Horizon 2020 Societal challenge 5
Climate action, environment, resource
Efficiency and raw materials

REPORT ON THE APPLICATION OF THE SERIOUS GAME FOR SECONDARY AND UNIVERSITY EDUCATION AND FOR SUPPORTING DECISION MAKING, FOR CIVIL SOCIETY/RAISING AWARENESS AMONG CITIZENS

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement NO 689150 SIM4NEXUS

PROJECT	Sustainable Integrated Management FOR the NEXUS of water-land-food-energy-climate for a resource-efficient Europe (SIM4NEXUS)
PROJECT NUMBER	689150
TYPE OF FUNDING	RIA
DELIVERABLE	5.8 Report on the applications of the serious game for education, supporting decision making
WP NAME/WP NUMBER	WP name / WP number
TASK	Task 5.3
VERSION	0.1
DISSEMINATION LEVEL	Public
DATE	18/11/2020 (Date of this version) – 30/06/2020 (Due date)
LEAD BENEFICIARY	Partner acronym
RESPONSIBLE AUTHOR	Mehdi Khoury
ESTIMATED WORK EFFORT	
AUTHOR(S)	Mehdi Khoury (University of Exeter)
ESTIMATED WORK EFFORT FOR EACH CONTRIBUTOR	
DOCUMENT HISTORY	

VERSION	INITIALS/NAME	DATE	COMMENTS-DESCRIPTION OF ACTIONS
2			

ADDRESSING REVISION COMMENTS	
COMMENT	RESPONSE
DELIVERABLE NAME SHOULD BE CHANGED TO THE ONE IN THE GA (COVER PAGE AND PG 2) "REPORT ON THE APPLICATION OF THE SERIOUS GAME FOR SECONDARY AND UNIVERSITY EDUCATION AND FOR SUPPORTING DECISION	DELIVERABLE NAME CHANGED AS SPECIFIED.

MAKING, FOR CIVIL SOCIETY/RAISING AWARENESS AMONG CITIZENS “. IF THE SERIOUS GAME HAS NOT BEEN APPLIED FOR RAISING AWARENESS AMONG CITIZENS/CIVIL SOCIETY THIS SHOULD BE MENTIONED AND JUSTIFIED UNDER CHANGES WITH RESPECT TO THE DOA.	
EXECUTIVE SUMMARY: PLEASE INCLUDE THE KEY CONCLUSIONS AND RECOMMENDATIONS, FROM SECTION 5	KEY RECOMMENDATIONS HAVE BEEN ADDED.
THE COMPLEMENTARITY OF THIS DELIVERABLE AND D5.9 MUST BE CLEARLY MENTIONED IN THE SUMMARY, THE SUMMARY SHOULD ALSO REFER TO THE D5.9.	ADDED TO EXECUTIVE SUMMARY THE FOLLOWING: “THIS DELIVERABLE IS COMPLEMENTARY TO DELIVERABLE D5.9 “PRACTICAL GUIDANCE ON THE APPLICATION OF SERIOUS GAME IN PARTICIPATORY PROCESSES UNDER REAL LIFE CONDITIONS".”
IT IS NOT CLEAR WHY THE INFORMATION INCLUDED IN SECTION 2 IS CONSIDERED AS VALID ONLY FOR A “NONSPECIALIZED AUDIENCE”. AT THE OPPOSITE, THE INFORMATION IS CERTAINLY THE BASIS FOR ANY TYPE OF AUDIENCE. IT IS SUGGESTED TO DEFINE THIS SECTION AS GAME DESIGN FOR EDUCATION AND AWARENESS CREATION, VALID FOR ANY TYPE OF AUDIENCE, AND WITHOUT REFERRING TO A “NON-SPECIALIZED AUDIENCE”.	ANY MENTION OF “NON-SPECIALIZED AUDIENCE” HAS BEEN DELETED AND REPLACED BY “GENERAL AUDIENCE”. SIMILARLY THE FOLLOWING: “WHEN FACING A NON-SPECIALISED AUDIENCE, EMPHASIS WAS PLACED ON…” WAS REPLACED BY: “FOR THE PURPOSE OF EDUCATION AND AWARENESS CREATION SUITABLE FOR ANY TYPE OF AUDIENCE, EMPHASIS WAS PLACED ON… “
STUDENTS SEEM TO BE CONSIDERED AS A NONSPECIALIZED AUDIENCE, WHICH IS DISTURBING.	REPLACED : “ THE SIM4NEXUS SERIOUS GAME WAS SUCCESSFULLY USED WITH THREE TYPES OF AUDIENCES: STUDENTS AND MEMBERS OF THE PUBLIC, SCIENTISTS AND ENGINEERS, AND POLICY MAKERS.” BY : “THE SIM4NEXUS SERIOUS GAME WAS SUCCESSFULLY USED WITH THREE TYPES OF AUDIENCES: THE GENERAL PUBLIC, STUDENTS AND SCIENTISTS, AND POLICY MAKERS.”
SECTIONS 3 AND 4 ARE A SHORT COLLECTION OF EXAMPLES OF LEARNING WHICH ARE TOO OBVIOUS TO BE CONVINCING. FOR EXAMPLE, THE FACT THAT WATER IS NEEDED TO CLEAN SOLAR PANELS IS PROBABLY NOT AN UNEXPECTED BEHAVIOUR FOR ENGINEERS AND SCIENTISTS. MORE ADVANCED EXAMPLES WOULD BE NEEDED TO JUSTIFY THE USE OF THE SERIOUS GAME.	SECTION 3.2 TITLE HAS BEEN CHANGED TO “SHOWING NEW WAYS TO COMPARE POLICIES ACROSS DOMAINS”. A MORE ADVANCED EXAMPLE HAS BEEN ADDED, AS WELL AS TWO EXTRA FIGURES.“
SECTION 5 CONCLUSIONS AND RECOMMENDATIONS: THIS IS RATHER SHORT, PLEASE ELABORATE EG ON SOME OF THE CONCLUSIONS/RECOMMENDATIONS “THE NEXT LOGICAL STEP WOULD BE TO EXTEND THE USE OF THIS TYPE OF TOOL TO TRAIN STUDENTS, MEMBERS OF THE PUBLIC, SCIENTISTS, AND POLICY MAKERS TO AVOID SILO THINKING WHEN	THE RECOMMENDATION SECTION HAS BEEN EXTENDED TO ELABORATE ON THOSE POINTS.

