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

D1.6: USE CASES FOR SIM4NEXUS CASE STUDIES

LEAD AUTHOR: Chrysaida-Aliki Papadopoulou (UTH)

OTHER AUTHORS: Maria P. Papadopoulou (UTH), Chrysi Laspidou (UTH), Xavier Domingo Albin (EURECAT), Maïté Fournier (ACT), Eunice Pereira Ramos (KTH), Floor Brouwer (WUR-LEI)

CS Contributions: Imen Arfa (UPM), Maria Blanco (UPM), Malgorzata Blicharska (UU), Ingrida Bremere (BEF), Albert Chen (UNEXE), Tobias Conradt (PIK), Jonathan Doelman (PBL), Matthew Griffey (UNEXE), Hauke Henke (KTH), Emeline Hily (ACT), Nicola Hole (UNEXE), Daina Indriksone (BEF), Jan Janse (PBL), Michal Kravčík (P&W), Jason Levin-Koopman (WUR-LEI), Vincent Linderhof (WUR-LEI), Simone Mereu (UNISS), Jan Pokorný (ENKI), Nico Polman (WUR-LEI), Elke Stehfest (PBL), Claudia Teutschbein (UU), Antonio Trabucco (UNISS), Ben Ward (SWW)

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RESPONSIBLE AUTHOR	Chrysaida-Aliki Papadopoulou (UTH)
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AUTHOR(S)	Maria P. Papadopoulou (UTH), Chrysi Laspidou (UTH), Xavier Domingo Albin (EURECAT), Maïté Fournier (ACT), Eunice Pereira Ramos (KTH), Floor Brouwer (WUR-LEI) CS Contributions: Imen Arfa (UPM), Maria Blanco (UPM), Malgorzata Blicharska (UU), Ingrida Bremere (BEF), Albert Chen (UNEXE), Tobias Conradt (PIK), Jonathan Doelman (PBL), Matthew Griffey (UNEXE), Hauke Henke (KTH), Emeline Hily (ACT), Nicola Hole (UNEXE), Daina Indriksone (BEF), Jan Janse (PBL), Michal Kravčík (P&W), Jason Levin-Koopman (WUR-LEI), Vincent Linderhof (WUR-LEI), Simone Mereu (UNISS), Jan Pokorný (ENKI), Nico Polman (WUR-LEI), Elke Stehfest (PBL), Claudia Teutschbein (UU), Antonio Trabucco (UNISS), Ben Ward (SWW)
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INTERNAL REVIEWER	Emmanouela Ieronymidi (EPSILON)

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1 Table of Contents

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Executive summary

The primary objective of this deliverable is the development of Use Cases for the SIM4NEXUS (S4N) Case Studies (CSs). Such Use Cases have been adapted to the generic ones, presented in deliverable D1.2 ‘Use Cases for SIM4NEXUS’. Use Cases for S4N CSs are connected to the learning goals of each CS and reflect its specific characteristics, goals, aspirations and future perspectives. It is recalled that the goal of Use Cases is to capture how the user will interact with the Serious Game (SG) to achieve their explicit goal. Under this framework, CSs built a series of Use Cases corresponding to the nexus sectors they are focusing on. They defined the goal of each Use Case, the actors involved, the actions that should be implemented towards the achievement of the goal, a group of indicators measuring the level of accomplishment of the goals as well as a number of successive steps that will be applied in the Serious Game environment describing: a) when the implementation of an action will be prompted by the SG, b) when the respective indicators will be estimated and c) chances to follow alternative paths in case the goal is not accomplished. A critical part of the entire process is the identification of actors wishing to test the SG along with the goals falling within their interest. Preconditions known to be true when the Use Case begins, alternative or/and exceptional flows, and post conditions that must be fulfilled when the Use Case is complete were also determined. The basic axes upon which the Use Cases for S4N CSs were designed are aligned to the priorities having been set by the EU as to the efficient use of resources under climate change conditions. Thus, among the main issues taken into consideration by case-specific Use Cases are: the transition towards a low-carbon economy, the mitigation of climate change impacts, the extensive exploitation of renewable energy sources, the protection of water resources (quality and quantity), the coverage of food needs (food security) and the sustainable management of land.

Changes with respect to the DoA

Not applicable.

Dissemination and uptake

This report will be released on the project website. The deliverable has been written to support the development of the SIM4NEXUS project and is open to all stakeholders, including the Case Study leaders and researchers contributing to the Case Studies.

Short Summary of results (<250 words)

This report presents case-specific Use Cases having been built by each CS. Such Use Cases refer to the nexus sectors involved in the CSs. Accordingly; Use Cases concerning the sectors of water, land, energy, food and climate were designed. They reproduce the way that users are going to interact with the Serious Game in order to achieve their goals. Users are expected to be representatives of the public and business sectors, NGOs, researchers and students. Each Use Case involves a specific goal, a possible actor (user), a number of actions through which the goal will be achieved and a group of indicators that measure actions’ performance and the accomplishment of the respective goal. In this report, Use Cases per each Case Study are delineated. Such Use Cases were adapted to the particular needs and features of each CS, satisfying at the same time their pre-defined learning goals. The total number of CSs is 12 including: 3 regional CSs (Andalusia, Sardinia, Southwest UK), 5 national CSs (Azerbaijan, Greece, Latvia, Netherlands, Sweden), 2 trans-boundary CSs (France – Germany, Eastern Germany – Czech Republic – Slovakia), 1 continental CS (European) and 1 global CS.

Evidence of accomplishment

Submission of report.

Glossary

Indicator: Metric used to express, in quantitative terms, the status of important elements within each nexus domain. They serve to evaluate the performance of an action, measure or change of status (climate), infer on its potential impact and/or implication, either directly or indirectly (proxy indicator). Further, indicators are often directly related to goals. Examples: Energy: Carbon intensity of electricity generation - CO_2/KWh; Water: annual water consumption per capita (m^3 PC).

Policy indicator: An indicator used to express, in quantitative terms, the success or failure of an implemented policy. It serves to evaluate the performance of a policy tested in the SG.

Use Case: A Use Case defines which the different paths of interaction between the user and the SG are. It captures possible ways the user may follow to achieve a specified goal, as well as alternative paths and/or results if feasible, such as things that can go wrong in the process.

Nexus approach: A systematic process of inquiry that explicitly accounts for water, land, energy, food and climate interactions in both quantitative and qualitative terms with the aim of better understanding their relationships and providing more integrated knowledge for planning and decision making in these domains.

Nexus interlinkage: A factor, connection, relation or association that connects or ties one thing to another (the condition of being linked) - in a nexus perspective it corresponds to interconnected elements within the same or between different nexus domains. A “linkage” is frequently used to convey a physical link or assemblies between parts of a mechanical device. A nexus challenge is derived from nexus interlinkages but the latter does not necessarily imply the former.

Nexus performance indicator: Indicators linking at least two nexus dimensions and quantifying their co-dependence, thus identifying possible vulnerabilities of one nexus dimension compared to another one. More advanced nexus indicators will link three or four nexus dimensions, e.g. the amount of *water* and *energy* required for the production of a unit of *food* and the amount of CO_2 produced (*climate*). Examples: *Energy* required for the production of *water* through desalination. A high value for this indicator will mean that the production of desalinated water is highly dependent on the availability of energy.

Policy goal: Policy goals are the basic aims and expectations that governments have when deciding to pursue some course of actions. They can range from abstract general goals (e.g. attaining sustainable development) to a set of less abstract objectives (e.g. increase energy efficiency) which may then be concretized in a set of specific targets and measures (e.g. achieve 10% renewable energy share).

Policy target: Policy goal expressed in a quantifiable manner. See policy goal. It informs on the success of achieving a policy. Example: Achieve 10% renewable energy share in a given year.

Systems Dynamic Model (SDM): Quantitative representation of the interactions and feedback loops within and between processes in a complex system (in the case of SIM4NEXUS, the main system structure is identified in the conceptual models). Relationships can often be non-linear and may include delay mechanisms. In SIM4NEXUS, the structure of the complex system developed for the SDM will be Case Study-specific (i.e. is developed in the form of the conceptual model with close cooperation with Case Study lead partners and stakeholders) and integrates elements from the five nexus domains in which the project focuses on. SDM is a modeling approach/philosophy, for which there are many software tools and graphic environments to develop quantitative models. SIM4NEXUS uses STELLA as the modeling software to develop the SDMs for each Case Study.

Knowledge Elicitation Engine (KEE): A Knowledge Elicitation Engine is the inference engine of an expert system (the Serious Game in SIM4NEXUS). Knowledge elicitation comprises a set of techniques and methods that attempt to elicit an expert's knowledge through some form of direct interaction with that expert.

Serious Game (SG): see Knowledge Elicitation Engine.

Complexity science conceptual model: Conceptual (sometimes also known as a 'mind map') representation of the key interactions between and within nexus systems in the form of a qualitative diagram. The conceptual design of how nexus domains interact in a Case Study will serve as the basis for the development of the quantitative System Dynamics Model (SDM). The conceptual model is an abstraction of reality, usually with both a physical and social meaning, and aims at providing a representation of the main complex relations between the sub-systems under investigation.

Acronyms

TERM	EXPLANATION/MEANING
AAD	Advanced Anaerobic Digestion
AES	Agri-Environmental Schemes
CCS	Carbon Capture and Storage
CHP	Combined Heat and Power
CS	Case Study
DG	Directorate General
ESD	Effort-Sharing Decision
GUI	Graphic User Interface
MEF	Minimum Environmental Flows
NGO	Non-Governmental Organization
PC	Policy Card
PES	Payment or Environmental Services
RE	Renewable Energy
REDD+	Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (United Nations Collaborative Programme)
RES	Renewable Energy Sources
RET	Renewable Energy Target
S4N	SIM4NEXUS
SG	Serious Game
UAA	Utilised Agricultural Area
WP	Work Package

1 Introduction

The objective of this Deliverable is to report on the structure of case-specific Use Cases to be applied in the SIM4NEXUS SG. Use Cases refer to the way the player interacts with the SG in order to achieve their goal. Thus, the main steps for building a Use Case include: the definition of a goal to be achieved, the identification of the user (actor), the description of successive actions contributing to the accomplishment of the goal and the definition of indicators measuring actions' performance/goal's achievement.

Under the nexus framework, Use Cases were built by each CS. CSs provided a series of Use Cases focusing on the nexus sectors involved in each of them. Such sectors include: water, land, energy, agriculture & food and climate. Pressures put on the nexus sectors by tourism, industry and power generation were also considered. A significant number of interlinkages, existing among the respective nexus sectors, were taken into account in order trade-offs and synergies to be identified. A critical step of the whole process concerned the determination of actors/group of actors that may be possible players of the SG. Five main categories of players were identified: a) public sector, b) private sector, c) NGOs, d) academic/research institutes and e) students.

More analytically, the rationale upon which the Use Cases were structured incorporates the following steps:

- Selection of a nexus sector
- Definition of a relevant goal
- Definition of a player (actor)
- Description of actions implemented towards achieving the goal
- Determination of indicators measuring actions' performance and goal's accomplishment

Use Cases, included in this deliverable, refer to multiple spatial scales – regional, national, trans-boundary, continental and global – according to the geographical extent covered by each Case Study. Twelve CSs built 68 Use Cases corresponding to their specific goals and future perspectives. Such CSs are: Andalusia (regional CS), Sardinia (regional CS), Southwest UK (regional CS), Azerbaijan (national CS), Latvia (national CS), Greece (national CS), Netherlands (national CS), Sweden (national CS), France – Germany (trans-boundary CS), Eastern Germany – Czech Republic – Slovakia (trans-boundary CS), European (continental CS) and Global (global scale CS). The design of case-specific Use Cases was based on the structure of generic Use Cases delineated in deliverable D1.2 'Use Cases for SIM4NEXUS'. Such generic Use Cases served as a guide in order more specific ones to be built by the CSs.

Use Cases are in line with the general and sectoral environmental and climate policy framework of EU. Accordingly; climate change resilience, low-carbon options, renewable energy solutions, confrontation of floods and droughts, food security and sustainable land use management constitute critical aspects of the proposed Use Cases and are incorporated in the relevant goals, actions and indicators determined by the CSs.

In the reminder of this deliverable the interaction of WP1-Task 1.2 (Development of Use Cases) with other WPs is described (Section 2). Section 3 focuses on a brief description of the functionality of Use Cases within a Serious Game environment. In section 4, case-specific Use Cases per each CS are presented. Finally, some conclusions are drawn.

2 Interaction with other Work Packages

The development of Use Cases is assumed in close collaboration with the consortium stakeholders which is defined for each Case Study (CS) in WP5. Use Cases will also be instrumental in defining the learning goals and the logic of the Serious Game (SG) which is done in close interaction with WP4 (Figure 1).

