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Debating Solutions to Water Contamination: a Role-Play game

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Contents

Abstract

The Joint Research Centre (JRC) Water Laboratory has worked with the Education for Climate Coalition to develop a role-play game on debating solutions to water quality contamination. The starting point and context for the game was provided by real water quality data collected as part of "The Gems of Water" citizen engagement initiative. The initiative, launched in 2021, in collaboration with the United Nations Environment Programme (UNEP), seeks to engage citizens in the collection of chemical water quality data particularly on pesticide presence. This report shares the structure of the role-play game, which was developed according to the frameworks set out by the participatory democracy principles of the Council of Europe, the Water Framework Directive and the European Green Deal. The report furthermore discusses its potential development as part of an environment-focused curriculum, using results and lessons learnt from a first trial conducted at the high school Liceo Classico Cairoli in Varese, Italy, in November 2024.

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1 Introduction

The report presents a unique role-play exercise designed to engage students (aged 16-18 years) in a debate to find solutions to water quality contamination issues. Inspired by the Model United Nations[1], and based on the principles of participatory democracy laid out by the Council of Europe[2], this exercise aims to foster critical thinking, public speaking, and debating skills while promoting awareness of environmental issues, in particular on water, and the role of science in policy-making. While this report presents a prototype of the role-play, the project long-term development aims at creating a game that can be easily reproduced in high schools around Europe.

1.1 Context

The focus on water quality as fundamental for a healthy and thriving society and ecosystem has its foundation in the Water Framework Directive, which, since 2000, seeks to ensure good quality and quantity of water resources in Europe, and reduce and remove pollution. In more recent years, beyond Europe and the European Union Water Wise campaign, water has been at the centre of various international initiatives, including the UN Water conference hosted in New York in 2023. Those initiatives highlight that promoting new approaches to water protection is urgent. In Europe, this has gained relevance through the Zero Pollution Action Plan and the Farm-to-Fork Strategy proposed by the European Commission in 2019 as part of the New European Green Deal[3]. The two commitments, among others, highlight the link between water quality and the European food system, proposing a substantial reduction in the use of pesticides.

The importance of public participation in the implementation of the Water Framework Directive, and, broader, in the collection of global water quality data for a worldwide assessment of the status of surface water quality is being recognized both by the European Union and the United Nations. The scientific, societal and policy value of citizen science was expressed in the European Commission Staff Working Document on Best Practices in Citizen Science for Environmental Monitoring (Centre of Expertise for Good Governance 2020). Additionally, the participation of society as a whole in water science should adopt the Quintuple Helix concept (Figure 1), which states that only through engagement of the different sectors of education, public sector, industry, civil society, and the natural environment an innovative and sustainable innovation water governance can be achieved (Gawlik et al. 2018).

[1] United Nations. Model United Nations https://www.un.org/en/mun

[2] Council of Europe. About participatory democracy https://www.coe.int/en/web/participatory-democracy/about-participatory-democracy

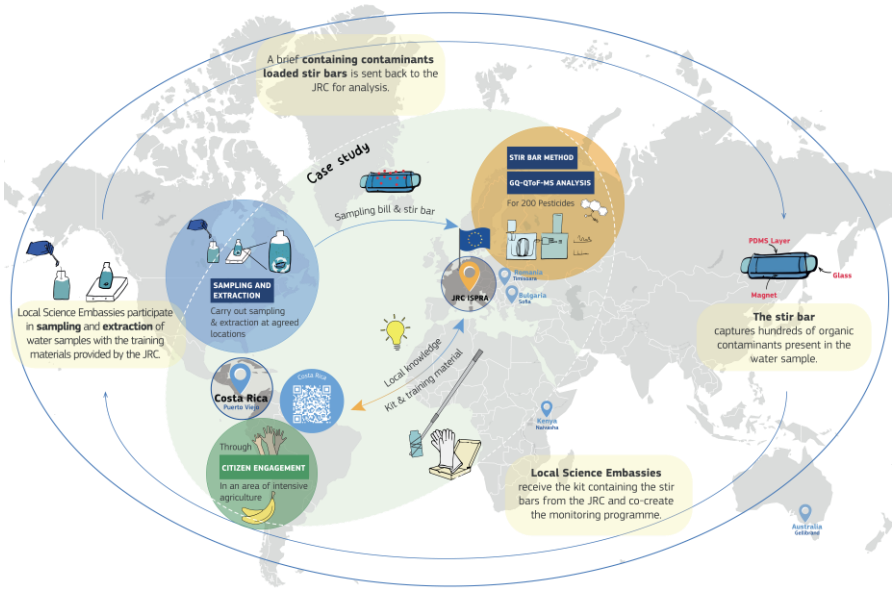
[3] European Commission. The European Green Deal https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

Figure 1. Graphical abstract exemplifying the Quintuple Helix concept

Source: Concept by Cacciatori C., design by Casado T.

In this space of conjunction between water quality and citizen engagement, starting from 2022, "The Gems of Water" activity was initiated at the JRC Water Laboratory in collaboration with the United Nations Environment Program (UNEP). "The Gems of Water" engages citizens in monitoring pesticides in surface water quality, using a wide-screening technique, called the Stir Bar Sorptive Extraction (SBSE). Through a collaborative co-creation process, local communities identify water quality concerns, co-define sampling locations, and, after receiving instructions and equipments, participate in sample collection and extraction using the stir bar method (Figure 2). The samples are then sent back to the JRC Water Laboratory, where advanced analysis allows for the identification and quantification of up to 400 pesticides. Figure 2 presents "The Gems of Water" workflow at the pilot in Costa Rica, with the QR Code linking to additional information.

