



Title: ARSINOE Serious Game

Deliverable 4.2

WP4: Environmental Intelligence Management and Services

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Date: 31/03/2025



This project has received funding from the European Union's Horizon 2020 innovation action programme under grant agreement 101037424.

Deliverable Number and Name	D4.2 ARSINOE Serious Game
Work Package	WP4 – Environmental Intelligence Management and Services
Dissemination Level	Public
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Date Due	31/03/2025
Date Submitted	31/03/2025
File Name	ARSINOE WP4 D4.2 report.pdf
Status	
Reviewed by (if applicable)	
Suggested citation	Lewis et al. (2025), D4.2 ARSINOE Serious Game, H2020 grant no. 101037424

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This document has been prepared in the framework of the European project ARSINOE. This project has received funding from the European Union’s Horizon 2020 innovation action programme under grant agreement no. 101037424.

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EXECUTIVE SUMMARY

This report provides information about the development of the ARSINOE Town Serious Game (ATSG), which is a multi-player, interactive tool designed to facilitate discussions on climate and economic consensus building, and the Cascading Failure of Critical Services (CFCS) digital serious game that illustrates how to combine protection measures over different infrastructure services to improve preparedness to a flood event in an unnamed coastal town.

Developed as an icebreaker, ATSG provides a structured yet engaging environment where participants explore town-scale resilience interventions using cliched personas to simulate diverse stakeholder perspectives. Balancing complexity and accessibility were key considerations during the game development, particularly when designing the intervention cards. The plan was to create something simple, with a playtime of around 30 minutes, and yet still meaningful. A simple qualitative macro-economic model was developed, allowing designers to consider the drivers and impacts of interventions through the STEEPLE lenses of society, technology, economy, environment, politics, legal, and ethics. This enabled interventions to be considered from the dual perspectives of what drove their creation, e.g. the productisation of new technology or fallout of new legalities, and what their impacts could be, in terms of who (society), and how, they would be affected (environment), the financial costs and benefits to stakeholders, and the political and ethical alliances that may be developed to support or frustrate such interventions.

When playing the game, participants can navigate the game in a fun way while also engaging with critical resilience challenges. Playtesting has confirmed ATSG's effectiveness, with positive feedback highlighting its ability to foster open dialogue, even on contentious topics. ATSG is open-source and available on GitHub, enabling broad accessibility and adaptation. This approach supports wider adoption, encourages community contributions, and ensures continued refinement of the game as a tool for collaborative learning and strategic discussions.

CFCS serious game links a digital interface to a ground-breaking simulation engine to show participants the simulated direct and indirect consequences of a flood on the integrity of critical services, as well as workforce availability for different industries, as well as an estimation of the number of vulnerable people impacted by the loss of services. It shows the states of the impacted services for the whole town and the detail for each of its neighbourhoods to allow both tactical and strategic planning for preparedness. CFCS does not require expertise of any kind from the participants and can potentially be played as an online individual game. It is nonetheless more beneficial to play it as a guided group exercise as it is rich in content, and a helper can present key vulnerabilities of each type of infrastructure when exploring the in-game preliminary information package to the audience.

The initial submission for this deliverable resulted in a request for revisions. Where possible, these revisions have been added in-line. However, to better address the open nature of some of the feedback requests, 'post-review summary' sections have been added to both games (section 2.4.2 and 3.4.2).

1.0 INTRODUCTION

This report outlines the development process of the two ARSINOE Serious Games. The first is the ARSINOE Town Serious Game (ATSG) that is a cardboard game designed for facilitating climate conversations among stakeholders to raise public awareness on climate resilience. The second is the Cascading Failure of Critical Services (CFCS) digital serious game that demonstrates the cascading effects of critical infrastructure failures.

ATSG is a multi-player card game designed to showcase the participants climate and economic consensus building for a medium-sized town and demonstrates the challenges and uncertainty in preparing for resilience challenges. The game is designed as a typical ‘ice breaker’ activity, bringing together participants in a safe space to discuss the relative merits of town-scale interventions using cliched personas.

The ATSG used STEEPLE analysis¹ during design to qualitatively model macro-economic environment. This enabled the game’s developers to understand the relationship between an intervention and its impact on the serious town, through the **S**ocial, **T**echnological, **E**conomic, **E**nvironmental, **P**olitical, **L**egal, and **E**thical lenses. The climate resilience aspects of the game were developed from WP2 ‘Systems Innovation Approach’, case studies and their climate issues, with an initial long list of per case study issues being grouped into the four resilience challenges presented in the game (flooding, drought, heatwave, and loss of biodiversity). Economic resilience was added as a non-climatic resilience to indicate the financial considerations of the interventions.

The interventions were largely drawn from WP5 ‘Portfolio of innovations and support schemes’, using the innovations that had been selected by the case studies where possible, but removing company identifying features. Digital dashboards and digital twins proved a popular choice of innovation, so this was rippled across to all four of the climatic resilience challenges. Each resilience challenge has 7 cards, typically these consist of the two ‘popular’ dashboard and digital twin options, up to four options from the associated open innovations, and at least one ‘novel’ option that provides a financial incentive. Given the nature of the financial incentive, these interventions were not developed from the pool of open innovations.

ATSG provides players and facilitators with post-game reflection events to consider how the players made their intervention choices, the effectiveness and ethics of their choices, and the impact of the end of game resilience challenges.

CFCS uses a powerful simulation engine combined with an interactive digital interface to demonstrate the consequences of a flood. Participants sees both direct and indirect impacts on essential services, workforce availability across industries, and the number of vulnerable people affected by service disruptions. The game provides a detailed view of a town’s infrastructure from overall conditions to neighbourhood-level specifics, enabling tactical and strategic preparedness planning. Users can immediately see how protective measures (like backup water for hospitals or improved internet access in pharmacies) impact service integrity and explore which services are most vulnerable and what combinations of solutions offer a better outcome. The CFCS is designed to be accessible, even playable as a solo online experience. It is nonetheless more beneficial to play as a guided group exercise that a helper can highlight key vulnerabilities of each type of infrastructure when exploring the in-game preliminary information package to the audience. The content is technically as accurate as the model can make it, and the simulated effects and impacts shown are as realistic as the accuracy of the data used for computation made it possible to be – potentially, with sufficiently accurate data, the game could be used as a decision support tool. A playing session will last approximately 90 minutes

¹ Aguilar, F.J. (1967). *Scanning the business environment*. Macmillan.

if one includes a pre- and post-game to measure how playing the game has induced a change in the way participants answer questions revolving around the impacts of the flood event on critical services, and the possible ways to improve preparedness.

Alongside this deliverable we have the following resources:

- A video walk-through of ATSG: <https://youtu.be/Y1UMQOzavEs>
- A promo video of ATSG that demonstrates it being tested at the University of Exeter: https://youtu.be/whqQk94_DfY
- The companion website for ATSG: <https://arsinoe-serious-game.github.io/martin-cs7/>
- A video that demonstrates CFCS: <https://youtu.be/RRRul6G04MM>

2.0 ARSINOE Town Serious Game (ATSG)

The ATSG was developed in three stages, the first stage initialised the concept and the storyline as the barebone design, while the second stage refined the components and rules. The third stage engaged with external participants to test the ATSG and the feedback were used to further improve the game design.

The aim of the game was defined as ‘Helping communication with the public about climate resilience through a gamified debating process’, with the following design pillars:

1. Roles with conflicting interests that reflect multiple stakeholders involved in climate decision-making
2. Role playing to enable players’ thinking from different perspectives
3. Measures with positive benefits, negative impacts, costs, and limitations to highlight that ‘one-for-all’ solution
4. Interactive dialogues to help players review the capacity and effectiveness of drivers and solutions, understanding the trade-offs to reach consensus in decision-making process.
5. Stages to reflect multifaced challenges in real-world situations
6. Multi risks and uncertainties reflected

2.1 Initial game design

An initial game mechanic was developed around the concept of town and its townspeople, where the town had several development opportunities (interventions) that the townspeople would vote on to implement. The selected intervention would then be implemented with a range of outcomes. The townspeople would have very different views on what should be implemented, creating the opportunity for discussion about what made sense for the town and the outcome would allow people to justify their decision making.