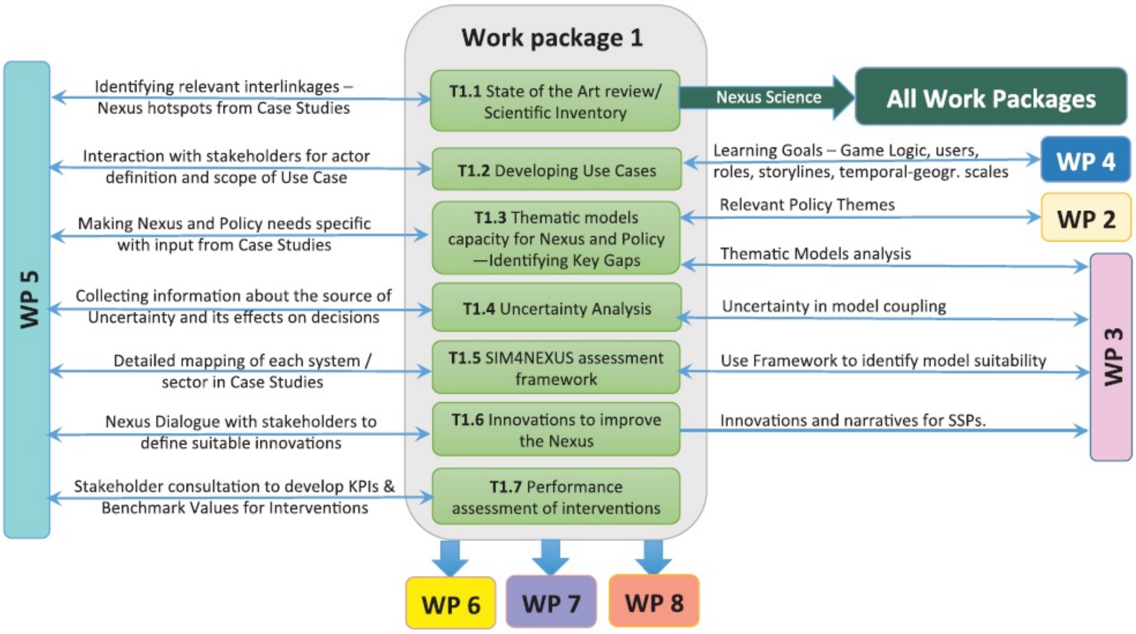

Figure 1: Task by task diagram of Work Package 1 and interactions with other Work Packages in the project as established in the SIM4NEXUS Grant Agreement

2.1 Interactions within WP1

In T1.1 “State of the art review – Creating a Scientific Inventory on the Nexus” a Scientific Inventory of the Nexus that will be used throughout the project was carried out. A thorough literature review related to the interlinkages of Water-Energy-Food-Land-Climate and Climate Change was composed. Low-carbon options were also reviewed. The literature review was based on a holistic approach and focused on the resource base taking into consideration both biophysical and socio-economic resources. T1.1 informed T1.2 through the clarification of interlinkages among the Nexus components in order such interlinkages to be embodied in the Use Cases designed. T1.2 is connected to T1.3 “Review on the Thematic Models in their capacity to address the Nexus and to cover relevant policy domains – Identifying Key Gaps” as the accomplishment of goals set by Use Cases are measured through a pool of indicators calculated by using the data provided by Thematic Models. T1.4 “Multifaceted uncertainty analysis” will provide feedback on uncertainty derived from complex interactions and human actions (human behaviour), parameters upon which the design of Use Cases is based on. T1.5 “SIM4NEXUS Framework for the Assessment of the Nexus in Case Studies” is expected to support the assessment of Use Cases’ implementation into the several Case Studies of the project. T1.6 “Innovations to improve the Nexus for Case Studies” sets the basis upon which Use Cases will be implemented as it assists scenario definition through a participatory Nexus dialogue. Finally, T1.7 “Assessment of the performance of innovations/interventions via

Nexus Performance Indicators” will support the assessment of interventions, in terms of their performance. In T1.7 specific performance indicators will be proposed to assess how efficiently environmental and human resources are used in the context of the S4N SG. Among the elements of each Use Case developed for the S4N SG are: a) the goal to be achieved, b) the available actions/interventions to be taken on each game session context, c) the indicators to assess the implementation level of each action/intervention. Before and after an intervention, the performance of each nexus component varies. The proposed Use Cases will support the assessment of such variations through the use of respective indicators. Then, the definition of the different Use Cases for each Case Study details the different scenarios, in their corresponding context and; with the different actions/interventions the user will face while trying to achieve the different objectives, and while learning by doing.

2.2 Interactions with WP4

T1.2 is related to WP4 in the level of defining and integrating learning goals in the Game logic, the clarification of users’ roles and the definition of storylines that will take place in several temporal-geographical scales. WP4 “Serious Game development and testing” concerns the definition of learning goals, the logic of the Game, the creation of the Game’s Semantic Repository, the development of the knowledge elicitation engine, the development of the SG GUI, the integration of the relative components, the test of the system with hypothetical scenarios and actors as well as the data management process. In the framework of a Use Case, a learning goal is of crucial importance as it refers to *what the user will finally learn by implementing a Use Case in the Serious Game*. Also, it is easily understandable that Use Cases constitute an essential part of the SG design process as they set the basis for the interaction of users with the Game through the definition of goals, the undertaking of relative actions and the development of indicators measuring the accomplishment of goals.

2.3 Interactions with WP5

The key element that connects T1.2 with WP5 is the interaction with stakeholders and the adaptation of Use Cases to their needs and their goals. Actors who are going to implement each Use Case in the SG are defined and the scope of each Use Case according to actors’ orientation is clarified. Such information is strongly related to the design of Case Studies and the identification of actors involved in each of them. WP5 “Implementing Nexus-compliant practices” briefly includes the development of a common application and evaluation framework for SIM4NEXUS tools, the management of the nexus challenges in the Case Studies and the definition of policy recommendations. Under this framework, Use Cases will be implemented by the Case Studies designed in WP5. Use Cases are taking into consideration both nexus challenges and policy paths that will address the management of nexus components through actions taken by users in order to achieve several policy goals.

3 Functionality of Use Cases in the S4N SG

As already mentioned, Use Cases define in detail the interaction between the users and the game and vice versa. Each Use Case needs to specify a goal, which has to be reached by the user through the game steps by applying actions. Depending on each Case Study, users will count with the complete set of available actions or just a subset of them depending on their role in the game. Moreover, only coherent actions will be shown, avoiding users being able to select non-coherent actions (i.e. conflicts of interest, etc.). The actions are translated into the game context as Interventions selection (or unselection) by the user. Finally, it is also needed a numerical way, based on the SDM available data, to check the achievement of the Use Case goals. This is done by defining indicators and thresholds.

The role of the player, their goals, the actions they implement and the level of accomplishment of a goal lie at the “heart” of a Use Case. A Use Case defines how the SG will correspond to several requirements through a flow of information between the user and the system that takes place by following a path of actions. In the end, the user learns about the impacts of the selected path on the sustainable and effective use of resources.

Each Use Case presents an initial state to the user who selects a goal and starts the effort for achieving it. Several options are offered to the users (different actors) and they are invited to choose a path of actions towards the accomplishment of the selected goal. Metrics (indicators) measure the achievement of the goal.

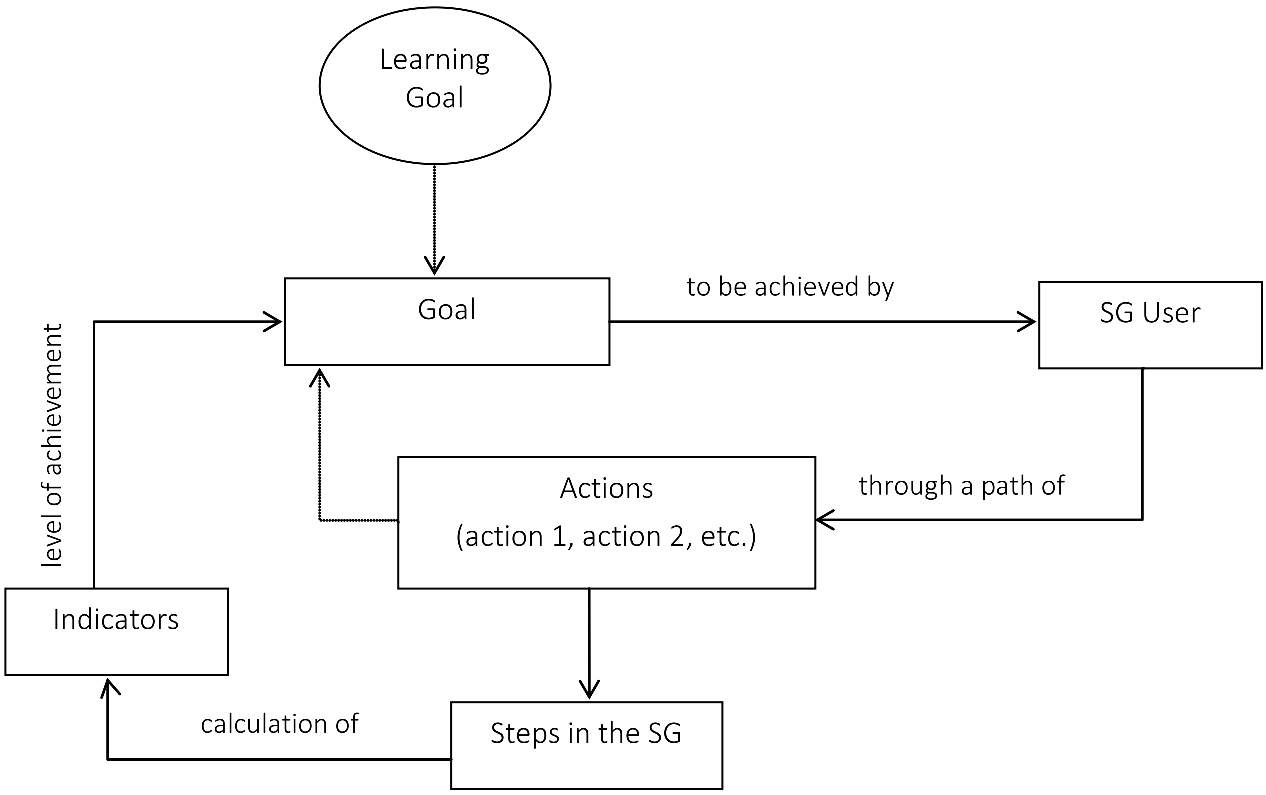

Figure 2: General structure of a Use Case

It should be mentioned that actions are taken under the framework of a nexus-related policy being applied in the context of a specific Use Case in a Case Study. Moreover, the design of Use Cases took into consideration the interlinkages existing among the nexus components. This is due to the fact that the implementation of a Use Case focusing on one nexus component may entail impacts to other nexus components managed by other Use Cases. Therefore, the process of structuring Use Cases pays attention not only on the management and future perspectives of the principle component that a specific Use Case deals with, but also on possible impacts on other nexus components.

4 Use Cases for the SIM4NEXUS Case Studies

In this section case-specific Use Cases, adapted to the particular requirements and characteristics of each Case Study, are presented. Case Studies provided a number of Use Cases considering the nexus sectors involved in each of them. The structure of such Use Cases was based on that of generic ones described in D1.2 'Use Cases for SIM4NEXUS'.

Firstly, a goal, reflecting the relevant future perspectives and the content of the respective Case Study-oriented learning goals, was defined. Then, the actions through which the accomplishment of the goal will be pursued were elicited. Indicators, measuring the level of accomplishment, were determined according to the data included in the SDM of each Case Study. Moreover, a brief presentation of the steps, going to be implemented in the Serious Game towards the achievement of each goal, took place.

4.1 Use Cases for Regional Case Studies

4.1.1 Andalusia

The Case Study of Andalusia involves three nexus sectors; water, energy and climate. Water needs for irrigation, pressures of urbanization and intensive farming on land and water resources, linkages between water saving technologies and energy use, economic growth and sustainable development are some core issues analysed by the Andalusian Case Study.

The main water consumer in Andalusia is agriculture where irrigation water is allocated to olive trees, rice, cotton, vegetables and fruits.

Regarding the sector of energy, emphasis is placed on the growth of wind industry, the development of small solar facilities for rural electrification and the extensive exploitation of biomass.

According to its learning goals, the Case Study of Andalusia investigates how policies in the domains of agriculture, sustainable water management and renewable energy can affect each other under climate change conditions in a region where high agricultural production and tourism are competing for water.

The Use Cases designed in the case of Andalusia are:

USE CASE AND.1	WATER
Related Learning Goals	Sustainable management of water resources
Goal	➢ Improve water availability ➢ Improve water use efficiency ➢ Enhance the status of water resources
User	➢ Public Sector: Regional Ministry of Agriculture, Livestock, Fishing and Sustainable Development ➢ Public Sector: River Basin Management Authorities ➢ Private Sector: Water Users Associations, Farmer Associations ➢ NGOs
Actions	➢ Economic support to construct small water reservoirs on farms

	➢ Incentives to enhance water reuse in the agricultural sector ➢ Water pricing policy in the agricultural sector ➢ Subsidies to apply water-efficient technologies in agriculture ➢ Nitrogen fertilizer tax
Indicator	➢ Water reuse/total water use in agriculture ➢ Water stress ➢ % of Utilised Agricultural Area (UAA) under irrigation/total UAA ➢ Irrigation water use ➢ Water use per sector ➢ Water productivity (€/m^3) ➢ Nitrogen fertilizer consumption per ha ➢ Nitrate concentration in water

Steps in the Serious Game:

1. Identify agricultural land use, agricultural water demand, surface water and groundwater availability, cost of irrigation water.
2. Calculate hydrological water balance, given climate data and water demands.
3. Calculate rate of change of hydrological water balance (monthly or yearly step).
4. Choose policies from the list of possible actions:
   - Financial support for the construction of small reservoirs on farms to increase resistance to extreme weather events.
   - Incentives to improve water reuse in the agricultural sector.
   - Implementation of technological solutions to reduce nitrate pollution.

USE CASE AND.2	ENERGY
Related Learning Goals	Energy efficiency and promotion of renewable energy sources
Goal	Increase RES share in the gross final energy production
User	➢ Regional Ministry of Finance, Industry and Energy ➢ Regional Ministry of Agriculture, Livestock, Fishing and Sustainable Development
Actions	➢ Support biomass production in the region[1] ➢ Incentives to introduce renewable energy in agriculture ➢ Subsidies to improve energy efficiency in agriculture

[1] Andalusian Bio-economy Strategy (p.234)

Indicator	➢ Renewable energy production/total energy consumption ➢ Renewable energy consumption in agriculture ➢ Energy consumption per sector ➢ Energy consumption/GDP ➢ % of energy efficiency per sector ➢ % of renewable energy ➢ Energy performance €/Ktoe ➢ Energy performance GDP/Ktoe

Steps in the Serious Game:

1. Identify current cost of electricity generation, the share of RES in the electricity generation mix; total land area used for RES infrastructure; annual CO_2 emissions from electricity generation; annual volume of water consumption for cooling systems; and, prices of selected crops.
2. Identify fuel demand in the agricultural sector.
3. Identify biomass demand in the agricultural sector.
4. Identify total electricity generation (electricity produced from all types of resources, conventional and renewable).
5. Define the share of renewable energy consumption in 2030 as 25% (e.g. 25% of renewable energy consumed from a combination of RES, e.g. solar, on-shore wind, geothermal, biomass, waste-to-energy).
6. Choose policies from the list of possible actions:

- Incentives for the introduction of renewable energies in agriculture.
- Subsidies to improve energy efficiency in agriculture.