Figure 2. Graphical map of "The Gems of Water" framework



Source: Concept by Cacciatori C., design by Casado T.

The activity has been successfully implemented in pilot projects in Romania, Bulgaria, Kenya, Costa Rica and Australia and the campaigns results are showcased and publicly accessible on the JRC website[4]. The data collected and openly shared not only represent an additional source of information on local water quality and pesticide pollution, but they can also be easily turned into educational material, given the user-friendly nature of the platform on which they are shared. The water quality data collected through "The Gems of Water" initiative have been used to develop a role-play game on finding solutions to water quality contamination. The role-play game offers the JRC an opportunity to share scientific data beyond traditional communication strategies, promoting the role of the JRC as an independent provider of science-based evidence for policy at the European level. The JRC Water Laboratory contributes to participatory science methods for water quality science, open science and science literacy.

1.2 Development and meaning of the role-play

Starting from a "The Gems of Water" case study from Costa Rica, the role-play game, described in this report, is designed to involve students (16-18 years old) to debate solutions for water contamination by by pesticides. In a 2-hour long exercise, the students, in 5 groups, take on various interest groups roles, including policymakers, farmers, citizens, scientific advisors and representatives of the pesticide industry. After familiarizing themselves with the local water quality context and with the assigned roles, students groups participate in a round table discussion, where they share their concerns and expectations and propose solutions to water contamination. The structure of the role-play game was developed in line with the recommendations on participation of citizens in local public life by the Council of Europe and it was modified based on advice received by the Education for Climate Coalition of the European Commission and the Participatory Democracy team of the JRC. The recommendations are based on the idea that decisions taken collectively and through civic participation contribute to increased trust between parties involved and policy makers, promote well-functioning democracy, and improved policy uptake (Centre of Expertise for Good Governance 2020).

Various are the learning objectives of the role-play for students involved. Through the game, students understand the complexity of environmental contamination issues and the potential consequences of water contamination by pesticides for local communities, the environment and the economy. By defending and clarifying the positions and roles assumed during the game, students learn to navigate and communicate the complexity of environmental problems and propose actionable solutions to water contamination. While practicing debating and public speaking skills, students work together towards a satisfactory compromise for different interest groups. Therefore, engagement in such an active-learning exercise, based on real-life challenges, can help students develop skills in data literacy, increase their awareness of environmental and water quality issues, and understand the importance of science in policymaking. The game provides a valuable platform to practice public speaking and debating and to develop communication skills. The context of the institutional framework brings the students closer to the concept of participatory democracy as a desirable decision-making process for policy. Moreover, the role-play provides teachers with real case studies and scientific data that could feed civic and environmental education curricula, without requiring additional preparation, but rather providing a starting point for future discussions on

[4] EU Science HUB. "The Gems of Water" https://joint-research-centre.ec.europa.eu/scientific-activities-z/gems-water-engaging-citizens-monitor-water-quality_en

multiple topics, such as participatory democracy, environmental protection, policymaking, and citizen science.

This initiative has the potential to be expanded to other topics, challenges and groups, paving the way for a society open to discussing complex issues, that may need complex solutions. By promoting participatory democracy, science literacy, and critical thinking, this role-play exercise can contribute to a society with more informed and engaged citizens, equipped to address the challenges of the 21st century.

1.3 Structure of the report

In Chapter 2, the report presents the preparation and structure of the role-play game. Playing material is attached in the Annexes. Chapter 3 describes a trial conducted at the Liceo Classico Cairoli in Varese in November 2024. It also summarizes lessons learnt, recommendations and potential expansion for further development of the role-play material. The report targets scientists interested in alternative ways of sharing their work and contributing to open-science and data literacy. Educators, and stakeholders of the education sector, can find in the report an example of how real environmental science case studies can be introduced in their courses and curricula.

2 Role-play for debating solutions to water contamination

The prototype presented in this report is based on data collected in Costa Rica through the citizen engagement activity "The Gems of Water". The role-play game is designed for students between 16 and 18 years old and it is set to take around 2 hours. The structure below describes the different parts of the game with an indication of the time required for each activity.

2.1 Role-play structure

1. Introduction to "The Gems of Water" case study findings in Costa Rica (ca. 15 min)
2. Familiarization with the roles (ca. 15 min)
3. Pitches (ca. 15 min)
4. Proposal of solutions (ca. 10 min)
5. Exercise 1,2-All the interest group (ca. 20 min)
6. Open discussion (ca. 20 min)
7. Debrief and feedback (ca. 15 min)

2.1.1 "The Gems of Water" findings in Costa Rica

The role-play game presented in this report is based on data collected in the case study in Costa Rica through the citizen engagement activity "The Gems of Water"[5]. In Costa Rica, the JRC Water Laboratory worked together with the Costa Rican NGO Coral Conservation to screen for pesticides in local rivers using the Stir Bar Sorptive Extraction (SBSE) and a wide-screening technology (Cacciatori et al. 2024). Citizens collected and extracted samples, using SBSE, from three rivers and two wells in the Caribbean area of Costa Rica, known for export-based banana agriculture. The advanced wide-screening method provided by the JRC Water Laboratory enabled the assessment of 230 agrochemicals in the water samples. The study collected new data on pesticide occurrence and toxicity in the local tropical environment, complementing on-going studies in the region. The study found 23 pesticides, most of which are fungicides registered for use in banana cultivation (i.e., azoxystrobin, difenoconazole, fluopyram, thiabendazole). The highest number of pesticides and cumulative pesticide concentrations were detected in the samples collected in the lower part of the rivers Carbon and Sixaola, surrounded by banana plantations. Similarly, at the sampling sites along the Carbon River and in the lower catchment of the Sixaola River, compounds fenamiphos, fenpropathrin and azoxystrobin were the main responsible for the elevated toxic units (Toxic Units > 0.01) for crustacean daphnia magna. Toxic Units are a method used to assess the risk of chemicals and chemical mixtures in environmental samples.

