D6.4 Stakeholder co-creation

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Author(s)	Fenintsoa ANDRIAMASINORO
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Summary

Regarding the tool to co-create with stakeholders, that would help them, in a contaminated site (ISLANDR Test Area, ITA), to confront their respective concerns, create different management scenarios, and analyse how they weigh pros and cons of these scenarios regarding their ability to meet the concerns, the ISLANDR project considered developing a serious game tailored to the specific context of the site. This tool was chosen because serious games have now spread to the realm of conservation policies (and therefore, by extension, to that of rehabilitation policies as in ISLANDR) as a tool for land-use planning or ecology; with the objective (inter alia) to explore, in predefined scenarios, the consequences of interactions between actors with divergent behaviours.

Beyond the game use itself (to co-create and discuss the scenarios), two elements of reflection were also planned in the scenario co-creation process. The first element is that to avoid this game being perceived as a 'black box' preconceived only by experts or researchers (in the conceptual phase) and then imposed on locals (in the operational phase), the co-creation process should also cover an upstream step of co-creating the game (= designing, testing) with these same stakeholders. The second element is that to make the co-creation 'faster', the game should not be co-created *ex-nihilo* either: the reflection should start from existing games already developed at BRGM during the last decade in various fields of geosciences related to pollution management like mine, aggregates and post-mine fields. In this case, the basis for thinking about a game for ISLANDR is the game called QualiTeD, created by the BRGM in the context of managing post-mining territories. Qualited stands for 'reQualification of Territories that are Degraded'; it was developed at BRGM between 2020 and 2023. The idea in ISLANDR was not necessarily to directly transpose QualiTeD onto an ISLANDR ITA; the idea was rather that QualiTeD should feed the thinking process to how the final game should be co-created so that the stakeholders want to appropriate it and use it.

This deliverable (Task 6.4 'Stakeholder co-creation') describes the thinking journey from the deployment of QualiTeD in ISLANDR to the final outcome that could be ultimately achieved in ISLANDR in terms of co-creation process with stakeholders.

The serious game referred to in ISLANDR is technically based on models; these models are developed for the purpose of sharing the multiple (often divergent) points of view of stakeholders on the management of the contaminated territory. From a theoretical point of view, the translation of these points of view into a game model, in a context of co-creation with stakeholders, is carried out in 2 phases: (1) the co-creation of a conceptual model (also called participatory modelling) which aims to describe and clarify the concepts used; then (2) the co-creation of an operational model (also called participatory simulation) which can be manipulated to carry out exploratory simulations of contaminated site remediation scenarios. The model for this second phase is presented in the form of a framework composed of two techniques: (a) agent-based computer simulation techniques and (b) role-playing techniques.

In terms of results of this task, there have been 2 advancements and 1 limitation.

Advancement 1. The first advancement is that the BRGM QualiTeD game was a source of inspiration for the implementation of a derivative game titled 'let's renovate Outokumpu'

(hereafter LRO) built by SYKE and GTK for the ITA of Outokumpu; this game, whose session was scheduled for June 12, 2024 in Outokumpu, saw the participation of stakeholders from all over the local territory and even from the national level of Finland.

> ☞ The detailed results of the Outokumpu session can be found in the deliverable 'D7.1 Multi-Actor Communication Framework' of ISLANDR.

Furthermore, at the end of the session, GTK / SYKE and the BRGM issued a joint recommendation regarding the adoption of the 'serious game' approach to discuss a problem because it creates a relaxed atmosphere and seems to provide an opportunity for stakeholders with divergent interests to discuss and even collaborate. Finally, these ISLANDR partners are planning to publish an article about the Outokumpu serious game and the play event, with the idea to submit the article during 2025.

Advancement 2. The second advancement is that during a game test workshop in Montpellier (France), the QualiTeD game received feedback from game practitioners (outside ISLANDR consortium); the integration of the feedback is in progress with the idea to use the new version for an ISLANDR session scheduled in Orléans in October 2025; in this session, it is also planned to invite stakeholders.

Limitation. The limitation corresponds to the absence of the co-creation phase of the conceptual model behind the game, by the stakeholders (i.e. no participatory modelling). The fact is that all the game in the project was first created by researchers and experts in the field (members of the ISLANDR consortium) and then presented to the stakeholders for testing. The possible consequence of these limitations would be that the stakeholders may not find their perception of the reality of contaminated sites in it, which would increase the chances that they will not mobilize these games if the goal is to help decision-making on contaminated site remediation scenarios. The ISLANDR game session at the Orléans meeting on October 25 will confirm / infirm this possibility.

Keywords

Serious game, stakeholder, co-creation, remediation scenarios, conceptual model, operational model, board game, computer simulation

Abbreviations and acronyms

Acronym	Description
ITA	ISLANDR Test Area
LRO	Let's Renovate Outokumpu: the game co-created by GTK and SYKE
MAH	Multi-Agent Human: a simulation tool with a decision-making by human agents (players)

Acronym	Description
MAHc	A MAH tool supported by a computer simulation of processes like e.g. pollution spread
MAV	Multi-Agent Virtual: a simulation tool with decision-making by virtual agents (in a computer)
QualiTed	reQualification of Territories that are Degraded: the game designed by the BRGM
WP	Work Package

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1. Introduction: stakeholder co-creation and the 'Qualited' serious game

Regarding the tool to co-create with stakeholders, that would help them, in a contaminated site, to confront their respective concerns, create different management scenarios, and analyse how they weigh pros and cons of these scenarios regarding their ability to meet the concerns, the ISLANDR project considered developing a serious game tailored to the specific context of the site. This tool was chosen because serious games have now spread to the realm of conservation policies (and therefore, by extension, to that of rehabilitation policies as in ISLANDR) as a tool for land-use planning or ecology (Barreteau et al., 2021); with the objective (inter alia) to explore, in predefined scenarios, the consequences of interactions between actors with divergent behaviours (ibid.; (Hassenforder et al., 2020)).

In ISLANDR, and after using these games, the final idea is then to deliberate on the motivations of the different stakeholders (weighing the pros and cons) in relation to different management scenarios imagined to remedy the target site.

Beyond the game use itself (to co-create and discuss the scenarios), two elements of reflection were also planned in the scenario co-creation process. The first element is that to avoid this game being perceived as a black box preconceived by only experts or researchers (in the conceptual phase) and then imposed on locals (in the operational phase), the co-creation process should also cover an upstream step of co-creating the game (= designing, testing) with these same stakeholders. The second element is that to make the co-creation 'faster', the game should not be co-created *ex-nihilo* either: the reflection should start from existing games already developed at BRGM during the last decade in various fields of geosciences related to pollution management like mine (Andriamasinoro et al., 2020), aggregates (Douguet et al., 2023) and post-mine (Qualited, 2024) fields. In this case, the basis for thinking about a game for ISLANDR is the game called QualiTeD (ibid), created by the BRGM in the context of managing post-mining territories. Qualited stands for reQualification of Territories that are Degraded; it was developed at BRGM between 2020 and 2023. The idea in ISLANDR was not necessarily to directly transpose QualiTeD onto an ISLANDR ITA; the idea was rather that QualiTeD should feed the thinking process to see how the final game should be co-created so that the stakeholders want to appropriate it and use it.