USE CASE AND.3	CLIMATE
Related Learning Goals	Climate change mitigation and adaptation
Goal	➢ 18% reduction in diffuse of GHG emissions compared to 2005 levels by 2030[2] ➢ Increase carbon sink capacity
User	➢ Public Sector: Regional Ministry of Agriculture, Livestock, Fishing and Sustainable Development ➢ NGOs
Actions	➢ Implementation of mitigation technologies in the agricultural sector ➢ Carbon tax

[2] Law on measure to face climate change

	➢ Subsidies for conversion of agricultural land to grassland
Indicator	➢ CO_2 emissions per sector ➢ CH_4 emissions from agricultural sector ➢ N_2O emissions from agricultural sector ➢ Global warming potential ➢ CO_2 emissions/GDP ➢ Grassland/Total UAA

Steps in the Serious Game:

1. Identify current CO_2 emissions per sector, CH_4 emissions from agricultural sector, N_2O emissions from agricultural sector, and global warming potential.
2. Identify CO_2 emissions/GDP, and Grassland/Total utilised agricultural area (UAA).
3. Choose one policy from the list of possible actions; Implementation of mitigation technologies in the agricultural sector to reduce GHG emissions with the aim of reducing 18% in diffuse of GHG emissions compared to 2005 levels by 2030.

USE CASE AND.4	LAND AND FOREST
Related Learning Goals	Fight against soil erosion and desertification
Goal	Reduce soil erosion
User	Public Sector: Regional Ministry of Agriculture, Livestock, Fishing and Sustainable Development
Actions	➢ Promote ecological focus areas[3] ➢ Strengthen agri-environmental measures
Indicator	➢ Surface of ecological focus areas ➢ Total land affected by erosion ➢ % of agricultural land ➢ % of wetland and forest land

Steps in the Serious Game:

1. Identify current surface of ecological focus areas, % of wetland and forest land, % of agricultural land and total land affected by erosion.
2. Choose one land management policy from the list of possible actions; promote ecological focus areas to address soil erosion.
3. Run the models / Progress through time.
4. Display indicators.

[3] Andalusian Sustainable Development Strategy 2030 (p.126)

USE CASE AND.5	AGRICULTURE AND FOOD
Related Learning Goals	Resource efficient food production
Goal	Sustainable agricultural production
User	➢ Public Sector: Regional Ministry of Agriculture, Livestock, Fishing and Sustainable Development ➢ Private Sector: Water Users Associations, Farmer Associations
Actions	➢ Direct payments reduction (to enhance market-oriented agricultural production, and promote generational renewal) ➢ Environmental payments (integrate requirements from European directives) ➢ Promote climate-resilient crops (e.g. crops with lower water footprint)
Indicator	➢ CAP payments/total agricultural income ➢ Crop and livestock production ➢ Area of land in agri-environment schemes ➢ Agricultural income per ha

Steps in the Serious Game:

1. Identify agricultural land use, CAP payments/total agricultural income and agricultural income per ha.
2. Quantify crop production and livestock production per unit of utilised agricultural area (in physical units).
3. Quantify water use in agriculture (abstraction of water for irrigation) per unit of agricultural area.
4. Select a policy from the list of possible actions: Reduction of direct payments under the CAP to improve market-oriented agricultural production and promote generational renewal.
5. Run the models / Progress through time.
6. Display indicators.

4.1.2 Sardinia

The Sardinian Case Study focuses on policy priorities concerning: the sustainable management of water resources, the promotion of renewable energy, the mitigation of climate change impacts, the sustainable development of tourism, the coverage of irrigation needs and the protection of ecosystems/biodiversity. The limitation of conflicts among several water uses and the transition to a low-carbon economy through increasing hydropower production represent important future perspectives. The driving forces of its economy are the industrial, tourist and agricultural sectors.

The nexus sectors explored include water, food, energy and climate. Accordingly, the Case Study analyses how policies (e.g. agricultural and tourist policies) and infrastructures can be integrated in order to support sustainable food production, provision of irrigation water, protection of water quality, climate change adaptation strategies and exploitation of renewable energy sources.

Forests cover the 45% of the island’s area while another 45% is characterized as agricultural area. Ecosystems and coasts are sensitive to climate change and vulnerable to fire risk.

Regarding the sector of water, the seasonality of precipitation in Sardinia creates the need to store water in reservoirs. There are also water losses in the distribution network. Water quality is threatened by eutrophication and insufficient purification plants. Climate change puts an extra pressure on water storage capacity.

As for the energy sector, Sardinia has largely invested in wind and solar parks. Hydraulic potential is also used for energy generation.

The learning goals of this Case Study focus on how regional policies in the domains of water management, agriculture, tourist development, hydropower and alternative energy sources can affect sustainable food/energy goals severely competing for water resources under climate change.

The Use Cases of the Sardinian Case Study are:

USE CASE SARD.1	WATER
Related Learning Goals	➢ Promote market of agricultural products ➢ Integrated water management
Goal	Improve water efficiency in agriculture
User	Public Sector: Ministry of Agriculture
Actions	➢ Change of irrigation systems ➢ Change in leakage of conveyance system for agriculture
Indicator	➢ Change of water productivity ➢ Change of total applied water for irrigation. ➢ Change in water share agriculture (reduced water conflict)

Steps in the Serious Game:

1. Identify cropland areas irrigated by a specific irrigation system (furrow, drip or sprinkler).
2. Specify the area and crop where the change of irrigation system will take place (ha^2).
3. Specify the new irrigation system.
4. Calculate total applied water before and after the change of irrigation system.

    - If total applied water from the new irrigation system is lower, change the existing irrigation system.
    - If total applied water from the new irrigation system is the same or higher, check an alternative irrigation system.
    - If total applied water from all available irrigation systems are the same, no need for immediate action.
    - If volume of total irrigation water is lower, change the existing irrigation system.

5. Identify percentage leakages per district.
6. Specify the desired percentage water losses due to leakages in the conveyance system.

7. Specify the district/s where the change is desired.
8. Calculate agricultural water demand over water supply before and after the change in leakage.

    - If water supply is the same or higher, check for alternative district/s or reduce leakages to a lower percentage.
    - If water supply is lower apply the leakage reduction.

USE CASE SARD.2	WATER
Related Learning Goals	➢ Increase water efficiency in agriculture ➢ Promote market of agricultural products
Goal	Integrated water management
User	Public Sector: Regional District for water management
Actions	➢ Change in leakage of conveyance system for domestic/tourist sector ➢ Guarantee Minimum Environmental Flows ➢ Increase resilience of water supply
Indicator	➢ Change in supply over demand ratio ➢ Change in total water for environmental flows ➢ Change in number of months where total supply is equal to (or greater than) the total demand

Steps in the Serious Game:

1. Identify percentage leakages for domestic/touristic uses per district.
2. Specify the desired percentage water losses due to leakages in the conveyance system.
3. Specify the districts where the change is desired.
4. Calculate ratio water demand over water supply before and after the change in leakage.

    - If ratio water demand over water supply is the same or lower, check for alternative district/s or reduce leakages to a lower percentage.
    - If ratio water demand over water supply is higher apply the leakage reduction.

5. Identify Minimum Environmental Flows (MEF) per district.
6. Specify the desired change in percentage flows for MEF.
7. Specify the district/s where the change is desired.
8. Calculate Effective Environmental Flow over MEF before and after the change.

    - If Environmental Flow over MEF increases but is below 1, apply change.
    - If Environmental Flow over MEF is the same or above 1, do not apply change.

9. Identify thresholds for applying water shortages rules; this is a reduction in % of water supply compared to water demand. The thresholds are calculated as percentage of water available in the reservoirs.
10. Specify the desired change in thresholds.
11. Specify the district/s where to apply the change.

12. Calculate total regional water demand over total regional water supply before and after the change.

USE CASE SARD.3	ENERGY
Related Learning Goals	➢ Zero net emissions by 2050 ➢ Reduce costs for energy
Goal	Increase Renewable Energy Share (RES) in the energy mix
User	Ministry of Environment and Energy
Actions	➢ Increase energy production from Photovoltaic (PV) ➢ Increase energy production from Wind ➢ Increase energy production from Biomass ➢ Implement smart grid and accumulator systems
Indicator	➢ Share of electricity generated from PVs in the gross final electricity generation ➢ Share of electricity generated from wind parks in the gross final electricity generation ➢ Share of electricity generated from biomass ➢ Energy production form conventional resources

Steps in the Serious Game:

1. Identify total electricity generation (electricity produced from all types of resources, conventional and renewable).
2. Identify share of electricity generated from PVs.
3. Identify share of electricity generated from wind parks.
4. Identify share of electricity generated from biomass.
5. Specify desired increase in electricity generated from PVs
6. Specify desired increase in electricity generated from Wind parks
7. Specify desired increase in electricity generated from biomass.
   - If RES increase to less than 70% of total energy production, further increase electricity production by one or more renewable types.
8. Identify amount of electricity generation by conventional resources.
9. Identify share of electricity by renewable resources.
10. Specify use of smart grids and accumulators.
    - If application of smart grids increases RES to less than 70% of total energy production, further increase application of smart grids.

USE CASE SARD.4	ENERGY
Related Learning Goals	➢ Zero net emissions by 2050 ➢ Increase RES share in the energy mix
Goal	Reduce costs for energy

User	Ministry of Environment and Energy
Actions	➢ Import methane for heating and electricity generation
Indicator	➢ Demand for methane

Steps in the Serious Game:

1. Identify total electricity generation (electricity produced from all types of resources, conventional and renewable).
2. Identify demand for methane in domestic heating sector.
3. Identify demand for methane for electricity generation.
4. Identify demand for oil, biomass and electricity for heating in the domestic sector.

- If share of methane demand over non conventional resources is greater than 50%, no need for further action.
- If share of methane demand over non conventional resources is lower than 50%, increase methane electricity generation.

USE CASE SARD.5	CLIMATE
Related Learning Goals	Increase RES share in the energy mix
Goal	Zero net emissions by 2050
User	Ministry of Environment and Energy
Actions	➢ Increase energy efficiency of households ➢ Increase energy efficiency of public buildings ➢ Increase share of renewables ➢ Import methane for heating and electricity generation
Indicator	➢ Change of GHG net emissions

Steps in the Serious Game:

1. Identify current total emissions.
2. Identify current CO_2 sequestration from land use changes.
3. Calculate mean energy efficiency class for households.
4. Specify desired change in energy efficiency class for households and public buildings.
5. Calculate net CO_2 emissions from energy use before and after the action/s.

- If net emissions after action are lower but higher than 0, take further action.
- If net emissions are higher, no further action is needed.

USE CASE SARD.6	LAND AND FOREST
Related Learning Goals	➢ Protection and expansion of ecosystems ➢ Sustainable water management

Goal	Regulate coastal landscape
User	Public Sector: Regional Ministry for the Environment and Ministry of Tourism
Actions	➢ Moderately increase hosting facilities ➢ Increase hosting facilities
Indicator	➢ Change of tourist flows over the seasons ➢ Change of domestic water demand

Steps in the Serious Game:

1. Identify current and future tourist flows.
2. Choose one policy from the list of possible actions.
3. Run the models / Progress through time.
4. Display indicators.

- If tourist flows increase and domestic water supply is higher than domestic water demand, no need for further actions.
- If tourist flows increase and domestic water supply is lower than domestic water demand, back to step 2.

USE CASE SARD.7	LAND AND FOREST
Related Learning Goals	➢ Protection and expansion of ecosystems ➢ Zero net emissions by 2050
Goal	Protection and expansion of ecosystems
User	Public Sector: Regional Ministry for the Environment and Regional Forest Authority
Actions	➢ Reforestation of follow land
Indicator	➢ Change in forested area ➢ Change in net CO_2 emissions

Steps in the Serious Game:

1. Identify current and future forested area and follow area.
2. Specify desired change in forested area from follow area.
3. Run the models.
4. Display indicators.

- If new forested area is higher than follow land, specify lower area to be reforested.
- If new forested area is lower or equal to follow land, and net CO_2 emissions decrease, accept policy.

USE CASE SARD.8	AGRICULTURE AND FOOD
Related Learning	➢ Integrated water management

Goals	➢ Improve water use efficiency in agriculture
Goal	Promote market of agricultural products
User	Public Sector: Ministry of Agriculture
Actions	➢ Agricultural area per crop type ➢ Irrigated area
Indicator	➢ Crop/pasture production ➢ Irrigation water supply-irrigation water demand

Steps in the Serious Game:

1. Identify current and future area per crop type.
2. Identify current and future pasture area.
3. Identify current and future irrigated area.
4. Specify desired change in area per crop.
5. Specify desired change in pasture area.
6. Specify desired change in irrigated area.
7. Run the model.
8. Display indicators.

- If production of the desired crop increases and water demand -water supply is higher than 1, no need for further action.
- If production of the desired crop increases and water demand-water supply is lower than 0.8, specify changes in crop area or irrigated area.

4.1.3 Southwest UK

The Southwest UK Case Study is going to address how policies and incentives (e.g. agricultural policy) can be integrated in order to support food production (agricultural sector) and the provision of water and wastewater services. It also recognizes the need to increase climate change resilience through the exploitation of renewables and the reduction of GHG emissions.

The main sectors supporting local economy are agriculture and tourism. Bathing beaches and protected areas put pressures on water quality issues related to heavy rain and waste water disposal. The nexus sectors involved in this Case Study are climate, food, water and energy.

Concerning water, there are 21 raw water impounding reservoirs, over 270 service reservoirs (storage facilities), over 200 drinking water pumping stations, 29 drinking water treatment works, 655 wastewater treatment works and over 900 sewage pumping stations.

Regarding the sector of energy, the region is at the forefront of emerging low carbon economies. Emphasis has been given to the extensive introduction of large scale solar parks, the development of wind farms, the exploitation of geothermal energy, the development of tidal and wave farms as well as the production of bio-energy.

