BONUS RETURN

Reducing Emissions by Turning Nutrients and Carbon into Benefits

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X	PU	Public.
	PP	Restricted to other project partners.
	RE	Restricted to a group specified by the consortium.
	CO	Confidential, only for members of the consortium.

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EXECUTIVE SUMMARY

This deliverable is part of Work Package 6 and Task 6.2. – Serious Game System Development. The overall aim of the Serious Game System (SGS) is to draw on empirical insights generated by the BONUS RETURN project, in a creative, safe and inclusive learning space that invites deliberation over the feasibility of different constellations of eco-technologies. Furthermore, it supports a participatory evaluation of the systemic impact different constellations of eco-technologies have on local contexts in the Baltic Sea Region (BSR). The SGS is intended to serve as a platform to foster systemic awareness of the biophysical, cultural and socio-economic status of the BSR in order to enhance agility and adaptive capacity when selecting eco-technologies and responding to disaster risks from unexpected nutrient and pollution emissions.

This deliverable describes the co-design process of the SGS, in the format of a board game entitled SELECT ECOTECH, with stakeholders from three case study contexts, namely Fyrisån (Sweden), Vantaanjoki (Finland) and Slupia (Poland). The co-design process presented in this report also provides the basis for the development of the digital game system, MONITOR ECOTECH, which is described in Deliverable 6.8.

SELECT ECOTECH is a learning platform that fosters knowledge co-production processes enacted through series of iterative playing sessions. In acknowledgement of the accelerated dynamics inherent within wicked situations within the BSR, systemic insights have been revealed in an exploratory and experiential process, grounded in the safe settings orchestrated by play and the "playing out" of challenging situations from the case study settings. Stakeholders both informed and co-developed parts of SELECT ECOTECH through their participation, from (1) contributing to the game content with their local knowledge of eco-technologies, land use measures and actions, vulnerability to shocks and disasters and; (2) testing and validating the game mechanics. Their contribution aided the incremental building of an increasingly solid and representational SGS.

SELECT ECOTECH has been developed as platform that can be implemented beyond the BONUS RETURN case studies. The game requires a skilled facilitator and can be played in different organisational settings to support learning processes and decision-making related to the selection and implementation of different constellations of eco-technologies and other environmental measures and actions. Potential users of SELECT ECOTECH are regional authorities, municipalities, interest organisations, water management companies, NGOs, farmers associations, etc.

1. Introduction

The degradation of the Baltic Sea is an ongoing problem, despite investments in measures to reduce external inputs of pollutants and nutrients from both diffuse and point sources. Available technological and management measures to curb eutrophication and pollution flows to the sea have not been adapted adequately to the contexts in which they are being applied. Furthermore, measures are often designed based on single objectives, thereby limiting opportunities for multiple benefits.

In addition, there is a general sense that measures to address the deterioration of the Baltic ecosystem are primarily technologically-driven and lacking broader stakeholder acceptance – the "experts" who define these measures have little engagement with industry, investors, civil society and authorities. This problem is magnified by governance and management, taking place in sectoral silos with poor coordination across sectors.

As a result, research shows that regional institutional diversity is presently a barrier to transboundary cooperation in the Baltic Sea Region (BSR) and that actions to achieve national environmental targets can compromise environmental goals in the BSR (Powell et al. 2013). The regional dimension of environmental degradation in the BSR has historically received weaker recognition in policy development and implementation locally. However, developments in recent years suggest a new trend with growing investments in environmental protection supporting social, economic, and territorial cohesion.

The BSR is an environmentally, politically and economically significant region and like other regions globally, its rapid growth needs to be reconciled with the challenges of sustainable development in a global setting that demands unprecedented reductions in GHG emissions. This poses a truly wicked problem exacerbated by the fact that many of the challenges in the BSR will also magnify in a changing climate. In order to navigate the uncertainties and controversies associated with a transformation towards a good marine environment, BONUS RETURN will enact an innovative transdisciplinary approach for identifying and piloting systemic eco-technologies.

The focus is on eco-technologies that generate co-benefits within other interlinked sectors, and which can be adapted according to geophysical and institutional contexts. More specifically, emphasis is placed on eco-technologies that reconcile the reduction of present and future eutrophication in marine environments with the regional challenges of policy coherence, food security, energy security, and the provision of ecosystem services.

1.1. Project Objectives

The **overall** aim of BONUS RETURN is to improve the adaptation and adoption of eco-technologies in the Baltic Sea Region for maximum efficiency and increased co-benefits.

The **specific objectives** of the project can be divided into six categories presented below. These categories are interlinked but for the purpose of providing a step-wise description, the following overview of each category proves useful. BONUS RETURN is:

1) Supporting innovation and market uptake of eco-technologies by:

- Contributing to the application and adaptation of eco-technologies in the BSR through an evidence-based review (systematic map) of the developments within this field.
- Contributing to the development of emerging eco-technologies that have the capacity to turn nutrients and carbon into benefits (e.g. bio-energy, fertilizers), by providing an encompassing framework and platform for rigorous testing and analysis.
- Developing decision support systems for sustainable eco-technologies in the BSR.
- Contributing to better assessment of eco-technology efficiency via integrated and participatory modelling in three catchment areas in Finland, Sweden and Poland.
- Contributing to methodological innovation on application and adaptation of eco-technologies.

2) Reducing knowledge gaps on policy performance, enabling/constraining factors, and costs and benefits of eco-technologies by:

- Assessing the broader socio-cultural drivers linked to eco-technologies from a historical perspective.
- Identifying the main gaps in the policy environment constraining the implementation of emerging eco-technologies in the catchments around the Baltic Sea.
- Informing policy through science on what works where and under which conditions through an evidence-based review (systematic map and systematic reviews) of eco-technologies and the regional economic and institutional structures in which these technologies evolve.

3) Providing a framework for improved systematic stakeholder involvement by:

- Developing methods for improved stakeholder engagement in water management through participatory approaches in the case study areas in Sweden, Finland and Poland.
- Enacting a co-enquiry process with stakeholders into opportunities for innovations in eco-technologies capable of transforming nutrients and pollutants into benefits for multiple sectors at different scales.
- Bringing stakeholder values into eco-technology choices to demonstrate needs for adaptation to local contexts and ways for eco-technologies to efficiently contribute to local and regional developments.
- Disseminating results and facilitating the exchange of learning experiences, first within the three catchment areas, and secondly across a larger network of municipalities in the BSR.
- Establishing new cooperative networks at case study sites and empowering existing regional networks by providing information, co-organizing events and engaging in dialogues.

4) Supporting commercialization of eco-technologies by:

- Identifying market and institutional opportunities for eco-technologies that (may) contribute to resource recovery and reuse of nutrients, micro-pollutants and microplastics (e.g. renewable energy).
- Identifying potential constraints and opportunities for integration and implementation of eco-technologies using economical models.
- Facilitating the transfer of eco-technologies contributing to win-win solutions to multiple and interlinked challenges in the BSR.
- Linking producers of eco-technologies (small and medium enterprises – SMEs), to users (municipalities) by providing interactive platforms of knowledge exchange where both producers and users have access to BONUS RETURN's envisaged outputs, existing networks, and established methodologies and services.

5) Establishing a user-driven knowledge platform and improved technology-user interface by:

- Developing an open-access database that maps out existing research and implementation of eco-technologies in the BSR. This database will be intuitive, mapped out in an interactive geographical information system (GIS) platform, and easily managed so that practitioners, scientists and policy-makers can incorporate it in their practices.
- Developing methodologies that enact the scaling of a systemic mix of eco-technological interventions within the highly diverse contexts that make up the BSR and allows for a deeply interactive medium of knowledge.

1.2. Project Structure

BONUS RETURN is structured around six Work Packages that will be implemented in three river basins: the Vantaanjoki river basin in Finland, the Słupia river basin in Poland, and Fyrisån river basin in Sweden.

- Work Package 1: Coordination, management, communication and dissemination.
- Work Package 2: Integrated Evidence-based review of eco-technologies.
- Work Package 3: Sustainability Analyses.
- Work Package 4: Environmental Modelling.
- Work Package 5: Implementation Support for Eco-technologies.
- Work Package 6: Innovative Methods in Stakeholder Engagement.

1.3. Deliverable context and objective

Deliverable 6.7 is part of WP6. The objective of WP6 is to serve as the platform to enable a co-enquiry process between stakeholders and the project. At the regional level, the 40 municipalities connected to Race for the Baltic will act as a sounding board to provide input to the Evidence-based Review in WP2.