This initial iteration of development was undertaken with the following goals in mind:

- explore and prototype core mechanics, and
- create and evaluate of a longlist of personas
- create and evaluate of a longlist of interventions

The game is set in a ‘medium’ sized coastal town and is an amalgam of several ARSINOE areas: Torbay, Cagliari, Esbjerg, and Tenerife. The town is large enough to not be a one-horse town, where the seaside would be the main industry, but small enough that everything is relatively local. The town has

a clear beach/coastal leisure economy, has available hinterland, has clear opportunities for industrial / commercial activities, and has links to other areas making it the local hub.

The longlist of persona cards (Figure 2.1) was developed by enabling participants² for role-playing of characters in typical social groups within communities: NEET (young people, not in employment, education or training), YUPPIE (young urban professional), JAM (just about managing), empty-nester (post-children families) and boomer (wealthy retired), and providing stock photos, and written back stories and 'likes and dislikes', to give players a clear insight into who the persona was and their values.

The interventions (Figure 2.2) were developed from recent economic / environmental news stories and consisted of a similar stock photo and back story to the persona cards. However, the back side of the card included a set of outcomes for the intervention. On choosing the card, a dice would be rolled to determine the outcome, with 1 as a very bad outcome and 6 as a very good outcome.

This also introduced the concept of the town 'mayor', one of the players that would be responsible for managing the intervention selection process. To add theatre to the game experience, the mayor would be 'voted in' through a dice roll off (the highest roll wins the mayoral election). However, bad intervention outcomes would result in the mayor being sacked, to illustrate the uncertainty of politics.

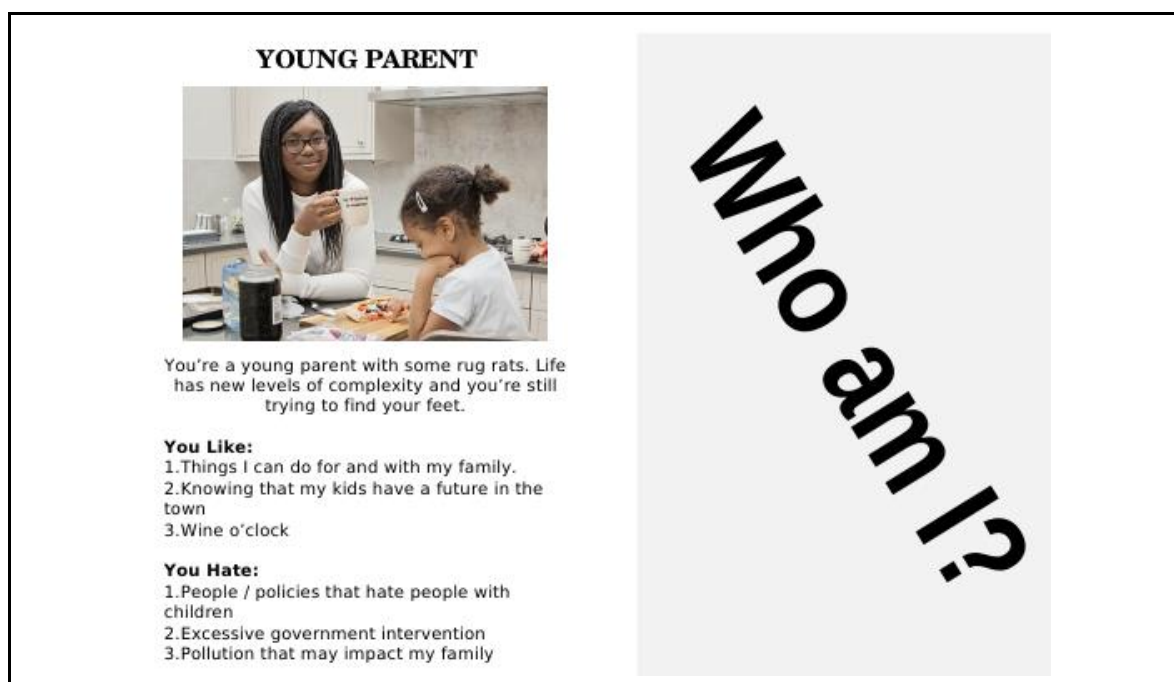


Figure 2.1 Persona card of a young parent which provides a description along with the 'likes and dislikes', to give players a clear insight into who the persona was and their values.

² Fleming, K., J. Abad, L. Booth, L. Schueller, A. Bails, A. Scolobig, B. Petrovic, G. Zuccaro, and M.F. Leone. (2020) 'The Use of Serious Games in Engaging Stakeholders for Disaster Risk Reduction, Management and Climate Change Adaption Information Elicitation'. *International Journal of Disaster Risk Reduction* 49: 101669. <https://doi.org/10.1016/j.ijdrr.2020.101669>.

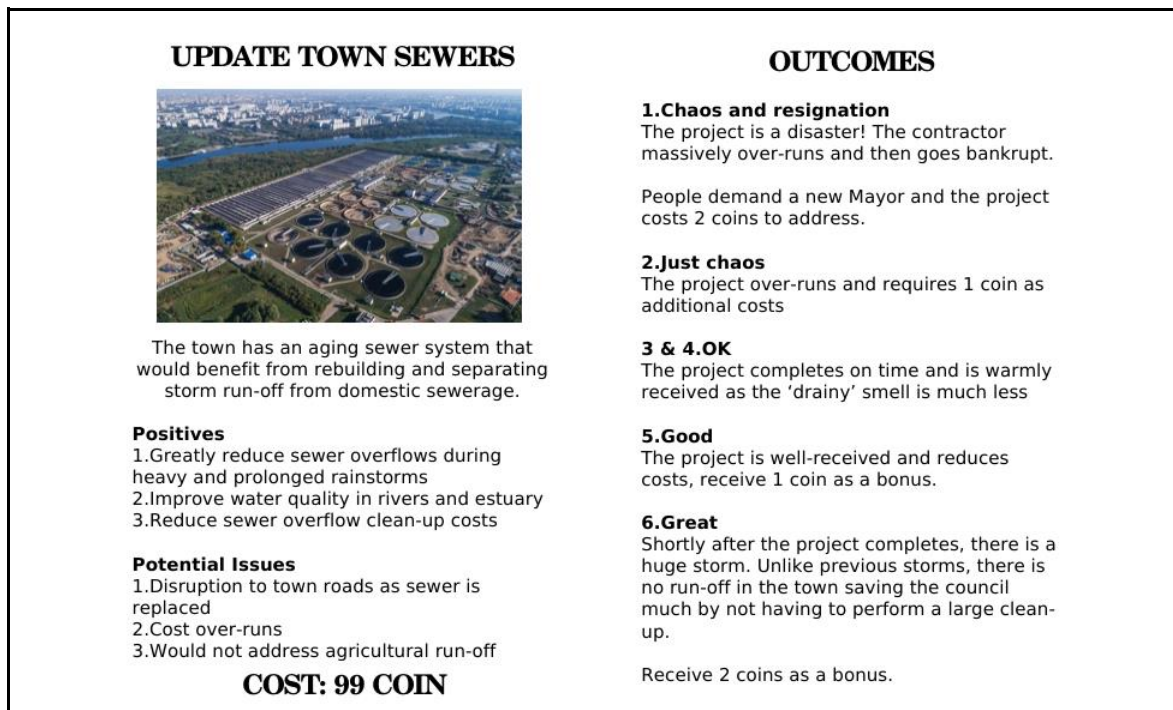
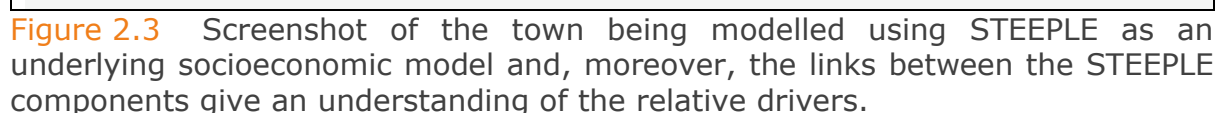


Figure 2.2 Example of an intervention card. On the left is a photo along with positives and potential issues of the intervention. On the right (which would be the reverse side) a set of outcomes for the intervention

We modelled the town using STEEPLE as an underlying socioeconomic model and, moreover, the links between the STEEPLE components to give an understanding of the relative drivers (Figure 2.3). This created a core model where people (social) would live, work, and play in and around the town driving the economy. These interactions drive the environmental model of the town, but needed to balance, in the sense that most people needed to have jobs to remain in the town, but those jobs / work / companies are likely to have negative impacts on the environment.