The learning goals of the Case Study focus on how regional policies for land use by agriculture, renewable energy (wind and solar farms), and water management affect each other in a region with high risk of rainfall and flooding.

The Use Cases designed for the Southwest UK are:

USE CASE SW-UK.1	WATER
Related Learning Goals	Security of supply: Reducing demand for drinking water entering municipal supply, thus offsetting the need for increased capacity
Goal	Demand reduction
User	Public and Private Sector: Economic regulator, Utility providers
Actions	O1- Water saving in households: ➢ PC Next Gen smart meters ➢ PC Water Efficient devices in homes ➢ PC Domestic Grey water reuse and rainwater harvesting ➢ PC Education and behavioural change programmes to reduce water consumption O2- Reducing losses of drinking water within the supply chain: ➢ PC Reduction in treatment losses ➢ PC Reduction of leakage from the drinking water distribution network
Indicator	➢ I1- Change of per capita drinking water consumption ➢ I2- Change of ratio between raw water abstraction and drinking water consumption

Steps in the Serious Game:

1. Calculate current per capita drinking water demand.
2. Determine percentage of domestic customers with active O1 PC.
3. Recalculate per capita drinking water demand.
4. Calculate drinking water consumption.
5. Calculate treatment and leakage losses.
6. Determine O2 PCs active and new treatment and leakage losses.
7. Calculate total drinking water consumption and raw water abstraction.

USE CASE SW-UK.2	WATER
Related Learning Goals	Security of supply: Enabling the drinking water and wastewater supply chain to respond to external shocks and pressures, while maintaining service
Goal	Flexibility and security
User	Public and Private Sector: Economic & Environmental regulators, Utility providers
Actions	O3- Ensure adequate water resources to meet drinking water

	demand: ➢ PC Interregional connection of drinking water resources ➢ PC Sea water Desalination for drinking water ➢ PC sustainable Surface water abstraction for drinking water ➢ PC Use of boreholes and ground water resources for drinking water ➢ Building new raw water reservoir storage O4- reduce dependence on external energy supply: ➢ PC Increase use of self-generated renewable energy; Hydro and CHP ➢ PC Energy efficiency of drinking and waste water treatment and transmission O5- Ensure adequate capacity within the urban water cycle to meet demand ➢ PC Improve drinking water and wastewater network capacity ➢ PC Improve drinking water and wastewater treatment capacity ➢ PC Separation of foul water and rainwater drainage systems ➢ PC use of Sustainable Urban Drainage systems
Indicator	➢ I3- Change of ratio between drinking water entering supply and available raw water resource, ➢ I4 - Change of ratio between self-supply of electricity and gross demand of electricity, ➢ I5- Change of ratio between demand and capacity of drinking water / wastewater supply chains

Steps in the Serious Game:

1. Calculate total drinking water demand.
2. Calculate total available raw water resource.
3. Determine O3 PCs active and new supply capacities.
4. Recalculate available raw water resource.
5. Determine ratio between resource supply and demand.
6. Calculate total electricity demand from urban water cycle.
7. Determine O4 PCs active, new generation capacities and operational efficiency.
8. Recalculate total electricity demand from urban water cycle.
9. Calculate wastewater flows.
10. Determine O5 PCs active and new treatment transport capacities.
11. Calculate ratio between demand flows and system capacity.

USE CASE SW-UK.3	WATER
Related Learning Goals	Environmental Sustainability: minimising the production of waste products requiring disposal to land and the associated emissions

Goal	Waste reduction
User	Public and Private Sector: Economic & Environmental regulators, Utility providers
Actions	O6- minimising the production of waste products requiring disposal to land and the associated emissions: ➢ PC Sewage sludge Incineration ➢ PC Sewage Sludge Advanced Anaerobic digestion ➢ PC Sewage Sludge Pyrolysis
Indicator	➢ I6- Change of sludge volume produced per capita ➢ I7- Change of ratio between sludge volume produced and disposed to land

Steps in the Serious Game:

1. Calculate sludge production from wastewater treatment.
2. Calculate sludge production per capita.
3. Determine O6 PCs active, and new capacities for incineration, AAD and pyrolysis.
4. Calculate final sludge production per capita.
5. Calculate ratio between sludge produced and sludge disposed to land.

USE CASE SW-UK.4	WATER
Related Learning Goals	Environmental Sustainability: Maintaining or improving drinking water and wastewater quality
Goal	Protection of human health and local environment
User	Public and Private Sector: Economic & Environmental regulators, Utility providers
Actions	O7- Improve drinking water quality: ➢ PC Increase drinking water quality standards O8- Improve river water quality: ➢ PC Increase wastewater effluent standards
Indicator	➢ I8- Change of ratio between drinking water quality and target ➢ I9- Change of ratio between wastewater effluent quality and target

Steps in the Serious Game:

1. Determine current drinking water quality.
2. Determine O7 PCs active and new drinking water quality.
3. Determine current wastewater effluent quality.
4. Determine O8 PCs active and new wastewater effluent quality.

5. Calculate ratio between drinking/waste water quality and targets.

USE CASE SW-UK.5	ENERGY
Related Learning Goals	Security of supply: Reducing demand for electricity entering municipal supply, thus reducing need for increased generation or transmission capacity
Goal	Demand reduction
User	Public and Private Sector: Economic regulator, Utility providers
Actions	O9- Improving the efficiency of energy use in households: ➢ PC Next generation smart metering ➢ PC Low carbon homes ➢ PC Behavioural change programmes to encourage demand reduction O10- increasing the use of renewable energy in households: ➢ PC Domestic scale self-supply of renewable energy
Indicator	➢ I10- Change of per capita electricity demand consumption ➢ I11- Percentage of domestic dwellings with self supply

Steps in the Serious Game:

1. Calculate current per capita electricity demand.
2. Determine percentage of domestic customers with active O9 PCs.
3. Recalculate per capita electricity demand.
4. Calculate total electricity consumption.
5. Determine O10 PCs active and new per capita electricity demand.
6. Recalculate total electricity consumption.
7. Calculate domestic dwellings with self supply.

USE CASE SW-UK.6	ENERGY
Related Learning Goals	Security of supply: Enabling the energy supply chain to respond to external shocks and pressures, while maintaining service
Goal	Flexibility and security
User	Public and Private Sector: Economic regulator, Utility providers
Actions	O11- ensure adequate capacity within the energy supply chain to meet demand: ➢ PC Distributed Electricity Storage ➢ PC Electricity Network capacity reinforcement O12- Improve the management flexibility of the energy distribution system to meet demand: ➢ PC Transition of Distribution Network Operator to Distribution

	System Operators ➢ PC Support for greater Demand Side Management
Indicator	➢ I12- Change of ratio between energy storage capacity and distribution network capacity ➢ I13- Change of ratio between electricity demand and distribution & transmission network capacities

Steps in the Serious Game:

1. Calculate total electricity demand.
2. Calculate total electricity distribution and transmission network capacity.
3. Determine O11 & 012 PCs active and new network capacities.
4. Calculate ratio between network capacity and electricity demand.
5. Calculate ratio between storage capacity and network capacity.

USE CASE SW-UK.7	ENERGY
Related Learning Goals	Security of supply and (Global) Environmental Sustainability: reducing the carbon emissions associated with the generation and supply of electricity
Goal	Decarbonisation of electricity supply
User	Public and Private Sector: Economic regulator, Utility providers
Actions	O13- Increasing the proportion of low carbon energy with the supply: ➢ PC Greater deployment of commercial scale onshore Wind Energy, ➢ PC Greater deployment of Biomass fuelled Electricity Generation, ➢ PC Greater deployment of commercial scale Solar PV, ➢ PC Development of Hinkley Point Nuclear Energy plant
Indicator	➢ I14- Change to tCO_2e per MWh electricity supplied ➢ I15- Change to the ratio between renewable electricity supplied and total electricity consumed

Steps in the Serious Game:

1. Calculate carbon intensity of electricity supply (tCO_2e/MWh).
2. Determine O13 PCs active and new generating capacities.
3. Recalculate carbon intensity of electricity supply.
4. Calculate proportion of renewable energy.

USE CASE SW-UK.8	LAND
Related Learning Goals	Environmental Sustainability: Ensuring that the local environment and human health is protected

Goal	Maintain and improve the natural capital of the region
User	Public and Private Sector: Environmental regulator, water Utility providers, local authorities
Actions	O14- Protection and creation of forests and woodlands: ➢ PC Reforestation O15- Protection and creation of wetlands and peatland restoration: ➢ PC wetland O16- Protection and creation of other natural habitats: ➢ PC Natural habitats
Indicator	➢ I16- Ratio between total land area and forestry area ➢ I17- Ratio between total land area and wetland area ➢ I18- Ratio between total land area and other natural habitats area

Steps in the Serious Game:

1. Calculate areas of land use.
2. Determine O14, O15, and O16 PCs active and new land use change rates.
3. Recalculate areas of land use.
4. Calculate proportion of total land use under forestry, wetland and natural habitat.

USE CASE SW-UK.9	LAND
Related Learning Goals	Environmental Sustainability: reducing the total volume of waste disposed to landfill and the associated environmental impacts
Goal	Minimisation of waste to landfill
User	Public and Private Sector: Environmental regulator, local authorities
Actions	O17- Waste recycling: ➢ PC increase recycling capacity O18- Green Waste composting: ➢ PC Increase composting capacity O19- Energy from Waste: ➢ PC increase capacity of energy from waste facilities
Indicator	➢ I19- Change of ratio between total waste produced and waste disposed to landfill ➢ I20- Reduction of waste to landfill per capita

Steps in the Serious Game:

1. Calculate areas of land use.
2. Determine O17, O18 and O19 PCs active and new land use change rates.
3. Recalculate areas of land use.
4. Calculate proportion of total land use under forestry, wetland and natural habitat.

USE CASE SW-UK.10	LAND
Related Learning Goals	Environmental Sustainability: Improving the urban environment to provide greater public amenity
Goal	Improvement of the urban environment
User	Public and Private Sector: Environmental regulator, Utilities providers, local authorities
Actions	O20- Increasing access to green spaces: ➢ PC creation of urban greenspace O21- Increasing housing stock: ➢ PC Increase demolition rate ➢ PC increase housing density
Indicator	➢ I21- Change of ratio between urban green space and residential area ➢ I22- Change of ratio between actual housing density and target housing density

Steps in the Serious Game:

1. Calculate area of residential land use.
2. Determine population and rate of occupancy.
3. Determine O20 and O21 PCs active and new land use change rates.
4. Recalculate area of residential land use.
5. Calculate area of urban green-space and ratio of urban green-space to residential area.

USE CASE SW-UK.11	AGRICULTURE AND FOOD
Related Learning Goals	Environmental Sustainability: minimise negative impacts of agriculture to the local environment and improve biodiversity
Goal	Sustainable agriculture
User	Public and Private Sector: Environmental regulator, Utilities providers, Farmers associations
Actions	O22 Improve biodiversity & Reduce agricultural chemical demand: ➢ PC Agricultural de-intensification

	➢ PC Organic farming ➢ PC catchment sensitive farming
Indicator	➢ I23- Ratio between sum area of agricultural land modified by above PCs, and total area of utilised agriculture

Steps in the Serious Game:

1. Calculate total area of utilised agricultural land.
2. Determine O22 PCs active and new land use change rate.
3. Calculate area of agricultural land use under modified practices.
4. Calculate ratio between total area of utilised agricultural land and area of agricultural land use under modified practices.

USE CASE SW-UK.12	AGRICULTURE AND FOOD
Related Learning Goals	Environmental Sustainability: Reduce surface run-off arising from agriculture thus protecting aquatic environment
Goal	Protect aquatic environment and raw water quality
User	Public and Private Sector: Environmental regulator, Utilities providers, Farmers associations
Actions	O23 Reduce agricultural run-off: ➢ Improve natural drainage on agricultural land ➢ Enclosed animal pens with drainage control ➢ Implement green belt land buffers
Indicator	➢ I24- Ratio between initial rate of agricultural run-off and modified rate of agricultural run-off

Steps in the Serious Game:

1. Calculate total area of utilised agricultural land.
2. Calculate initial rate of agricultural run-off.
3. Determine O23 PCs active and new land use change rate.
4. Calculate area of agricultural land use under modified practices.
5. Calculate ratio between initial rate of agricultural run-off and modified rate of agricultural run-off.

4.2 Use Cases for National Case Studies

4.2.1 Azerbaijan

Azerbaijan, as a member of the Council of Europe and the EU Eastern Partnership, has signed agreements with the EU for implementing EU Directives. However, it has not implemented them so far. It represents a specific case because its economy is mainly based on fossil fuels (oil and gas) while a significant part of the country suffers from drought and floods. A significant priority of this Case Study is to estimate the cost of externalities caused by drilling activity and linked to the use of resources (water), land use and emissions. In this context, it aims to run various scenarios to assess the impact of moving towards a diversified economy with higher share of renewables and lower oil exports. Reforestation is another priority that will contribute to mitigating effects of GHG emissions. Rational use of water resources and sustainable development of agriculture are also considered.

The Case Study of Azerbaijan focuses on the investigation of four nexus sectors: climate, energy, water and land.

As for water resources, Azerbaijan is dependent on trans-boundary water resources while wastewater treatment is practically non-existent. The possibility of water reuse for irrigation is under study.

Land use sector is strongly affected by climate conditions. Irrigated land is located in the lowlands, characterised by low precipitation. The region is also prone to floods.

Regarding the energy sector, the decarbonisation of energy generation through the exploitation of renewable energy is pursued.

The learning goals of the Azerbaijan Case Study focus on how policies in the domains of agriculture, sustainable water management, and renewable energy can affect each other under climate change conditions, in a region where high agricultural production and tourism are competing for water.