The scientific question underlying the use of QualiTeD is twofold:

- *q1. given that the actors have often divergent issues (explicit or hidden), and therefore divergence in contaminated site management scenarios (which can generate conflicts), how can each actor achieve the collective objective of stopping the spread of pollution (in progress) on the site concerned, while still attempting to satisfy these individual issues?*
- *q2. how does civil society (residents, biodiversity protection associations, etc.) perceive the remedial actions decided by the authorities?*

This deliverable (Task 6.4 'Stakeholder co-creation') describes the thinking journey from the deployment of QualiTeD in ISLANDR to the outcome that could be ultimately achieved in ISLANDR in terms of co-creation process with stakeholders.

Content of the rest of this document

2. Theoretical background on co-creation and serious games

In this Section, we first aim to define the concepts that underlie our work in terms of links between serious games and stakeholder co-creation; the aim of defining is to avoid the semantic ambiguities carried by the so-called spontaneous sociology (Burawoy, 2017), based on prenotions or *a priori* evidence, which have nothing scientific about them, and which we must therefore try to deconstruct (ibid) via this Section.

In addition to serious games and stakeholder co-creation concepts, the other concept to be defined in this Section is 'complexity'. Indeed, co-creation aims to support stakeholders in exploring so-called 'complex' scenarios (for remediation of polluted sites, in the case of ISLANDR). Complex scenarios are scenarios based on situations • where points of view are often divergent, • where uncertainties make scientific expertise inconclusive and therefore • where it is no longer a question of proposing the best solution from a technical point of view, decided behind closed doors between politicians and experts (Dionnet et al., 2017).

Content of this Section

2.1. Serious games and their possible objectives

A serious game, and in the case of ISLANDR, a serious game in the form of role-playing games, aims to combine playful elements with serious aspects such as teaching, learning, communication, or even information (Djaouti et al., 2011; Barreteau et al., 2021). Such an association therefore aims to move away from simple entertainment.

Based on various sources (Müller et al., 2013; Le Page et al., 2014; Hassenforder et al., 2020; Barreteau et al., 2021), including this work, it is possible to identify (at least) 7 objectives of serious game sessions. These objectives are divided into 4 major categories of game use (cf. Table 2.1 on page 14) and are not mutually exclusive.

Table 2.1: Category of uses and session objectives of a serious game, as well as, for each session, the precise objective of the players concerned

No.	Game usage category	Description of the objective of a session	Objectives for players
1.	Use for 'test' purposes	Test, validate or improve a game	the players see together at the end whether the game is representative of real dynamics, whether it is fun and interesting for all players, and finally usable for other categories of use
2.	Use for 'educational' purposes	Promote knowledge transfer and learning	the players acquire new notions, knowledge or concepts; this objective includes game sessions with an educational aim including the method itself (i.e. role-playing)
3.	Use for 'action' purposes	Express values or concerns	the players express their preferences, what they consider good or bad, just or unjust, sacred, fair, etc. or even the situations that concern them (pollution, low attractiveness of their territory, etc.)
		Explore new individual strategies (stimulate the emergence of new practices)	the players imagine and test new ways of setting up their activities and/or propose new actions (e.g. favouring the photovoltaic panel on the rehabilitated land, even if this provides few jobs)
		Stimulate the emergence of new organizations and institutions	the players discuss new rules (management, sanction, incentive, laws, etc.) and/or propose new collective organizations (e.g.: committee, association, network, cooperative, etc.)
		Foster relationships between players	each player tries to understand the other players' perspectives and constraints, for new interpersonal relationships to be created, and for tensions to diminish; the method here is to prioritize role swapping between rounds of the session.
4.	Use for 'scientific' purposes	Contribute to building a computer simulation tool	the players, through their in-game behaviours, help build equations or algorithms that would feed into a computer simulation model
		Elicit knowledge	the players, in this case thematicians of a field, are invited to explain (aloud) the actions that they would undertake in relation to different situations presented to them; this is a complementary approach to the interview

Each game session can have its own objective (Hassenforder et al., 2020); for example, a first session may aim to test or improve the game (cf. Table 2.1, line 1), and subsequent sessions to promote player learning (cf. Table 2.1, line 2).

2.2. A kind of game: the 'role-playing game / computer simulation' framework

The serious game referred to in ISLANDR is a role-playing game based on models; these models are developed for the purpose of sharing the multiple (often divergent) points of view of stakeholders on the management of the territory studied (Le Page et al., 2014; Barreteau et al., 2014), in this case, in ISLANDR, on a contaminated site. The translation of these points of view into a game model is done in two phases (cf. Figure 2.1 below): • the development of a conceptual model, which aims to describe and clarify the concepts used, then • the development of an operational model that can be manipulated to carry out exploratory simulations of contaminated site remediation scenarios. The model for this second phase is presented in the form of a framework composed of two techniques (Barreteau et al., 2021): (a) agent-based computer simulation techniques, and (b) role-playing techniques often supported by a board-game.

Figure 2.1: Process of translating reality into a simulation model based on a role-playing game / agent-based computer simulation' framework