The legal and technology components of STEEPLE create push/pull drivers for interventions within the town, in that legislation (legal) pass by external national and regional lawmakers create interventions for the town, e.g. a law passed to limit car use would lead to intervention opportunities for reducing car use. Whereas the development of new technology would also lead to intervention opportunities, e.g. the development of high-capacity batteries could lead to the intervention of developing an electric bus infrastructure for the town.

The political and ethical aspects of the STEEPLE model were provided by the players. Political 'pressure' could be applied between personas for specific interventions to be chosen, e.g. the 'reduce hotel planning laws' intervention would drive the hotelier persona to push for it, given self-interest. Ethical considerations would be applied between players on decided between what is 'within the law' and what is 'right'.



2.2 Revised game design

⁴ IPCC. 'Climate Change 2022 – Impacts, Adaptation and Vulnerability: Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change'. Intergovernmental Panel On Climate Change, 22 June 2023. <https://doi.org/10.1017/9781009325844>.

The selected risks, along with an economic risk, provided the framework and ending for the game, in that the players would need to select interventions to protect their town from 5 resilience challenges at the end of the game. The inclusion of economic risk was deliberate to demonstrate the balance between environmental and economic considerations.

A smaller set of intervention cards (Figure 2.4) was developed using the open innovations as a starting point, creating 7 cards for each of the four climate change risk types. Given the budgets of the open innovations, several cards were added to consider bigger and more impactful interventions and to offer a trade-off between climate protection and economic performance. Also, given the popularity of dashboard and digital twins during the open innovation presentations, each climate change risk type included dashboard and digital twin options. Each intervention card was scored for its impact, both positive and negative, on the five resilience challenges, as EP for economic protection, BP for biodiversity protection, FP for flooding protection, DP for drought protection, and HP for heat protection. The outcomes were also reduced from 6 to 4 to give more context to the outcomes.

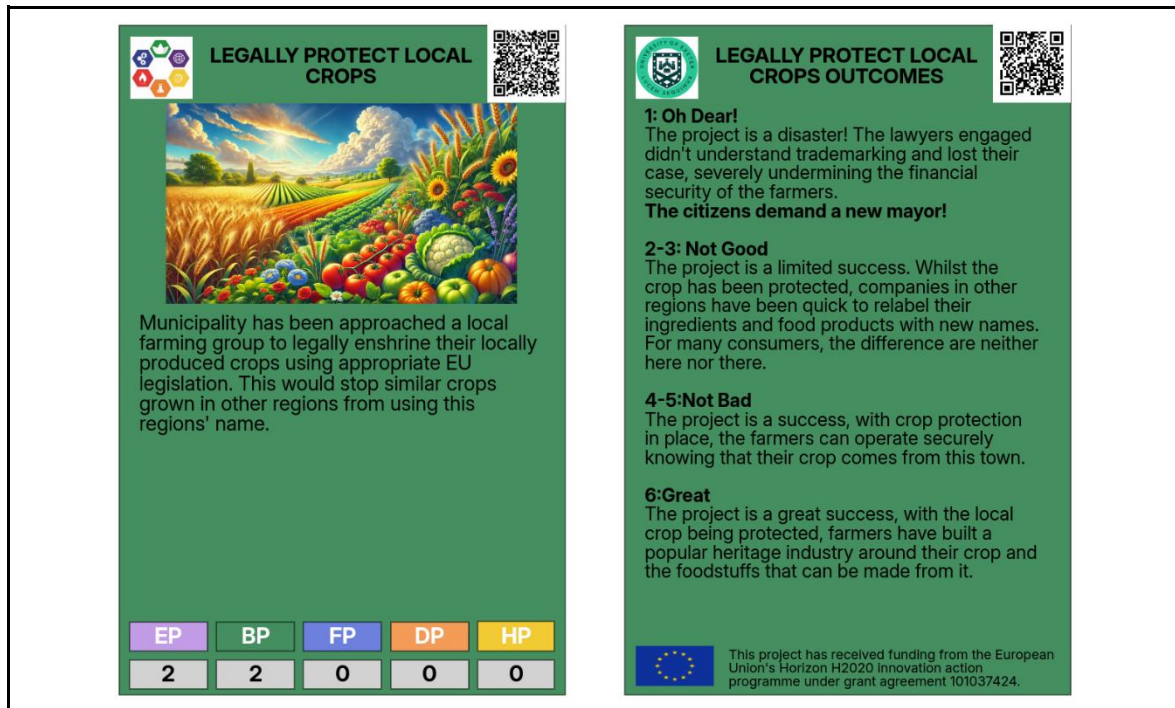


Figure 2.4 Intervention cards were developed using the open innovations as a starting point, creating 7 cards for each of the four climate change risk types.

2.2.1 Playing ATSG

The game was now played in two parts. The first part was similar to the first iteration, in that players would choose their personas and play through four rounds of intervention choosing and outcomes. Each selected intervention would be kept for the second part.

From feedback in the first iteration, we reduced the number of personas (Figure 2.5) for the game to six, in order to make them clearly distinguishable and added more backstory to give the players a clearer understanding of persona values.

In the second part of the game, players would go through the five resilience challenges (Figure 2.6). Each challenge consisted of a card stating the nature of the challenge on one side and the outcomes of the other, with the challenge severity table being used to determine the appropriateness of the interventions that the town had put in place.



Figure 2.5 The persona cards that are used in the game



Figure 2.6 An example of one of the resilience challenges

For each event, a die was rolled to determine the event severity (across the top of the table). Challenges were ranked as minor, average, or extreme. Next, the players would go through their selected intervention cards to add up the overall protection against the event and read the score on the left of the table. Where the event severity and resilience meet, is the outcome, with outcomes of severely under-prepared, under prepared, fitting and overkill, with description of each outcome type on the reverse of the card.

After the game, we had four questions for the players to consider:

- How well did your town do against the resilience challenges?
- Was there any luck with the severity of the challenges you faced?
- How well did your intervention choices perform against the resilience challenges?
- What would you do differently next time?

In general, towns will perform well, fitting or overkill outcomes, against the resilience challenges if most of the scores are low or average. The overkill outcomes are a useful discussion point as it suggests that the town has over-protected against a resilience event and could consider more resilience in other areas. If the resilience challenges are extreme, then the town will struggle to have fitting responses. This creates discussion points around how much resilience can be applied to the town and whether all resilience types are equal in their destructive power.

2.2.2 Website

An online version of the ATSG (Figure 2.7) is available at: <https://arsinoe-serious-game.github.io/martin-cs7/>. This enables participants to learn about the game, watch a play through version provided by YouTube (See below), understand the rules, and to download the cards so people can play at home. The website also enables participants to learn more about the interventions used within the game, and to access the Mural version.



Figure 2.7 Screenshot of the ATSG Homepage

Key differences between the website and board game is the access to extra information available within the serious town knowledge base. This Knowledge Base exists to provide more background information about the game and provides clear links between the game, the activities in ARSINOE's 'Systems Innovation Approach' (work package 2)⁵ and broader activities within the flood, drought, heat wave and biodiversity spheres. The storyline in the game is directly linked to the flood risk that case studies Denmark (CS7) and Torbay (CS8) are facing and can be quickly converted to other case studies.