The Use Cases of the Azerbaijan Case Study are:

USE CASE AZ.1	ENERGY/CLIMATE
Related Learning Goals	Gain understanding of the relation of energy policies and emissions reduction
Goal	Reduction of greenhouse gas emissions from the energy sector
User	Public Sector: e.g. Ministry of Energy, Ministry of Environment
Actions	➢ Training programs to raise awareness for energy savings ➢ Adoption of subsidies for renewables ➢ Direct investments in renewables by the government
Indicator	➢ Emissions from energy production ➢ Power generation mix ➢ Power generation capacity mix ➢ Energy consumption ➢ Power generation from renewables ➢ Power generation from fossil fuels ➢ Energy demand industry ➢ Energy demand agriculture ➢ Energy demand services ➢ Energy demand transport

Steps in the Serious Game:

1. Identify the current level of emissions from energy production, composition of the power generation mix and capacity mix and the energy demand from the different sectors (industry, agriculture, services, transport).
2. Define a minimum of absolute emissions reduction from the energy sector that should be achieved, e.g. below the level of 2002.
3. The emissions of the energy sector depend on the mix of supply technologies and the level of demand. Reducing the demand can reduce the emissions as long as the demand is not increasing. Increasing the share of renewable energy technologies can reduce the amount of emissions unless there is a significant demand increase at the same time. The player needs to apply actions targeting at reducing emissions. Actions are applied in several steps.
4. At the end of one round of the game, one controls if the emission reduction target defined in step 2 is achieved or not. If it is achieved, no need for further actions. If it is not achieved, another round of the game should start.

USE CASE AZ.2	ENERGY/CLIMATE
Related Learning Goals	Gain understanding of the relation of energy policies and emissions reduction
Goal	Reduction of greenhouse gas emissions from the energy sector
User	Private sector: e.g. Power utilities, Transmission system operators
Actions	➢ Training programs to raise awareness for energy savings
Indicator	➢ Emissions from energy production ➢ Power generation mix ➢ Power generation capacity mix ➢ Energy consumption ➢ Power generation from renewables ➢ Power generation from fossil fuels ➢ Energy demand industry ➢ Energy demand agriculture ➢ Energy demand services ➢ Energy demand transport

Steps in the Serious Game:

1. Identify the current level of emissions from energy production, composition of the power generation mix and capacity mix and the energy demand from the different sectors (industry, agriculture, services, transport).
2. Set an amount for the reduction of energy demand.
3. Apply the action related to energy savings.
4. Depending on the development of the selected demand the following should be done:

- Demand has been reduced by the amount aimed for or more: nothing, goal achieved.
- Demand has not been reduced or is higher than aimed for: play again, taking different measures.

USE CASE AZ.3	ENERGY/CLIMATE
Related Learning Goals	Gain understanding of the relation of energy policies and emissions reduction
Goal	Reduction of greenhouse gas emissions from the energy sector
User	NGOs
Actions	➢ Training programs to raise awareness for energy savings
Indicator	➢ Emissions from energy production ➢ Power generation mix ➢ Power generation capacity mix ➢ Energy consumption ➢ Power generation from renewables ➢ Power generation from fossil fuels ➢ Energy demand industry ➢ Energy demand agriculture ➢ Energy demand services ➢ Energy demand transport

Steps in the Serious Game:

1. Identify the current level of emissions from energy production, composition of the power generation mix and capacity mix and the energy demand from the different sectors (industry, agriculture, services, transport).
2. Set an amount for the reduction of energy demand.
3. Apply the action related to energy savings.
4. Depending on the development of the selected demand the following should be done:

- Demand has been reduced by the amount aimed for or more: nothing, goal achieved.
- Demand has not been reduced or is higher than aimed for: play again, taking different measures.

USE CASE AZ.4	ENERGY/WATER
Related Learning Goals	Understanding the linkage between water sector and power generation
Goal	Reduction of water usage by the energy sector
User	Public sector, e.g. Ministry of Energy, Ministry of Water
Actions	➢ Coordinated management of reservoirs ➢ Adoption of subsidies for renewables (not including hydropower) ➢ Direct investments in renewables by the government
Indicator	➢ Water consumption by hydro power ➢ Water consumption per kWh ➢ Water consumption per condenser ➢ Water consumption for energy produced

Steps in the Serious Game:

1. Identify the current level of water usage by the energy sector. The main usages are the usage of water for hydro power and the usage in condensers.
2. Reduce water usage by x%. Could be in percent or in total numbers.
3. Depending on water usage after the implementation of the aforementioned action:

- If water demand has been reduced as aimed for or more: no need for immediate action.
- If water demand has not been reduced as much as aimed for: play again and try a different set of policies.

USE CASE AZ.5	ENERGY/WATER
Related Learning Goals	Understanding the linkage between water sector and power generation
Goal	Reduction of water usage by the energy sector
User	Private sector, e.g. Energy utility company, Water utility
Actions	➢ Coordinated management of reservoirs
Indicator	➢ Water consumption by hydro power ➢ Water consumption per kWh ➢ Water consumption per condenser ➢ Water consumption for energy produced

Steps in the Serious Game:

1. Identify the current level of water usage by the energy sector. The main usages are the usage of water for hydro power and the usage in condensers.
2. Reduce water usage by x%. Could be in percent or in total numbers.
3. Depending on water usage after the implementation of the aforementioned action:

- If water demand has been reduced as aimed for or more: no need for immediate action.
- If water demand has not been reduced as much as aimed for: play again and try a different set of policies.

4.2.2 Greece

The Greek Case Study focuses on the mitigation of climate change impacts, expected to strongly affect agriculture and tourism, the key drivers of its economy. Thus, extensive use of renewable energy and rational management of water resources are encouraged. Food production and elimination of land use conflicts are also considered.

Under a nexus framework, some indicative interlinkages, going to be explored in the case of Greece, include: climate-food interlinkages and their impacts on agricultural production, water-energy interlinkages and their impacts on hydropower sector, food-land interlinkages and their impacts on the use of fertilizers, land-water interlinkages and their impacts on eutrophication, energy-climate interlinkages and their impacts on the energy mix.

The Greek Case Study investigates policies having to do with water resources efficiency, sustainable food production, low-carbon energy transitions and climate change adaptation. More specifically, it gives emphasis on the protection of surface water and groundwater quality, the management of flood and drought risks, the regulation of land uses, the certification of food products, the penetration of renewable energy in the national energy mix, the promotion of climate change mitigation practices and the sustainable development of tourism.

The Greek Case Study involves five nexus domains: water, energy, land, food and climate. Concerning water resources, water needs are covered by both surface water and groundwater. Agricultural sector is the biggest water consumer in Greece. Athens receives its water from a series of reservoirs. Islands in the Aegean Sea are mainly supplied by groundwater resources while some small islands are supplied with water from tankers. As for energy, the main electricity supplier in Greece is the Public Power Corporation S.A. 61% of the energy needs is covered by imports (petroleum products and natural gas). The rest 39% is covered by national energy sources (lignite and RES). Further exploitation of solar, wind, hydropower energy and biomass is encouraged.

The learning goals of Greece explore how national policies in the domains of water management, renewable power production, and land use affect each other and result in changes in food production, tourism, GHG emissions and quality-quantity of water resources.

The Use Cases designed for the Greek Case Study are:

USE CASE GR.1	WATER
Related Learning Goals	Sustainable management of water resources
Goal	Water saving in agricultural sector
User	Public Sector: ➢ Ministry of Rural Development and Food ➢ Local Organisations of Reclamation Services
Actions	➢ Change of irrigation systems / practices
Indicator	➢ Change of water losses ➢ Change of total irrigation water

Steps in the Serious Game:

1. Identify cropland areas irrigated by a specific irrigation system (furrow, drip or sprinkler).
2. Specify the area where the change of irrigation system will take place (m^2).
3. Specify the new irrigation system.
4. Calculate water losses for the irrigation systems, the new and the old one.
5. Calculate total irrigation water before and after the change of irrigation system.

- If the new irrigation system water losses are lower than the current one, change the existing irrigation system with the proposed new one and consequently the total available water for irrigation will increase.

- If the new irrigation system water losses are the same or higher than the current one, choose an alternative irrigation system to replace the current one.
- If water losses from all available irrigation systems are less than a benchmark value, no need for immediate action.

USE CASE GR.2	ENERGY
Related Learning Goals	➢ Renewable power production ➢ Reduction of GHG emissions
Goal	Increase RES share in the gross final energy production
User	Ministry of Environment and Energy
Actions	➢ Use of bio-fuels in the transportation sector ➢ Use of biomass in the agricultural sector ➢ Electricity generation from PVs, wind and hydro-power plants
Indicator	➢ Bio-fuels used in the transportation sector in relation to other fuels ➢ Biomass used in the agricultural sector in relation to other fuels ➢ Share of electricity generated from PVs in the gross final electricity generation ➢ Share of electricity generated from wind parks in the gross final electricity generation ➢ Share of electricity generated from hydro-power plants in the gross final electricity generation

Steps in the Serious Game:

1. Calculate bio-fuel demand in the transportation sector

- If bio-fuel demand is lower than a benchmark value, continue implementing the relevant policy.
- If bio-fuel demand is equal to or higher than a benchmark value, no need for immediate action.

2. Calculate biomass demand in the agricultural sector.

- If biomass demand is lower than a benchmark value, continue implementing the relevant policy.
- If biomass demand is equal to or higher than a benchmark value, no need for immediate action.

3. Calculate total electricity generation (electricity produced from all types of resources, conventional and renewable).
4. Calculate share of electricity generated from PVs.
5. Calculate share of electricity generated from wind parks.
6. Calculate share of electricity generated from hydro-power plants.

- If share of electricity generated from renewables is lower than a benchmark value, continue implementing the third action.
- If electricity generated from renewables is equal or higher than a benchmark value, no need for immediate action.

USE CASE GR.3	CLIMATE
Related Learning Goals	Reduction of GHG emissions
Goal	Non-ETS emissions reduction target by 2050: -60% compared to 2005 emissions
User	Ministry of Environment and Energy
Actions	➢ Decrease of oil used in agriculture ➢ Decrease of oil used in non-ETS industry ➢ Decrease of oil used in non-ETS transportation sector ➢ Decrease of oil used in the household/commercial sector ➢ Decrease of oil used in the construction sector ➢ Decrease of oil used in other non-ETS sectors
Indicator	➢ Change of GHG emissions derived from all non-ETS sectors ➢ Change of GHG emissions derived from the agricultural sector ➢ Change of GHG emissions derived from the non-ETS industrial sector ➢ Change of GHG emissions derived from the non-ETS transportation sector ➢ Change of GHG emissions derived from the household/commercial sector ➢ Change of GHG emissions derived from the construction sector ➢ Change of GHG emissions derived from other non-ETS sectors

Steps in the Serious Game:

1. Identify current total non-ETS emissions.
2. Identify current non-ETS emissions per each sector, namely: agriculture, non-ETS industry, non-ETS transportation, household/commercial sector, construction sector, other non-ETS sectors.
3. Calculate total non-ETS emissions in 2050.
4. Calculate non-ETS emissions per each sector in 2050.

- If total non-ETS emissions reduction is lower than 60% in 2050, continue implementing the relevant policies.
- If total non-ETS emissions reduction is equal to or higher than 60% in 2050, no need for any additional action.
- If non-ETS emissions per each non-ETS sector are equal or higher than a benchmark value, continue implementing the relevant policy.
- If non-ETS emissions per each non-ETS sector are lower than a benchmark value, no need for immediate action.

USE CASE GR.4	LAND AND FOREST
Related Learning Goals	Sustainable management of land
Goal	Sustainable management of forest land, wetland and grassland
User	Public Sector: Land management authority
Actions	➢ Reforestation ➢ Effective management and confrontation of forest fires ➢ Management of land use conflicts
Indicator	➢ Change of forest land ➢ Change of grassland ➢ Change of wetland

Steps in the Serious Game:

1. Identify current share of grassland, wetland and forest land.
2. Choose one land management policy from the list of possible actions.
3. Run SDM.
4. Estimate indicators.

- If the share of forest land increases, no need for immediate action.
- If the share of grassland increases, no need for immediate action.
- If the share of wetland increases, no need for immediate action.
- If the share of forest land and/or grassland and/or wetland decreases, the goal is not reached and actions must be re-taken.

USE CASE GR.5	AGRICULTURE AND FOOD
Related Learning Goals	Sustainable food production
Goal	Cover food needs, fodder needs and needs related to industrial crops
User	Public Sector: Ministry of Rural Development and Food
Actions	➢ Increase agricultural production ➢ Protect/Increase agricultural land use
Indicator	➢ Crop food production ➢ Crop feed production ➢ Crop industrial production

Steps in the Serious Game:

1. Identify area of crops that produce food.
2. Identify area of crops that produce feed (fodders).
3. Identify area of industrial crops.

4. Select a policy from the list of possible actions.
5. Run the SDM.
6. Display indicators.

- If area of crops that produce food increases, no need for immediate action.
- If area of crops that produce feed increases, no need for immediate action.
- If area of industrial crops increases, no need for immediate action.
- If area of crops that produce food/feed or/and area of industrial crops decreases, continue implementing the relevant policies.

4.2.3 Latvia

The Latvian Case Study considers the sectors of energy, water, food, land and climate. It places emphasis on the mitigation of climate change impacts through the extensive use of renewables for energy production (e.g. exploitation of biomass). It adopts an interdisciplinary approach for evaluating abatement costs of different energy policies and their impacts on water, air, biodiversity, land uses and climate change.

The energy sector in Latvia is strongly dependent on imported fossil fuels and electricity. Its future perspectives focus on the development of a low-carbon bio-economy and the exploitation of its high RES potential.

Other issues being investigated include: the reduction of GHG emissions, the elimination of eutrophication threatening water quality, the management of flood and drought risks, the excessive moisture of soils, the development of biological farming, the pressures put on agricultural land by the urban sprawl, the management of land use conflicts between energy crops and food crops, the mitigation of pressures put on forest land by biomass harvesting.

Learning goals in the case of Latvia focus on how national and local policies, aiming at a low-carbon economy and energy autarky, interact and affect policies in the domains of land use for forestry and biomass production, biological food production, ecosystem services, and water quality management.