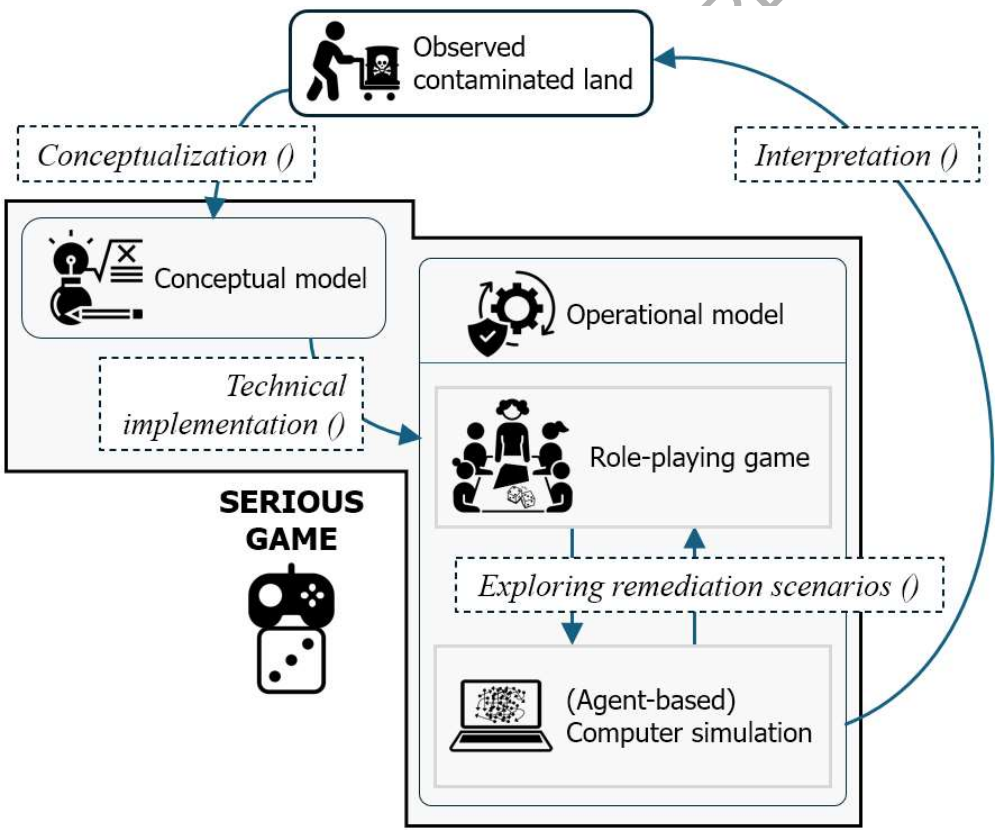


Table 2.2 on page 16 details the links between the two components - role-playing game / computer simulation - of the operational model, as presented by Le Page's team (Le Page et al., 2014). In this table, the notations generically beginning with MAH (let's denote MAH*) correspond to simulations with decision-making by human agents (hence the 'H',) at 100% or in hybrid with computers; and the notations generically denoted MA*V* correspond to simulations with decision-making by computer or virtual agents (hence the

'V') at 100%, or in hybrid with humans. These same notations will be used throughout the rest of this document.

Table 2.2: The different links between the 'board' (human) and 'computer simulation' (virtual) components of the serious game envisaged in ISLANDR

	Board game / computer simulation link type	Human component content (around the board game)	Virtual component content (in computer)	Notation
1.	100% human-decision agent modelling 	All decisions are made exclusively by human agents	N / A	MAH
2.			A computer simulator that implements economic and environmental processes related to the problem being addressed, and which are not subject to player decision-making (e.g.: spread of pollutants)	MAHc
3.	Hybrid human/virtual decision agent modelling 	Some of the decisions are made by human agents, often few in number.	Another part of the decisions is taken by virtual or computer agents, often more numerous (e.g. a simulator composed of hundreds of people making up the population of the contaminated site, and which interacts in a loop with the board game of the 'human component')	MAHV
4.	100% virtual decision-making agent modelling 	N / A	All decisions are made exclusively by virtual agents (e.g. the 100% computer version of the corresponding board game, for analysis purposes outside the game session)	MAV

A simulation using a MAV-type tool (hereafter abbreviated as MAV - idem for the other notations) is justified when the system to be studied is located on a spatiotemporal scale larger than a role-playing game (which is often carried out with a limited number of players and turns); computer simulation is thus the only tool that can be implemented.

A MAH* simulation and a MAV simulation can also be two forms of implementation of the same conceptual model of the observed world. In this case, the role-playing game is used to directly discuss remediation scenarios while the MAV consists first of all in identifying

and implementing the decision rules at the origin of the interactions (= flows), possibly relying on theories. It then allows the actors to validate the interactions between the different representations and the dynamics of the system integrated into the model. This validation thus participates in a learning process, by the stakeholders, of the system studied (Barreteau et al., 2014).

Figure 2.2 below gives an example of a 'board game / computer simulation' framework from the BRGM QualiTeD game. The Qualited framework is of MAHc type (cf. Table 2.2, line 2, on page 16 for the definition of the type): the computer is used here only to simulate the spread of pollution taking place in the degraded territory.

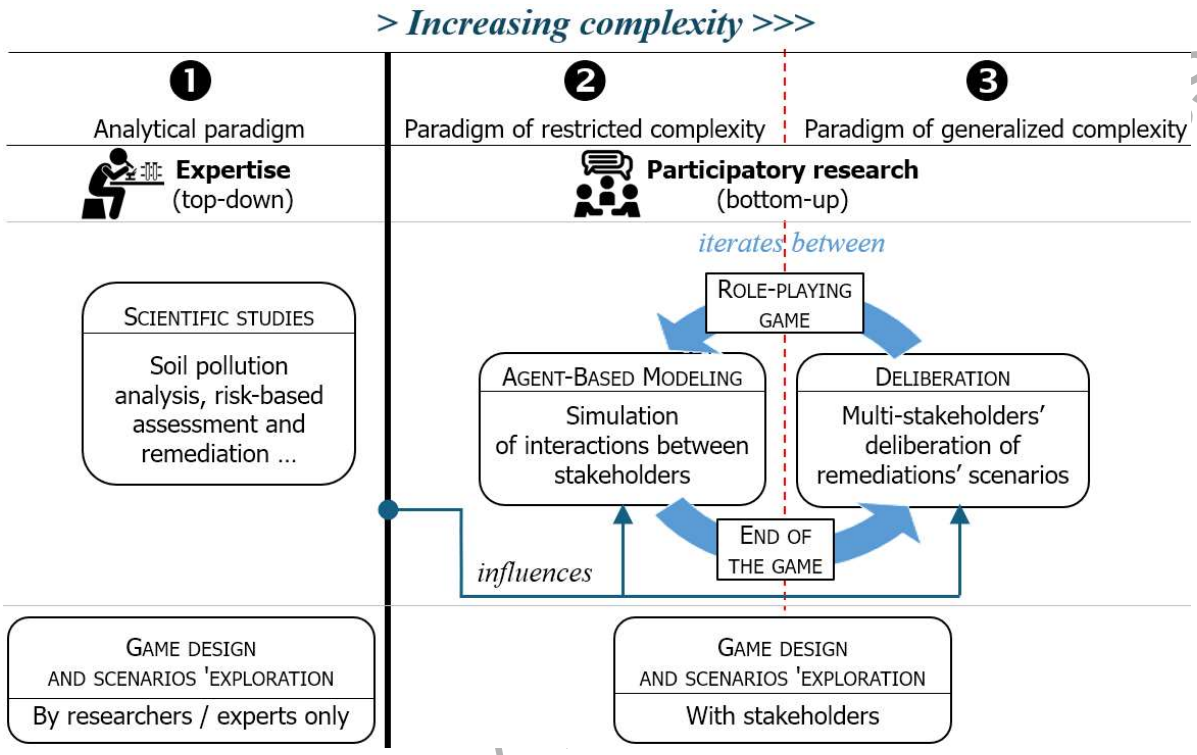
Figure 2.2: An example of a 'board game / computer simulation' framework from the BRGM QualiTeD game (© BRGM 2022)

2.3. Paradigms of complexity in co-creation

In co-creation, the complexity paradigm of each person (physical or moral) involved in the problem of contamination is translated here by the way of thinking of this person on the level of complexity up to which the contaminated territory should be represented, and then the associated game should be created, as questioned by works (Dionnet et al., 2017; Taillandier et al., 2019): behind closed doors between only politicians / experts / researchers? or by involving stakeholders?

In the literature, Jean-Yves Rossignol defines three levels of complexity (Rossignol, 2018): ❶ the simple (analytic) paradigm, ❷ the restricted complexity paradigm, and ❸ the generalized complexity (deliberative) paradigm. Figure 2.3 below illustrates these points.