ATSG is about the relationships between personas, the people that live in the town, the interventions they approve, to improve the lot of the town, and the resulting resilience challenges that the town then faces. Each of those three aspects are presented with the knowledge base.

The knowledge base is separated into 3 main sections:

1. **Personas:** The Personas follow the ones described within section 1.3 Iteration 2 of this deliverable (Student, young worker, family, politician, business owner and retiree. This variation of personas within the population of Arsinoe Serious Town, provide a multitude of opinions as to what interventions the municipality should follow. Like all people, the personas are motivated by self-interest, so much of the intervention selection process is about building a consensus, where interventions may not perfectly map to self-interest. The personas of student, young worker, family and retiree show a broad human life cycle. Whilst it's not completely inclusive, it captures key life stages. Whereas the business owner and politician personas aren't so age-specific but give players the opportunities to look at situations from a more business perspective (in the case of the business owner) and more political perspective (in the case of the politician).
2. **The Interventions:** The intervention cards for ARSINOE Serious Town are grouped into four resilience types, with each type having seven interventions. Each intervention has positive impacts for the town's resilience but may also have negative impacts. Where possible, these interventions have been drawn from the open innovation activities in ARSINOE's Systems Innovation Approach work package. However, we have also added some interventions that were beyond the scope of the open innovation activities budgets and timelines to demonstrate how larger interventions can often have positive, and negative, effects on a town's resilience. Within the knowledge base for each intervention a (i) brief description is given, (ii) key facts or types, (iii) a list of potential benefits and limitations, (iv) real life examples are given via a variation of links to news articles, websites, journals and youtube videos and finally (v) links to ARSINOE specific examples.

A few examples are shown below

- https://arsinoe-serious-game.github.io/martin-cs7/kb/interventions/interventions_0.html
- https://arsinoe-serious-game.github.io/martin-cs7/kb/interventions/interventions_04.html
- https://arsinoe-serious-game.github.io/martin-cs7/kb/interventions/interventions_12.html

⁵ Georgios Ganas, Dimitra Petousi, Akrivi Katifori, Lori Kougioumtzian, Ebun Akinsete, George Halkos, Conrad Landis, Panagiotis Aslandis (2024). Report on an innovation approach to train to climate change in order to increase local adaptive capacity. ARSINOE D2.5, H2020 grant no. 101037424

- https://arsinoe-serious-game.github.io/martin-cs7/kb/interventions/interventions_16.html
3. **Resilience Challenges:** ATSG has five resilience challenges that players must engage with once they have selected their interventions. Four of the five challenges are closely tied to the Systems Innovation Approach of work package 2, and cover biodiversity, flood, drought and heat wave resilience, whilst economic resilience has been included to demonstrate that towns are not just subject to environmental concerns, there is also a financial consideration. Each resilience challenge shares a severity/resilience matrix, where the impact of each resilience challenge can be determined against the interventions that have been selected for the town, giving outcomes of severely under-prepared, under-prepared, fitting, and overkill. The website provides an example/guide for each of the Resilience Challenges, these have been written from “our” (the creators) lived-experiences, being based in the South West of the UK. The examples given have not been chosen simply as the best or worst examples of those experiences, they were selected to present a consistent narrative of resilience challenges that occur in a region that the authors know and have experienced. For each of the 5 resilience challenges a description and examples for a Minor, Average and Major challenge have been described.

Below is the Example provided for an economic resilience challenge.

https://arsinoe-serious-game.github.io/martin-cs7/kb/resilience/resilience_0.html

2.3 ATSG Piloting

2.3.1 Overview of the playtesting

On January 22, an in-person playtesting event was held at the University of Exeter, shown in Figure 2.8. A total of 12 participants attended, representing eight different sectors: Private Sector (2), Research (2), Local Government (2), National Government (1), Engineering consultancy (1), Education (2), Environmental Management (1), and Water company (1).

The session began with an introduction to the game, after which participants were divided into three groups. The first round was facilitated to ensure all players understood the game mechanics. Each group then proceeded at their own pace for the second and third rounds. The final section of the game, which introduced resilience challenges, was played collectively, fostering competition among the groups. This approach successfully encouraged engagement and collaboration.



Figure 2.8 A group playing the game

At the end of the session, participants completed an online survey and took part in a group discussion, addressing the following key questions:

- How did you find playing the game?
- What factors were most important in your town's decision-making process for interventions?

2.3.2 ATSG testing feedback

Prior to the playtest, four participants had some knowledge of climate resilience and adaptation, four had a good understanding, and four possessed strong expertise and experience in the field. All attendees were familiar with the concepts of climate resilience and adaptation.

Figure 2.9 illustrates that over 90% of participants found the game easy to play, and all agreed or strongly agreed that they gained additional knowledge on climate resilience and interventions. Furthermore, the game significantly increased awareness, with all participants agreeing or strongly agreeing that they recognized the broader impacts of climate interventions beyond their intended scope.

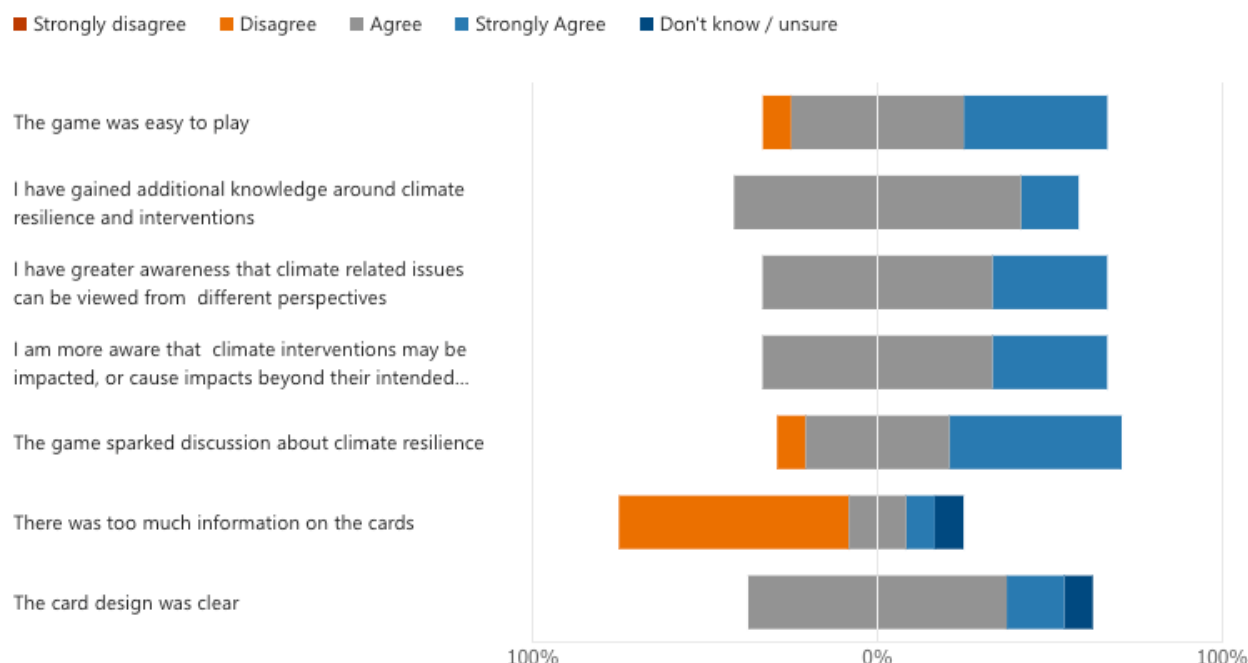


Figure 2.9 Survey results from the playtest

Regarding the game's practical application, seven out of the twelve participants stated they would use the game in their work, while four were unsure. Only one participant said they would not use the game professionally. The discussion highlighted potential applications, particularly in stakeholder engagement and community discussions on flooding and climate change:

"Yes, I think that this game would work in our work for wider stakeholder engagement. Though would be more difficult to use in projects that have a specific focus on one element of the cards i.e. flood resilience" P#11

"With slight adaptations the game could be used in a stakeholder engagement session on water/catchment management and climate adaptation" P#12

"When talking to community groups about flooding and climate change" P#7

A couple of participants noted that the game could be adapted for students. This was an interesting insight as the game was originally designed for professional use.