The Use Cases developed by Latvia are:

USE CASE LV.1	WATER
Related Learning Goals	Improving water quality
Goal	Reduction of nitrogen leakage in surface waters
User	➢ Public Sector: Ministry of Agriculture ➢ Private Sector: Farmers' Unions
Actions	➢ Application of precise technologies for fertilization (subsidies) ➢ Application of direct injection of organic slurry (subsidies) ➢ Increase of biological farming (rural support payments) ➢ Application of green cover before next spring crops (rural support payments)
Indicator	➢ Change of nitrogen loss

Steps in the Serious Game:

1. Identify cereals area which is fertilised.
2. Identify the measure to be applied (precise fertilisation, direct slurry injection, biological farming, green cover).
3. Specify the area where the change of fertilisation will take place.
4. Calculate reduction of N leakage from reduced amount of fertilisers.

- If the effect on water health is negligible, check an alternative measure and/or increase subsidies/ support payment.
- If the effect on water health is pronounced, no need for immediate action.

USE CASE LV.2	ENERGY
Related Learning Goals	Decreasing energy demand
Goal	Increasing energy efficiency
User	Public Sector: Ministry of Economy
Actions	➢ Improvement of energy efficiency in industry by available subsidies for investments in more efficient technologies and insulation of industrial buildings ➢ Improvement of energy efficiency in households by available subsidies for insulation of buildings ➢ Improvement of energy efficiency in tertiary sector by available subsidies for insulation of public buildings
Indicator	➢ Energy (heat) demand by industry ➢ Energy (heat) demand by households ➢ Energy (heat) demand by tertiary sector

Steps in the Serious Game:

1. Identify current total heat demand.
2. Identify the measure to be applied to reduce heat demand in sectors (industry, households, tertiary sector).
3. Calculate the reduction of heat demand.

- If the effect on energy health is negligible, check an alternative measure and/or increase subsidies.
- If the effect on energy health is pronounced, no need for immediate action.

USE CASE LV.3	ENERGY
Related Learning Goals	Increasing electricity production from RES
Goal	Increasing electricity production from RES

User	Public Sector: Ministry of Economy
Actions	➢ Application of new more efficient technologies for electricity production from biomass ➢ Increase wind energy production by support for broader application of wind energy technologies (feed-in tariffs and subsidies)
Indicator	➢ Electricity production from biomass ➢ Electricity production from wind ➢ Total electricity production from RES

Steps in the Serious Game:

1. Identify the electricity produced from RES.
2. Identify the measure to be applied to increase electricity production (biomass efficient technologies, increased wind energy).
3. Calculate the total electricity production from RES.

- If the electricity produced from RES is lower than 100%, increase subsidies for application of measures
- If the electricity produced from RES is 100%, no need for immediate action.

USE CASE LV.4	ENERGY
Related Learning Goals	Replacement of fossil fuels in transport
Goal	Decarbonisation of transport
User	Public Sector: Ministry of Economy
Actions	➢ Encouraging uptake of electric cars (subsidies for purchasing of electric vehicles) ➢ Increasing use of biofuels in road transport (subsidies)
Indicator	➢ Reduction of oil consumption in transport

Steps in the Serious Game:

1. Identify oil consumption in transport.
2. Identify the measure to be applied.
3. Calculate the total reduction of oil consumption in transport.

- If the reduction of oil demand is less than 18%, increase subsidies for application of measures
- If the reduction of oil demand is equal to or more than 18%, no need for immediate action.

USE CASE LV.5	CLIMATE
Related Learning Goals	Reduction of GHG emissions
Goal	Emission reduction in the agricultural sector
User	➢ Public Sector: Ministry of Agriculture ➢ Private Sector: Farmers unions
Actions	➢ Increase production of biogas from manure (subsidies for investments) ➢ Improvement of feed quality (subsidies) ➢ Promote fertilization planning (rural support payments)
Indicator	➢ Change of GHG emissions derived from agriculture

Steps in the Serious Game:

1. Identify current GHG emissions from agriculture.
2. Identify the measure to be applied (production of biogas, improvement of feed quality, promotion of fertilization planning).
3. Calculate the GHG emissions from agriculture.

- If GHG emissions decrease from agriculture is negligible, check an alternative measure and/or increase subsidies/support payments.
- If GHG emissions decrease from agriculture is pronounced, no need for immediate action.

USE CASE LV.6	CLIMATE
Related Learning Goals	Increase CO_2 sequestration
Goal	Increase CO_2 sequestration in forestry
User	Public Sector: Ministry of Agriculture, Ministry of Environmental Protection and Regional Development
Actions	➢ Increase support to young forest maintenance (subsidies) ➢ Increase afforestation (subsidies)
Indicator	➢ Change in CO_2 sequestration derived from forestry

Steps in the Serious Game:

1. Identify current CO_2 sequestration from forests.
2. Identify the measure to be applied (young forest maintenance, afforestation).
3. Calculate the CO_2 sequestration from forests.

- If CO_2 sequestration increase is negligible, check an alternative measure and/or increase subsidies for application of measure.
- If CO_2 sequestration increase is pronounced, no need for immediate action.

USE CASE LV.7	LAND AND FOREST
Related Learning Goals	Sustainable management of land
Goal	Sustainable land use (arable land and grassland) taking into account farm welfare
User	➢ Public Sector: Ministry of Agriculture ➢ Private Sector: Farmers unions
Actions	➢ Increase of arable land (rural support payments) ➢ Maintaining the share of perennial grasslands on arable land (rural support payments) ➢ Increase land for energy crops (rape) (rural support payments) ➢ Cultivation of legumes in crop rotation (rural support payment)
Indicator	➢ Change of arable land ➢ Change of perennial grasslands ➢ Change of land for energy crops (rape)

Steps in the Serious Game:

1. Identify current share of arable land, perennial grasslands, and energy crops and the farm welfare.
2. Select the land management measures.
3. Calculate the change in land-use ratio and farm welfare.

- If the farm welfare decreases by changing the land-use options, the goal is not reached and actions must be taken to alter the rural support and improve land use policies, land use limitations.

USE CASE LV.8	AGRICULTURE AND FOOD
Related Learning Goals	Sustainable food production
Goal	Food security and sustainable food production (SDG2)
User	Public Sector: Ministry of Agriculture
Actions	➢ Support to biological cereals in food production (rural support payments) ➢ Promotion of export of cereals (rural support payments) ➢ Promotion of more productive cultivars of cereals (rural support payments)
Indicator	➢ Production of organic cereals ➢ Share of cereals export ➢ Total production of cereals

Steps in the Serious Game:

1. Identify amount of cereals produced.
2. Identify the measures to increase production of cereals in conventional and biological farming.
3. Calculate the production of cereals in conventional and biological farming.

- If the produced organic cereals increase is pronounced, no need for immediate action.
- If the produced conventional cereals increase is pronounced, no need for immediate action.
- If the produced organic cereals increase is negligible, increase rural support payments.
- If the produced conventional cereals increase is negligible, increase rural support payments.

USE CASE LV.9	AGRICULTURE AND FOOD
Related Learning Goals	Changing dietary patterns
Goal	Sustainable consumption and production patterns
User	Public Sector: Ministry of Agriculture
Actions	➢ Promotion of reduction of meat consumption (communication measure) ➢ Balance meat production to self-supply (rural support payments)
Indicator	➢ Consumption of meat ➢ Share of meat cattle

Steps in the Serious Game:

1. Identify amount of meat consumed.
2. Identify the measures to balance meat production to self-supply.
3. Calculate the meat production.

- If the produced meat meets the self-supply, no need for immediate action.
- If the produced meat is lower than the self-supply, increase rural support payments.

4.2.4 Netherlands

The Dutch Case Study deals with the potential benefits of introducing nexus-compliant practices in achieving the national energy ambitions, taking into account resource efficiency targets and the transition towards a circular economy. It also explores how energy practices can be integrated with agricultural land management, rational management of water resources and climate change adaptation/mitigation.

The nexus sectors involved in this Case Study are water, energy, food, land and climate. Among its main priorities is the establishment of a low-carbon economy through the implementation of the most efficient policy mix. Towards this direction, water, land and carbon footprints of Dutch production and consumption are analysed. Moreover, increased energy efficiency and use of bio-energy and Carbon Capture and Storage (CCS) strategies are encouraged.

The main source of GHG emissions in the Netherlands is CO_2 emissions. Agricultural sector is responsible for a small share of GHG due to animal production, use of fertilizers and fossil fuels, heating and tractor use.

The relevant learning goals explore how policies aiming at a low-carbon economy with reduced energy demand per capita and reduced greenhouse gas emissions, can affect land and water use including land, carbon and water footprints, agricultural production, and risks of flooding and droughts under different climate change scenarios.

The Use Cases designed by the Case Study of Netherlands are:

USE CASE NL.1	ENERGY
Related Learning Goals	➢ Renewable power production ➢ Reduction of GHG emissions
Goal	Increase the share of renewable energy in the gross final energy production
User	Ministry of Economic Affairs and Climate
Actions	➢ Electricity generation from solar power in urban and rural areas ➢ Electricity generation from wind power off-shore and on-shore ➢ Use of biomass in the agricultural sector ➢ Use of bio-fuels in the transportation sector
Indicator	➢ Share of electricity generated from solar power in energy production ➢ Share of electricity generated from wind power in energy production ➢ Energy form biomass in energy production

Steps in the Serious Game:

1. Identify renewable energy demand in all sectors.
2. Identify non-renewable energy demand in all sectors.
3. Identify oil-based energy production.
4. Identify gas-based energy production.
5. Identify energy-saving options in all sectors.
6. Calculate the share of renewable energy.

    - If share of renewables is lower than the policy target and demand for renewables energy is increased to replace the demand for non-renewable energy by renewable energy, see policy options (actions).
    - If share of renewables is equal to or higher than 10% of the total fuel demands, no need for immediate action.

7. Identify renewable energy demands in all sectors.
8. Identify energy production from solar power.

9. Identify energy production from wind power.
10. Identify energy production from biomass.
11. Calculate the share of RE.

- If share of renewables is lower than the policy target, increase price of non-renewable energy by lowering the ETS emission ceiling.
- If share of renewables is equal to or higher than the policy target, no need for immediate action.

USE CASE NL.2	CLIMATE
Related Learning Goals	Reduction of GHG emissions from energy production (towards a low carbon economy)
Goal	➢ Carbon Capturing and Storage (CCS) ➢ Closure of coal power plants
User	Ministry of Economic Affairs and Climate
Actions	➢ Increase of CCS for energy production ➢ Reduction of coal-fired power plants ➢ Reduce non-energy related GHG emissions
Indicator	➢ Change of GHG emissions from energy production ➢ Change non-energy related GHG emissions

Steps in the Serious Game:

1. Identify GHG emissions from energy production.
2. Identify the CCS option for emissions from energy in the manufacturing industry.
3. Calculate the GHG emissions.
4. Calculate total non-ETS emissions in 2050.
5. Calculate non-ETS emissions per each sector in 2050.

- If non-agricultural GHG emissions reduction is lower than 95% in 2050 compared to policy target, then abolish coal-fired power plants.
- If non-agricultural GHG emissions reduction is equal to or higher than 95% in 2050, no need for immediate action.

6. Identify coal-fired energy production.
7. Select one of the options to abolish coal-fired plants.
8. Calculate non-ETS emissions per each sector in 2050.

- If non-agricultural GHG emissions reduction is lower than 95% in 2050 compared to policy target, then other policy options should be considered.
- If non-agricultural GHG emissions reduction is equal to or higher than 95% in 2050, no need for immediate action.

USE CASE NL.3	LAND AND FOREST
Related Learning	➢ Sustainable management of land

Goals	➢ Reduce emissions from peatland
Goal	Sustainable management of forest land, wetland and grassland
User	Public Sector: Staatsbosbeheer (land management organisation)
Actions	➢ Reforestation ➢ Effective management of land
Indicator	➢ Change of forest land ➢ Change of cereals ➢ Change of peatland

Steps in the Serious Game:

1. Identify current share of peatland.
2. Choose the land management policy for peatlands.
3. Run the models / Progress through time.
4. Display indicators.
   - If share of peatland GHG reduction is lower than 95% in 2050, consider other climate policy options.
   - If share of peatland GHG reduction is higher than 95% in 2050, no need for immediate action.
5. Identify current share of land with cereals.
6. Choose the land management policy for land with cereals.
7. Run the models / Progress through time.
8. Display indicators.
   - If the share of land with cereals is lower than 30% in 2050, consider other land use options.
   - If the share of land with cereals is higher than 30% in 2050, no need for immediate action.
9. Identify current share of forest land.
10. Choose the land management policy for forest land / reforestation actions.
11. Run the models / Progress through time.
12. Display indicators.
    - If the share of forest land is lower than policy target in 2050, consider other land use options.
    - If the share of forest land is higher than policy target in 2050, no need for immediate action.
    - Start again a new round.

USE CASE NL.4	AGRICULTURE AND FOOD
Related Learning Goals	Sustainable food production and consumption
Goal	Plant-based diets

User	Ministry of Economic Affairs and Climate
Actions	➢ Crop productivity
Indicator	➢ Demand for plant-based proteins ➢ Food crop production ➢ Share of plant-based proteins in diets

Steps in the Serious Game:

1. Identify area of crops that produce food.
2. Identify area of crops that produce fodders.
3. Select a policy to increase the demand for plant-based proteins.
4. Run the models / Progress through time.
5. Display indicators.

   - If area of crops that produce food increases, no need for immediate action.
   - If area of crops that produce feed increases, no need for immediate action.
   - If the share of plant-based proteins is less than 50% reiterate.

4.2.5 Sweden

The Swedish Case Study focuses on the best possible distribution of land uses in order to optimize forestry, low-carbon options, food security and hydropower production. The main nexus sectors being addressed by this Case Study are water, energy and land/forests. Accordingly, the goals of the Swedish Case Study include: the increase of renewable and energy efficiency, the reduction of several hydrological risks, the reduction of climate change impacts, the protection of lakes and streams, the protection of groundwater quality and the sustainable management of forest land. In this context, the learning goals of the Swedish Case Study investigate how increasing afforestation for biomass and energy production interferes with water management policies aiming to reduce risks of flooding, droughts, water shortages for hydropower, and water quality, related to climate change.

