (2004). MDA: A formal approach to game design and game research. In *Proceedings of the AAAI Workshop on Challenges in Game AI* (Vol. 1). AAAI Press.

[3] Sicart, M. (2011). Against procedurality. *Game Studies, 11*(3). https://gamestudies.org/1103/articles/sicart_ap/

[4] Katsaliaki, K., & Mustafee, N. (2015). Edutainment for sustainable development: A survey of games in the field. *Simulation & Gaming, 46*(6), 647–672. https://doi.org/10.1177/1046878114552166

[5] Lebreton, L., Slat, B., Ferrari, F., Sainte-Rose, B., Aitken, J., Marthouse, R., Hajbane, S., Cunsolo, S., Schwarz, A., Levivier, A., Noble, K., Debeljak, P., Maral, H., Schoeneich-Argent, R., Brambini, R., & Reisser, J. (2018). Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic. *Scientific Reports, 8*, Article 4666. https://doi.org/10.1038/s41598-018-22939-w

[6] Harada, M. (1995). Minamata disease: Methylmercury poisoning in Japan caused by environmental pollution. *Critical Reviews in Toxicology, 25*(1), 1–24. https://doi.org/10.3109/10408449509089885

[7] Feng, X., Fu, B., Piao, S., Wang, S., Ciais, P., Zeng, Z., Lü, Y., Zeng, Y., Li, Y., Jiang, X., & Wu, B. (2016). Revegetation in China's Loess Plateau is approaching sustainable water resource limits. *Nature Climate Change, 6*, 1019–1022. https://doi.org/10.1038/nclimate3092

[8] Ren, Z., Li, Z., Liu, X., Li, P., Cheng, S., & Xu, G. (2018). Comparing watershed afforestation and natural revegetation impacts on soil moisture in the semiarid Loess Plateau of China. *Scientific Reports, 8*, Article 2972. https://doi.org/10.1038/s41598-018-21362-5