Stakeholder platforms have be established at the case study sites to support the identification of eco-technologies for analysis in WP3, WP4 and WP5. These platforms have served as opportunities to further test, develop, adapt and use the eco-technologies based on the assumption that their effectiveness and relevance depends on context, as defined by institutional, economic, social and bio-physical barriers and opportunities. WP6 has contributed to understanding historical drivers, policy instruments, governance structures and local needs with regards to implementation of the selected eco-technologies in the three case study sites.

The task connected to this deliverable is T 6.2 – Serious Game System Development. The aim of the Serious Game System (SGS) is to draw on empirical insights generated by the BONUS RETURN project, in a creative, safe and inclusive learning space that invites deliberation over the feasibility of different constellations of eco-technologies. Furthermore, it will support a participatory evaluation of the systemic impact different constellations of eco-technologies have on the Baltic Sea Region (BSR). It is intended that the SGS will serve as a platform to foster systemic awareness of the biophysical, cultural and socio-economic status of the BSR in order to enhance agility and adaptive capacity when selecting eco-technologies and responding to disaster risks from unexpected nutrient and pollution emissions.

This deliverable describes the development process of the SGS in the format of a board game, hereafter referred to as SELECT ECOTECH, through a co-design process with stakeholders in the three case study contexts, namely Fyrisån (Sweden), Vantaanjoki (Finland) and Slupia (Poland).

1.4. Outline of the report

This report begins by introducing the concept and purpose of the SGS. Thereafter the co-design process is outlined, and finally the board game mechanics and rules are described. Data used in the play sessions of the SGS, such as eco-technologies, development interventions, constellations of eco-technologies, system shocks, disasters and policy interventions are included in the Appendices.

2. Serious Game System - SELECT ECO TECH

2.1. Concept for the Serious Game System

Serious games as an exploratory method and a transdisciplinary research approach

Serious games are used for purposes rather than entertainment and are gaining increasing attention within both the sustainability discourse and natural resource management. They have been used for a whole host of different purposes, for instance, teaching and training, research and data collection, facilitating social learning and change of practices (Flood et al., 2018; Rodela et al., 2019). Serious games are increasingly seen as a robust method for engaging with stakeholders and end-users and enhancing the learning effects (ibid). They can represent real-world issues, but at the same time, offer greater freedom to think outside the box (Gugerell & Zuidema, 2017). Serious games can provide a safe, creative and open space for multiple stakeholders to cross knowledge boundaries, navigate "wicked"[1] situations and explore different pathways for transformation towards sustainability (Gugerell & Zuidema, 2017; Jean et al., 2018). It is in this setting where co-production of knowledge and real empowerment take central place (de Suarez et al 2012; Flood et al., 2018), where systems understanding can be improved and novel solutions and approaches can be identified (Gugerell & Zuidema, 2017). Co-designing a serious game with stakeholders thus enables the process of exploring, experimenting, learning and developing novel narratives in a realistic but inconsequential context (ibid).

Serious Game System: SELECT ECOTECH in the context of BONUS RETURN

SELECT ECOTECH is a learning platform that hosts knowledge co-production processes enacted by a series of iterative playing sessions. Conventional eco-technological innovations tend to grow out of normal scientific traditions, which focus on generating knowledge that optimizes an outcome for a single interest and as such are maladapted in "wicked" situations. In response, transdisciplinary science (knowledge co-production between stakeholder and researchers), facilitated by participatory methods, such as the SGS, has emerged as a viable alternative (Medema et al., 2019).

Epistemologically, SELECT ECOTECH operates beyond the normal conceptualization of science as a practice for producing research findings to fill defined knowledge gaps in society. Rather, in acknowledgement of the accelerated dynamics inherent within wicked situations within the BSR, systemic insights have been revealed in an exploratory and experiential process, grounded in the safe settings orchestrated by play and the "playing out" of challenging situations from the case study settings. Moreover, in order to ensure that selected constellations of eco-technologies are systemic and have high adaptive capacity[2], SELECT ECOTECH's structures have been designed to stimulate players' anticipation of future uncertainties, from projected changes in bio-physical regimes, climate change and other interconnected challenges within the BSR, in order to improve systems practice and agility of those implementing eco-technologies.

Stakeholders both informed and co-developed parts of SELECT ECOTECH through their participation, from contributing to the game content with their knowledge of eco-technologies, developments, shocks and disasters of relevance to their local context; to testing and validating the game mechanics (see Table 1 for the list of stakeholder meetings throughout the co-development process). Their contribution aided the incremental building of an increasingly solid and representational form. The investigative playing-out of various situations was not dependent on SELECT ECOTECH being a fully functional game. Rather, the learning and co-production of knowledge began at the onset of the development process. In so doing,

[1] Wicked situations are situations characterized by a high degree of uncertainty, complexity and controversy (Rittel & Weber 1973).

[2] Adaptive capacity for the purposes of this report refers to the capacity for a constellation of eco-technologies to sustain its functional properties in response to the inherent socio-ecological uncertainties within the BSR associated with conflicting interests and non-equilibrium properties (Berkes and Folke 1998; Collin and Ison 2009).

SELECT ECOTECH was informed and shaped by stakeholders who are continuously navigating wicked situations in the context where they are performing their daily professional roles.

At its inception, the development of SELECT ECOTECH began as an emergent process of coevolution in a game space where players play out their roles and thus exert forces that influence other players and various factors. Concurrently, the environment changes and thereby orchestrates agency (affordances). As a representation of a so-called real context, SELECT ECOTECH exposes a diverse set of players to a range of dilemmas and crises in order to support both an intersubjective[3] and systemic understanding of the eco-technologies' performance.

Key attributes of SELECT ECOTECH:

- SELECT ECOTECH helps expose dynamics operating in the system and in so doing enhances the decision-making capacity in wicked situations.
- SELECT ECOTECH enables co-learning processes that have merit in reconciling multiple demands i.e., when intersubjective outcomes are sought.
- SELECT ECOTECH is inherently inconsequential and thus particularly suited to wicked situations which are often characterised by controversy and complexity.
- SELECT ECOTECH allows for iterations and future scenarios, which again points at their suitability in hosting learning processes about uncertain futures characterised by shocks and surprises.

2.2. Process design and methodology for SELECT ECOTECH

Participatory game design process (co-design process)

Participatory design or co-design is emerging as a potential approach in serious game design. Participatory design is generally understood as involving various stakeholders in the design process to facilitate learning, minimize designer bias and ensure that the products and outcomes generated are better aligned with stakeholder needs (Khaled and Vasalou, 2014; Ampatzidou and Gugerell, 2018). In game design, stakeholder participation in co-design activities will help bring real-world knowledge, perceptions and interests to the game content, which in turn will lower the risk of failure due to blind spots or misinterpretation of the domain-specific content (Ampatzidou and Gugerell, 2018).

There are four common ways to engage with stakeholders in game design processes: i) stakeholders as users of the game, ii) stakeholders as testers (they test playable prototypes), iii) stakeholders as informants (they inform and consult the game design team), iv) stakeholders as design partners who are fully engaged in a co-design process (Mildner and Mueller, 2016). In the BONUS RETURN project, we adopted the fourth design strategy which embraces the highest level of stakeholder engagement,

[3] Abram (1996, p. 37) describes intersubjectivity as "multiple subjectivities". If several subjects each endowed with their range of interpretative filters, arrive at a similar interpretation of a particular phenomenon or problem, then the interpretation should be legitimate in the eyes of the larger community.

recognising stakeholders as equal partners for the design of much of the content operating in the serious game system.

Our choice of designing SELECT ECOTECH in the format of a board game is motivated by the fact that board games can be used as a natural starting point for new serious digital game projects, especially in cases where stakeholders are co-designers as this format can support the participatory design process to a great extent (Castronova and Knowles, 2015). Unlike digital games, the rules of a board game are generally explicit and can be modified easily and rapidly, allowing for flexibility and swiftness that is often desirable in iterative game design processes. Another advantage of board games is their transparency, exposing players to the various mechanics and data that create complex and dynamic systems/situations (ibid).

Process design for SELECT ECOTECH

The process design for SELECT ECOTECH in the BONUS RETURN project is depicted in Figure 1. Our iterative development process is comprised of three main phases.