Figure 2.3: The 3 paradigms of complexity, divided between expertise (by researchers/experts only) and participatory research (with stakeholders)



The simple (analytical) paradigm (paradigm ❶) is the classic 'top-down' modelling paradigm. It is adopted by default, in this case by experts or researchers, to model a problem by positing that the mind first draws interpretations of the world that are as simple as possible, or, at least, that are biased toward simplicity (Feldman, 2016). The drawback of this paradigm is that it considers very weakly the heterogeneity of the real site studied wherever it is necessary, in particular the multiple feelings, history and opinions (often divergent) of each actor involved in the problem.

The restricted complexity paradigm (paradigm ❷) is the 'bottom-up' modelling paradigm that considers this heterogeneity. Unlike the analytical paradigm, the desired solution would emerge from the interaction between multiple opinions. This is where the term co-creation takes on its full meaning and where the board game/computer simulation framework (cf. Section 2.2) is used.

The generalized complexity paradigm (paradigm ❸), also called the deliberative paradigm, assumes that, however, at a given moment, a model alone is not enough: the objective evaluation (estimation of remediation scenarios through games) should then be followed by a subjective evaluation (giving them a societal meaning). In this second evaluation, different actors 'deliberate' (Frame & O'Connor, 2011; O'Connor & Douguet, 2024), that is, exchange points of view via a dialogue built on the capacity of each scenario (in this case,

site remediation) to satisfy each of the issues (e.g., technical-economic feasibility, drastic reduction of pollution, compliance with legal barriers, etc.); this dialogue will be based on (inter alia) the results of the serious game.

Let us note that even though already belonging to the paradigm ❷ (from the model perspective), the role play can also be seen as part of the paradigm ❸ (from the human perspective).

2.4. Links between 'stakeholder co-creation' and serious games

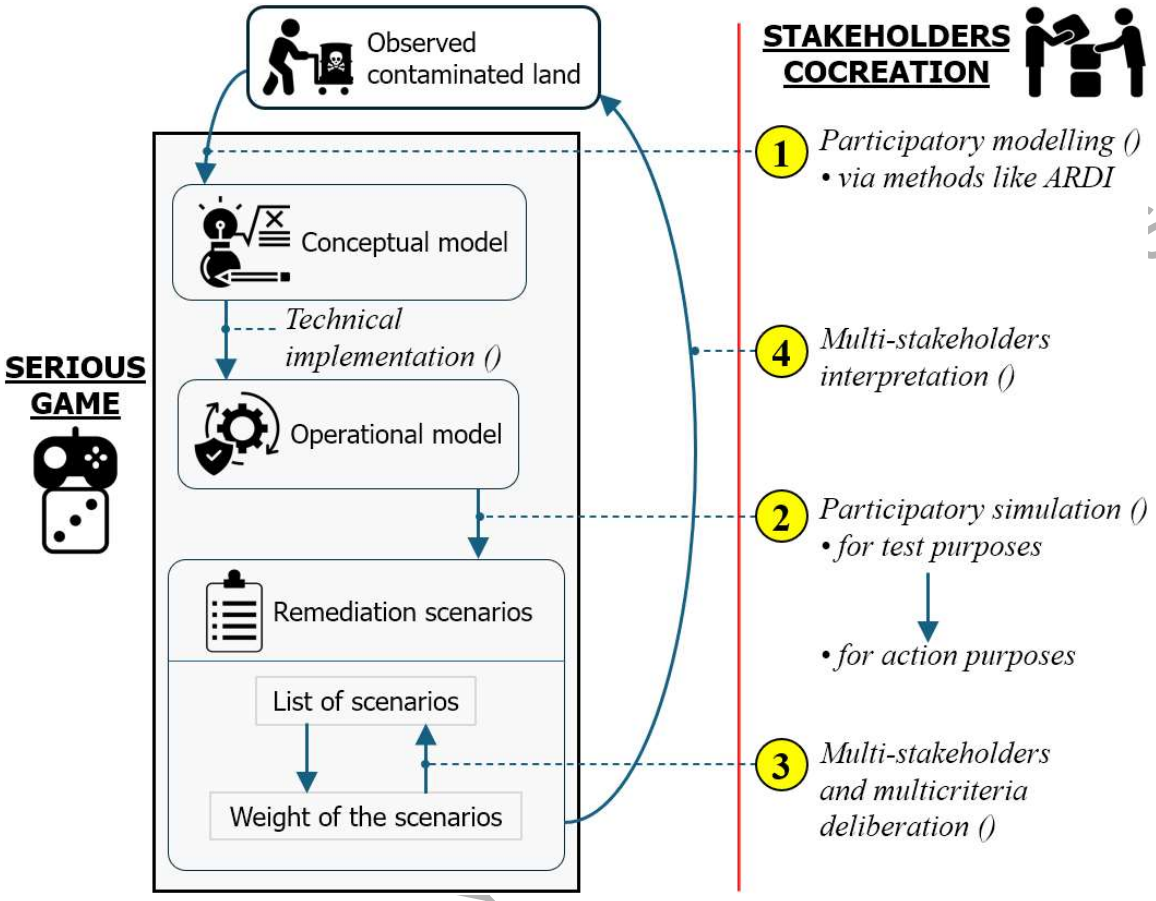
2.4.1. From the 'researchers only' paradigm to 'stakeholder co-creation'

Let us recall first that the intended purpose of using the game in ISLANDR is that it be a support for exchange for at least 2 objectives: • to allow stakeholders to co-create remediation scenarios in different contexts (urban, rural, mining, etc.), and • to help them decide on the scenarios that are most capable of meeting the challenges (technical-economic feasibility, low environmental impacts, etc.).

However, the literature claims that only a handful of simulation models - and this game falls into this category - has really been used to assist in the decision-making process, and that the main reason for this situation comes from the lack of involvement of stakeholders in the upstream processes of design and exploration (simulation) of these models (Taillandier et al., 2019). Indeed, most of the time, models are developed and explored only by researchers (ibid); we are therefore here entirely in the paradigm ❶ of complexity.

To try to remedy this, the initial idea in ISLANDR was to create a game that considers more the paradigms ❷ and ❸ in a whole process of co-creation of remediation scenarios. This means that the process of co-creation of scenarios via a serious game should contain, in total, the following consecutive phases (cf. Figure 2.4 on page 20): • the modelling phase, also called participatory modelling (Abrami et al., 2021), • the simulation phase, also called participatory simulation (Taillandier et al., 2019), • the deliberation phase, also called multi-actor and multi-criteria evaluation (Frame & O'Connor, 2011; O'Connor & Douguet, 2024) of these scenarios, and • the interpretation phase (Le Page et al., 2014) where the stakeholders question the coherence between their points of view in the game and the consequences of their joint simulation in relation to the real world as experienced by them.

Figure 2.4: The different theoretical phases where the stakeholder is involved in the co-creation of remediation scenarios via a serious game



2.4.2. Co-creation in the conceptual phase.

The idea of introduction of co-creation from this phase is that each stakeholder could integrate as soon as the conceptual model of the game (via a facilitator) their mental representation of the contaminated site, their own concerns, their strategies, etc. The final model then emerges from the interaction between the different representations.