Based on the results of "The Gems of Water" case study, the presence of several pesticides and their potential toxicity for the local environment, in particular at sites located nearby banana plantations, students are asked to discuss and propose solutions to reduce the harmful effect of pesticides on the local environment and to reduce pesticide use in the area.

[5] Joint Research Centre. The Gems of Water x Coral Conservation https://web.jrc.ec.europa.eu/dashboard/embed/GOW_CR/index.html

2.1.2 Familiarization with the roles

Once the context and case study has been provided, the class is divided into five groups, each representing an interest group. The five groups are farmers, the pesticide industry, citizens, policy makers and advisors. The students have ca. 15 minutes to read the role descriptions, which include the point of view of the interest group they represent. The role descriptions are reported as simple text in Box 1 below, and their game presentation in Annex 1. While the role descriptions provide a starting point, students are invited to use their own imagination and additional information to enrich and strengthen their reasoning and opinions. Each group representing farmers, the pesticides industry and citizens are asked to prepare a max. 3 minutes pitch, which will be presented to the policy-makers. The group representing policy-makers are also asked to prepare a speech explaining what they hope to achieve during the round-table discussion. In the meantime, the advisors familiarize themselves with their role and with solution cards (Table 1, Annex 3). After the pitches, the advisors will share the different solutions, keeping in mind that they have free choice of whether to lean towards one or more solutions or to be neutral towards them. There is no correct number of solutions to be proposed, but advisors should be ready to justify their choice.

Box 1. Roles descriptions for the interests groups of the round table

Farmers: Representing farmers who cultivate bananas along the catchment of the Sixaola and Carbon River. The scientific news on contamination linked to the use of pesticides in farming practices is alerting for them, as they have been using some of the detected compounds. The farmers' primary need is to continue growing bananas at high productivity for the export market and to protect the plants from a wide-spread fungus that attacks bananas, called *black Sigatoka*. The pesticides they are applying and the methods of application (with a light aircraft – weekly) (Brühl et al. 2023) have been working well so far. Farmers are generally dubious and have reservations about biological alternatives and their efficacy.

Pesticide industry: Reading the news, the pesticide industry is concerned that the Costa Rican government might become stricter on pesticide use, affecting the sales of major pesticides producing companies, which in the country are going very well, as Costa Rica ranks amongst the highest in pesticide use per hectare worldwide (23.4 kg/he) (FAO 2022). Chemical pesticides have played an essential role in protecting crops from fungal infection, they are selective, easy to apply and safe for consumers and the environment, contributing to supplying food for the growing world population. The pesticide industry is well aware of the length and investment (9 years, 150 million dollars)[6] required for developing and registering a new pesticide. The outcomes of the round table are worrying as they might affect the market share and the sales.

Citizens: Citizens living in the area of Puerto Viejo, Costa Rica, have been involved with a local NGO in a water quality monitoring campaign and found some contaminants in the Sixaola and Carbon river. Their results, and other independent research have shown that pesticides might be linked to toxic effects on the ecosystem. Costa Rica is known to have one of the richest biodiversity on the planet and coral reefs in the area might be affected by river pesticides runoff (Brühl et al. 2023). Citizens are worried about the risk that water quality pollution represents to human health and the environment.

Policy-makers: Policy-makers receive information on recent scientific evidence indicating pesticides contamination in the Sixaola and Carbon rivers in the area of Puerto Viejo, Costa Rica. They know that

[6] Royal Society of Organic Chemistry. Organic Chttps://www.rsc.org/membership-and-community/connect-with-others/join-scientific-networks/subject-communities/organic/resources-for-the-organic-chemistry-community/feed-the-world/

citizens are worried about it and have launched local awareness campaigns. It is urgent to respond to the situation by proposing and implementing solutions to reduce rivers contamination and high pesticide use, while accounting for the importance of banana plantations for the country's economy. To take informed decisions, they have invited upon representatives of different groups to speak out about their concerns in a round-table and asked advisors from different sectors to help finding a solution.

Advisors: Advisors are scientific experts in pesticide use, agricultural practices, nature-based solutions and environmental protection. The policy-makers have summoned them to join a round-table on a case of pesticides contamination of rivers in the area of Puerto Viejo in Costa Rica. Based on their expertise, the advisors provide guidance and propose solutions on reducing pesticide use, water contamination and potential adverse risk for the aquatic ecosystem.

2.1.3 Pitches

Each interest group chooses one or more representatives to deliver the pitches.

Farmers, the pesticide industry and citizens present in 3 minutes maximum their position to the policy makers, highlighting their concerns and their requests. During the pitches, policy makers are provided with an *evaluation sheet* (Annex 2) to quickly assess each interest groups' presentation based on clarity of the message (argumentation), supporting evidence (examples) and effectiveness (how convincing the message is). Finally, policy makers also deliver a short 3-minutes speech to present their expectations for the convened round-table. The whole pitches exercise should not last more than 15 minutes.