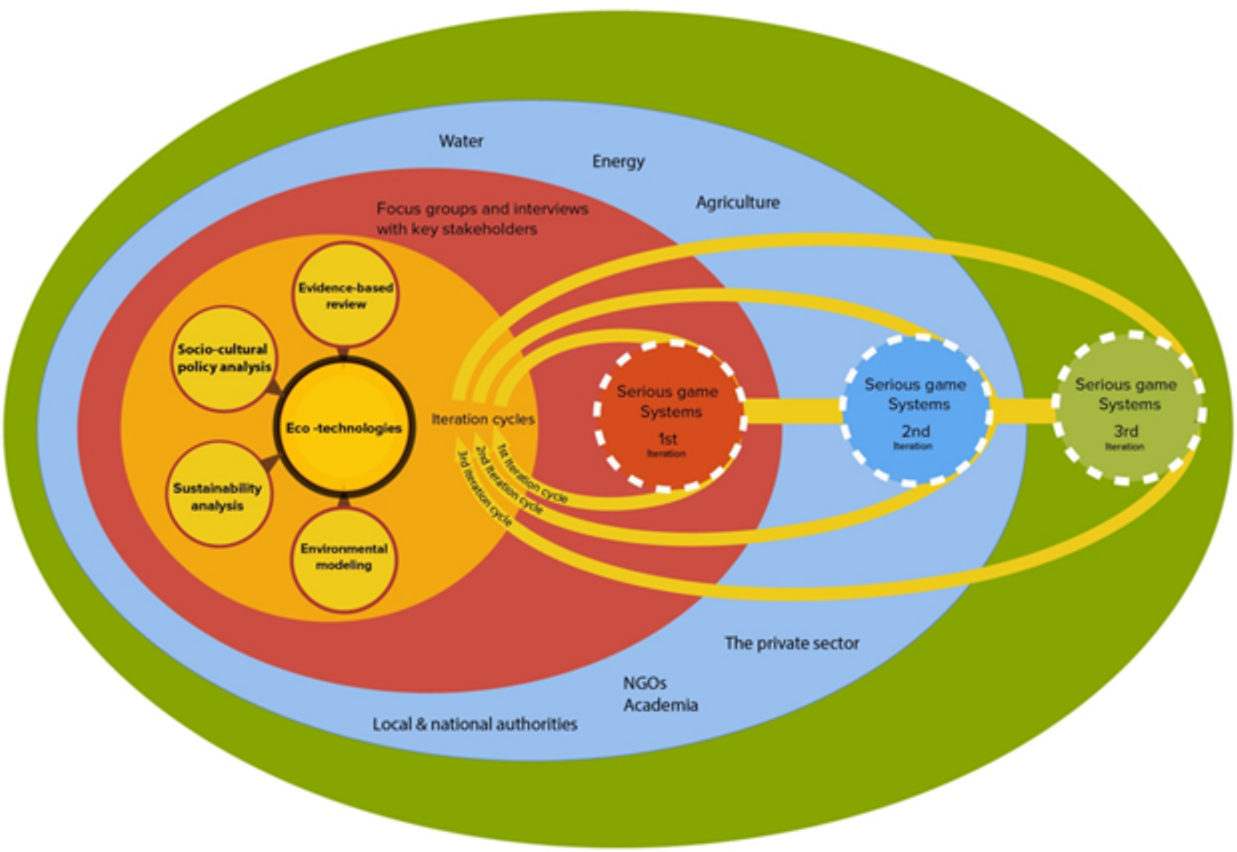

Figure 1. Process design for SELECT ECO-TECH in the BONUS RETURN project

Phase 1: The concept design phase

In this phase, we drew on the project's scientific expertise (the orange core in Fig. 1) to elicit a preliminary understanding of the project's empirical context (blue space), namely Fyrisån (Sweden), Slupia (Poland) and Vantaanjoki (Finland) and the problem domain. Key stakeholders for the co-design process were identified based on Soft Systems Methodology (Checkland, 2000) and initial interaction with stakeholders was established through key informant meetings (more details on the methodology can be found in Deliverable 6.1). During this interaction, the stakeholders developed rich pictures (see Fig. 2) based on an issue framing exercise to depict how different issues were framed in their respective river catchments. Based on an analysis of the rich pictures, it was possible to identify those who potentially had a stake in eco-technologies designed to support nutrient and carbon recycling. Moreover, this supported our understanding of what co-benefits would be desirable to derive from the implementation of proposed eco-technologies. At the end of this phase, a learning platform began to emerge which was comprised of a group of key stakeholders who expressed an interest in taking part in the co-design and co-development of SELECT ECOTECH.

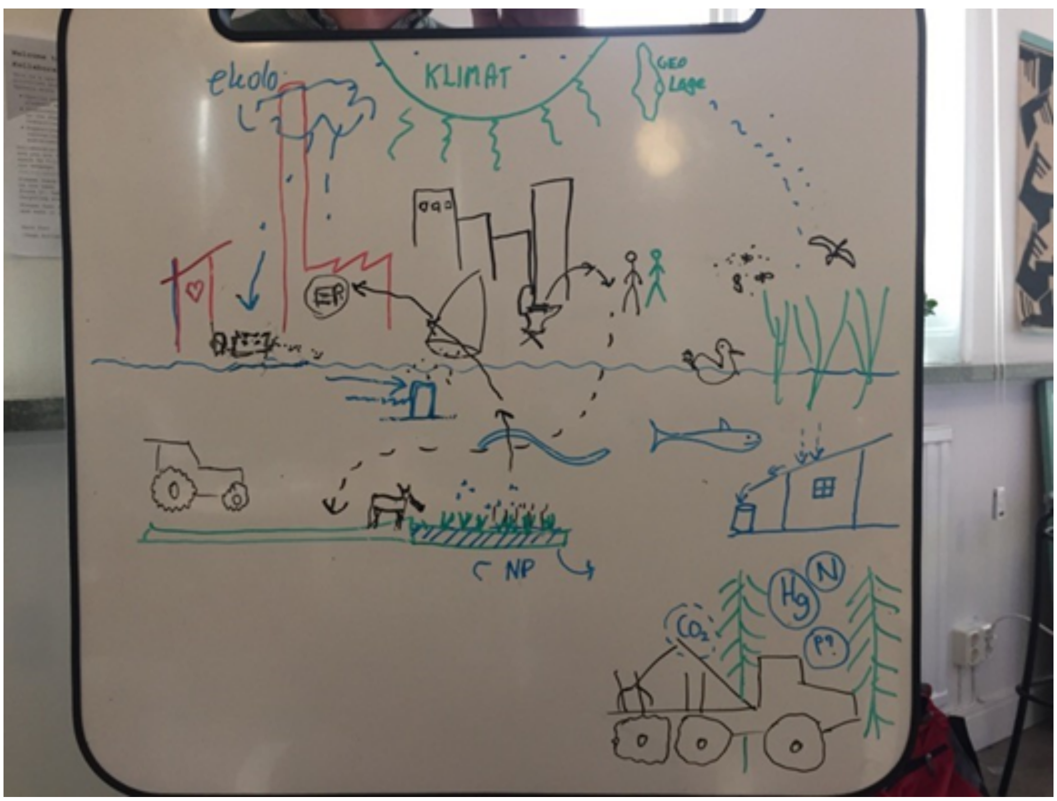

Figure 2. A rich picture of the Fyrisån case study created by the stakeholders in Uppsala (Photo: Olle Olsson)

Phase 2: The game co-design phase

A series of interviews and focus groups with key stakeholders were implemented in the three case study sites in order to support the co-development of SELECT ECOTECH's game mechanics and functions (see Fig. 3). The first round of focus groups fostered critical reflection on the dilemmas the stakeholders face in their respective contexts and surfaced numerous local approaches to address. The second round of focus groups introduced the first iteration of the board game to mediate stakeholder dialogue pertaining to eco-technology preference and appropriate modes of implementation. Further insights emerged when players were faced with challenging situations and needed to respond by devising an appropriate constellation of eco-technologies and developments that could best serve their multiple interests. The safe setting of SELECT ECOTECH also helped cast light on more controversial insights into why barriers to implementation of eco-technologies persist, are reproduced, or are amplified in in their own contexts and thereby opened up a space to learn about how these situations could be transformed. During this phase, the stakeholders were further offered an opportunity to playtest and co-develop some aspects of the board game. The open and iterative structure of the SGS also allowed the stakeholders to generate new ideas for game rules and mechanics and experiment with them on the spot.

Figure 3. Playtesting and co-developing aspects of the board game with stakeholders (Photo: Steven Bachelder)

Phase 3: The final co-development phase

The insights harvested from the second phase were analysed in order to refine the board game mechanics and functions. The second iteration of SELECT ECOTECH was developed to mediate stakeholder dialogue in a cross-case SGS workshop with a focus on the risks and challenges growing out of the uncertainties and controversies connected to the BSR's marine and terrestrial environments (see Fig. 4). During this interactive session, stakeholders from all the three case studies explored how different constellations of eco-technologies perform in the face of disaster risks and threats that are presently manifest within the BSR, whilst revealing similarities and differences within and between contexts. The data generated supported continuous improvement and validation of SELECT ECOTECH, leading to the production of the third version.