☞ The interest of this action is (at least) twofold:
(1) to avoid stakeholders' perception of a 'black box' model preconceived only by researchers or experts (at the conceptual phase) and then imposed to them (at the operational phase);
(2) to anticipate a significant development cost of the game which would result from a gap between (2a) what was initially built by these researchers and (2b) what the stakeholders ultimately want.

2.4.3. Co-creation in the operational phase

The other phase of co-creation with stakeholders (whether they were involved in the conceptual phase) is at the operational level. This is a more traditional approach in which stakeholders is involved • to use the game first for 'test' purposes (cf. Table 2.1, line 1, on

page 14) • then to use the game (already validated) for purposes such as 'action' (cf. Table 2.1, line 3, on page 14), in particular the action of co-creating and exploring remediation scenarios in different contexts (urban, rural, mining, etc.).

2.4.4. The ARDI co-creation method

One of the methods for co-creating the conceptual part with stakeholders is the ARDI method (Etienne et al., 2011). ARDI (for Actors, Resources, Dynamics and Interaction) is a multi-actor support process for building a conceptual model of a game as is defined in Section 2.2 on page 15.

In ARDI, each letter is associated with questions that the facilitator must answer to create the conceptual model:

- 'A'ctors: who are the key actors involved in the issue of the relationship between humans and polluted territory?
- 'R'esources: what are the material resources (e.g., forest in the degraded area) and immaterial resources (e.g., regulations) relevant to this issue? what are the indicators of these resources (e.g., available forest area) that constitute an issue for each stakeholder?
- 'D'ynamics (i.e. processes that are not generated by players' decisions): what are the anthropogenic (e.g., population growth) and physical (e.g., a climate change variable) processes that affect the functioning of actors and resources?
- 'I'nteraction: What are the interactions between the processes and the decisions behind these interactions?

2.5. Summary of the theoretical concepts

To conclude this Section on theory, Table 2.3 below summarizes the main points of our discussion by presenting all the paradigms for creating the game and the remediation scenarios.

Table 2.3: Description of the different theoretical paradigms of game creation and remediation scenarios: by researchers only or in co-creation with stakeholders

No.	Construction or use Stage	Game usage category (cf. Table 2.1 on page 14)	Complexity paradigm (see Section 2.3 on page 17)	Co-creation with stakeholders?	Co-creation mode
1.	Conceptual phase (modelling)	n / A	Modelling by researchers / experts only (paradigm ❶)	No	Create the conceptual model of the game only within a group of researchers or experts in the field belonging to the same institution or consortium

No.	Construction or use Stage	Game usage category (cf. Table 2.1 on page 14)	Complexity paradigm (see Section 2.3 on page 17)	Co-creation with stakeholders?	Co-creation mode
2.		n / A	Participatory modelling (paradigm ❷)	Yes	Co-create the conceptual model of the game by involving stakeholders from this point on in order to integrate their respective (often divergent) representation of the contaminated site studied.
3.	Operational phase (simulation)	Use for 'test' purpose	Simulation by researchers / experts only (paradigm ❶)	No	Test the game only within a group of researchers or experts in the field belonging to the same institution or consortium
4.			Participatory simulation (paradigm ❷)	Yes	Co-create a reliable game for stakeholders, involving them in testing and validating the game with a view to using it as a support for developing remediation scenarios for contaminated sites
5.		Use for 'action' purpose (exploration of remediation scenarios)	Simulation by researchers only (paradigm ❶)	No	Explore remediation scenarios only within a group of researchers or experts in the field belonging to the same institution or consortium

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No.	Construction or use Stage	Game usage category (cf. Table 2.1 on page 14)	Complexity paradigm (see Section 2.3 on page 17)	Co-creation with stakeholders?	Co-creation mode
6.			Participatory simulation (paradigm ❷)	Yes	Using the game in the field (with stakeholders) to explore contaminated site remediation scenarios
7.	Deliberation phase	Use for 'action' purpose (deliberation of scenarios)	Multi-stakeholder and multi-criteria deliberation (paradigm ❸)	Yes	Co-create, through deliberation, knowledge on the scenarios that are most popular for remediating contaminated sites (weigh the pros and cons)

3. The 'QualiTed' former version (v1) and its contribution to ISLANDR

So that the co-creation of the game with the stakeholders does not happen *ex-nihilo,* it was necessary to have a reference game. In this case, the basis for thinking about the game planned in ISLANDR is an existing game called QualiTeD, that was created in the context of managing the degradation of a post-mining territory, QualiTeD was developed at BRGM between 2020 and 2023, as a proof of concept. The original version of QualiTeD was developed by Audrey BAILLS, Gael BELLENFANT, Daniel MONFORT, Baptiste LEBOT, Sami BERRI and Fenintsoa ANDRIAMASINORO.

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3.1. Description of the former version

QualiTeD v1 is composed of 4 elements: (e1) a main board on which the degraded territory is located, (e2) 4 roles which each target specific issues, (e3) rules of the game, and (e4) a set of chance cards to introduce random events.

The game is played in 3 rounds, for one afternoon.

The degraded territory of QualiTeD (element e1) is composed of 14 hexagonal zones (cf. Figure 3.1 on page 26), each characterized *at least* by its current use (landfill, wasteland, water point, etc.) and by its environmental state (red, yellow, green).

In addition, QualiTeD includes 4 roles (element e2); each of them targets specific issues (cf. Table 3.1 below)

Table 3.1: The roles in the QualiTeD game, and the (sometimes divergent) associated issues.

Role	Role challenges
the municipality	• attract investors • get re-elected
the CCI (Chamber of Commerce and Industry)	• invest in projects in degraded areas • generate profits
the representative of the defenders of biodiversity	• protect water points • promote green spaces
the residents' representative	• increase employment • preserve health