Regarding the sector of forest land, 69% of Sweden is covered by forests. Forest industry has a long tradition and it significantly contributes to the national GDP. Emphasis is placed on the protection and development of forest land while there is an increase in standing volume, biomass and felling rate.

Water, historically, abounds in Sweden. About 9% of its area is covered by water while there are about 95,700 lakes. Sweden is the largest hydropower producer in Europe and local water supply is covered by both surface water (50%) and groundwater (50%). However, there are increasing concerns related to water quality (e.g. eutrophication) as mobilized N and P is flushed from land to water.

As for the energy sector, it is characterized by a growing demand for bio-energy, an increasing energy production from solid biofuels and a growing wind power industry. Sweden holds also a green electricity certification for promoting renewable energy.

The Use Cases designed for Sweden are:

USE CASE S.1	CLIMATE
Related Learning Goals	Effects of reducing greenhouse gas emissions and climate impacts
Goal	Limiting the rise in the global average temperature by reducing emissions
User	Students
Actions	➢ Increase the share of environmentally friendly heavy trucks (>3.5 ton) on the road through providing subsidies ➢ Re-wetting 10% (i.e. 154,580 ha) of drained peat-land (formerly ditched and drained to create productive land) to reduce GHG emissions
Indicator	➢ CO_2,eq emissions from transport sector ➢ Total CO_2,eq emissions

Steps in the Serious Game:

1. Identify number of trucks (>3.5 ton) on the road and CO_2, eq emissions per truck.
2. Identify area of drained peat-land (in ha) and estimate CO_2, eq emissions per hectare.
3. Calculate rate of change in emissions:
   - With different levels of subsidies on environmentally friendly trucks
   - With different amounts of drained peat-land area re-wetted

USE CASE S.2	WATER
Related Learning Goals	Sustainable use and management of water resources
Goal	Improving management of water resources to increase water quality and decrease water use
User	Students
Actions	➢ Reduce the use of fertilizer (through a fertilizer tax) and thereby the leakage of nitrogen and phosphorus from agricultural land ➢ Reduce the domestic water use through water fees
Indicator	➢ Nitrogen and phosphorus concentrations in water (lakes/rivers) ➢ Amount of water used in domestic and service sectors

Steps in the Serious Game:

1. Identify level of fertilizer use and nitrogen/phosphorus concentrations.
2. Identify water used in domestic and service sector.

3. Calculate rate of change in:
    - Water use in domestic and service sector
    - Water quality

USE CASE S.3	LAND (FOREST)
Related Learning Goals	Importance of a rich diversity of plant and animal life
Goal	Improvements in land use to foster higher biodiversity
User	Students
Actions	➢ Increase the average stand age of spruce and pine through legislation regulating the rotation age ➢ Increase the area of non-productive (protected) forest through financial compensation for protecting forests
Indicator	➢ Average forest stand age ➢ Amount of non-productive forest land in hectares

Steps in the Serious Game:

1. Identify the average stand age of spruce and pine.
2. Identify the area of non-productive (protected) forest.
3. Calculate rate of change in:
    - Average forest stand age
    - Amount of non-productive forest land in hectares

4.3 Use Cases for Trans-boundary Case Studies

SIM4NEXUS project involves two trans-boundary Case Studies. The first one covers the Upper Rhine area, between France (ALCA region: Alsace-Lorraine-Champagne Ardennes) and Germany (Federal State Baden Württemberg). The second one encompasses the Eastern parts of Germany, the Czech Republic and Slovakia.

4.3.1 France – Germany

In this Case Study emphasis is placed on water, energy and biodiversity domains while the main question, reflecting the nexus context, focuses on the identification of pathways in order to achieve the below 2^{o} target in a balanced way. The learning goals concern the identification of synergies and trade-offs in policies regarding flood protection, water retention and design of natural habitats, and wetlands, on the one hand, and renewable energy policies, regarding hydropower and biomass on the other hand, in the densely-populated, industrial area of the Upper Rhine.

Concerning the nexus water-energy, the most important issues investigated refer to water resources management, energy generation and improvement of climate change resilience in the energy sector. Despite the significant development of other renewable energy generation technologies (wind-power in Grand Est. and PV-Solar in Baden-Württemberg) hydroelectricity still plays a key role. A great number of hydroelectricity plants are located along the Rhine (10 plants located within the Case-study territory). Moreover, a significant share of electricity generation in Grand Est. and Baden-Württemberg regions is based on nuclear and thermal power, displaying substantial water requirements for cooling.

Besides, the Rhine itself as well as its aquatic ecosystem and adjacent alluvial plains have been designated in 2008 as a protected natural area under the RAMSAR convention on wetlands. Ecological flows – corresponding to the minimal water flow required for the good functioning of Rhine water ecosystems – have been defined. The latter constrain water abstraction for energy generation in case water flow is less or equal to the ecological flow. Then, water abstraction for energy generation purposes is forbidden and compromised.

Finally, expected impacts of climate change regarding water resources and especially summer precipitations in the Upper Rhine region are the following (Riach et al., 2019):

- Higher occurrences of summer droughts (increased drought risk) and dry summers
- Decrease in summer precipitations up to 25%
- Intensified dry periods in summer

Regarding the nexus energy-water-land, the main goal is to ensure a sustainable energy transition. The Upper-Rhine is considered as a model region regarding energy transition. The deployment of renewables resulted – among others – in a significant development of bio-energy. This development has important implications especially in terms of competition for land use between food production and biomass production but also for the efficient and sustainable use of water resources, both in terms of quality and quantity.

For instance, in Baden-Württemberg biogas production based on cultivated crops underwent a significant development starting in the early 2000s. Between 2001 and 2019, a 100% increase in cultivated area dedicated to silage maize; one of the main resources used to produce biogas (around 40% in mass) could be observed, along with a decline in cultivated area especially for pulses and root crops.

Based on the aforementioned priorities, the Use Cases designed for the France-Germany trans-boundary Case Study are:

USE CASE FR-DE.1	CLIMATE / ENERGY
Related Learning Goals	➢ Learn about the impact of climate change in the specific Upper Rhine context and resulting challenges ➢ Learn about synergies and trade-offs between policies but also test and learn about the feasibility of specific policy objectives (low carbon and no nuclear, 100% food self-sufficiency, etc.)
Goal	Improve climate resilience in the electricity sector
User	Public Sector (e.g. Ministry of Energy Planning, Energy Agency, Local Authorities)
Actions	➢ Define the foreseen reduction in hydropower production due to climate change

	➢ Diversification of the electricity generation mix (decrease the share of energy generation technologies needing water for cooling → thermal; support the development of PV and wind-power) ➢ Power purchase agreements (electricity import agreements) must be established with neighbouring countries to compensate for low production due to climate change and to reduce risk of high electricity import prices ➢ Phase out once-through cooling systems and invest in less water intensive cooling systems
Indicator	➢ % energy mix based on thermal (in production) ➢ % energy mix based on hydroelectricity (in production) ➢ Annual hydropower production ➢ Water used annually (abstracted / withdrawn) by cooling systems in thermal generation power plants ➢ % cooling systems by type (e.g. 50% once-through, 45% closed-cycle / cooling tower, 5% dry-air cooling) ➢ Annual electricity imports

Steps in the Serious Game:

1. Identify resilience indicators:
   - % energy mix based on thermal (in production) (E3ME, SDM)
   - % energy mix based on hydroelectricity (in production) (E3ME, SDM)
   - Annual hydropower production (SWIM, SDM)
   - Annual electricity generation based on thermal (E3ME, SDM)
   - Water used annually (abstracted / withdrawn) by cooling systems in thermal generation power plants (SDM)
   - % cooling systems by type (e.g. 50% once-through, 45% closed-cycle / cooling tower, 5% dry-air cooling)
   - Annual electricity imports (SDM)
2. Set a forecast of reduction in hydropower generation (SWIM, SDM), -x% of base year generation; and a decrease in surface water availability for cooling systems (SWIM, SDM), -y% of water used for cooling in the base year (e.g. 100%).
3. Select measures from a pool of options that decrease the dependence of the electricity generation mix to water quantity to be applied over the period of the game:
   - Increase deployment of RET in electricity generation (e.g. solar, wind, biomass)
   - Phase out of once-through or upgrade cooling systems to less water intensive options (e.g. closed-cycle, dry-air cooling)
   - Set a minimum of electricity imports correspondent to, for example, the decrease in annual hydropower generation;
4. Run model / game – Indicators presented in 1) are displayed.
5. Re-start game acting over the elements manipulated in 2).

USE CASE FR-DE.2	LAND / ENERGY
Related Learning Goals	➢ Learn about the trade-offs linked with energy transition choices in the Upper Rhine ➢ Learn about synergies and trade-offs between policies but also test and learn about the feasibility of specific policy objectives (low carbon and no nuclear, 100% food self-sufficiency, etc.)
Goal	Ensure a sustainable energy transition
User	Public Sector (Ministry of Energy Planning, Energy Agency, Local Authorities)
Actions	➢ Increase deployment of "non-biomass" RET in electricity and heat generation (especially of PV and "wind-power on "low-value lands") ➢ Increase/support deployment of electric cars ➢ Increase/support deployment of the use of manure and food waste for biogas production ➢ Control the deployment of energy crops [set a cap in terms of total Utilized Agricultural Area (UAA) dedicated to energy crops] ➢ Decrease the use of agricultural inputs for energy crops
Indicator	➢ Share of energy crops in primary energy production/generation ➢ Quantity and share of available manure used for biogas production ➢ Quantity and share of available food waste used for biogas production ➢ Share of primary energy production based on manure (from total primary energy production and primary energy production from renewables) ➢ Share of primary energy production based on food waste (from total primary energy production and primary energy production from renewables) Cultivated area dedicated to energy crops Share of cultivated area dedicated to energy crops with respect to total utilized agricultural area ➢ Water demand from energy crops ➢ Fertilizer use for energy crops ➢ Ammonia output for energy crop

Steps in the Serious Game:

1. Identify sustainability indicators:
   - Share of energy crops in primary energy production/generation (SDM, E3ME)
   - Quantity and share of total resource available of manure used for biogas production (SDM)

- Quantity and share of total resource available of food waste used for biogas production (SDM)
- Share of primary energy production based on manure (from total primary energy production and primary energy production from renewables) (SDM)
- Share of primary energy production based on food waste (from total primary energy production and primary energy production from renewables) (SDM)
- Cultivated area dedicated to energy crops (SDM)
- Share of cultivated area dedicated to energy crops with respect to total utilized agricultural area (SDM)
- Water demand from energy crops (CAPRI, SDM)
- Fertilizer use for energy crops (CAPRI, SDM)
- Ammonia output for energy crop (CAPRI, SDM)

2. Determine the sustainable upper limit/cap for the UAA dedicated to energy crops. Determine the aimed for decrease in the use of agricultural inputs (for this maximum area dedicated to energy crops) and determine the corresponding agricultural production and primary energy production (and the corresponding "energy gap" to be bridged in terms of primary energy production).
3. Select measures from a pool of options that increase the sustainability of energy transition with regards to land and/or water resources to be applied over the period of the game:
    - Increase deployment of "non-biomass" RET in electricity and heat generation
    - Increase/support deployment of electric cars (decrease dependence on gasoline even bio-based)
    - Increase/support deployment of the use of manure and food waste for biogas production
4. Run model / game – Indicators presented in 1) are displayed.
5. Re-start game acting over the elements manipulated in 2).

USE CASE FR-DE.3	CLIMATE
Related Learning Goals	➢ Learn about synergies and trade-offs between policies but also test and learn about the feasibility of specific policy objectives (low carbon and no nuclear, 100% food self-sufficiency, etc.) ➢ Learn about the impact of climate change in the specific Upper Rhine context and resulting challenges
Goal	Climate-proofing agriculture in the Upper Rhine
User	Public Sector (Local authorities), Private sector (Farmers and Chambers of Agriculture)

Actions	➢ Implement Payment or Environmental Services/Agri-Environmental Schemes (PES/AES) to incentivize the implementation of soil conservation measures by farmers (increase carbon storage) ➢ Establishing sustainable water management policies (incentives to invest in more water-efficient irrigation systems, define a cap for water use in agriculture) ➢ Cultivate drought-resistant crop varieties ➢ Establish flood prevention policies (establish water retention areas/flood meadows)
Indicator	➢ Annual water use for irrigation in agriculture ➢ Share of water use for irrigation in agriculture as a % of total water demand/use ➢ % irrigation systems by type ➢ Area of flood meadows established on rivers with frequent flooding (wetlands) ➢ Total annual carbon storage in wetlands ➢ Total annual carbon storage in agricultural soils ➢ Total agricultural production (feed + food) ➢ Agricultural output/person (compared to a threshold value which could be the initial value of this indicator or a target value with a nutritional meaning) ➢ Cost of inaction

Steps in the Serious Game:

Possibility to play either in the baseline scenario or the +2°C scenario → the player gets to choose the scenario they want to play with (but no possible endogenous relationship between actions and climate can be modelled in the SDM).

1. Identify resilience indicators:
    - Annual water use for irrigation in agriculture
    - Share of water use for irrigation in agriculture as a % of total water demand/use
    - % irrigation systems by type
    - Area of flood meadows established on rivers with frequent flooding (wetlands)
    - Total annual carbon storage in wetlands
    - Total annual carbon storage in agricultural soils
    - Total agricultural production (feed + food)
    - Agricultural output (food)/person (in kg/pers * yr, compared to a threshold value which could be the initial value of this indicator or a target value with a nutritional meaning)
    - Cost of inaction
2. Determine the resilient upper limit/cap in terms of water use in agriculture and the lower limit in terms of agricultural production (total feed and food production and food/person).
3. Select measures from a pool of options that increase the resilience of agricultural production to climate change in an attempt to meet these targets:

- Implement PES/AES schemes to incentivize the implementation of soil conservation measures by farmers (increase carbon storage)
- Provide incentives/funding to invest in more water-efficient irrigation systems
- Cultivate drought-resistant crop varieties
- Establish flood prevention policies (establish water retention areas/flood meadows)

4. Run model / game – Indicators presented in 1) are displayed.
5. Re-start game acting over the elements manipulated in 2).