2.1.4 Proposal of solutions

In 10 minutes, advisors propose three solutions to the interest groups of the roundtable. The solutions can be used individually or combined. The three solutions, listed in Table 1, are (1) improved practices, (2) use of biological pesticides and (3) agro-forestry. The solutions are based on the toolbox of good practices of Integrated Pest Management (IPM) by the European Commission (Commission, Agriculture, and Development 2023), which provides an inventory of IPM practices, technologies and techniques based on examples from Member States. They are categorized according to their mode of action regarding pesticide reduction: efficiency, substitution or redesign, according to the framework from conventional to traditional agriculture by Hill et al. (1996). The framework defines efficiency as changes proposed within the structure of the conventional agricultural system, substituting environmentally unsafe products with less disruptive ones, and redesigning as the change of land management approaches, based on local context.

Table 1. Brief description of the solution cards provided to the advisors

Solutions	Description	Category	Pesticide reduction	Complexity	Cost	Potential conflict
Improved practices	Application of pesticides by precision spraying and correct timing	Efficiency	+	+	+	+
Biological pesticides	Substitution of harmful chemical pesticides by biological ones	Substitution	++	+	+++	++

Solutions	Description	Category	Pesticide reduction	Complexity	Cost	Potential conflict
Agro-forestry	Agricultural practices integrating trees, with crops and animals	Redesign	+++	+++	++	++

Source: Solutions adapted by the Toolkit of good practices of Integrated Pest Management (IPM)

On the cards provided to the students (Annex 3), each solution is described and characterised based on potential pesticide use reduction, complexity and cost of implementation, and potential conflict with interest groups. During the presentation of solutions to the round table, the advisors can either lean towards one or more solutions or maintain a neutral position towards them. There is no correct number of solutions to be proposed, advisors should nonetheless be ready to justify their choice. Most solutions are more effective if they are implemented conjointly (Commission, Agriculture, and Development 2023).

2.1.5 Exercise 1,2-All the interest groups

Farmers, the pesticide industry and citizens reflect on and discuss on the proposed solutions, trying to answer the question: *"Which solution best fits my interests?".* Policy-makers reflect on the proposed solutions, trying to answer the question: *"Which solution is best to solve the problem of pesticides contamination?"*. Post-it notes are distributed and used to write down thoughts. The reflection exercise is modified based on the 1-2-4-All engagement exercise structure proposed by Lipmanowics and McCandless (2013). The exercise aims at immediately including everyone in the reflection, regardless of the size of the whole group.

The structure of the reflection and internal group discussion exercise is as follows:

1. Each person reflects alone on the question for three minutes. The answers and reflections should be reported on a post-it.

2. Two people belonging to the same interest groups generate and compare ideas in pairs for around 5 minutes, building on the post-it from the self-reflection.

3. The whole interest group compares thoughts on the questions based on the previous reflections in a smaller sub-group and seek to find a position to present during the open discussion. This last reflection lasts 10 minutes.

During this reflection exercise, the advisors are asked to go around the room and provide suggestions or further advice on the solutions to the different interest groups.

2.1.7 Open discussion

The open discussion time lasts 20 minutes. All the interest groups are reunited together in the roundtable. Each group has 1 to 2 minutes to express their positions regarding the proposed solutions based on the answers and reflections from the previous exercise. Once the presentation round is finished, the open discussion starts. Groups publically deliberate and discuss the proposed solutions, until they reach a compromise or consensus. Policy-makers can choose to take the lead, trying to make clear during their discussion how they plan to address the concerns of the different interest groups. Policy-makers can also base their choice on the evaluation sheet they filled in during pitches.

2.1.6 Debrief and feedback

The debrief and feedback session is set to last for around 15 minutes. The first 5 minutes are dedicated to collecting feedback from participants. The feedback can be collected using online survey tools, such as Slido, which help with the visualization of responses. The questions proposed for the final survey are reported in Annex 4. They cover aspects such as identifying learning achievements, choosing the most interesting part of the game and whether everyone felt engaged and listened to during the role-play.

The final 10 minutes of debriefing are dedicated to sharing resources on the framework in which the game was developed, in particular, on:

- The **solutions** and their **ideation** based on the toolkit of Integrated Pest Management practices, by the European Commission.
- The **complexity** of environmental, and in particular, water pollution issues and the importance of **independent scientific evidence** to guide policy making, such as that provided by institution as the Joint Research Centre.
- The **difficulties** and **challenges** of the **policy-making work** towards integrating different interests, compromising and assessing risks linked to decisions.
- The importance of **citizen science** and **participatory democracy,** as mechanisms of a functioning democracy, where all interest groups can voice concerns, share opinions and contribute to decisions that better reflect context-specific problems and provide fit-for-purpose solutions.

3 Role-play trial at the Liceo Classico Cairoli, in Varese

The role play was tested for the first time in November 2024 at Liceo Classico Cairoli, in Varese, with a class of 17-years-old-students (Figure 3). The game was part of a civic education course the class is undertaking for a total of 30 hours. Twenty students participated in the role-play, with four students per interest group. The activity lasted around two hours in total.