TRYING TO "SAVE" THE NEXUS." AND "BEYOND THINKING OF NEW CROSS-SECTORIAL SOLUTIONS, ANOTHER INTERESTING ASPECT OF THIS TYPE OF TOOL IS THAT IS LENDS ITSELF TO TEACH HOW TO REACT TO DIFFERENT PROJECTED SITUATIONS, IN A WAY SURGEONS OR A PILOTS LEARN TO FACE EMERGENCIES."	
INTRODUCTION: "STUDENTS AND MEMBERS OF THE PUBLIC,": DO YOU REFER TO THE GENERAL PUBLIC/ CITIZENS?	CLARIFIED IN THE FOLLOWING SENTENCE: "THE SIM4NEXUS SERIOUS GAME WAS SUCCESSFULLY USED WITH THREE TYPES OF AUDIENCES: THE GENERAL PUBLIC, STUDENTS AND SCIENTISTS, AND POLICY MAKERS"
FIGURE 7 & 8 CAPTIONS "COMPOSITION OF GREENHOUSE GAS" IS NOT CORRECTLY FORMULATED? IT REFERS ACTUALLY TO THE SOURCES OF THE GREENHOUSE GAS EMISSIONS? PLEASE CORRECT.	CHANGED "COMPOSITION" WITH "SOURCES" IN BOTH CAPTIONS.
EDITORIAL CHANGES: COVER PAGE: PLEASE REMOVE "XXXXX PERSON-MONTHS" NEXT TO ESTIMATED WORK EFFORT FOR EACH CONTRIBUTOR	REMOVED.
EDITORIAL CHANGES: TABLE OF CONTENTS: EXPLORATORY AND FINAL PHASE (NOW 2.1.1 AND 2.1.2) SHOULD NOT BE UNDER INTRODUCTORY PHASE?	CORRECTED AS RESPECTIVELY, INTRODUCTORY PHASE 2.1 , EXPLORATORY PHASE 2.2 AND FINAL PHASE 2.3.
EDITORIAL CHANGES: PG 7 - COMPLETE THE REFERENCES (EG. KHOURY ET AL. – MISSING YEAR AND REFERENCE).	REPLACED "KHOURY ET AL" BY "(KHOURY ET AL. 2018) [1]" REFERENCE.

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Executive summary

The Sim4Nexus Serious Game has achieved its primary educational goal: making the complex subject of the Nexus interactions between Water, Energy, Land, Food, and Climate accessible to a general audience.
A secondary aim was also reached regarding the capacity of the system to allow transparent and detailed analysis of the System Dynamic Model behind the Nexus for each case study to be useable as scientific/engineering exploration tool.
Finally, the ability to experiment with different combinations of policy cards and compare their effects in different contexts gives the Serious Game the ability to train policy makers and make them find a cross-sectorial solutions to the Nexus problems.
The next logical step would be to extend the use of this type of tool to train members of the public, students and scientists, businesses, and policy makers to consider the consequences across multiple nexus domains of decisions.
Beyond thinking of new cross-sectorial solutions, another interesting aspect of this type of tool is that is lends itself to teach how to react to different projected situations, in a way surgeons or a pilots learn to face emergencies. Most experts that have to deal with emergencies learn to build a checklist of observable events and associate it with actions that minimise damage or cascading failure. Developing a Serious Game with this approach in mind would be give decision makers a training in nexus resilience.
This type of tool has made it possible to gather people online, and allow them to compare their own strategies with others. This suggest that there is value in creating repositories of Serious Games possible solutions to different problems so as create a culture of exposure to constructive criticism and therefore more robust decisions making.
This deliverable is complementary to deliverable D5.9 “Practical guidance on the application of serious game in participatory processes under real life conditions".

Changes with respect to the DoA

A two weeks delay was allowed due to the fact several games were developed, and we needed to wait for the system dynamic modelling teams to finish some of the late case studies in order to finish the latest games and then write the report.

Dissemination and uptake

This deliverable is aimed at the Commission.

Short Summary of results (<250 words)

The SIM4NEXUS Serious Game has made the complex subject of the Nexus interactions between Water, Energy, Land, Food, and Climate accessible to a general audience. It has also allowed scientists and engineers to analyse in depth the behaviours of the System Dynamic Models behind different case studies and push further the boundaries of their understanding of the concept of Nexus. Finally, it has the potential to train policy makers to learn about cross-sectorial approaches and acquire a more informed way to practice decision making.

Evidence of accomplishment

See playable game on Sim4nexus web site at
https://www.sim4nexus.eu/page.php?wert=SeriousGame

1 Introduction

The Sim4nexus Serious Game was successfully used with three types of audiences: the general public, students and scientists, and policy makers. In all three instances, the goals of each session were quite different.

For the purpose of education and awareness creation suitable for any type of audience, emphasis was placed on confirming or rejecting general hypotheses related to the subject of the Nexus while exploring how a case study would react to some applied policies.

When facing scientists and engineers, the game tools allowed the identification of expected Nexus behaviours, the discovery of unexpected cross sectorial dependencies, and the exploration of multi-optimisation problems related to the Nexus.

Finally, policy makers were able to analyse the geographic particularities, weaknesses and strengths of each region, find suitable policies for different case studies, and experiment with combinations of policies.

This report is structured in four subsequent Chapters as follows:

Chapter 2 describes the general design of the game as intended for a general audience.

Chapter 3 shows additional game design aspects that make the game useful for scientists and engineers.

Chapter 4 shows additional game design aspects that make the game useful for policy makers.

Chapter 5 contains the conclusions and recommendations.

2 Description of overall Game design-applicable to a general audience

The primary aim of the game is for the user to explore the effects of applying different combinations of policies on the Nexus health. The Nexus health is the amalgamation of five different health scores corresponding to the five areas of the Nexus: water, energy, land, food, and climate.

The secondary aim is to discover optimal combinations of measures that lead to best outcomes in the context of problems posed in game through a set of questions. These questions aim at exploring the issues and specifics of each case study. Some of these issues can involve additional optimisation goals such as cost minimisation.

During the initialisation of the game, a facilitator presents the general game goals and provides contextual information regarding the case study, as well as explanations regarding how to use the interface, as well as technical concepts such as the metrics used to compute the Nexus health score.

Although the game can be played as a single player experience, several participants can play it in parallel in the same room. Communication between participants is not compulsory, but is encouraged so that they can freely discuss their choice with their neighbours when answering questions.

The user interface makes use of ground-breaking design techniques and sophisticated visualisation technology in order give users the ability to visualise and understand the behaviour of the Nexus, a socio-technical-environmental system with a significant level of complexity that involve tens of thousands of interacting variables.

Performance feedback during gameplay is quasi-instant as the player is immediately informed of the consequences of his actions as cost and outcomes are computed and returned in the next second after pressing the “next turn” button by a System Dynamic Model running on a distant server.

Progress monitoring, as well the “capability of saving game results for follow up analysis” is provided as the user can switch back any time to a high score ranking table where combinations of measures made by different users can be reviewed and discussed.