"Workshop material for students to teach them divergence in decision making" P#6

"I found that the card game was a useful tool for considering the impacts of different activities and evaluating these from differing perspectives. It seems to me that this might be a useful tool for use with 6th Form or undergraduate students, studying planning or could be used by planners to consider different stakeholder groups." P8

Additionally, one participant noted that the game could be useful for developing integrated adaptation plans:

"Developing adaptation plans that are integrated across several sectors." – P#9

"The game could sharpen the focus on the trade-offs that need to be resolved when making choices across different timescales (i.e., short/medium term vs. long term)." – P#9

Overall, participants found the game to be an effective tool for fostering discussion on climate resilience. However, some emphasized that additional time would be beneficial for deeper conversations. The game was praised for its visuals and ease of facilitation, making it accessible for external use:

"I thought it was a great game to generate conversations around climate resilience, though more time is needed for this. Good visuals, and for use externally it is easily understandable and easy to facilitate" P#11

2.4 ATSG Summaries

2.4.1 Initial summary

The development of the ATSG has successfully created an engaging, multi-player experience that facilitates discussions around climate and economic consensus building. The game is designed as an icebreaker and provides a safe space for players to explore town-scale resilience interventions through the lens of clichéd personas.

The game leverages macroeconomic modelling through a strategic planning framework that assesses the external factors impacting operations, considering aspects like social, technological, economic, environmental, political, legal, and ethical (STEEPLE), in developing plausible interventions based on the outcomes from the ARSINOE open-innovation work package (WP2), allowing players to see the impact of both single interventions and their combined impact on reducing five resilience challenges.

Throughout development, balancing complexity with accessibility was a challenge, particularly in designing the game's intervention cards. Prioritising simplicity ensured a smoother gameplay experience while still maintaining depth. The STEEPLE framework proved invaluable in linking interventions to resilience types and town personas, strengthening the game's structure.

Playtesting demonstrated the game's effectiveness, with participants providing positive feedback. The use of personas encourages open discussion, even on difficult topics, making ATSG an excellent tool for sparking conversations in meetings or workshops.

Finally, ATSG's open-source availability via GitHub ensures accessibility, allowing anyone to download, print, and host the game. This openness supports wider adoption and encourages further refinement through community contributions.

2.4.2 Post-review summary

The expert review of this deliverable raised some extremely interesting points from the reviewers concerning the ATSG which are best answered as replies rather than attempting to edit the initial deliverable.

The game is aimed at 2-6 people, when in reality, decision-making should be open to a much broader stakeholder group. Could this be discussed in the deliverable – which different groups of people could use the game?

The game is aimed for 2-6 players as the core gameplay element of the game involves discussing the relative merits of interventions. Adding more players to this would increase the time taken to have those discussions and extend the length of the game, having a cap of 6 keeps the game manageable. For larger groups of players, multiple instances of the game were played, for example the initial playtesting described in the report had 12 players and three instances of the game, with four players per game.

In terms of the personas that were designed for the game, we had six (effectively limiting the number of players). The six that were chosen were taken from a longer list of 18 and were chosen to be largely orthogonal to create discussion.

The game was initially designed as an ice-breaker activity for people involved in town planning activities, assuming a degree of domain expertise, but limited understanding of broader stakeholder issues other than their own lived experiences. The game had three broad goals; demonstrate that different stakeholders had different needs, viewpoints and positions about interventions for their

town, show that planning for climate resilience is incredibly difficult given the limited resources and unknowns that planners are dealing with, and to get people talking openly using the personas as masks, such that they could adopt 'difficult' or potentially problematic positions without being held liable for them.

On page 14 (of the PDF – page numbers should be inserted in the document), section 2.3.1 we learn that a total of 12 participants attended. Would it be possible to provide more information on how many were from each stakeholder category, how these participants were chosen, invited and recruited? This is important since conclusions on the perceptions of participants can be biased towards certain types of stakeholders

For the initial playtest, we recruited domain experts from private sector, research, local government, national government, engineering consultancy, education, environmental management, and a water company. These were all drawn from existing warm contacts at the university, but several were unknown to each other, and met the goals for an ice breaker activity in a professional context.

Since the initial submission of this report, the game has undergone four more rounds of playtesting:

- The game was taken to Denmark by the WP3 lead and played by around 100 environmental studies undergraduate students. Student feedback was generally very positive with students wanting to take the game home and play it further.
- The game was played by 12 Exeter undergraduate students (from engineering and humanities courses) as part of an environmental entrepreneur course, with all students finding it more engaging than a lecture on the subject.
- The game was played during a board meeting of the Devon Resilience Innovation project (<https://www.devon.gov.uk/floodriskmanagement/flood-and-coastal-resilience-innovation-programme-fcrip/>), by 16 members: Charity (4), Environment Agency (2), Local Government (5), Education (1), Environmental Management (1), Research (3). Again, the game was generally well-received, though some concerns were raised about the accuracy of some of the interventions.
- The game was played during the ARSINOE's final general assembly, with around 85 players. Formal feedback was not collected, but the game appeared to be well-received, with several discussions about localising the game.

None of these rounds of playtesting had formal participant selection policies and participants have been split between 'domain experts' and students. Post-play survey results suggest that participants reacted positively to the statement 'I have greater awareness that climate related issues can be viewed from different perspectives' and 'I am more aware that climate interventions may be impacted, or cause impacts beyond their intended scope'.

Also, some reflection on how the games can be transferred to non-coastal realities are recommended

Playing the game at the ARSINOE general assembly revealed some interest in localising the game for Greek participants. Initially, this was a discussion purely about localising the text from English to Greek. From initial inspection, this would not appear to be a huge challenge, as all the text is stored in a spreadsheet that could mechanistically be translated to another language. However, creating meaningful content for the cards proved to be a large, and time-consuming, challenge in the project, in making interesting and informative text fit the area available for it on each card. It's likely that the process of translating the game from English to another language will highlight issues with text size, meaning, and pacing. Some text meanings could vary due to language use, or some options might not

be feasible due to environmental, societal or cultural backgrounds. This would require local experts' help for replicating the gaming experience.

This also raised the issue that if the text could be changed, surely the interventions and personas could also be changed. As the reviewer has stated, the game was developed for a 'British' coastal town with largely British issues, interventions and personas. For a Greek version, or any other version, of the game it is unknown if the British personas relate to local personas.

At this point, there is a lot of value in separating the content and mechanics of the game as the mechanics (the concept of having resilience challenges, interventions, and personas discussing the relative merits of each intervention) are relatively universal, but the actual content is broadly domain specific.

This approach was followed for most of the development process, in that the game content exists as a spreadsheet that is processed to produce the cards as a set of printable images. However, when development moved into its final stages, the printing process was changed to facilitate the production of finalised (pre-cut) cards by a remote provider. For future development and localisation work, the game process can be reverted to the original pipeline.

In terms of creating content for a non-coastal reality, the core challenge is how much drift is there between the current and target reality? It should be relatively straightforward to replace the coastal interventions with non-coastal alternatives and to replace / revise the personas to better fit local stereotype stakeholders. A deeper challenge is with the role of resilience types (financial, flooding, drought, heatwave and biodiversity). If a region doesn't face all those challenges or faces different ones, it impacts the design of the cards, in terms of the risk types on the front of the card. Whilst this is not an insurmountable challenge, it would necessitate re-developing the card generation process. However, this could be undertaken by building the cards from scratch in a graphic design application (PowerPoint, Photoshop, Canva etc).