Figure 3. Pictures taken during the role-play game at Liceo Classico Cairoli, Varese, Italy

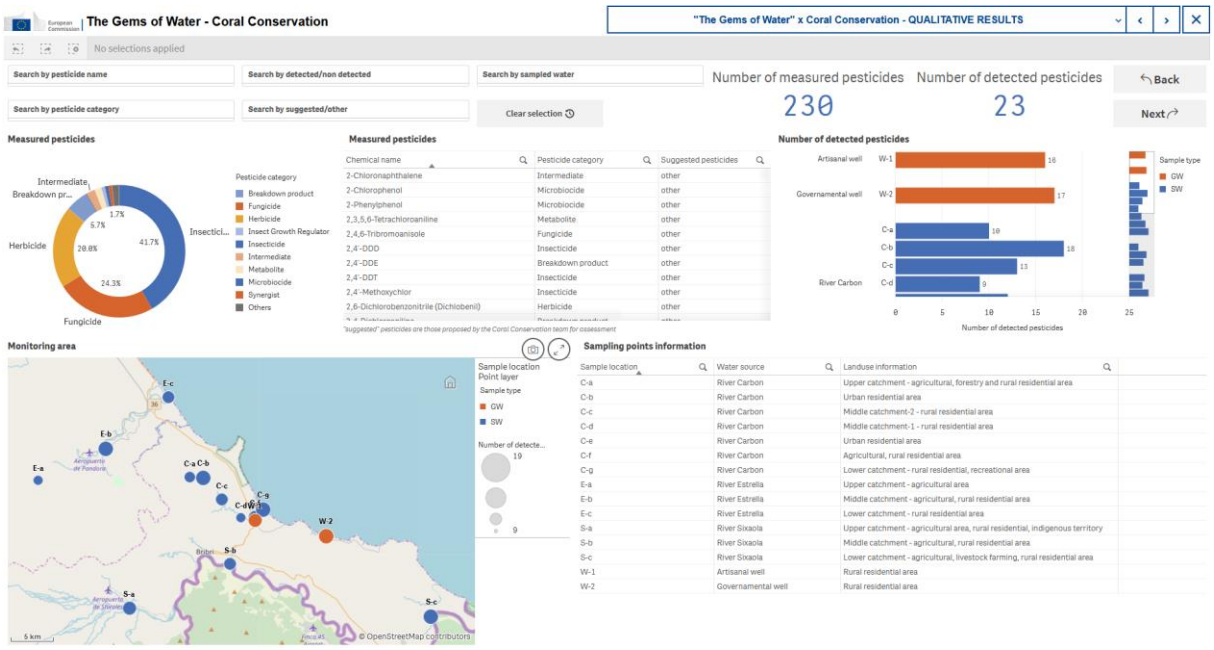
Source: Photos by D. Dietz

3.1 Discussion

The activity was conducted according to the role-play structure described in Chapter 2, starting with a brief presentation on "The Gems of Water" activity and results from the Costa Rica citizen engagement campaign, setting the scene for the discussion around the problem of pesticide contamination of rivers water. While the initial presentation was, in this specific case, provided by a JRC scientist involved in the activity using the dashboard[7], with water quality results from the case study in Costa Rica (Figure 4), a brief training to teachers and professors on the citizen engagement project and data platform would allow the game to be initiated independently, without JRC guidance.

[7] Joint Research Centre. The Gems of Water x Coral Conservation https://web.jrc.ec.europa.eu/dashboard/embed/GOW_CR/index.html

Figure 4. Screenshot of the dashboard from "The Gems of Water" website



Source: "The Gems of Water" website

Both the initial information and the solution cards appeared to be clear to the students, as per observation of the organizers. They were well interpreted by the students, who already, during the pitches, showed good personification of the roles and a good understanding of the situation. This aspect was probably encouraged by advising the students to use imagination, and, potentially, online resources to strengthen their positions. The three solutions cards were enough to create a satisfactory level of complexity. Adding few data in the role description cards (i.g., the time and investment needed to introduce of new pesticides) was important. Students not only picked up the numbers and used important details in their speeches, but also added derived calculations and made specific remarks and requests linked to the information provided. Additional help was not really needed throughout the exercises, except in a few cases where asking questions to the different interest groups inspired students to see the problem from another angle and to nourish the discussion further. Throughout the activity, it seemed that the structure of the game was well organized and that each activity naturally flowed into the next one. Only one modification was made to the original game. During the pitches, initially, it was not envisioned that policy-makers would also present themselves, but on request of the students, they also took part in the pitches exercise. During the 1,2-All interest groups exercise (Paragraph 2.1.5), it had to be firmly said that the first part required individual reflection, as students tended rather to discuss together or in pairs. While time was well organized, the open discussion was probably the only part where more time could have been useful. Without proper moderation, the open discussion can get particularly complex, especially in this case, where most of students was well engaged and willing to speak. Due to limited time available, the role-play was concluded with voting not really finding a different way of compromising on one or several solutions.