Game portability is fairly good as the game can be played online from any laptop or desktop with a chrome web browser and a working internet connection.

In order address the problem highlighted by the action research and fulfill our aim to help participants to explore and understand complex scientific models, the game flow is designed using three steps as shown in Figure 1 – this design is similar to the Millbrook Serious Game developed in (Khoury et al. 2018) [1].

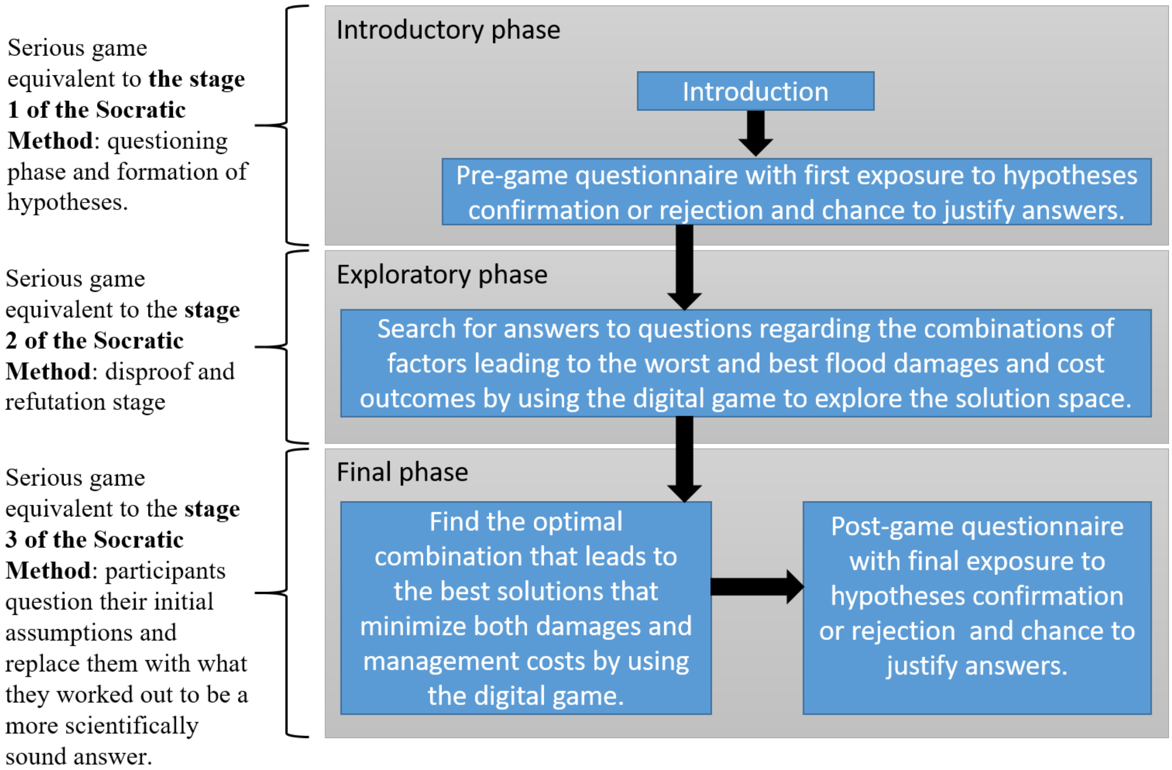


Figure 1. Three parts of the Serious Game process

2.1 The introductory phase

Participants are given a general introduction about the case study, and then asked to fill in a pre-game questionnaire in which they need to confirm or validate different hypotheses, for the following reasons:

- The evaluation of any eventual cognitive change brought about by the Serious Game. This allows us to understand the pre-game state of the initial participants' views on the case study specific problems. This includes possible pre-formed opinions (perception of the truth) on what would be the best possible decisions to achieve the balance between nexus health and cost.
- It alerts participants to the crucial questions that they need to keep in mind while they improve their understanding of the problem, and therefore helps them to consolidate memories on technical issues, and to validate or reject hypotheses at the end of their investigative work.
- It creates a Serious Game equivalent of the questioning phase of the Socratic Method. The only difference is that instead of it emerging naturally through dialogue, the hypotheses are artificially created by the mix of introductory materials and the pre-game questionnaire.

2.2 The exploratory phase

During the exploratory phase of the game, players must survey the space of possible solutions and answer questions e.g. "What is the combination of measures that leads to the best Water health score?" The next two questions focuses on finding combinations leading to outcomes with the lowest and highest associated management costs. The last question is about finding an optimal solution that minimizes both flood and cost. During this phase, the digital game provides the players with the freedom to apply their own management decisions. It gives them feedback under the form of simulation results, which they can use to check the validity of the given hypotheses.
The use of compulsory ordered questions is essential because:

- It reduces an overwhelmingly large combination of solutions into a manageable list of five tasks that are essentially guiding participants' explorations of the different solution scenarios.
- It forces participants to answer questions where the solutions shown by the game might contradict what they initially thought were the best decision, hence targeting preconceptions. This corresponds to the Serious Game equivalent of the disproof and refutation stage of the Socratic method.

2.3 The final phase

Finally, in the third phase, players are asked to capitalize on the previous explorative work by finding the solutions that minimizes both damages and management costs. They then have to fill in the post-game questionnaire and apply inductive reasoning from the data revealed by their exploratory work to reject or confirm the presented hypotheses. Note that players can justify each answer in their questionnaire, giving them the opportunity to reach the Serious Game equivalent of the third step of the Socratic Method, namely to question their initial assumptions ("perception of the truth") and replace them with what they worked out to be a more scientifically sound answer ("the truth").

3 A Serious Game for scientists/engineers

The Sim4nexus serious game features for each case study a complex model with interactions between variables belonging to different sectors. As a scientist or an engineer using the Serious Game, there is an interest in studying how the Nexus Model reacts. The Serious Game can provide the following insights for scientists or engineers:

- Finding expected behaviours related to one's field of expertise
- Discovering new ways to compare policies mostly due to way cross domain interactions are visualised
- Finding valuable innovative solutions to the multi-optimisation problems present in the Nexus

3.1 Identifying known Nexus behaviours

If a participant is an expert in the land-use or the water domain, he might expect the Serious Game to reproduce results consistent the expected behaviour of known examples of land-use or water systems. The game provide tools that allow to identify such behaviours.

The result view allows the user to spot variations in the energy demand for example. These variations can be seen over decades as shown in Figure 2 where one sees an overall decrease in household/commercial energy demand and a fairly stable situation for agricultural energy demand.

Figure 2. Showing variations over 40 years.