3.0 CASCADING FAILURE OF CRITICAL SERVICES (CFCS) SERIOUS GAME

This CFCS digital serious game has been designed to show how different critical services are impacted by a flood resulting from a hypothetical extreme weather event, combining an intense rainfall and a storm surge, and how a pseudo town could prepare in order to minimise the loss of services and resulting impact on the population.

3.1 User interface design – information presentation

The game was designed to provide detailed and elaborate information about the unnamed town and how it is impacted by the flood event. From a visual design perspective as indicated in Figure 3.1, the left side of the screen shows the step-by-step guided tour the participant has to go through while the right side of the screen shows results pertaining to cascading failure of critical services and its consequences.

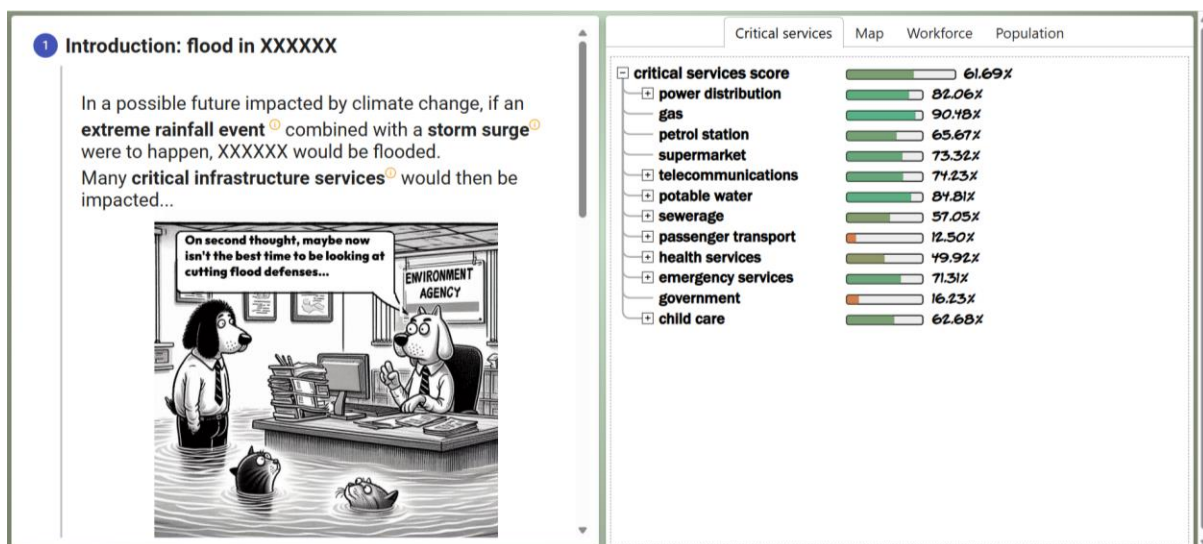


Figure 3.1 Visual design: step by step information package on the left and simulation results on the right

Additional information is displayed when clicking on the info sign after some of the key words in bold (i) – a popup window with text and audio the appears as shown in Figure 3.2.

The step-by-step information package expose participants to preparative knowledge and engage them by inviting them to explore what would happen in some “what if” scenarios. The players can navigate between 12 different sections: 1 introduction, 2 electric grid power service, 3 water service, 4 telecommunications, 5 health services, 6 public transports, 7 emergency services, 8 child-care and schools, 9 government, 10 supermarkets and petrol stations, 11 information about the town communities, and 12, the “put it all together” interactive section.

The “What if” scenarios show what would happen if there were infinite resources and if all directly impacted nodes could be “flood-proof” as opposed to a select few most important ones so as to show that a few selected nodes can have a major impact on limiting service loss . Another couple of boxes are showing how other services can affect the performance of telecommunication. For example, looking at the effects of adding power backups, or what happens if we replace fibre-based internet broadband (that rely on cabinets that can be flooded) for 6g mobile broadband that rely on satellite.

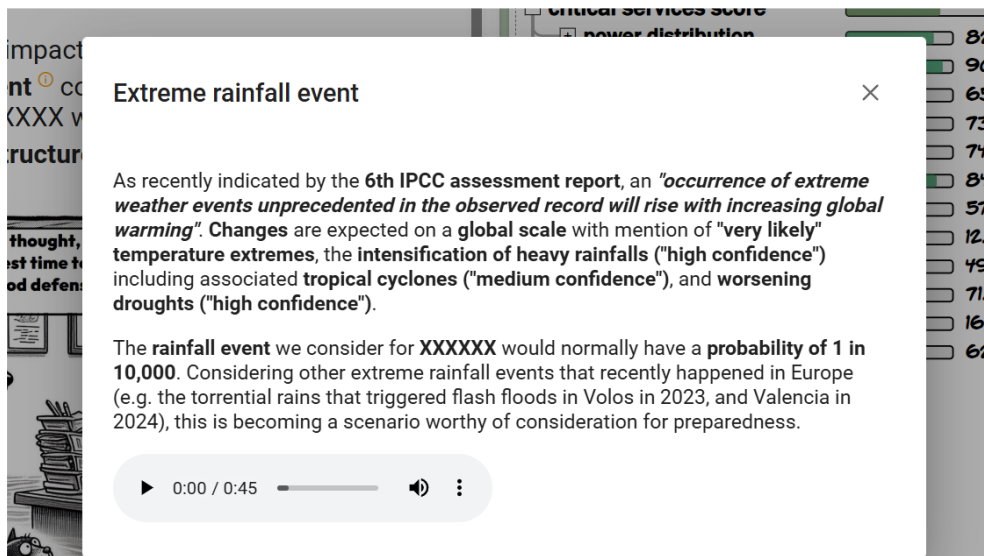


Figure 3.2 Information package: popup window with text and audio when clicking in info sign near key words

4 Telecommunications



Only 7 mobile towers (over a total of 40) and 11 internet broadband fiber cabinets (over a total of 104) would be directly flooded. Nevertheless, the **telecom service would be decreased by about 25% because of indirect effects on power supply availability.**

We estimate that about 7% of the workforce might be unavailable due to other critical services shutting down.

Click to see what would happen if you were able to "flood-proof" and protect a number of the most important nodes in both broadband and mobile telecom.

Protect 8 Protect All Flooded (19) Reset

Click to see what would happen if you were able to add 6 hours power backup (for example, using power generators or batteries) to all nodes in both broadband and mobile telecom.

Power Backup All Reset

Click to see what would happen if you were able to install 6g mobile based internet broadband (where the internet does not depend on fiber cabinets, but on satellite signals) to all gov. offices, bus, train, supermarkets, and petrol stations nodes.

6G internet Reset

← Back Next →

Figure 3.3 Information content and what if scenario for the telecommunications section

3.2 User interface design - simulation results

The goal of the game exposed in the step 12 is simple: increase the critical service score on the top right as much as possible by implementing some combinations of measures to increase preparedness. Figure 3.5 shows all the critical services considered (on the left the short-collapsed version and on the right, the extended version when the user clicks on the different collapsible signs).