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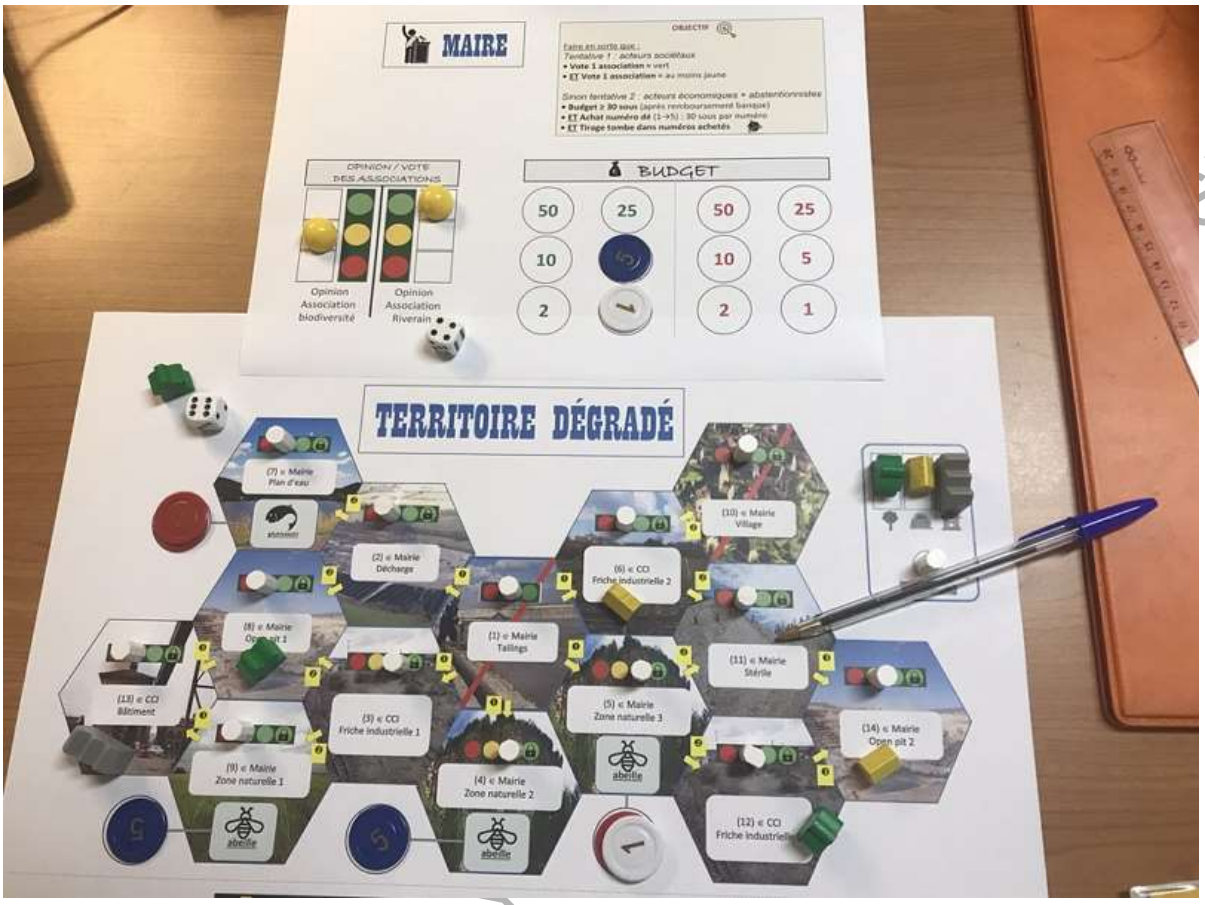
Figure 3.1: A partial view of the QualiTeD game: the board (lower part) and the municipality role information (upper part)



Alongside these divergent issues, these different roles nevertheless share a common goal: to combat the ongoing spread of pollution across the territory, transmitted between zones.

For this fight, the players must fill each area with a project (cf. Table 3.2 on page 27), which corresponds to the new use of the contaminated land (after decontamination). However, as the consequences of each project on the issues targeted by the respective roles is often divergent, the players will have to negotiate on which project to finally put on each round.

QualiTeD v1 game also provides each role with (element e3): • the rules of the game, • the environmental cost of decontamination according to use, and • the benefits of each project (employment, health, etc.).

Finally, the game contains a set of chance cards (element e4), each modelling • either an external event (tornado arrival, fishing policy revision, etc.), • or the action of a role which exists in the real world (e.g.: the State) but which does not appear among the 4 roles mentioned above.

Table 3.2: List of possible QualiTed projects to be implemented to rehabilitate the contaminated site

Project Description	Meaning behind the project
a mining museum creation	The creation of a mining museum would allow authorities and associations to raise awareness among residents and visitors about the mining history of the degraded area; this museum would also serve as an education centre on the environmental issues of mining. When a mining museum already exist, the game allows for more attractiveness of such museum, while broadening the scope of it and give perspective for rehabilitation.
a landscape rehabilitation	Mining can leave behind contaminated soil, toxic waste and degraded landscapes, which can lead to environmental concerns and health risks for local populations.
a photovoltaic panel installation	Installing photovoltaic panels on the site of the former mine would produce clean, renewable energy to power the city; this initiative would help reduce dependence on (polluting) fossil fuels and promote the transition to a more sustainable economy.
a waste recovery	Mining waste recovery could contribute to site decontamination by recovering valuable materials; this approach would transform waste into useful resources and limit its dispersion in the environment.

To resume the terms described in Table 2.2 on page 16, QualiTeD is a MAHc type framework (cf. line 2), that is to say composed: • of a board game and • of a computer tool responsible for simulating a function already existing in the conceptual model: the propagation of pollution.

3.2. The former version (co?)creation mode

Referring to the different theoretical paradigms of co-creation of a game with stakeholders (cf. Figure 2.3 on page 18), the original game was created only by experts and/or internal researchers - or affiliated - to BRGM. This way of creation was adopted at both the conceptual and operational levels. More precisely, once an initial conceptual model had been created (cf. Table 2.3, line 1, on page 21) and then implemented at the operational level, the game was subject to an iterative process of corrections resulting from internal tests at BRGM (cf. Table 2.3, line 3, on page 22) carried out • with experts in the field of polluted sites and soils and • students in environmental sociology, on placement at BRGM (Figure 3.2 on page 28).

In sum, there was no co-creation of the Qualited game with stakeholders and the ARDI (cf. Section 2.4.4 on page 21) method has not been used.

Figure 3.2: A photo taken during a test session of the QualiTeD game internally carried out at BRGM (© BRGM 2022)

3.3. Bringing the former version to ISLANDR

Even though this original version of QualiTeD was not co-created by the stakeholders, it was presented at the ISLANDR meeting of March 2024 in Brussels, in exhibition and oral presentation (no session played due to the agenda). During that presentation, the audience was made aware of 2 points: • highlighting the benefit of serious game as a support for exchange to co-create remediation scenarios • soliciting the stakeholders of an ITA to create this game as soon as the conceptual phase, in particular by presenting to this audience (a) the interest of this action, as was explained on page 20, and (b) the ARDI co-creation method (cf. Section 2.4.4 on page 21).

As a result of this awareness, the presentation of QualiTeD in Brussels gave rise to SYKE and GTK jointly implementing a derivative game, tailored for the ITA of Outokumpu (Finland). The latter game is titled 'Let's Renovate Outokumpu' (hereafter LRO). We consider this decision as a progress obtained in ISLANDR in the sense that a former game developed as a proof of concept (QualiTed) has been used as an inspiration to another game (LRO) mobilized on a concrete case (an ITA). The derivation has been eased by the facts that some Qualited concept also exists in the targeted ITA reality. For example, regarding the Qualited 'mining museum' project presented in Table 3.2 on page 27, a very nice museum already exists in Outokumpu; the LRO game only suggests to widen its scope. This idea is used in the game in a technical sense, so that it brings more money to the town to be used (both in the game and in the reality) for remediation among other things.

On the other hand, the idea of involving stakeholders as soon as the conceptual phase for the LRO game was not retained: the conceptual model behind LRO was developed by researchers only (cf. Table 2.3 line 1 on page 21 for the theoretical approach related to this). These researchers are • Aura NOUSIAINEN and Jylhä HENNA (for SYKE) and • Kristiina NUOTTIMÄKI and Emilia KOSONEN (for GTK).