Via the zoom functionality, seasonal changes can also be observed as shown in Figure 3 where one can see that in the Greek region of the Peloponese, agricultural energy demand picks between June and July while household/commercial energy demand picks between September and October.

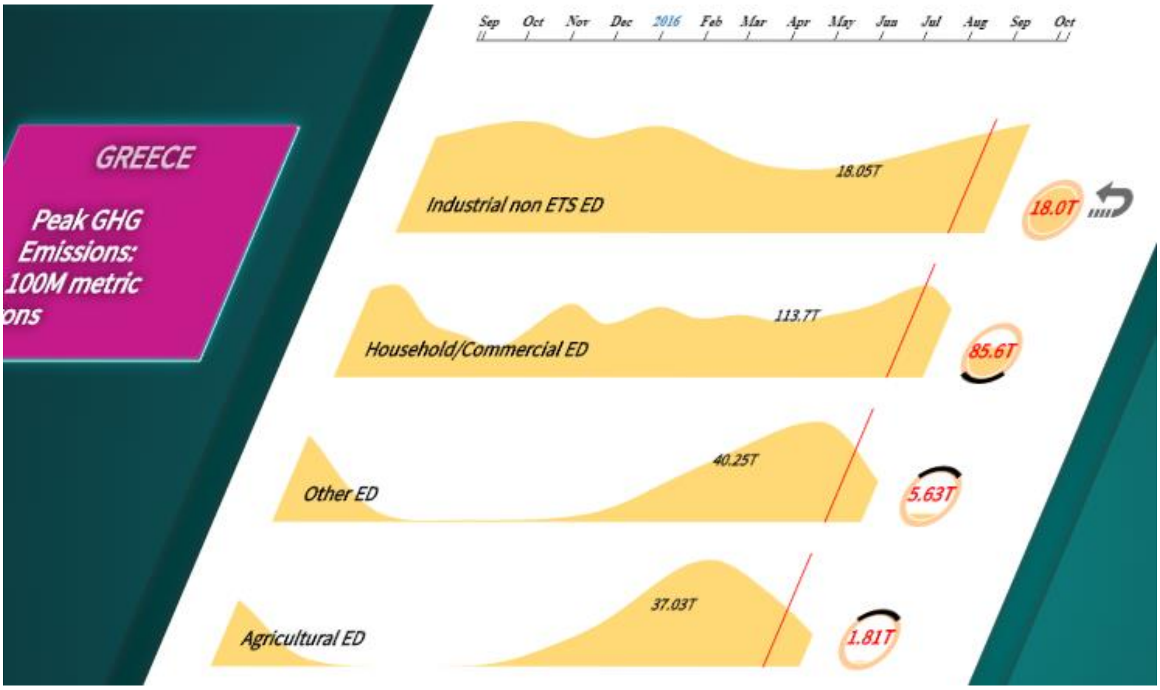


Figure 3. Showing seasonal variations.

The overview of the Nexus health scores per sector through time also allows a comparison between business as usual and the regular and continuous application of a certain type of policy.
For example in the Latvian case study, growing energy crops such as rapeseed increase the welfare of agricultural activity. Nevertheless, as profitable as they may be, first generation energy crops such as rapeseed release a lot of nitrogen and negatively impact the quality of water.

Therefore, as shown in Figure 4, the health scores for land-use that take into account agricultural welfare will increase while growing energy crops (period where rapeseed policy cards are applied from 2025 to 2035) while the quality of water will decrease. Inversely, as soon as the rapeseed crops end, as expected, the health scores for land-use that take into account agricultural welfare will decrease while the quality of water will increase.

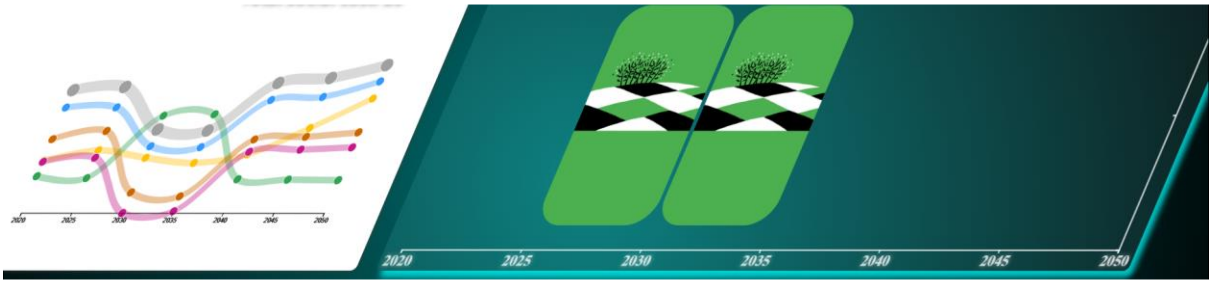
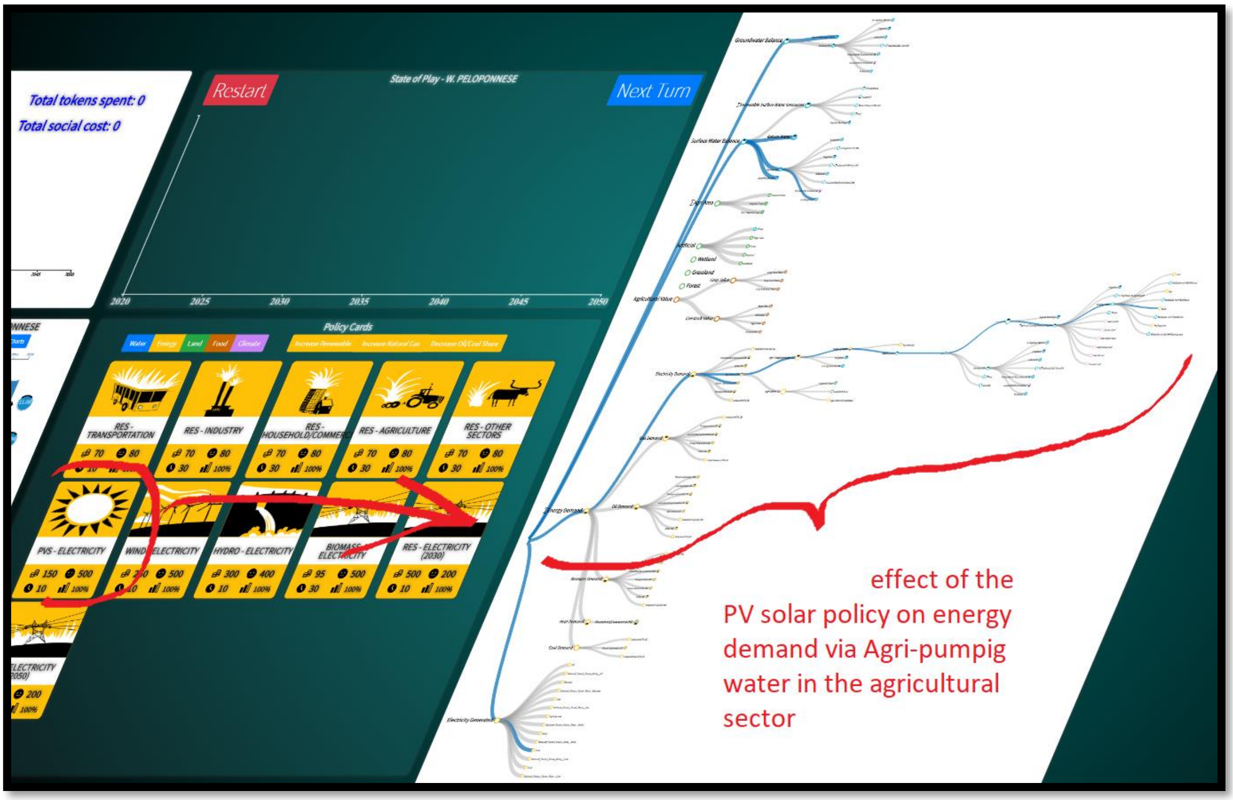