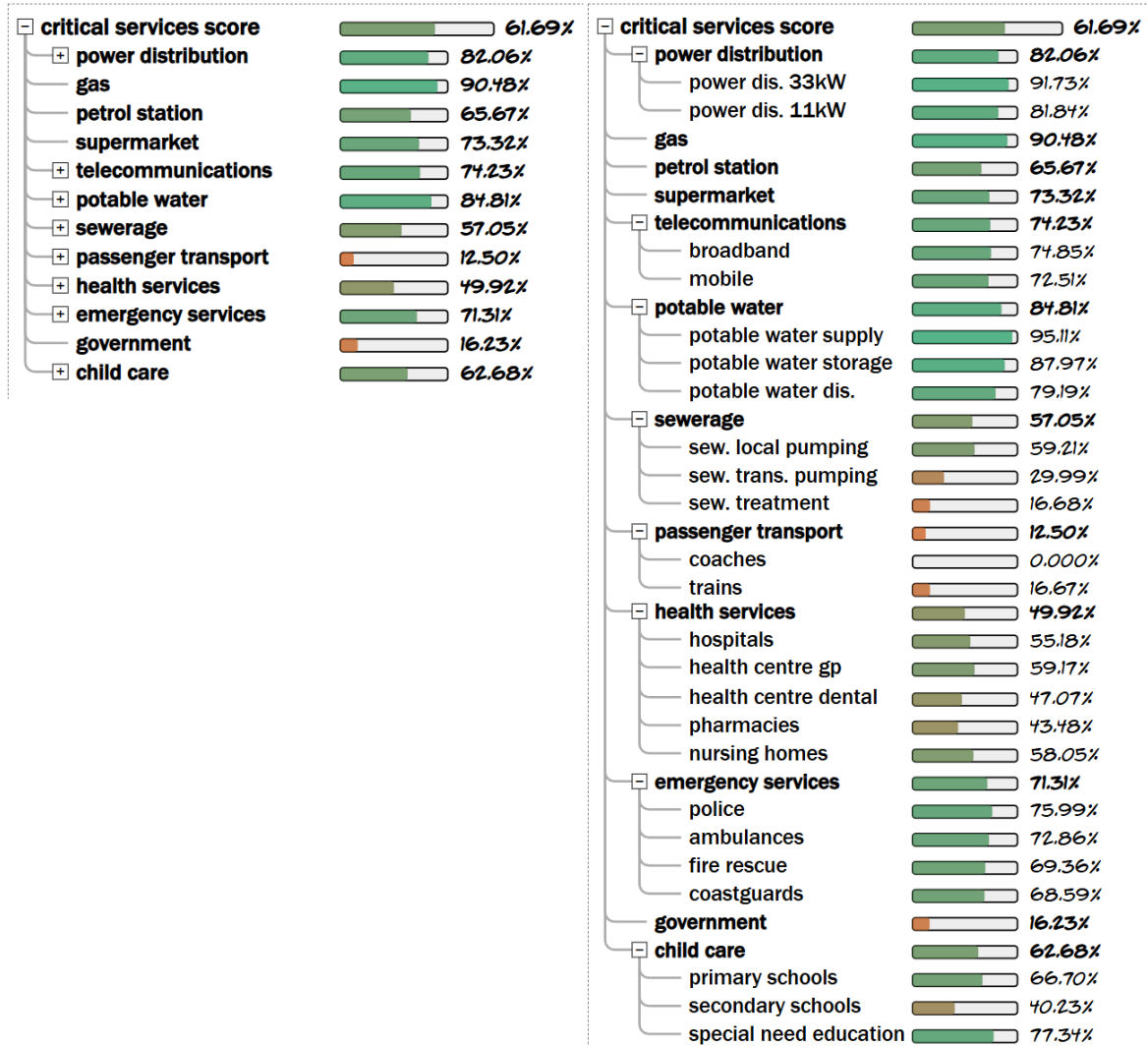


Figure 3.5 Short versus detailed version of the status of services scores visible on the right side of the screen as simulation results after the initial flood.

Another three tabs can be selected to show respectively the zoomable map with services per area as well as floodprint, the workforce availability per type of industry after the flood (Figure 3.6) and the impact on the vulnerable parts of the population (Figure 3.7).

Critical services	Map	Workforce	Population
Workforce availability per industry			
A : Agriculture forestry and fishing		386.3 / 407.7 (94.7%)	
C : Manufacturing		1195.0 / 1300.8 (91.9%)	
D : Electricity gas steam and air conditioning supply		94.9 / 101.5 (93.5%)	
E : Water supply; sewerage waste management and remediation activities		91.5 / 99.8 (91.7%)	
F : Construction		4560.6 / 4896.0 (93.1%)	
G : Wholesale and retail trade; repair of motor vehicles and motorcycles		6064.9 / 6542.0 (92.7%)	
H : Transportation and storage		1166.4 / 1241.0 (94.0%)	

Figure 3.6 Simulation results about workforce availability per industry for the area considered

Critical services	Map	Workforce	Population
Stats and data about the effects on the population			
workforce not driving car or van having problem with train service		26,624	
workforce not driving car or van having problem with bus service		26,624	
vulnerable residents having problem with general health/dentistry services		6,785	
vulnerable residents having problem with hospital services		6,785	
vulnerable residents having problem with ambulances service		6,785	
vulnerable residents having problem with pharmacy service		6,785	
vulnerable residents having problem with power service		6,785	
vulnerable residents having problem with water service		4,709	

Figure 3.7 Simulation results how many residents (grouped into different categories) are impacted by the loss of critical services

3.3 Interactive part where players “put it all together”

After having gone through 11 preparation steps, the users are finally invited to explore combinations of measures to increase preparedness and minimise the critical services losses that would normally occur after the flood.

The participants can (as shown in Figure 3.8):

1. allocate limited resources to "flood-proof" up to 30 critical infrastructure nodes,
2. install backup batteries/power generators in up to 10 nodes of their choice,
3. install backup paper filing systems for patient files in all pharmacies, GP surgeries, and dentist surgeries,
4. install 6g internet broadband (using satellites) in all the government offices, bus stations, train services, supermarkets, and petrol stations
5. install backup water cisterns in up to 20 nodes of their choice (primary schools, secondary schools, special need education, hospitals)

Note that participants can save and load different combinations of measures taken, leaving them free to explore and reuse past solutions in order to find what could look like the most promising solution.

Allocate limited resources to "flood-proof" infrastructure nodes

Types of service nodes **0/30**

Power distribution	—	0	+
Water & sewerage	—	0	+
Broadband fiber cabinets	—	0	+
Mobile towers	—	0	+
Gov. offices	—	0	+
Bus transportation	—	0	+
Train services	—	0	+
Hospitals	—	0	+
GP surgeries	—	0	+
Dentist surgeries	—	0	+
Pharmacies	—	0	+
Nursing homes	—	0	+
Supermarkets	—	0	+
Petrol stations	—	0	+
Primary Schools	—	0	+
Secondary Schools	—	0	+
Special Needs Education	—	0	+

Allocate limited resources to install 6-hours backup power generators or batteries for infrastructure nodes

Types of service nodes **0/10**

Water & sewerage	—	0	+
Broadband fiber cabinets	—	0	+
Mobile towers	—	0	+
Gov. offices	—	0	+
Bus transportation	—	0	+
Train services	—	0	+
GP surgeries	—	0	+
Dentist surgeries	—	0	+
Pharmacies	—	0	+
Nursing homes	—	0	+
Supermarkets	—	0	+
Petrol stations	—	0	+

Allocate limited resources to install backup paper filing systems for patient files (does not consume significant resources)

Install paper backup filing systems

GP surgeries ☐

Dental surgeries ☐

Pharmacies ☐

Allocate limited resources to install backup potable water cisterns for infrastructure nodes

Types of service nodes **0/10**

Hospitals	—	0	+
Dental surgeries	—	0	+
Nursing homes	—	0	+
Primary Schools	—	0	+
Secondary Schools	—	0	+
Special Needs Education	—	0	+

Install 6g internet broadband (using satellites) in all the gov. office, bus stations, train services, supermarkets, and petrol stations

Types of service nodes **Install 6g internet broadband**

Gov. offices ☐

Bus transportation ☐

Train services ☐

Supermarkets ☐

Petrol stations ☐

Figure 3.8 The User Interface allowing participants to take different combinations of measures using limited resources

3.4 CFCS Summary

3.4.1 Initial Summary

Through CFCS, for the first time, participants are able to evaluate the direct and indirect consequences of an extreme flood event by looking at the simulated impacts of the cascading failure of critical infrastructure services. Participants are then able to implement measures combining different sectors to decrease the loss of service and increase preparedness.