More specifically, it was interesting to observe how the single interest groups undertake their roles throughout the role-play. The farmers, for instance, appeared to be more willing to work together and find compromises that would be acceptable for the citizens and the pesticide industry. They mainly supported the redesign strategy, showing a willingness to promote change in their practices. They proposed a slow transition starting from a smaller area of land. They asked for a raise in the

price of bananas while proposing to offer job opportunities to the community. The pesticide industry and citizens both proposed as first solution the substitution of harmful chemical pesticides with biological ones, followed by redesign. To do so, the pesticide industry asked for additional funds to speed up research of alternative plant protection products and agreed to start a fund dedicated to monitoring of water quality. The advisors were keen primarily on the substitution solution, seeing it as the most feasible in the short-term. Interestingly, the role of the advisors shifted a bit, with one advisor lobbying for one solution, mainly based on political views. This might have resulted due to the limited scientific knowledge provided to back up one or the other solution. It also shows how personal bias might play a role during discussion, highlighting the importance of independent science. As for the policy-makers, the 1-2-All interest groups exercise led to a division among their views with two policy-makers strongly supporting a more moderate substitution solution while other two pushing for redesign, based on strong environmental concerns. Finally, the efficiency card was disregarded by all interest groups because it did not really tackle the pesticide contamination problem. All groups understood, and exemplified in their pitches, the importance of economy and costs as a major point of discussion and a limiting factor for which solution would be more feasible and applicable.

Overall, students showed extensive enthusiasm throughout the game and understood the regulatory framework of Integrated Pest Management and participatory democracy explained during the debrief session.

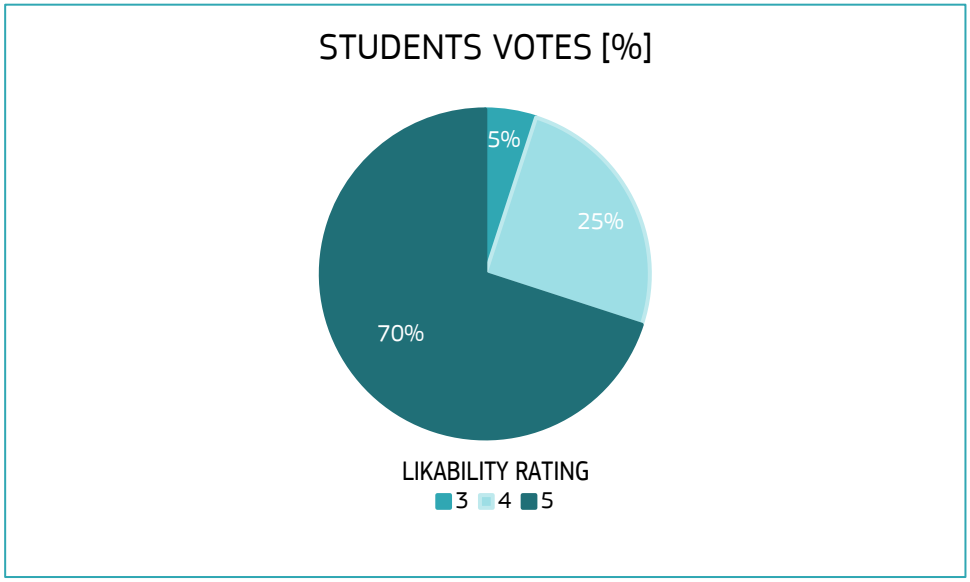
3.2 Lessons learnt

Throughout the role-play it became clear that students tend to want to discuss together before the open discussion time, thus reducing alone or within interest group discussion time. This might be overcome by giving more time to students to study the topics before the game, or, to ask more questions during the initial presentation, as well as by having facilitators responsible of managing the groups, the activities and time. While it is true that some students showed to be more active and participative than others, the overall impression was that almost everyone spoke both in the small interest group discussions as well as in the final open discussion. Small groups and structured exercises facilitate the exchange and involvement of everyone, creating a safe space to share ideas. Additionally, providing scientific information at the beginning of the role-play allowed every student to start with equal knowledge, thus promoting a healthy environment of exchange, where no one felt they knew more or less than the other. In future developments of the role-play game, scientific information could be shared before the game, giving students more time to familiarize with the implications of contaminations on the environment and public health. The hardest part of the role-play was the final discussion, for which more time might have been useful. While it was easy for the interest groups to separately present their views on which solution better helped solve the issue of water contamination by pesticide, it was hard for the groups to come to a synthesis or compromise. Although some interest groups were pushing for the same solution, it was hard for them to see common positions, because they were focused on pushing for their interest. Therefore, a more structured and better moderated open discussion might help to come to a final decision. Nonetheless, this ending surely provided points for reflection for the students, allowing them to see the difficulty of debating, compromising and taking a decision. Additionally, it showed that emotions, personal experiences and interests can bias opinions. Time did not need to be held strictly, allowing for flexibility, but it is important to check that each interest group and person who would like to intervene is given the time to do so.

3.3 Feedback survey results

Feedback on the role-play game was collected from the students through an online survey on Slido (Annex 4). When asked to respond to what students learned in one word (Question 1, Annex 4), the words that came up, in order of frequency, were compromise, debate, dialogue, democracy and economy (Annex 5). Other elements are research, interests, politics, confrontation and communication. From 0 to 5 of liking the activity (Question 2, Annex 4), 70% of students voted for 5, 25% voted for 4 and 1 student (5%) voted for 3 (Figure 4). In contrast, no student voted for 1 and 2, leading to a total likability score of 4.7.