The third version SELECT ECOTECH mediated another cross-case SGS workshop with a focus on understanding how the existing policy environment enables or hinders the implementation of different eco-technologies in agriculture, forestry and urban areas. Insights from this workshop supported the final stage in the development of SELECT ECOTECH.

Figure 4. Stakeholders explored, play-tested and co-developed the SGS in Uppsala in October 2019 (Photo: Brenda Ochola)

The co-development process of SELECT ECO-TECH is outlined in Table 1 as a series of stakeholder meetings run throughout the course of the project.

Table 1. The process supporting the co-development of SELECT ECO-TECH in the three case studies.

Activity	Time	Place	No. of participants	Sectors represented
Workshop with key informants in the Vantaanjoki case study	10 October 2017	Helsinki, Finland	7	Environment, water protection, municipality
Workshop with key informants in the Fyrisån case study	27 October 2017	Uppsala, Sweden	11	Wastewater treatment, water management, energy, forestry, academia
Workshop with key informants in the Slupia case study	11 December 2017	Slupsk, Poland	12	Wastewater treatment, water management, agriculture, environmental protection, environmental consulting, academia
A series of interviews with key stakeholders in Uppsala	October - November 2018	Uppsala, Sweden	6	Agriculture, water management, wastewater treatment, energy, municipality, regional authority
First SGS focus group with Finnish stakeholders (see Appendix 6 for the invitation)	11 October 2019	Helsinki, Finland	11	Academia, agriculture, wastewater treatment, forestry, municipality
First SGS focus group with	11 December	Slupsk, Poland	14	Academia,

Polish stakeholders (see Appendix 6 for the invitation)	2018			Agriculture, wastewater, regional administration, forestry, energy, private sector, biodiversity
First SGS focus group with Swedish stakeholders (see Appendix 6 for the invitation)	17 December 2018	Uppsala, Sweden	10	Academia, agriculture, wastewater, municipality, regional authority, energy
Second SGS focus group with Finnish stakeholders (see Appendix 7 for the invitation)	8 May 2019	Helsinki, Finland	7	Academia, agriculture, water protection, forestry
Second SGS focus group with Polish stakeholders (see Appendix 7 for the invitation)	14 May 2019	Slupsk, Poland	10	Academia, water supply and management, wastewater treatment
Second SGS focus group with Swedish stakeholders (see Appendix 7 for the invitation)	17 June 2019	Uppsala, Sweden	6	Academia, agriculture, wastewater, municipality, regional authority
SGS cross-case workshop focusing on potential risks and threats to the BSR (see Appendix 8 for the agenda)	28 October 2019	Uppsala, Sweden	11	Academia, agriculture, wastewater, water protection, municipality
SGS cross-case workshop focusing on the policy environment (see Appendix 9 for the agenda)	13 December 2019	Helsinki, Finland	10	Academia, agriculture, wastewater, water protection, forestry

2.3. Description of the board game mechanics and functions

The transdisciplinary research process that we have enacted over the course of the BONUS RETURN project has resulted in a board game version SELECT ECOTECH, which embodies the co-production of knowledge between researchers and stakeholders during the project. This SGS serves as a learning platform to support the selection of implementable constellations of eco-technologies that (1) reduce nutrient and carbon emissions; (2) maximise co-benefits and; (3) have the adaptive capacity to respond to the socio-ecological uncertainties manifest within the Baltic Sea region.

2.3.1. Objectives of the board game

The players' objective in SELECT ECOTECH is threefold: i) *to reduce emissions from their respective land use systems (urban areas, forestry, and agriculture) ii) to increase the productivity of these systems iii) to increase the adaptive capacity of their land use systems.* The players must use resources to purchase both eco-technologies and development interventions in order to achieve those objectives. When deploying eco-technologies and development interventions, the players need to navigate the checks and balances from a dynamic policy environment; the potential conflicts of interests with other players, as well as the shocks and risks they may encounter in a dynamic socio-ecological system.

2.3.2. Set-up of the board game

SELECT ECOTECH requires a facilitator who is familiar with the game mechanics and functions to guide players through the play session. The game can be played between two players or two teams.

The board game SELECT ECOTECH includes the main board, 6 hexagon tiles for three different land use systems (2 for Agriculture, 2 for Forestry and 2 for Urban area) and a number of game tokens, including eco-technology token (white), development token (black), resource tokens (green) and emission tokens (red). The board game is set up at the beginning of a play session as follows (see Fig. 5):

- Place the game board on a flat surface and within easy reach of all players. The hexagon "W" at the centre of the board represents the Baltic Sea.
- Divide the players into 2 teams, each responsible for a separate catchment.
- Each team is provided with 3 *hexagon tiles* representing 3 respective land use systems – Agriculture (A), Forestry (F), and Urban area (U). The tiles differ in the shade of colour (one team has the darker colour).
- Each team takes turns populating their catchment around the Baltic Sea by placing the hexagon tiles one at a time around the board. The tiles can be placed anywhere out of 6 positions on the board, but those belonging to the same team must be adjacent.
- Determine which team goes first by throwing a dice. The team that has a higher number on the dice takes the first move.

- The sector with the highest total emission (agriculture in the Vantaanjoki and Slupia cases and forestry in the Fyrisån case) must always be placed with the big arrow downstream towards the Baltic Sea.
- Once both teams have laid out all their tiles on the board, start calculating the emissions for each team.

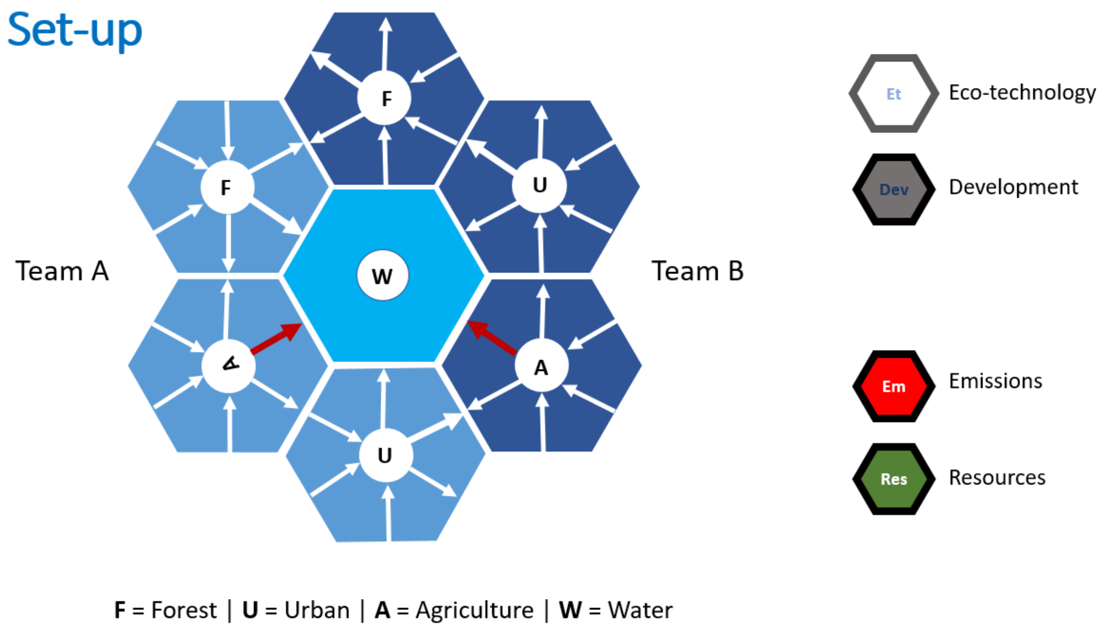

Figure 5. Set up of the board game

2.3.3. Sets of rules

Baseline emissions

Total baseline emissions in Agriculture will depend on which context the game is played. Data from WP4 (Environmental Modeling) suggests that the relative contribution of total emissions between the three sectors varies between cases (see Table 2). Figure 6 depicts Agriculture's P and N emissions in the Vantaanjoki catchment, which are equivalent to 120 emissions in the game setting. Each downstream flow carries 40 emissions. The emissions from these flows converge before they get divided up into one mainstream and two tributaries as follows:

- Mainstream: 50% of the total emissions (60 emissions)
- Tributaries: 25% of the total emissions (30 emissions each)