The game allows participants to locate which services are particularly impacted by a given event and evaluate how much of the loss of service is due to direct damage (e.g. flood) and how much loss is due to indirect damages (e.g. a un-flooded node can be affected because of the loss of needed services to function) showing interdependencies between sectors, which strengthens the awareness on resources prioritisation - how protecting a small number of chosen critical nodes can significantly minimise the loss across sectors in other services due to the knock-on effects. The CFCS highlights the impact on different areas, what groups of residents are affected, and how many of them have a limited access to services they need (e.g. working parents of young children that do not have access to the “primary education” service in their area) – opening the doors to setting resources aside to support these groups during a flooding event. The CFCS demonstrates how, despite limited resources, protective measures engaging across different interdependent services can lead to significantly better outcomes compared to vast resources engaging in an isolated service.

3.4.2 Post-review summary

However, there is no lesson learnt on the implementation of the second serious game. Is there no evaluation of the game? If there is, please provide some results on the evaluation as it was done for the first case.

A trial of the CFCS game involved a small number of internal members for testing. It was found, despite the CFCS could highlight how the cascading failure could affect the community, modifications are required to create multiple gaming stages, each with a clear objective to help participants understanding specific climate resilience knowledge.

There is no evaluation of the CFCS game; has anyone played? Do you have results on its usefulness?

The game underwent a single round of playtesting, with warm contacts from the university. Anecdotal feedback was positive, but there was no formal feedback collected. The game

Figure 3.6 – workforce availability per industry, the last line is cut; can it be adjusted? In general figures are hard to read. Can the resolution be improved?

This figure captures a scrolling window in the game application. The data is:

A : Agriculture forestry and fishing	407.7 / 407.7 (100.0%)
C : Manufacturing	1300.8 / 1300.8 (100.0%)
D : Electricity gas steam and air conditioning supply	101.5 / 101.5 (100.0%)
E : Water supply; sewerage waste management and remediation activities	99.8 / 99.8 (100.0%)
F : Construction	4896.0 / 4896.0 (100.0%)
G : Wholesale and retail trade; repair of motor vehicles and motorcycles	6542.0 / 6542.0 (100.0%)

H : Transportation and storage	1241.0 / 1241.0 (100.0%)
I : Accommodation and food service activities	6243.3 / 6243.3 (100.0%)
J : Information and communication	692.3 / 692.3 (100.0%)
K : Financial and insurance activities	156.3 / 156.3 (100.0%)
L : Real estate activities	548.1 / 548.1 (100.0%)
M : Professional scientific and technical activities	2666.5 / 2666.5 (100.0%)
N : Administrative and support service activities	2508.7 / 2508.7 (100.0%)
O : Public administration and defence; compulsory social security	1010.8 / 1010.8 (100.0%)
P : Education	5616.8 / 5616.8 (100.0%)
Q : Human health and social work activities	8319.8 / 8319.8 (100.0%)
R : Arts entertainment and recreation	886.7 / 886.7 (100.0%)
S : Other service activities	544.1 / 544.1 (100.0%)
33150 : Repair and maintenance of ships and boats	1.0 / 1.0 (100.0%)
351 : Electric power generation transmission and distribution	91.7 / 91.7 (100.0%)
35130 : Distribution of electricity	91.7 / 91.7 (100.0%)
352 : Manufacture of gas; distribution of gaseous fuels through mains	9.7 / 9.7 (100.0%)
36 : Water collection treatment and supply	3.6 / 3.6 (100.0%)
37 : Sewerage	3.9 / 3.9 (100.0%)
38 : Waste collection treatment and disposal activities; materials recovery	90.4 / 90.4 (100.0%)
38110 : Collection of non-hazardous waste	76.6 / 76.6 (100.0%)
38210 : Treatment and disposal of non-hazardous waste	13.7 / 13.7 (100.0%)
421 : Construction of roads and railways	19.1 / 19.1 (100.0%)
42110 : Construction of roads and motorways	19.1 / 19.1 (100.0%)
43210 : Electrical installation	467.9 / 467.9 (100.0%)
43220 : Plumbing heat and air-conditioning installation	354.5 / 354.5 (100.0%)
4520 : Maintenance and repair of motor vehicles	433.9 / 433.9 (100.0%)
472 : Retail sale of food beverages and tobacco in specialised stores	66.5 / 66.5 (100.0%)
4773 : Dispensing chemist in specialised stores	206.4 / 206.4 (100.0%)
491 : Passenger rail transport interurban	65.2 / 65.2 (100.0%)
4931 : Urban and suburban passenger land transport	74.0 / 74.0 (100.0%)
494 : Freight transport by road and removal services	3.5 / 3.5 (100.0%)
4941 : Freight transport by road	2.0 / 2.0 (100.0%)
5010 : Sea and coastal passenger water transport	22.9 / 22.9 (100.0%)
61 : Telecommunications	108.5 / 108.5 (100.0%)
619 : Other telecommunications activities	91.7 / 91.7 (100.0%)

841 : Administration of the State and the economic and social policy of the community	278.3 / 278.3 (100.0%)
8411 : General public administration activities	185.1 / 185.1 (100.0%)
842 : Provision of services to the community as a whole	576.1 / 576.1 (100.0%)
8424 : Public order and safety activities	456.3 / 456.3 (100.0%)
8425 : Fire service activities	105.1 / 105.1 (100.0%)
843 : Compulsory social security activities	189.3 / 189.3 (100.0%)
8430 : Compulsory social security activities	189.3 / 189.3 (100.0%)
8510 : Pre-primary education	73.6 / 73.6 (100.0%)
8520 : Primary education	3283.5 / 3283.5 (100.0%)
8531 : General secondary education	1198.2 / 1198.2 (100.0%)
86101 : Hospital activities	964.3 / 964.3 (100.0%)
86102 : Medical nursing home activities	420.1 / 420.1 (100.0%)
86210 : General medical practice activities	668.5 / 668.5 (100.0%)
86220 : Specialist medical practice activities	20.7 / 20.7 (100.0%)
86230 : Dental practice activities	291.7 / 291.7 (100.0%)
8710 : Residential nursing care activities	884.4 / 884.4 (100.0%)
8720 : Residential care activities for learning disabilities mental health and substance abuse	864.1 / 864.1 (100.0%)
8730 : Residential care activities for the elderly and disabled	947.5 / 947.5 (100.0%)
8810 : Social work activities without accommodation for the elderly and disabled	511.6 / 511.6 (100.0%)
8891 : Child day-care activities	

4.0 CONCLUSIONS

This report demonstrates the development of the two serious games, the ATSG, a multi-player, interactive tool designed to facilitate discussions on climate and economic consensus building, and the CFCS that illustrates how to combine protection measures over different infrastructure services to improve preparedness to a flood event in an unnamed coastal town. The games are able to simulate complex scenarios in an engaging and entertaining way. This method of engagement creates an interactive environment for people to learn and test different strategies without making mistakes and then having the real-world consequences. The games also act as a tool to encourage collaboration, enabling participants to have potentially difficult conversations but in a playful and 'safe' setting.

The ATSG successfully engages participants and creates an experience that facilitates discussions around climate and economic consensus building. It is designed as an icebreaker and provides a safe space for players to explore town-scale resilience interventions through the lens of clichéd personas. The playtesting demonstrated the game's effectiveness, with participants providing positive feedback. The game leverages macroeconomic modelling by using a STEEPLE strategic planning framework that assesses the external factors impacting operations to create plausible interventions, allowing players to see the impact of both single interventions and their combined impact on reducing five resilience challenges.

The CFCS game enables participants to evaluate the direct and indirect consequences of an extreme flood event by looking at the simulated impacts of the cascading failure of critical infrastructure services. They can then implement cross-sector measures to reduce service disruptions and enhance preparedness. The game enables participants to identify which services most affected by a given event and determine whether service loss is due to direct damage or due to indirect impacts, which shows the sector interdependencies. CFCS enhances awareness of resource prioritisation by optimising the protection strategies to significantly reduce losses across multiple sectors through knock-on effects. Finally, the game demonstrates how, despite limited resources, protective measures engaging across different interdependent services can lead to significantly better outcomes compared to vast resources engaging in an isolated service.



This project has received funding from the European Union's Horizon H2020 innovation action programme under grant agreement 101037424.