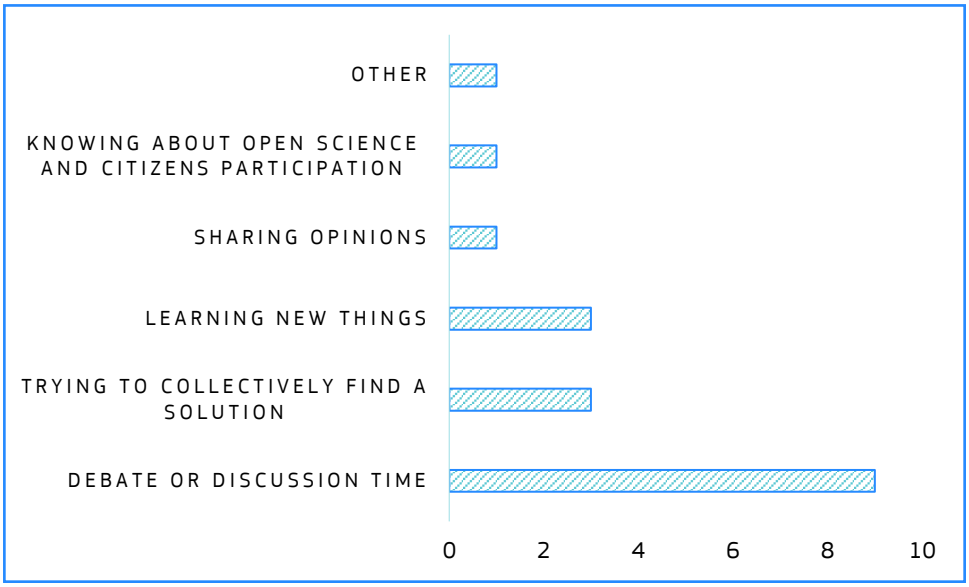
Figure 5. Answers to the question: "how much did you like the activity from 0 to 5?"



Source: Modified from Slido responses

Question 3 (Annex 4) asked students to specify what they liked most about the game, with an open-ended question. Results are reported in Figure 6. The majority of students (8) responded with debate or discussion time. Three students wrote that they particularly enjoyed trying to find a solution collectively and learning new aspects they were unfamiliar with. One student mentioned sharing opinions as a likable element of the game, while another showed interest in open science and citizens' participation in scientific activity. One student responded ironically; therefore, the response is listed as other in Figure 6.

Figure 6. Answers to the question "what did you like the most during the role-play?"



Source: Modified from Slido responses

To the question on which part of the game was most boring (Question 4, Annex 4), students answered by mentioning names of specific students, others some interest groups or answered ironically. The responses show that an anonymous survey does not necessarily work as a way to collect constructive feedback, as it allows respondents to answer ironically. Additionally, it shows potential for improvement in the phrasing of this question. Finally the last question was aimed at understanding how much each student felt heard and listened to during the role-play. Out of 14 responses, six students responded with "no", three students responded with "sufficiently", and six responded with "yes". Their responses indicate that there is space for improvement in terms of students participation in the open discussion, through more structured moderation and, eventually, longer time.

4 Conclusions

A role-play game on proposing solutions to water contamination starting from real data collected as part of “The Gems of Water” activity is described in this report. The game is designed as a collaborative role-play, simulating a discussion between different interest groups trying to find solutions to complex environmental problems. The role-play has a relatively simple structure and requires limited materials, namely role descriptions and solution cards. The role-play is designed to promote critical-thinking and the ability to speak in public and debate, while raising awareness on environmental problems, in particular on water, and the role of science in guiding policies. The exercise follows principles of participatory democracy, allowing students to understand the importance of civic participation in decision-making processes.

The game has been tested, as described in this report, at the Liceo Classico Cairoli of Varese, Italy, with a class of 20 students of 16-17 years old. The trial in the school allowed to identify elements of success and parts which might rather be improved. While overall, the rules and information provided seemed to be clear and logical, the main aspect to improve would be the structuring and moderation of the final open discussion, to facilitate the decision-making progress. The policy framework was also well understood, but there’s a possibility of expanding and providing more in-depth information, should the role-play become part of an ad-hoc curriculum. In this case, the frameworks of participatory democracy, Integrated Pest Management and the topic and legislation on water quality could become a study topic in preparation for the game. Initially, the role-play envisioned the presence of a JRC scientist to introduce the subject. Still, it is not excluded, in future uses, that the game could be initiated independently as part of a civic education curriculum following a short training and familiarization of teachers with “The Gems of Water” project and online data platform. For future uses, there is a possibility to increase the complexity of the game by, for instance, introducing constraints (i.e., limited budget), or adding possible solutions to the problem. The role-play has further the potential to be applied to other case studies and results from “The Gems of Water”, with little modifications in the role-play description. The structure of the role-play can also serve as inspiration for future applications to different relevant JRC subjects, bringing scientists closer to society and educational institutions and paving the way towards open discussions towards fit-for-purpose solutions.

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List of abbreviations and definitions

Abbreviations	Definitions
JRC	Joint Research Centre
SBSE	Stir Bar Sorptive Extraction
UNEP	United Nations Environment Programme
IPM	Integrated Pest Management

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Annexes

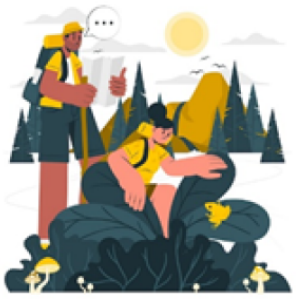
Annex 1. Roles descriptions for the interests groups of the round table

Farmers

You represent farmers who cultivate bananas along the catchment of the Sixaola and Carbon River.
The scientific news on contamination linked to use of pesticides in farming practices alerts you, as you have been using some of the detected compounds. Your main need is to continue growing bananas at high productivity for the export market and to protect the plants from a wide-spread fungus that attacks bananas, called *black Sigatoka*. From your long experience, you learnt that the pesticides you are applying and the methods of application (with a light aircraft – weekly) have been working for you. You are quite dubious of alternatives methods and their efficacy.