Figure 4. Showing how the application of the rapeseed energy crops policy card decreases the Nexus water health score by impacting water quality and increases the Nexus land health score resulting from the welfare of agricultural activity.

Similarly, as shown in Figure 5, in the Greek case study, the policy card that increase electricity generation from photo voltaic cells to have a direct impact on Energy demand in the agricultural sector. One of the best way to expose the relationships between variables is to look at the hierarchical tree. When clicking on a given policy card, one might see links to more variables belonging to more sectors than anticipated.



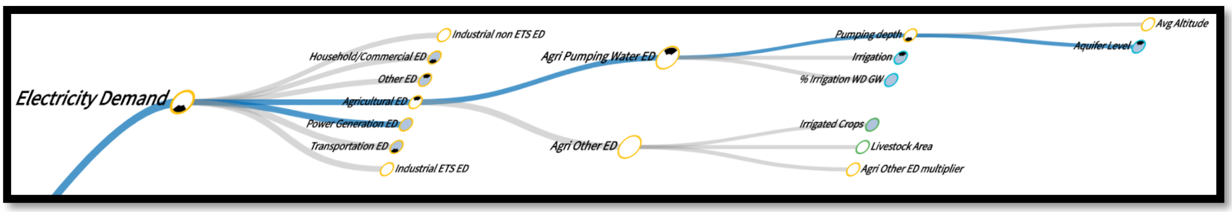


Figure 5. At the top (a) is the overview of the trail of variables in the Nexus impacted by the policy card “PV solar”. At the bottom (b) is a closer view showing that the usage of photovoltaic cells exerts a strain of energy demand in the agricultural sector via the pumping of water from the aquifer levels – washing solar panels require an abundant quantity of water.

In this instance, as shown, the usage of photovoltaic cells exerts a strain of energy demand in the agricultural sector via the pumping of water from the aquifer levels. This is because washing solar panels require an abundant quantity of water.

3.2 Showing new ways to compare policies across domains

We are going to compare two groups of policies by running alternative scenarios in the Serious Game. In scenario A, we apply a group of two policies. One is about saving water in all households by establishing water saving equipment (e.g. smart tap) and changing consumption behaviour. The other one is to promote the reuse of recycled water in the industrial sector.

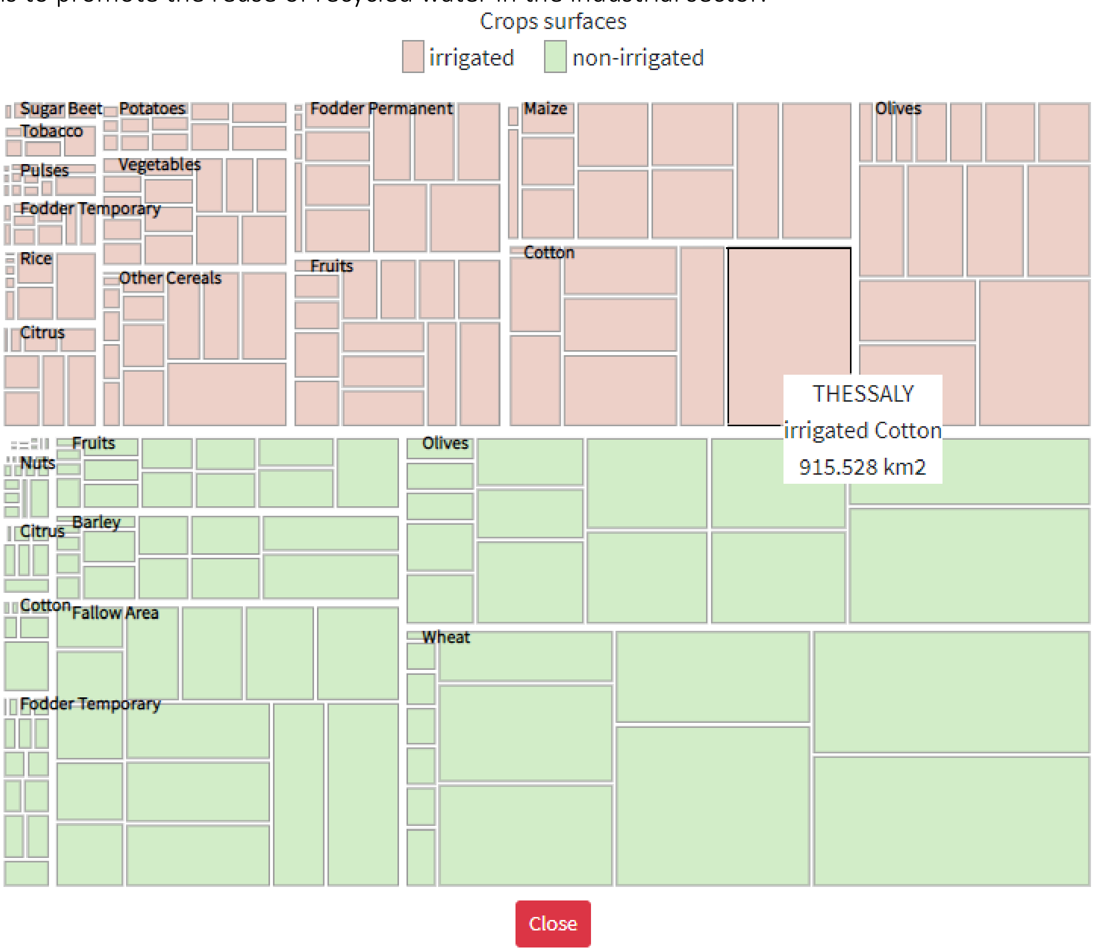


Figure 6. Interface showing the distribution of irrigated and non-irrigated surfaces by types of crops for each region of Greece. The mouse hovering over a given square gives of the region. Here, Thessaly is the region with the largest cotton surface.