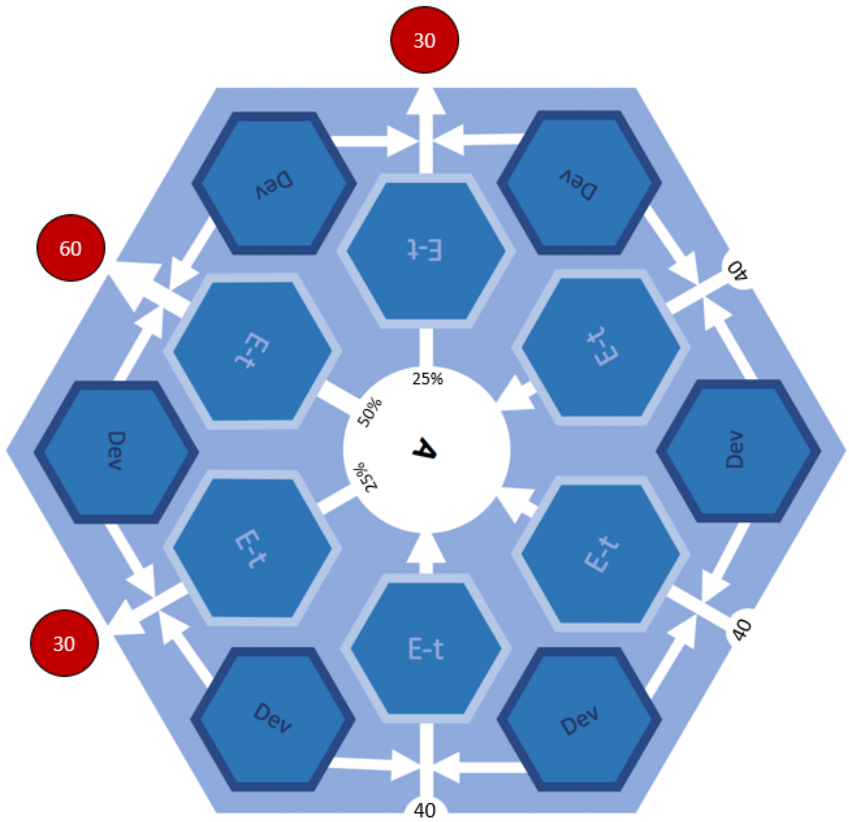

Figure 6. Baseline emissions in Agriculture

Table 2. Representational contribution of total emissions between the three sectors from the three case studies

	Agriculture	Forestry	Urban area
Fyrisån	38%	52%	10%
Vantaanjoki	80%	4%	16%
Slupia	53%	40%	7%

Total urban baseline emissions within the Vantaanjoki catchment are equivalent to 24 emissions (see Fig. 7). Each upstream flow carries 8 emissions. The emissions from these flows converge before they get divided up into one mainstream and two tributaries as follows:

- Mainstream: 50% of the total emissions (12 emissions)
- Tributaries: 25% of the total emissions each (6 emissions each)

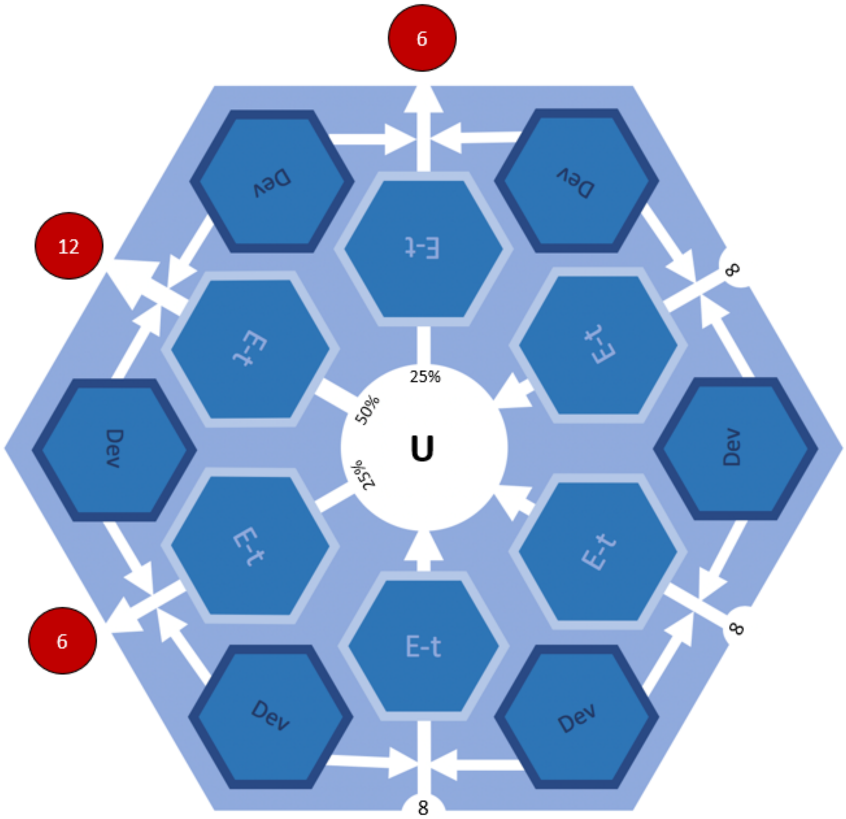

Figure 7. Baseline emissions in Urban area

Total baseline emissions within the Forestry sector in the Vantaanjoki catchment is equivalent to 6 emissions (see Fig. 8). Each upstream flow carries 2 Emissions. The emissions from these flows converge before they get divided up into one mainstream and two tributaries as follows:

- Mainstream: 50% of the total emissions (3 emissions)
- Tributaries: 25% of the total emissions each (2 emissions and 1 emission respectively). In case of an uneven division, the tributary to the right of the main stream gets the higher amount.

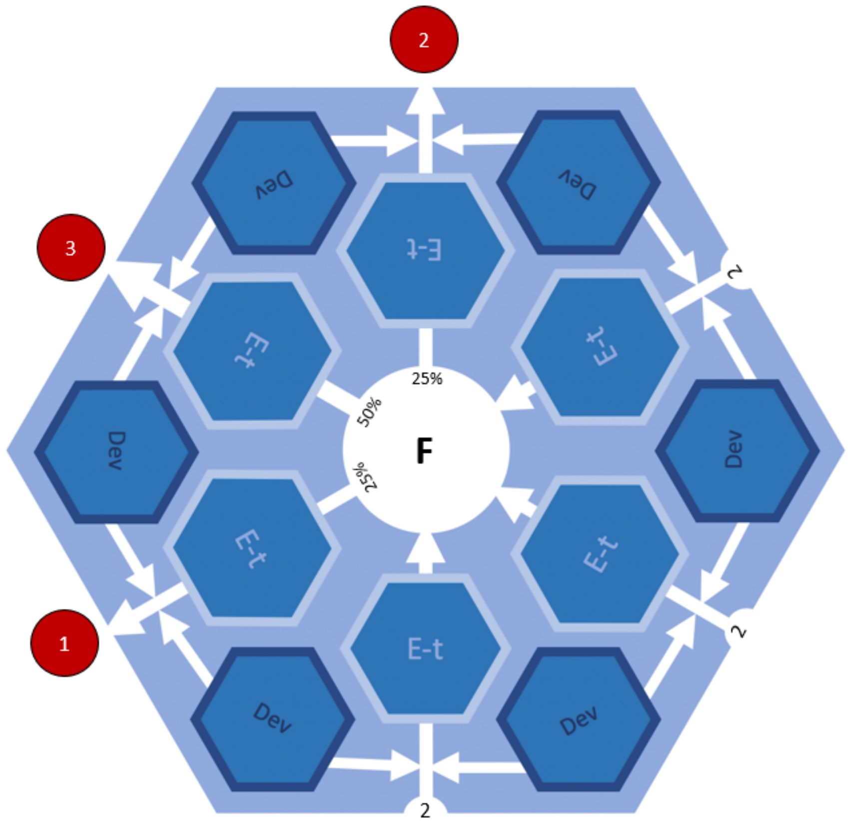

Figure 8. Baseline emissions in Forestry

The interaction of flows and how to calculate the amount of emissions

- Follow the direction of flows to calculate the emissions in different spots. Begin from Agriculture as the direction of flows in Agriculture is "locked-in" downstream towards the Baltic Sea.
- When emissions from one sector flow into another sector within the same catchment, these emissions will be carried over to the latter and added together with its own baseline emissions before being divided up into one main stream and two tributaries according to the ratio 50%-25%-25%. (See example illustrated on Fig. 9)
- When an emission flow from Team A's catchment runs into Team B's, the emissions will be transferred from Team A to Team B (and vice versa) and calculated in a similar way to when emissions move between sectors within the same catchment.
- When 2 flows from 2 different catchments meet each other (see Fig. 10), the emissions carried by these flows will end up in the Baltic Sea at the end of the year (after 3 rounds).