Regarding the LRO use, the objective was to be able to organize a game session at the meeting in Outokumpu which took place in June 12, 2024 (cf. Figure 3.3 below).

Figure 3.3: A photo taken from the gaming session at Outokumpu (courtesy of GTK/SYKE, 2024)

☞ The detailed results of the Outokumpu session can be found in the deliverable 'D7.1 Multi-Actor Communication Framework' of ISLANDR.

Following the Outokumpu session, GTK / SYKE and the BRGM issued a joint recommendation regarding the adoption of the 'serious game' approach to discuss a problem because it creates a relaxed atmosphere and seems to provide an opportunity for stakeholders with divergent interests to discuss and even collaborate. Furthermore, these ISLANDR partners are planning to publish an article about the Outokumpu serious game and the play event, with the idea to submit the article during 2025.

4. The ‘QualiTed’ improved version (v2) and its perspectives in ISLANDR

Following the feedback from Outokumpu (where BRGM participated as a player), and in preparation for another session using QualiTeD in ISLANDR (cf. Section 4.3 on page 35 for details), BRGM decided to test, within the context of ISLANDR, the QualiTeD game at a conference named ‘jeux et enjeux’ (translated as 'games and issues' which we will now abbreviate in this document as G&I) and which took place from June 24 to 28, 2024 in Montpellier, France (Anon., 2024).

ISLANDR's participation in this conference was twofold: • to make an oral presentation, which included both QualiTeD and a sample from the session with LRO (with GTK's authorization); and • to participate in demonstration and experimentation workshops to test QualiTeD. The latter was therefore in a 'test' purpose use (cf. Table 2.1, line 1 , on page 14 for the definition).

Content of this Section

4.1. Description of the improvement via a test

4.1.1. The test location

☞ Note: all the descriptions in this subsection are extracted from the G&I conference website (Anon., 2024)

The number of actors using participatory games or simulations in their professional practice is constantly increasing in France, as in many foreign countries. We are seeing a proliferation of initiatives, with great diversity in the tools and methods used, but also in the pursued goals: • transferring knowledge to teach / to raise awareness, • working together by approaching problems differently, and • changing behaviours to transform society.

The idea of the G&I conference was to bring together practitioners of serious gaming and participatory simulation by extending and strengthening the structuring of a French-speaking community composed of • members of civil society organizations working to improve the living conditions of citizens, • teaching staff (primary-secondary-higher) open to the diversity of teaching methods, and • scientists who place their work within a transdisciplinary practice.

4.1.2. The QualiTeD testers

The purpose of ISLANDR's participation in the workshops was to obtain feedback from external stakeholders (cf. Table 2.3, line 4, on page 22), and in particular from what we call "serious game practitioners". These are people who are familiar with serious games but who do not come from ISLANDR's field (i.e. polluted sites and soils) or from BRGM (the initial designer of the game). Rather, they are practitioners of games applied to the management of non-renewable resources for many years, and with different profiles (sociologist, environmentalist, etc.). Most are members of the COMMOD collective, which has existed for 20 years (Collectif_Commod, 2005).

In this workshop, the aim is therefore to improve (= correct, enrich, etc.) QualiTeD by putting it to the test again but outside BRGM (cf. Figure 4.1 below).

Figure 4.1: A photo taken during a round of the QualiTeD game for 'test' purposes at the G&I conference (© G&I, 2024)

4.1.3. The test session

The game session took place according to the classic sequence composed of 3 stages (Hassenforder et al., 2020): • briefing, • game rounds (3 in this case), and • debriefing, largely developed in Section 4.2 below.

4.2. Feedback on the test (debriefing)

During the debriefing (cf. Figure 4.2 on page 33), we asked the players – game practitioners – the main points of improvement to be carried out on the game.

Figure 4.2: A photo taken during the debriefing with the players – game practitioners (© G&I, 2024)

The points for improvement from the debriefing and their respective detailed descriptions are grouped in Table 4.1 below; the comments in this table are more recommendations for game building in general, not QualiTeD in particular. Afterwards, Table 4.2 on page 34 provides additional comments on each point of improvement, beyond its simple description; these comments refer to QualiTeD specifically.

Table 4.1: The main points of improvement to be made on QualiTeD according to the testers

N°	Point for improvement	(General) description of the point
a1.	Specify the context	Every player, regardless of their profile, objectives, or skills in the field (in this case, polluted sites and soils), must be informed of common information that the game facilitator must explain from the start of the game: the context; a 'quick' way to self-immerse in this context is to highlight it in a form of a story, even if it is a fictional story.
a2.	Stay in the quest for meaning instead of being in management	In a game, the player should not behave like a player seeking points, but rather like a stakeholder seeking *meaning* from their actions within their territory. Consequently, in this type of tool, qualitative variables should be favoured over quantitative variables, whenever possible. Otherwise, the tool becomes a management tool, which is not what one expects from a game.
a3.	Strengthen the asymmetry of the game	In real life, actors only have a partial perception of their respective environments; as a result, they respectively never have the same level of information and, conversely, may only wish to communicate part of their information. This information asymmetry forces interaction between actors to search for (or hide) information. In the corresponding game, it should be the same.

N°	Point for improvement	(General) description of the point
a4.	Reduce randomness	While randomness is important (a game should not be deterministic), too much of it prevents players from moving the territory to a given direction, the new solution that players collectively want to adopt. Moreover, even natural phenomena (reproduction within flora and fauna) should have at least one determinant from the game.
a5.	Reduce complexity	A role-playing game can be boring. It should be as simple as possible and not last long (1 afternoon max).
a6.	Assist the set with a computer	In a board game, it is sometimes necessary to understand phenomena at a detailed level. To be able to simulate this complex phenomenon in a simple game because it must be achieved in one afternoon (cf. a5 above), computer simulation is the solution. We here fall into a framework of the MAHc type (cf. Table 2.2, line 2 , on page 16 ,for the definition).

Table 4.2: Additional information from the debriefing, on each point for improvement, beyond the simple description of the point

	Point for improvement	Additional comment in the context of QualiTeD
a1	Specify the context	The former v1 version "forgot" to implement the context because the initial creators were domain experts (recall Figure 3.2 on page 28), so they already knew this context "by heart". The consequence is that as soon as the test context changed, the new context (i.e. a tester in the G&I conference) immediately noticed that the game lacked information about the context.
a2	Stay in search of meaning instead of being in management	In this case, a G&I tester suggested that the social variables (employment, health) in QualiTeD should become qualitative and not quantitative variables so that it can be said, for example: 'such a project increases employment slightly' instead of 'such a project increases employment by 1'. On the other hand, the economic variables (clean-up cost, income of the town hall, etc.) should remain quantitative because there is money to be exchanged, and its value must be measured for the exchange to take place.
a3	Strengthen the asymmetry of the game	In version v1, all information (objectives, rules, impacts of actions, budget available to the town hall, etc.) was public. Information asymmetry between players was therefore almost non-existent.
a4	Reduce randomness	Ideally, randomness should be limited to disruptive events that come from outside (via chance cards) and that aim to destabilize a solution (i.e. direction in which to move the territory) being found by the players.
a5	Reduce complexity	Reducing complexity yes; however, the positioning of the cursor between simplicity and complexity for serious gaming is still debated (cf. a6)

	Point for improvement	Additional comment in the context of QualiTeD
a6	Assist the set with a computer	An example of a complex phenomenon, essential to the game (and which therefore calls into question the reduction of complexity), is the spread of pollution. In the v1 version, this spread was done manually (rolling dice). But on 14 zones, this manual spread became time-consuming, whence the idea of a new software simulating pollution

4.3. Towards a game second version and its perspectives in ISLANDR

Now that the G&I test has been carried out, our current action in ISLANDR consists of implementing the improvement points resulting from it (cf. Tables 5 and 6). A new version (v2) of QualiTeD should therefore appear in the short term. The next prospect of using it is in a game session during the ISLANDR meeting which will take place in Orléans from October 28 to 30, 2025. For this event, it is also planned to invite stakeholders.