In scenario B, we only apply one water saving policy that swaps a single irrigated crop (cotton) for a non-irrigated one (citrus). Note that we can only convert up to a maximum of 10000 hectares of the existing cotton crops per region. The crop interface shown in Figure 6 shows that the region with the greatest surface of cotton is Thessaly. We want to test the following hypothesis : scenario A leads to a better nexus water health score expressing the sustainable management of water resources, a lower peak water stress, and a lower energy demand than scenario B.

We test that hypothesis by first applying scenario A and B only in the region of Thessaly, and then to the whole country. Results show that our hypothesis is rejected by the model. In fact, the opposite happens. Game results shown in figure 7 reveal that swapping a single irrigated crop (cotton) for a non-irrigated one (citrus) leads to a better nexus water health score expressing the sustainable management of water resources, and a lower peak water stress and energy demand than applying combined household and industrial water saving policies.

Applying water saving policies in all households and promoting water reuse in the whole industrial sector

Changing irrigated Cotton crops for non-irrigated Citrus crops (up to a maximum of 10000 ha per region of existing cotton)

Reflecting policy goal PG1-W : "Sustainable management of water resources"

Policies only applied to Thessaly

Peak water stress:	**53%**	**51%**
Regional nexus Water health score:	**54.89%**	**56.82%**
Peak energy demand in July	**1.590 TWh**	**1.584 TWh**

Policies applied to all of Greece

Peak water stress:	**32%**	**31%**
National nexus Water health score:	**79.06%**	**79.81%**
Peak energy demand in July	**31.06 TWh**	**31.03 TWh**

Figure 7. The output of the game shows that swapping a single irrigated crop (cotton) for a non-irrigated one (citrus) leads to a better nexus water health score expressing the sustainable management of water resources, and a lower peak water stress and energy demand (in July) than applying 2 policies combining general household and industrial water saving policies.

3.3 Finding novel solutions to the multi-optimisation problems present in the Nexus

There are many different problems to optimise. At first, participants can be asked to maximise the Water Nexus health score for example, by applying all sorts of policy cards from different sectors until they find the best combination. They can then be asked to do the same for each area of the Nexus. Then, then can explore if they can find the best combination of policy cards that would optimise two areas of the Nexus at the same time, and then all of them.
Maximising the Nexus heath scores can then be combined with minimising the amount of resources spent (number of tokens and social cost).

The large choice of policy cards, as well as the fact that some policies counter-act against each other while others complete and enhance other policies to magnify the resulting combined effect means that there are many possibilities to explore.

4 A Serious Game for policy makers

Unlike scientists or engineers, policy makers might be less interested in studying the behaviour of the model in detail, and more likely to explore the best combinations of policies that would maximise Nexus health for a given area with limited resources. For this type of user, the game needs to firstly provide an overview of the strengths and weaknesses of the region studied, and then allow the discovery of how some policies are more suitable than others for solving the problem at end, and finally compare the merits of different combinations of policies.

4.1 Providing an overview of the weaknesses and strengths of the region studied

In a case study where there are several regions, this is especially important. One would want to identify outliers among the regions i.e. which one produce the most greenhouse gas. Then one would want to identify specific needs among them i.e. what areas might suffer from water scarcity.
In the Greek case study, the strategic map shown in Figure 6 allows to identify the two regions that emit the most greenhouse gas: Attica, and Western Macedonia.

Figure 6. Strategic map showing the regions with the most greenhouse gas emission.

The analytic view shows in Figure 7a for Western Macedonia that most emissions are fuel emissions. When clicking on those, we can observe in Figure 7b that 93.6% of these are ETS emissions.

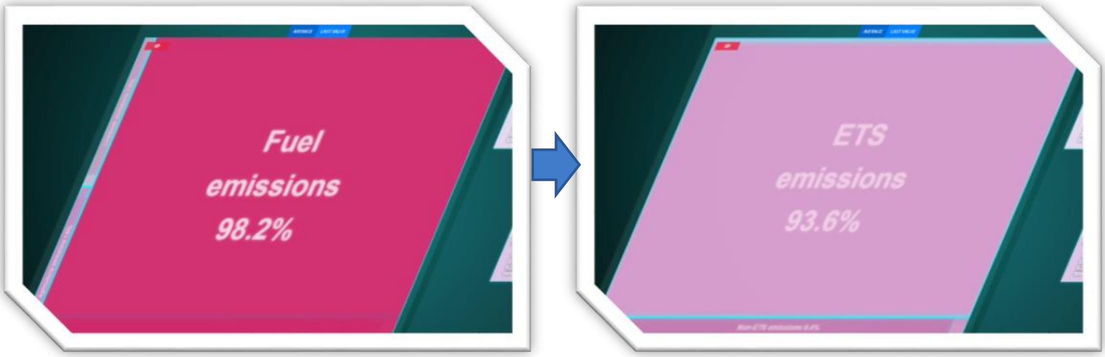


Figure 7. Analytic view showing the sources of greenhouse gas for Western Macedonia: global view on the left (a) shows they are mostly fuel emissions. When clicking on those (b), the majority of fuel emissions are ETS emissions.

The analytic view shows in Figure 8a for Attica that most emissions are fuel emissions. When clicking on those, we can observe in Figure 8b that 78.1% of these are ETS emissions.

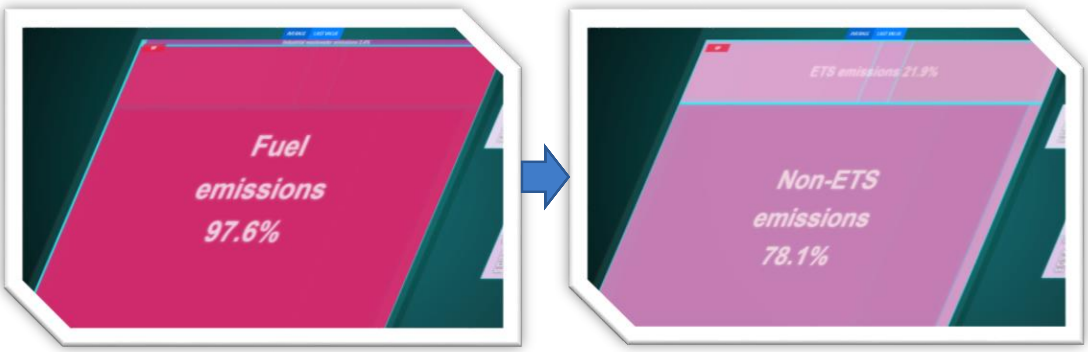


Figure 8. Analytic view showing the sources of greenhouse gas for Attica: global view on the left (a) shows they are mostly fuel emissions. When clicking on those (b), the majority of fuel emissions are Non-ETS emissions.