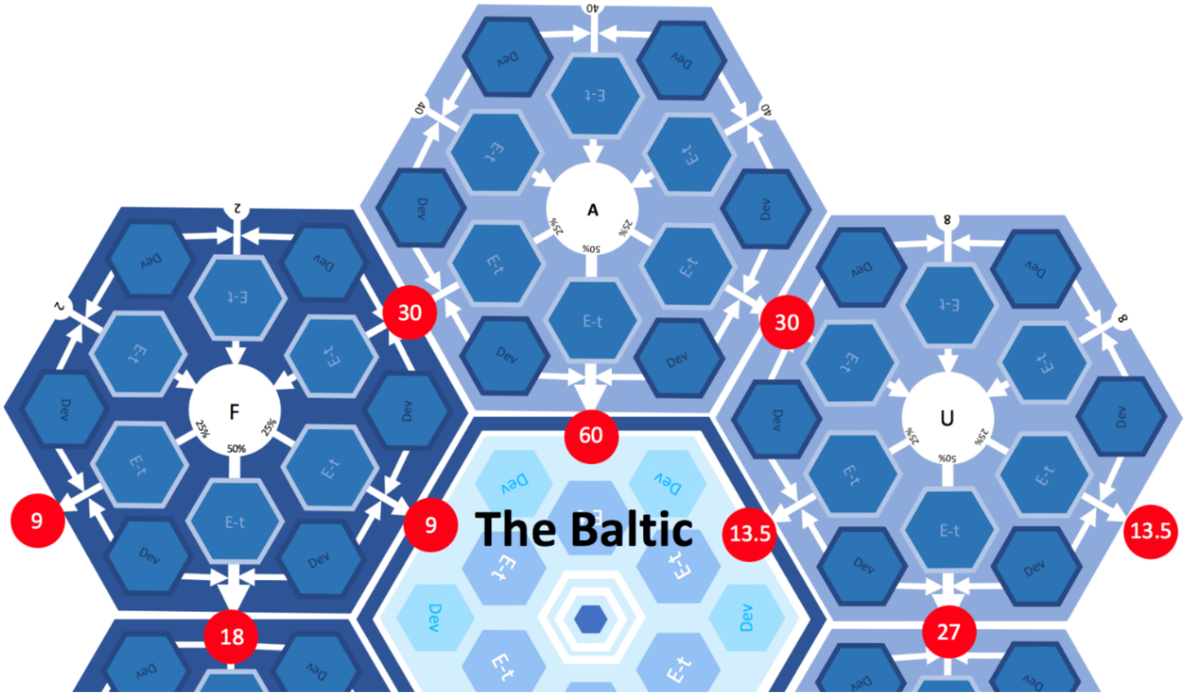

Figure 9. Emissions flow from Agriculture to Forestry and Urban area by 30 respectively

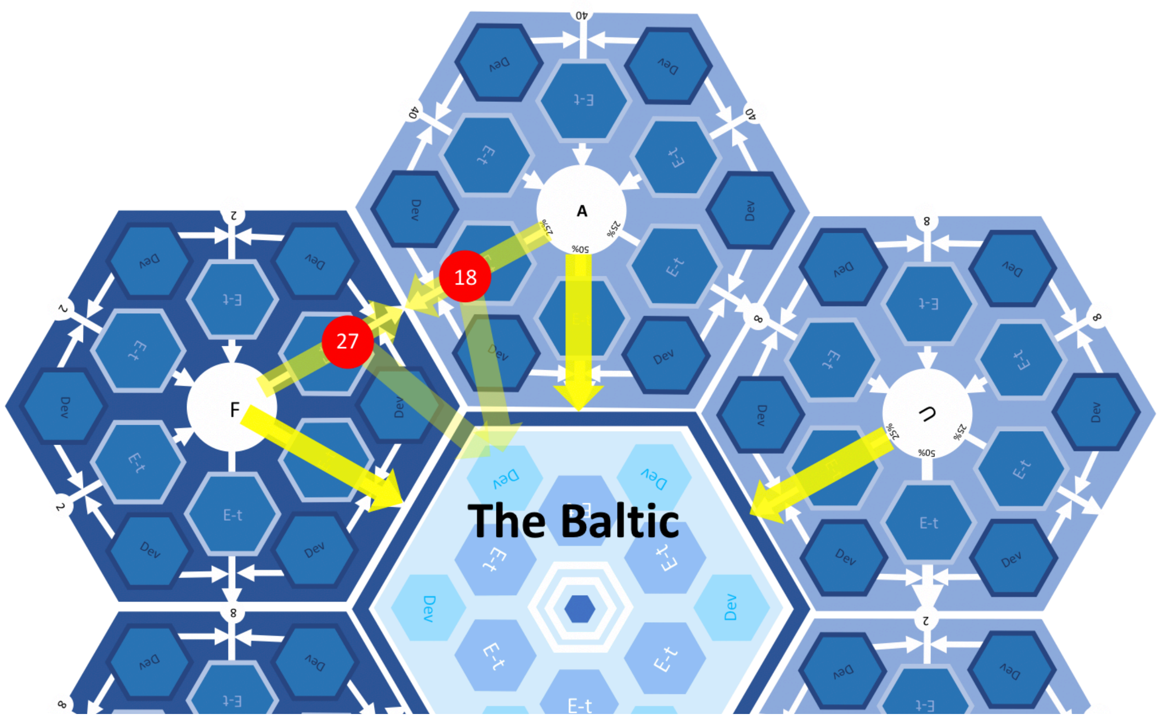

Figure 10. When two catchments interface

2.3.4. How to play

- Each team is given 100 Resources at the start of the game.
- At the beginning of each round, throw the dice to determine how many eco-technologies and/or development interventions a team can buy with their resources (The team with a higher number on the dice goes first). See Appendix 1 and 2 for suggestions on eco-technologies and developments which have grown out of the stakeholder engagement process. However, the choice of eco-technologies and/or development interventions is not bound by these lists. In fact, players have the freedom to write into the game new eco-technologies or developments as they play along. The key idea is to develop synergistic constellations of eco-technologies and developments in order to fulfill the three main objectives of the game (see Appendix 3 for examples of synergistic constellations).
- At the end of each round, a volunteer player will draw a ”shock” card randomly from a given deck of cards. The shock will affect both teams’ eco-technologies and developments.
- If the ”shock” card is blank, cast dice to decide which team can write on the card. The team with a higher number on the dice will be given the opportunity to come up with any shock or policy change that can minimize their loss but maximize their opponent’s loss. (See Appendix 4 for potential shocks, and Appendix 5 for potential policy changes)
- Re-calculate the emissions only at the end of the year, i.e. at the end of every third round. Note that a year is equivalent to 3 rounds.

2.3.5. The game economy

The game economy consists of eco-technologies and developments (see Fig. 11). The cost and capacity to reduce emissions of an eco-technology is based on its cost-effectiveness (see Table 3). A development, on the other hand, costs 20 Resources to purchase, but generates 10 Resources per round and 10 Emissions per year. Note that an eco-technology or development can be implemented upstream or/and downstream (this information is given on the eco-technology cards). Special sea measures, e.g. mussel farming, seaweed farming, irrigation with seawater, that are considered both eco-technologies and developments, cost 35 Resources to purchase, and generates 10 Resources per round and reduces 5 Emissions per year.

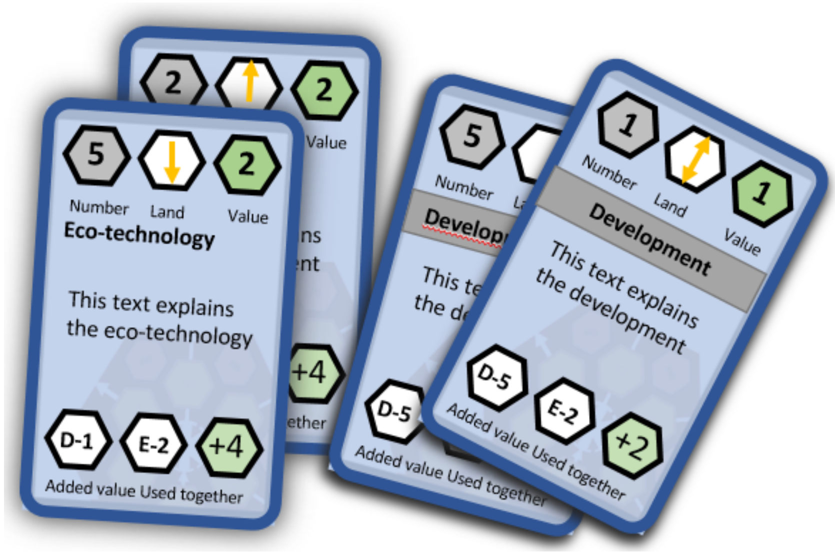

Figure 11. Eco-technology and Development cards

Table 3. Cost-effectiveness of the eco-technologies (1 - the most cost-effective; 5 - the least cost-effective)

Cost-effectiveness	Costs	Emission reduction
1	40	40
2	25	13
3	15	5
4	13	3
5	10	2

2.3.6. Ending of the game

The game ends after 2 years (after 6 rounds)[4]. In order to determine which team wins, do the calculations as follows:

- First, count the emissions each team has on their respective catchment and in the sea adjacent to these.
- Second, tally up each team's total resources.