Pesticide industry

You represent the pesticide industry. You are concerned that the Costa Rican government might become stricter on pesticide use, affecting your sales, which in the country are going very well, as it ranks amongst the highest in pesticide use per hectar worldwide (23.4 kg/he). Your pesticides have played an essential role in protecting crops from fungal infection, they are selective, easy to apply and safe for consumers and the environment, contributing to supply food for the growing world population. You are aware of the length and investment (9 years, 150 million dollars) required to develop and register a new pesticide. You are worried of how the outcomes of the round-table might affect your profits.



Citizens

You are a representative of citizens living in the area of Puerto Viejo, Costa Rica. You know that a local NGO has participated in water quality monitoring campaign and found some contaminants in the Sixaola and Carbon river. Their results, together with other independent research have shown that pesticides might be linked to toxic effect on the ecosystem. Costa Rica is known to have one of the richest biodiversity of the planet and coral reefs in the area might be affected by river pesticides runoff. You are worried for the risk that water quality pollution represents for human health and for the environment.

Policy makers

You have received information on recent scientific evidence indicating concerning pesticides contamination in the Sixaola and Carbon rivers in the area of Puerto Viejo, Costa Rica. You are aware that citizens are worried about it and have launched local awareness campaigns to spread the news. It is urgent to respond to the situation by proposing and implementing solutions to reduce contamination of the rivers and high pesticide use. To take informed decisions, you have called upon representatives of different stakeholder groups to speak out about their concerns in a round-table and you have asked advisors from different sectors to join help you with a proposal.

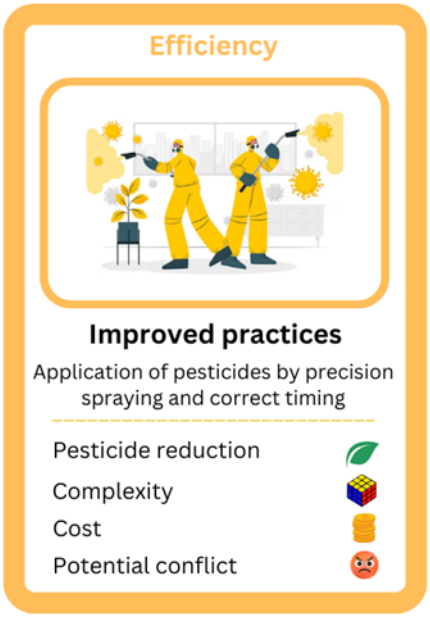
Advisors

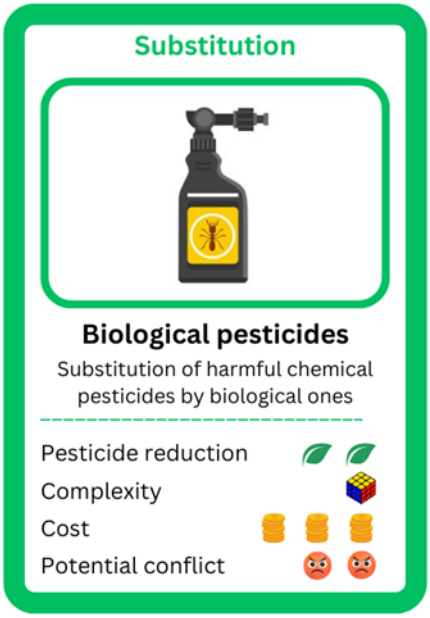
You are a group of experts in pesticide use, agricultural practices, nature based solutions and environmental protection. You have been called by the policy makers to join a round table on a case of pesticides contamination of river water in the area of Puerto Viejo in Costa Rica. Based on your expertise, you provide guidance and propose solution to the problem.

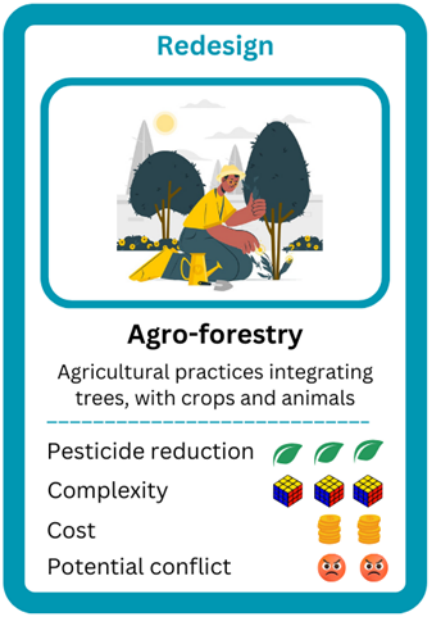
Annex 2. Evaluation papers for policy makers

Pitch evaluation	Clarity of message	Supporting evidence	Efficacy	Overall
Farmers				
Pesticide industry				
Citizens				

Annex 3. Solutions cards presented by the advisors







Annex 4. Slido questions

1. What did you learn in a keyword?
2. How much did you like this activity? From 1 to 5.
3. What did you like the most? What impressed you?
4. What would you have liked to last longer or shorter?
5. Did you feel like your voice counted in the decision-making process? Why?

Annex 5. Wordcloud responses from feedback survey (in Italian)

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