This shows that applying ETS emissions related policy cards will have a profound impact on Western Macedonia, while non-ETS emissions related policy cards will have a greater effect on Attica. See Figure 9 shows examples of climate policy cards applicable in that instance.

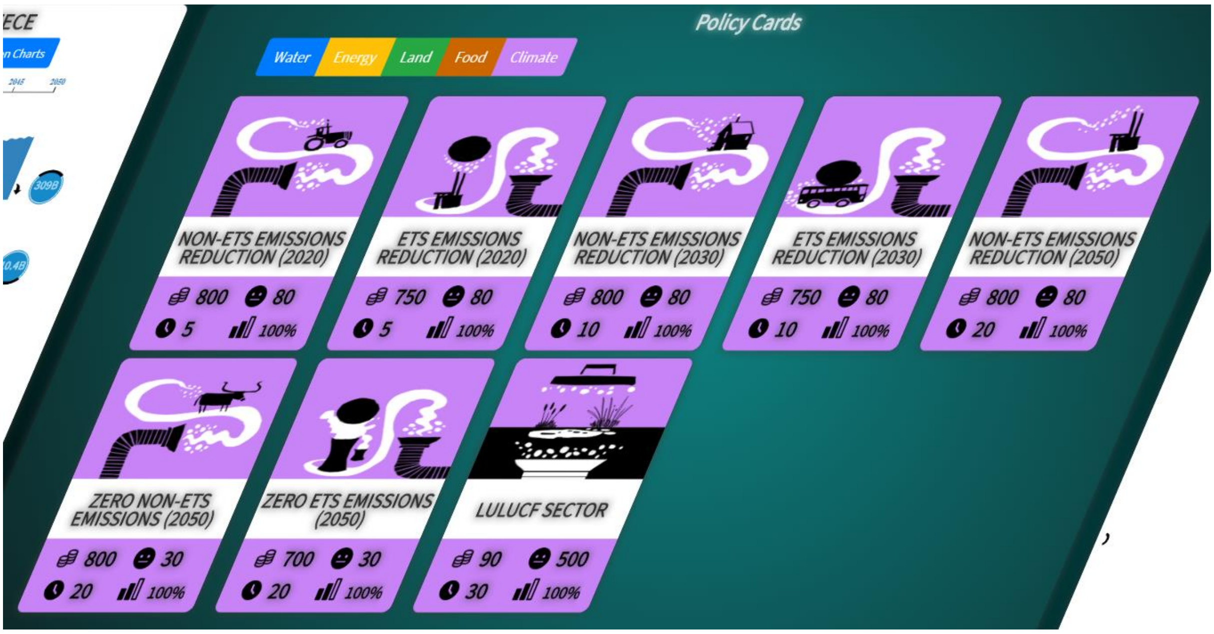
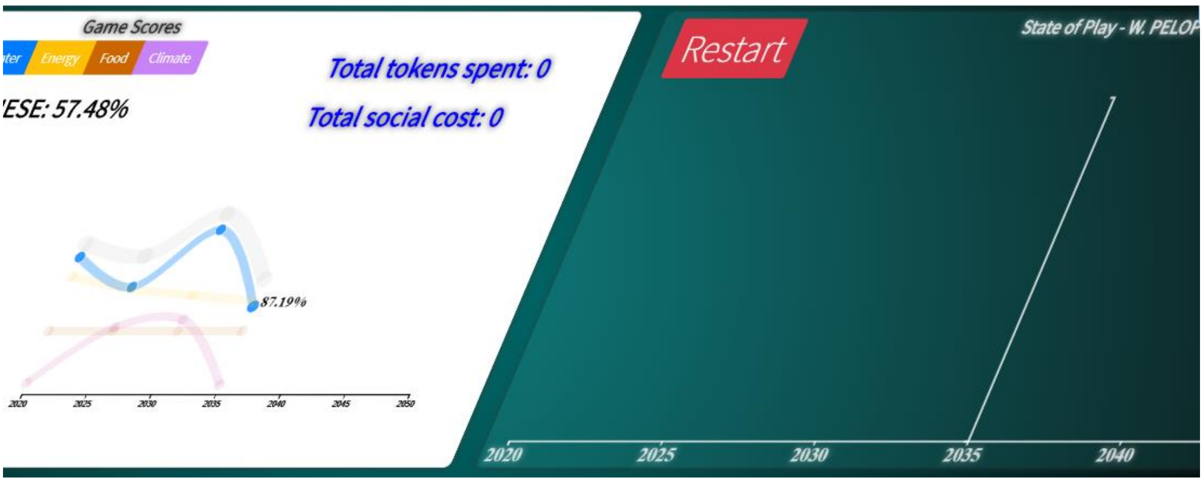


Figure 9. Example of ETS and non-ETS policy cards from the climate sector.

4.2 Finding policies suitable for the peculiarities of the case study

In the case of the Greek case study, water scarcity is paramount, while in the Latvian case study water quality is the only relevant problem. Policy makers that would apply energy policy cards such as increase in Solar generation and increase in Hydroelectric generation would notice that the Nexus Water health for Western Macedonia in Greece would decrease due to the resulting effects on the amount of surface water available (see Figure 10).