[4] The game can also be played more than 6 rounds, depending on the time allocated for the play session.

- Third, calculate how many resources it would take to offset the remaining emissions according to the following rules: *It costs 5 Resources to remove 1 Emission on land and costs 10 Resources to remove 1 Emission in the sea.*
- The team that has the most resources wins the game.

Final Resources = Total Resources – (5 Resources x Total emissions on land) – (10 Resources x Total emissions in the sea)

2.3.7. Future use of SELECT ECOTECH

SELECT ECOTECH can be applied beyond the BONUS RETURN project boundaries and the group of stakeholders who have been directly involved in the co-development process. The game requires a skilled facilitator (game master) and can be played in different organisational settings to support learning processes and decision-making. This SGS supports the selection and implementation of different constellations of eco-technologies and other environmental measures and actions that have the capacity to address nutrients, carbon and emission of other pollutants, whilst remaining cognisant of the need for these eco-technologies to reconcile multiple demands at the local context. Potential users of SELECT ECOTECH are regional authorities, municipalities, interest organisations, water management companies, NGOs, farmers, etc.

3. Concluding Remarks

This report shows that co-developing a Serious Game System with stakeholders offers a promising approach to support knowledge co-production processes between scientists and a diverse group of stakeholders in a creative, safe and inclusive space. Within this setting, meaningful and locally relevant narratives can be created to enable choices that move beyond technocratic solutions and take into account the inherent complexity of the bio-physical, socio-cultural, economic and political landscape. Findings from the development of SELECT ECOTECH suggest that the open and iterative structures of the board game supported deliberation and decision making connected to the selection and implementation of existing constellations of eco-technologies under wicked and contested real world conditions. Furthermore, SELECT ECOTECH created the space for exploration and experimentation of innovative constellations that have the capacity to create more synergies. This took place in the inconsequential and playful setting of the game system, which was found to be crucial in triggering thinking outside the box and the crossing of knowledge boundaries. Another important finding was that the learning and co-production of knowledge already began at the onset of the SGS development process and was not dependent on a fully functional game with prescriptive rules and mechanics. The stakeholders who were involved in the process viewed themselves as co-developers of the board game, which was essential in creating an equal playing field for the emergence of a truly engaging and exploratory learning platform.

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5. Appendices

Appendix 1. List of eco-technologies in the SGS

No.	Eco-technology	Placement	Cost-effectiveness
1.	Wetlands	Upstream	1
2.	Buffer strips	Upstream + Downstream	2
3.	Catch crops	Upstream + Downstream	3
4.	Crop rotation	Upstream + Downstream	3
5.	Retention ponds	Upstream	2
6.	Biochar application Agriculture	Upstream + Downstream	3
7.	Biochar application Forest	Upstream + Downstream	5

8.	Compost application Agriculture	Upstream + Downstream	3
9.	Compost application Forest	Upstream + Downstream	5
10.	Sludge application Agriculture	Upstream + Downstream	1
11.	Sludge application Forest	Upstream + Downstream	3
12.	Improving drainage management on farms	Upstream + Downstream	3
13.	Restoration of riparian areas	Upstream + Downstream	3
14.	Floodplains	Downstream	3
15.	Liming / gypsum	Upstream	4
16.	Optimizing fertilization rates based soil parameters using geo-location systems	Upstream + Downstream	1
17.	Optimization of livestock density for nutrient management	Upstream + Downstream	2
18.	Microstrainer technologies at fish farms	Upstream + Downstream	3
19.	Connecting 100% of population to wastewater treatment	Upstream + Downstream	4
20.	Improved stormwater management	Upstream + Downstream	3
21.	Improving on-site treatments	Upstream + Downstream	5
22.	Source separation of waste for scattered settlements	Upstream + Downstream	3
23.	Urine-diversion toilets	Upstream + Downstream	4
24.	Wastewater improvements that deal with overflow	Upstream + Downstream	3
25.	Biochar treated with source-separated blackwater as soil improver	Upstream + Downstream	3
26.	Incineration and phosphorus recovery from ash	Upstream + Downstream	4
27.	Biochar filter	Upstream + Downstream	3

28.	Enhanced wastewater treatment level through ultrafiltration and UV-disinfection	Upstream + Downstream	2
29.	Irrigation with seawater	Downstream	1
30.	Mussel farming	Downstream	3
31.	Seaweed farming	Downstream	3

Appendix 2. List of developments in the SGS

1. District heating
2. Green house
3. Tourism
4. Building houses for rent
5. Slaughterhouse
6. Biogas plant
7. Increase in fertilisation
8. Acquiring new areas for crop cultivation
9. Mechanization of agriculture
10. Advanced decentralized wastewater system
11. Getting stumps out of the forests
12. Seaweed farm
13. Mussel farm
14. Irrigation with seawater
15. Urban farming

Appendix 3. List of synergistic constellations of eco-technologies and developments

1. Small scale district heating

   Combined with: Incineration and phosphorus recovery from ash
2. Greenhouse

   Combined with: District heating, biochar, compost or irrigation from nutrient-rich retention ponds
3. Hunting tourism

   Combined with: Riparian zones, wetlands and buffer strips
4. Building houses for rent

Combined with: District heating with renewable energy, urine-diversion toilets, source separation of waste from scattered settlements.

5. Slaughterhouse

   Combined with: Biogas plant and biochar production

6. Biogas plant

   Combined with seaweed farm, mussel farm and buffer strips

Appendix 4. List of system shocks generated by stakeholders in the SGS

Swedish case study	Finnish case study	Polish case study
● Change of chemicals legislation: all new chemicals supplied to society must be investigated before import and use ● Wastewater as a resource would feel "safer" for the public ● Prohibition of sewage sludge use ● Highly increased transportation costs (for water) ● Fast cost reduction on decentralised and mass produced wastewater treatment technology ● New legislation on drainage ● Ecological tax reform on electricity ● Subsidies/support for technical development in biogas	● Warming climate (mild winter and rainfall) ● Extreme drought ● Massive flood episodes ● No ground frost during the whole winter ● Strict nitrogen budget in the EU's Common Agricultural Policy (CAP) ● Only EU's developing countries are entitled to receive subsidies from CAP ● Decrease of animal manure due to an increase in vegetarian diets ● Heath problem(s) caused by the use of sludge on agricultural lands ● Profitability in farming increases dramatically ● Permits for peatland management, drying peatlands	● Rapid increase in prices for fuels (oil, gas, electric energy) ● Long period of dry years (severe drought) due to climate change ● Accident at the Composting Plant – no possibility to collect and compost the organic waste ● Lack of energy supply – industrial catastrophe ● Infrastructure damage caused by flood ● Quick and dramatic climate change followed by change in agricultural policy ● Change in regulations which prohibit any new damming constructions in the catchments ● Long-lasting rainfall (flooding)

Appendix 5. Social, market and policy changes for the SGS

1. Increase in vegetarian and vegan diets causes a reduction in livestock production and animal manure
2. Increasing demand in diet diversification and high-value and processed food products in developed countries
3. Rising energy prices increase the costs of agricultural production (e.g. fertilizers, farm machinery, irrigation systems, processing and transportation)
4. Raised targets for biofuels in the EU Renewable Energy Directive lead to the expanding use of agricultural commodities as feedstocks for biofuel production
5. Loss of good-quality cropland increases due to urban and industrial development, roads and reservoirs and low economic returns on farm capital and labour
6. Growing concerns about water availability for agricultural production raise the water supply costs for farmers
7. Food contamination and animal disease outbreaks cause market disruptions
8. The CAP budget will be reduced due to less contributions, with a future EU of 27 members
9. The CAP sets higher ambition on environmental and climate action, enforcing mandatory requirements on preserving carbon-rich soils through wetlands and peatlands protection, nutrient management, and crop rotation instead of crop diversification
10. The CAP's governance model shifts the emphasis from compliance and rules towards results and performance
11. The EU adopts new rules on fertilizers, tightening the limits for cadmium content in phosphate fertilizing products
12. The EU opens the Single Market for recovered and bio-based fertilizing products
13. The use of sludge on agricultural lands is prohibited
14. Nutrient tax is introduced in the EU Water Framework Directive
15. Carbon emission tax is introduced in forest use
16. Tax cuts are placed on carbon neutral wood products (replacing non-renewable raw materials)
17. Increasing diets on wild fish and herrings from the Baltic Sea

Appendix 6. Invitation to the first SGS focus group

Dear *(name)*,

On behalf of the BONUS RETURN project team, we would like to invite you to take part in a focus group to give us input on the content and design of a Serious Game System (SGS). The overall aim of the SGS is to create a co-learning space for a mixed group of stakeholders to support the identification, selection and implementation of eco-technologies that can produce multiple benefits to different sectors and society at large.