It should be remembered that Orléans is not an ISLANDR ITA; however, organizing a game session there would be a way to consolidate the consortium's experience acquired during the game sessions on the ITAs, and therefore to provide more details on the interest of the 'game' approach in the remediation of contaminated sites. In addition, if the objective of the game session in the G&I workshops in Montpellier was clearly for a 'test' (cf. Table 2.1, line 1, on page 14), the objective of the game (v2) during the Orléans meeting would be for 'action' (cf. Table 2.1, line 3, on page 14).

5. Concluding remarks

In terms of Stakeholder co-creation of contaminated site remediation scenarios, via games, the QualiTeD game, initially developed at BRGM for post-mining land management, has brought scientific and operational advancements and limitations to ISLANDR purposes.

To understand the characteristics of these two aspects, let us first review the different achievements obtained so far in ISLANDR and look, through the prisms of the co-creation theoretical process (recall Table 2.3 on page 21) how far the paradigms of co-creation with the actors (i.e. paradigms ❷ and/or ❸) have developed in these respective achievements (cf. Table 5.1 below).

Table 5.1: The different achievements in ISLANDR (last column) to assess the level of integration of co-creation with stakeholders, in comparison with what was expected in the theoretical process expressed in Table 2.3

Construction or use Stage	Game usage category (cf. Table 2.1 on page 14)	Complexity paradigm (cf. Section 2.3 on page 17)	Co-creation with stakeholders?	Achievements in ISLANDR
Conceptual phase (modelling)	*n/a*	Modelling by researchers / experts only (paradigm ❶)	No	a) presentation in Brussels in March 2024 of the construction of QualiTeD, by BRGM b) construction of the LRO game from QualiTeD, by SYKE and GTK
	n/a	Participatory modelling (paradigm ❷)	Yes	None
Operational phase (simulation)	Use for 'test' purpose	Simulation by researchers / experts only (paradigm ❶)	No	a) presentation of the BRGM internal QualiTeD test in Brussels in March 2024 (cf. Section 3.3) b) external test of QualiTeD during the G&I conference in Montpellier on June 28, 2024 (cf. Figure 4.1 on page 32)

Construction or use Stage	Game usage category (cf. Table 2.1 on page 14)	Complexity paradigm (cf. Section 2.3 on page 17)	Co-creation with stakeholders?	Achievements in ISLANDR
		Participatory simulation (paradigm ❷)	Yes	LRO test at Outokumpu on June 12, 2024 (cf. Figure 3.3 on page 29)
	Use for 'action' purpose (exploration of remediation scenarios)	Simulation by researchers only (paradigm ❶)	No	none
		Participatory simulation (paradigm ❷)	Yes	none
Deliberation phase	Use for 'action' purpose (deliberation of scenarios)	Multi-stakeholder and multi-criteria deliberation (paradigm ❸)	Yes	none

Advancements. During the ISLANDR meeting in Brussels in March 2024 where there was an oral presentation + presentation of the QualiTeD game, we were able to theoretically show the interest of a serious game for the construction of remediation scenarios for contaminated sites. This is how QualiTeD was a source of inspiration for the construction of the derivative game LRO (let's renovate Outokumpu) by SYKE and GTK; a game whose session on June 12, 2024, saw the participation of stakeholders from Outokumpu and even from the national level of Finland. We are here clearly in a paradigm of co-creation (participatory simulation) with a 'test' purpose. Furthermore, at the end of the session GTK / SYKE and BRGM issued a joint recommendation regarding the adoption of the 'serious game' approach to discuss a problem.

In addition, the QualiTeD game was able to be improved in view of the ISLANDR session in Orléans in October 2025; a session where it is planned to also invite stakeholders. As the 'test' session has already been carried out for QualiTeD during the G&I conference (cf. Section 4), it is hoped that this session in Orléans will have an 'action' purpose to effectively co-create and discuss remediation scenarios for contaminated sites.

Limitations. To understand the limits of ISLANDR's co-creation efforts through games to date, let us simply locate, in Table 5.1 on page 37, each row where the word 'none' is mentioned in the 'Achievements' column.

> ☞ Compared to what is theoretically expected in the process of co-creating scenarios with stakeholders (cf. Table 2.3 on page 21), the steps that are not carried out in ISLANDR are located • either at the level of participatory modelling, • or at the level of using games for an 'action' purpose (exploration of scenarios, deliberation).

☞ These unrealized steps all correspond to the paradigm ❷ and/or ❸; they were therefore carried out only by experts or by researchers (BRGM, GTK, SYKE).

The possible consequence of these limitations in the future is that stakeholders may not find in the game their perception of the reality of contaminated sites; what would increase the chances that they will not mobilize these games to help them for decision-making (Taillandier et al., 2019), particularly during the remediation scenarios deliberation. The ISLANDR game session at the Orléans meeting will confirm / infirm this possibility. *A fortiori,* stakeholders will also not want to mobilize a game composed of agent-based computer simulation tools (and therefore their strengths), such as MAHV (cf. Table 2.2, line 3, on page 16) and / or MAV (Table 2.2, line 4, on page 16); indeed, these tools are certainly much richer, but also much more complex to understand (Hamill & Gilbert, 2016; Taillandier et al., 2019) than a board game.

Obviously, other tools than the 'board game / computer simulation' framework can also be used to explore and bring out remediation scenarios for contaminated sites. It is even possible to go directly to the scenarios' deliberation phase (paradigm ❸) without using tools to support dialog. Nevertheless, let us point out that adopting the paradigms of complexity ❷ and ❸ to generate scenarios via the above framework is today already well integrated by participatory research, especially in the field of renewable natural resources, since at least 2 decades (Barnaud et al., 2006; Le Page et al., 2014; Perrotton et al., 2017; Taillandier et al., 2019; Abrami et al., 2021). We then think that transposing such an approach to another field related to environment management is not absurd. However, as stated by Fermet-Quinet, the renewable natural resources field is currently the only field to adopt the paradigm ❷ (Fermet-Quinet, 2024); and this weak presence of co-creation with stakeholders in current ISLANDR achievements (staying mainly on paradigm ❶) confirms this.

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