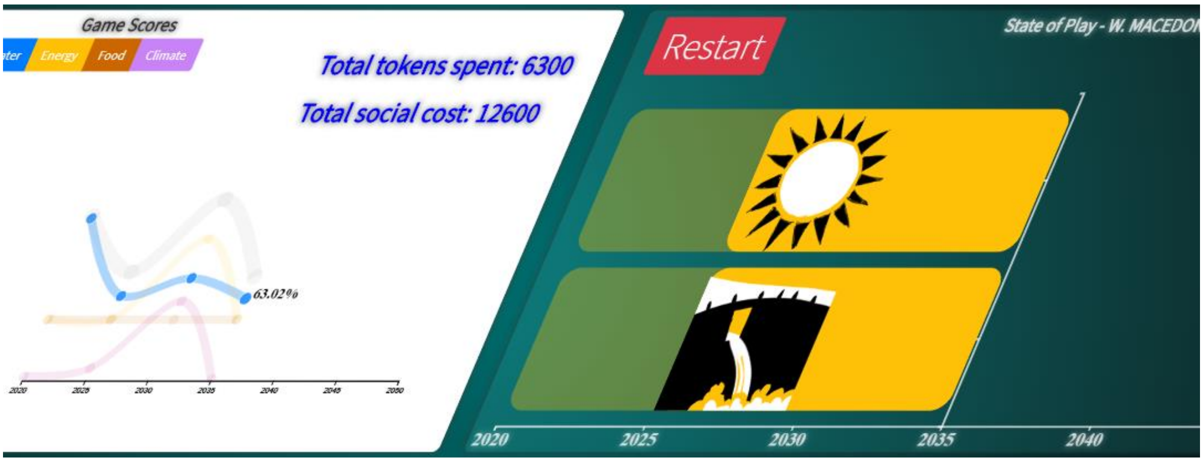
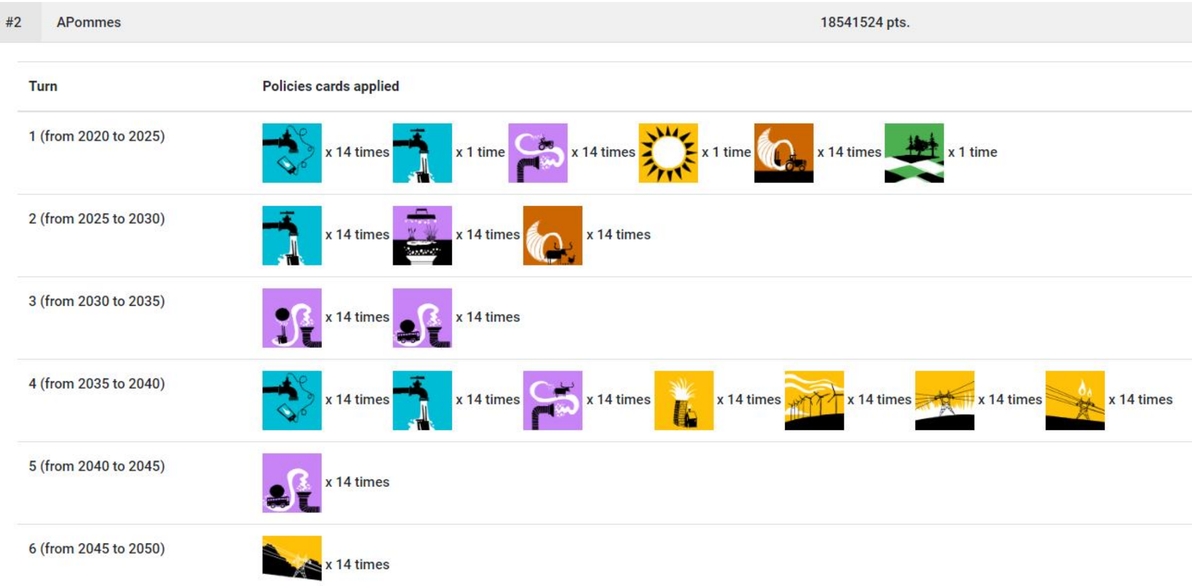


Figure 10. At the top (a) is the Water Nexus health score in a business as usual situation (87.19%). At the bottom (b) is the Water Nexus health score (63.02%) after applying policies that increase Solar and Hydroelectric energy generation. Clearly, water stress is increased when water scarcity is a significant problem.

Applying similar energy policies would have no impact on the Latvian case study, because water scarcity is not an issue for Latvia. The Nexus water health score would only take into account problems of water quality.

4.3 Comparing the merits of different combinations of policies

Many different combinations of policies can be applied in each round of the game resulting in different Nexus health scores as well as different levels of use of available resources. A ranking board of all played game is available to compare how different combinations of policies led to better of worst results and encourage discussion between policy makers (see Figure 11).



#2 APommes 18541524 pts.

Turn	Policies cards applied
1 (from 2020 to 2025)	x 14 times, x 1 time, x 14 times, x 1 time, x 14 times, x 1 time
2 (from 2025 to 2030)	x 14 times, x 14 times, x 14 times
3 (from 2030 to 2035)	x 14 times, x 14 times
4 (from 2035 to 2040)	x 14 times, x 14 times, x 14 times, x 14 times, x 14 times, x 14 times, x 14 times
5 (from 2040 to 2045)	x 14 times
6 (from 2045 to 2050)	x 14 times

Figure 11. Extract of the ranking table for Greece. It shows the combinations of policies that were applied each round and that led to the second best score.

5 Conclusions and recommendations

The Sim4Nexus Serious Game has achieved its primary goal: making the complex subject of the Nexus interactions between Water, Energy, Land, Food, and Climate accessible to a general audience. It is also useable as a scientific/engineering exploration tool allowing the transparent and detailed analysis of the System Dynamic Model behind the Nexus for each case study. Finally, the ability to experiment with different combinations of policy cards and compare their effects in different contexts makes Sim4Nexus a highly innovative tool to help policy makers to learn about cross-sectorial approaches to solve the Nexus problems.

The next logical step would be to extend the use of this type of tool to train members of the public, students and scientists, businesses, and policy makers to avoid silo thinking when trying to "save" the Nexus. For example, return on investment might seem poor in the water sector compared to the energy sector, but if given a chance to explore the overall cross-sectorial benefits of water related policies, the added value of the investment might be end up being greater than anticipated for the whole nexus. Links between water and exergy could be explored to show tremendous benefits at the system level i.e. just recycling the traces of Aluminium found in the domestic wastewater that comes daily to the entrance of a water treatment plant for a town of 100 000 inhabitants can save energy that would normally be spent mining it and refining the same amount of metal. The amount of energy that could potentially be saved for this town just by recycling that aluminium would the equivalent of 3290 electric cars driving 100 kms each daily.

Beyond thinking of new cross-sectorial solutions, another interesting aspect of this type of tool is that is lends itself to teach how to react to different projected situations, in a way surgeons or a pilots learn to face emergencies. Most experts that have to deal with emergencies learn to build a checklist of observable events and associate it with actions that minimise damage or cascading failure. Developing a Serious Game with this approach in mind would be give decision makers a training in nexus resilience.

Finally, this tool has made possible to gather people online, and allow them to compare their own strategies with others. This suggest that there is value in creating repositories of Serious Games possible solutions to different problems so as create a culture of exposure to constructive criticism and therefore more robust decisions making.

6 References

[1] Khoury, M.; Gibson, M.J.; Savic, D.; Chen, A.S.; Vamvakeridou-Lyroudia, L.; Langford, H.; Wigley, S. A Serious Game Designed to Explore and Understand the Complexities of Flood Mitigation Options in Urban–Rural Catchments. Water 2018, 10, 1885.