The focus group will be facilitated by the researchers from Swedish International Centre of Education for Sustainable Development (SWEDESD), Uppsala University. During the focus group, we would like to gain a more in-depth perspective of some of the important issues connected to water management in the *(name)* catchment. As a second step, we would like to run an exercise with you, which draws on your knowledge and experience, to identify innovative approaches to address these issues. Your view will serve as a valuable input to the development of the SGS.

The focus group will be held on *(date)* at *(place)* with a group of participants representing agriculture, wastewater, energy and forestry sectors together with some BONUS RETURN researchers. Lunch and coffee will be provided. More background information will be sent to those confirming attendance before the focus group.

If you would like to participate in the focus group, please let us know by responding to this email by *(date)*. In case you are unable to attend, we would appreciate it if you could suggest a colleague of yours that we can invite. If you have any questions, please do not hesitate to contact us via email thao.do@swedesd.uu.se or neil.powell@swedesd.uu.se.

We look forward to hearing from you soon!

Appendix 7. Invitation to the second SGS focus group

Dear *(name)*,

On behalf of the BONUS RETURN project team, we would like to invite you to *the second focus group meeting and the further development of the Serious Game System (SGS)*. The SGS serves as a collaborative space to support a diverse group of stakeholders with the identification, selection and implementation of eco-technologies that can produce multiple benefits to different sectors and society at large. This system will be used across case areas and countries to help stakeholders find better solutions under difficult circumstances.

The focus group is to be held at *(place)* on *(date)*. It will start at (time) and is expected to end by (time). Lunch and coffee will be provided. The meeting is organised by the Swedish International Centre of

Education for Sustainable Development (SWEDESD), Uppsala University in collaboration with *(case study partner)*.

During the focus group, we would like to invite you to "play out" different stakeholder roles in the system and give us feedback on the first version of the SGS. This session will be interactive as we will explore different pathways in your different roles and your motivations underlying the different actions you take. The insights and patterns emerging from this meeting will be analysed and incorporated into the second version of the SGS. Thus, your participation and perspective will be of much value to the development process of the SGS.

If you would like to participate in the focus group, please let us know by responding to this email no later than *(date)*. If you have any questions, please do not hesitate to contact us.

Appendix 8. Agenda of the SGS cross-case workshop in Uppsala on 28 October 2019

Workshop title: Serious Game System (SGS) Workshop - Navigating disaster risks from unexpected nutrient and pollution emissions in the Baltic Sea Region (BSR)

Time: 28 October 2019, 9:30 – 15:00

Venue: Room PLA 00 205 Tuvstarren, Segerstedthuset, Dag Hammarskjölds Väg 7, 752 37 Uppsala, Sweden

Time	Activity
9:30 – 9:45	Welcome and a round of introduction Introduction of the workshop
9:45 – 10:15	**Exercise:** Filling out the Excel sheet on how eco-technologies/ measures perform against a set of criteria (co-benefits) and under different conditions

10:15 – 10:45	**Plenary discussion:** Group reflection on the exercise - Similarities and differences among the 3 case study contexts - Potential synergies or conflicts resulting from the combination of different eco-technologies/measures
10:45 – 12:15	**SGS Play Session 1**
12:15 – 13:15	**Lunch break** Fazer Food & Co Segerstedt
13:15 – 14:30	**SGS Play Session 2**
14:30 – 15:00	**Debrief and closing of the workshop**

Appendix 9. Agenda of the SGS cross-case workshop in Helsinki on 13 December 2019

Workshop title: Serious Game System (SGS) Workshop - Navigating the policy environment that enables or hinders the implementation of different eco-technologies in the Baltic Sea Region

Time: 13 December 2019, 9:00 – 15:00

Venue: Meeting Room A1, Latokartanonkaari 9, 00790 Helsinki, Finland

Time	Activity
9:00 – 9:30	Welcome and a round of introduction Introduction of the workshop

9:30 – 11:00	**Serious Game System Play Session 1**: - Introduction to the Serious Game System - Understanding how the game operates and playtesting
11:00 – 12:00	**Group Exercise and Reflection:** - Opportunities and barriers that the current policy environment presents in relation to the implementation of different eco-technologies - Possible policy changes and how they would impact the implementation of different eco-technologies
12:00 – 13:00	**Lunch**
13:00 – 14:30	**Serious Game System Play Session 2**: Insights emerged from the group exercise will be used in this session.
14:30 – 15:00	**Plenary discussion and closing of the workshop**

Appendix 10. List of contributors to the co-development of the SGS

All the contributors listed below have given consent to having their names published in this deliverable.

No.	Name	Organisation	Case study
1.	Jon Wessling	Federation of Swedish Farmers (LRF)	Fyrisån, Sweden
2.	Torbjörn Larsson	Vansta Lantbruk	Fyrisån, Sweden
3.	Zahrah Lifvendahl	Uppsala municipality	Fyrisån, Sweden
4.	Elin Kusoffsky	Uppsala Vatten	Fyrisån, Sweden

5.	Helena Holmberg	County Administration Board Uppsala (Länsstyrelsen)	Fyrisån, Sweden
6.	Nils Hagenvall	Lövsta biogas plant	Fyrisån, Sweden
7.	Henrik Eckersten	Swedish University of Agricultural Sciences	Fyrisån, Sweden
8.	David Jedland	Uppsala municipality	Fyrisån, Sweden
9.	Karin Tonderski	Linköping University	Fyrisån, Sweden
10.	Magnus Bergström	Skogvision	Fyrisån, Sweden
11.	Jari Koskiaho	Finnish Environment Institute (SYKE)	Vantaanjoki, Finland
12.	Sirkka Tattari	Finnish Environment Institute (SYKE)	Vantaanjoki, Finland
13.	Turo Hjerppe	Finnish Environment Institute (SYKE)	Vantaanjoki, Finland
14.	Sari Väisänen	Finnish Environment Institute (SYKE)	Vantaanjoki, Finland
15.	Paula Lindell	Helsinki Region Environmental Services Authority Water Services	Vantaanjoki, Finland
16.	Minna Kolari	Centre for Economic Development, Transport and the Environment	Vantaanjoki, Finland
17.	Antti Leinonen	Finish Forest Centre	Vantaanjoki, Finland
18.	Kari Koppelmäki	University of Helsinki	Vantaanjoki, Finland
19.	Janina Käyhkö	University of Helsinki	Vantaanjoki, Finland
20.	Turunen Marita	Helsinki Region Environmental Services Authority Water Services	Vantaanjoki, Finland
21.	Pentti Mattila	Organic farmer	Vantaanjoki, Finland
22.	Markku Nieminen	City of Hyvinkää	Vantaanjoki, Finland
23.	Marek Giełczewski	Warsaw University of Life Sciences	Slupia, Poland
24.	Marta Księżniak	Warsaw University of Life Sciences	Slupia, Poland
25.	Mikołaj Piniewski	Warsaw University of Life Sciences	Slupia, Poland
26.	Andrzej Wójtowicz	Słupsk Waterworks	Slupia, Poland
27.	Anna Jarosiewicz	Pomeranian University in Słupsk	Slupia, Poland

28.	Jakub Drożdż	Słupsk Waterworks	Slupia, Poland
29.	Klaudia Walicka	Słupsk Waterworks	Slupia, Poland
30.	Eugeniusz Dańczak	Pomeranian Agricultural Advisory Center	Slupia, Poland
31.	Grzegorz Bartosiewicz	Farmer in the Słupia Catchment	Slupia, Poland
32.	Arkadiusz Grochulski	Energa Production	Slupia, Poland
33.	Paweł Struski	Polish Waters, Słupsk Supervision of Water	Slupia, Poland
34.	Andrzej Tonderski	POMINNO, Gdynia	Slupia, Poland
35.	Piotr Perliński	Pomeranian University in Słupsk	Slupia, Poland
36.	Michał Arciszewski	Koszalin University of Technology	Slupia, Poland