4.3.2 Germany – Czech Republic – Slovakia

This Case Study encompasses the Eastern parts of Germany, Czech Republic and Slovakia. It focuses on the exploration of nexus-related challenges on shared water bodies using the Elbe case. Among the issues, being explored by this second trans-boundary Case Study, are: pressures on water resources put by intense melioration (e.g. drainage), water regulations (e.g. hydropower) and expansion of bio-fuels, water shortages, management of floods and droughts, improvements of water quality and river structure, and renewable energy strategies.

Energy, water, land and climate are the main nexus sectors involved and connected to large scale drainage of agricultural land, change of crops and ongoing mineralisation/erosion of soils. The main goals of the Case Study include: sustainable management of water resources, water retention, restoration of agricultural landscape, development of smart sustainability in terms of renewable energy and water cycle.

Accordingly, the learning goals focus on the interrelations between effects of upstream land use and water retention policies and downstream stability of flow that may prevent floods and sedimentation, and water availability for irrigation in the Elbe/Labe basin. The SG user will learn about land use policies that increase retention of rainwater in forested, agricultural, and urban landscapes; retention in ecosystems will lead to decrease of run-off, and reduce vertical cloud formation that leads to heavy local rainfall and flooding in other areas.

The Use Cases designed for this Case Study are:

USE CASE DE-CZ-SK.1	WATER
Related Learning Goals	Sustainable management of water resources
Goal	Increase water retention in the landscape
User	Public Sector: Ministries of Agriculture and Environment
Actions	➢ Building of new reservoirs ➢ Restoration of natural wetlands ➢ Construction of artificial bio-wetlands ➢ Transform huge field blocks into small structures ➢ River restorations towards longer stream channels ➢ Soil quality improvement (higher organic content, decrease of compaction)

	➢ Smaller water cycle restoration via permanent vegetation
Indicator	➢ Water volume stored in the landscape ➢ Share of water surface areas in the landscape ➢ Balanced runoff

Steps in the Serious Game:

1. Take any of the actions, alone or combined.
2. a. Observe the positive changes in the water-in-landscape indicators - b. Observe drawbacks with other nexus components, e.g. losses in agricultural productivity due to crop areas converted to wetlands.
3. Re-consider taking actions in the next time step and loop over with 2a+b…
4. …until an acceptable trade-off between indicators is achieved.

USE CASE DE-CZ-SK.2	WATER
Related Learning Goals	Sustainable management of water resources
Goal	Increase water retention in the landscape
User	Private Sector: Farmers and rural communities
Actions	➢ Restoration of natural wetlands ➢ Construction of artificial bio-wetlands ➢ Transform huge field blocks into small structures ➢ Plants shelterbelts (local initiatives, cf. Use Case DE-CZ-SK.7) ➢ Decentralise water sector through local wells
Indicator	➢ Water volume stored in the landscape ➢ Agricultural yields

Steps in the Serious Game:

1. Take any of the actions, alone or combined.
2. a. Observe the positive changes on yields and in the water-in-landscape indicators - b. Observe drawbacks, e.g. losses in agricultural productivity due to crop areas converted to wetlands.
3. Re-consider taking actions in the next time step and loop over with 2a+b…
4. …until an acceptable trade-off between indicators is achieved.

USE CASE DE-CZ-SK.3	ENERGY
Related Learning Goals	➢ Reduction of GHG emissions ➢ Maintain stability of power grid

Goal	Transformation of the electrical energy sector
User	Governments, Ministries of Energy and Agriculture
Actions	➢ Subsidies for bio-energy farming ➢ Turning agriculture into energy forests ➢ Shutdown of lignite mining ➢ Shutdown of fossil fuel driven power plants ➢ Shutdown of nuclear power plants (only DE, CZ and SK are dependent on NP production) ➢ Deployment of electricity storage systems ➢ Building more high-voltage power lines
Indicator	➢ Share of electricity generated from renewables ➢ Volatility/stability indicator of the power grid ➢ Occurrence of blackouts ➢ Agricultural productivity, especially food production

Steps in the Serious Game:

1. Identify electricity demands.
2. Try to meet the demands by a high share of electricity produced from renewables through enacting combinations of the measures.
3. Take care of grid instabilities and avoid a blackout.
4. If a blackout occurs, retry to obtain non-catastrophic results in another game session.
5. If you managed to keep electricity provision stable, retry to obtain better results regarding renewables' share and GHG mitigation.
6. Observe that any furthering of bio-energy minimizes food production.

USE CASE DE-CZ-SK.4	ENERGY
Related Learning Goals	➢ Reduction of electricity demand ➢ Reduction of GHG emissions ➢ Improvements for urban climate
Goal	Transformation of the building sector towards environmentally sustainable architecture and engineering
User	Governments, Ministries of Building, Energy and Infrastructure
Actions	➢ Eco-technology mandatory for new buildings ➢ Subsidise eco-tech for existing buildings

Indicator	➢ Electricity demand ➢ Volatility/stability indicator of the power grid ➢ Surface-dependent temperature surplus of settlement areas (urban heat island effect)

Steps in the Serious Game:

1. Implement the measures listed under actions.
2. Observe the entirely positive shifts in all the indicators.
3. Learn that the actions are effectively no-regret measures that should be taken in the framework of our serious game.
4. Be aware of the bias to reality where such transformation needs decades to be accepted by the public: If you were politician in a democracy, you wouldn't be re-elected after implementing these confinements for architects and house owners.

USE CASE DE-CZ-SK.5	CLIMATE
Related Learning Goals	Cooling the agricultural landscape, increasing precipitation and hence agricultural productivity and carbon sequestration
Goal	Reduce surface-near air temperatures by at least 2 K
User	Regional policy makers and rural communities
Actions	➢ Technical measures to cool the agricultural landscape (e.g. distribution of white pigments) ➢ Natural measures to cool the agricultural landscape (Integrated land and water management)
Indicator	➢ Temperature surplus of agricultural areas ➢ Agricultural productivity: food ➢ Agricultural productivity: bio-energy ➢ Land cover heterogeneity

Steps in the Serious Game:

1. Identify current temperature, yield and production levels.

2. Calculate costs and benefits:

- If technical measures are chosen, increased productivity lasts only the first time step; every application of technical measures incurs however high costs
- If natural measures are chosen, costs diminish with renewed application while productivity is sustainably increased

3. Learn that only natural measures lead to sustainable benefits in the long run.

USE CASE DE-CZ-SK.6	LAND AND FOREST
Related Learning Goals	Sustainable flood protection
Goal	Avoiding flood damages under climate change
User	Public Sector: Ministries for the Environment and Civil Protection
Actions	➢ Dike building ➢ Enforced relocation of homes, work places and infrastructure ➢ Dike removal
Indicator	➢ Change of flood frequencies ➢ Settlements situated in flood zones

Steps in the Serious Game:

1. Identify current exposition to flood risks.
2. Choose from the list of possible actions: Dike removal should however only be chosen after relocation took place.
3. Run the models / Progress through time.
4. Note that dike building shelters only for a limited amount of time and needs to be repeated (incurring costs) on a regular basis to stay efficient. Relocation and removal come with very high social costs during implementation, but in the long run this is both the cheapest and safest solution contributing also to the re-emergence of natural wetlands in riparian zones which in turn are highly positive for biodiversity and the regional climate.

USE CASE DE-CZ-SK.7	AGRICULTURE AND FOOD
Related Learning Goals	Sustainable food production
Goal	Maintain high productivity for both food and bio-energy while transforming land use with respect to the environment
User	Public Sector: National and regional governments
Actions	➢ Subsidies for irrigation systems ➢ Subsidies for technical innovations at small farms ➢ Subsidies for investments in lighter machinery ➢ Subsidies for organic farming ➢ Planting of shelterbelts (ordered by law, cf. Use Case W.2) ➢ Mandatory greening in agriculture ➢ Turning forests into agriculture ➢ Limiting energy plants in favour of food crops ➢ Re-allow using food residues for animal feeding
Indicator	➢ Crop food production

	➢ Crop feed production ➢ Bio-energy production ➢ Soil erosion ➢ Changes in water storage in agricultural land

Steps in the Serious Game:

1. Identify area of crops that produce food or feed and their current yield levels.
2. Identify area of bio-energy plants including forests and their current yield levels.
3. Identify current levels of soil erosion.
4. Select some policies from the list of possible actions.
5. Run the models / Progress through time.
6. Review the indicators and take additional or other actions for the next time step.
7. Repeat steps 5+6 and see which actions are no-regret options and which come with larger trade-offs. It is expected that the positive effects of lighter machinery, greening and shelterbelts on soil erosion will be moderate under climate change (albeit appreciable), and that one can have either more food or more bio-energy production, but hardly both at the same time.

4.4 Use Cases for the European Case Study

4.4.1 European

The European Case Study addresses Europe as a whole. It focuses on the exploration of barriers when it comes to policy integration and on medium-term pathways for sustainable growth till 2050 under the nexus framework. It partially draws from the national and regional Case Studies. It also exploits outcomes from thematic models and integrates them with public domain data.

This Case Study involves all five nexus sectors (water, energy, land, food and climate) and examines the transition to a low-carbon economy. Emphasis is placed on: the promotion of mitigation strategies in order to combat climate change, the reduction of fossil fuels use and the extensive exploitation of renewables, the assessment of changes in water demand for hydropower and irrigation of bio-energy crops, the assessment of food security and the exploration of linkages between land use related mitigation options and biodiversity.

Physical demands and economic linkages investigated by the European Case Study include: water demand by food crops, energy crops and hydropower; climate impacts on agricultural yields; impacts of climate and energy policies on land prices and how these in turn affect food prices and food accessibility.

The learning goals of the European Case Study focus on how policies targeting indicators for one of the sustainable development goals impact those for other goals; in particular with respect to indicators for renewable energy, water, food security related goals as well as planetary boundaries, in a European context.

The Use Cases designed for the European Case Study are:

USE CASE EUR.1	CLIMATE
Related Learning	Learn what the major contributors to greenhouse emissions are in

Goals	Europe and the impact on the other nexus elements of reducing those emissions at their source
Goal	Reduce Greenhouse Gas Emissions in Europe – Consistent with at least an RCP2.6 degree pathway
User	Public Sector, national and EU level (DG ENERGY, CLIMA)
Actions	Focus on reducing emission in ETS sector to achieve the goal ➢ Investments in Carbon Capture and Storage (CCS) to reduce the GHG emission coefficient in Electricity production (Negative for Bioelectricity) ➢ Renewable Energy Mandates ➢ Carbon tax on ETS sectors
Indicator	➢ Total kg of CO_2, eq emissions ➢ kg of CO_2,eq emissions in the electricity generation sector/ EJ of electricity generated ➢ Total annual CO_2 eq emissions from energy use in power generation and industry ➢ Electricity price (related to the learning goal)

Steps in the Serious Game:

1. Calculate total GHG emissions in current period for all 6 European regions.
2. Calculate GHG emissions from electricity, industry, and other fuels for all 6 European regions.
3. Compare European emissions in current period to target European emissions in current period to reach 2 degree pathway by 2050 (Policy Goal).
4. Calculate share of GHG emissions from ETS sectors to total GHG emissions.
5. If total GHG emissions are below the target for the period then do nothing.
6. If total GHG emissions are above the target for the period then the player can decide to implement one or more of the following actions:

    - Increase investments in Carbon Capture and Storage (CCS) to reduce the GHG emission coefficient in Electricity production (Negative for Bioelectricity)
    - Increase renewable Energy Mandates
    - Implement a carbon tax on the ETS sectors

7. Display the following indicators at the end of the period:

    - Total kg of CO_2,eq emissions
    - kg of CO_2,eq emissions in the electricity generation sector/ electricity generated
    - Total annual CO_2 eq emissions from energy use in power generation and industry
    - Electricity price

USE CASE EUR.2	CLIMATE
Related Learning Goals	Learn what the major contributors to greenhouse emissions are in Europe and the impact on the other nexus elements of reducing those emissions at their source

Goal	Reduce Greenhouse Gas Emissions in Europe – Consistent with at least an RCP2.6 degree pathway
User	Public Sector, national and EU level (DG AGRI, CLIMA)
Actions	Focus on Non-ETS sectors to achieve the goal ➢ Invest in GHG emissions abatement in agriculture ➢ Promotion of electric vehicles through regulation and investment ➢ (Effective) Carbon tax on ESD sectors (Agriculture, transport, etc.)
Indicator	➢ kg CO_2,eq emissions in the total ESD sectors ➢ kg CO_2,eq emissions in agriculture ➢ kg CO_2,eq emissions in transport ➢ Quantity of food production of crops and livestock (related to learning goal) ➢ Price of production for crops and livestock (related to the learning goal)

Steps in the Serious Game:

1. Calculate total GHG emissions in current period for all 6 European regions.
2. Calculate GHG emissions from agriculture, transport, other services for all 6 European regions.
3. Calculate share of GHG emissions from Non-ETS sectors to total GHG emissions.
4. Compare European emissions in current period to target European emissions in current period to reach 2 degree pathway by 2050 (Policy Goal).
5. If emissions are below the target for the period then do nothing.
6. If emissions are above the target for the period then the player can decide to implement one or more of the following actions:
    - Invest in GHG emissions abatement in agriculture
    - Promotion of electric vehicles through regulation and investment.
    - Implement a carbon tax on Effort Sharing Decision (ESD) sectors (Agriculture, transport, etc.)
7. Display the following indicators at the end of the period:
    - kg of CO_2,eq emissions in the total ESD sectors
    - kg CO_2,eq emissions in agriculture
    - kg CO_2,eq emissions in transport
    - Quantity of food production of crops and livestock (related to learning goal)
    - Price of production for crops and livestock (related to learning goal)

USE CASE EUR.3	AGRICULTURE AND FOOD
Related Learning Goals	➢ Explore the trade-offs between exploiting additional land-water resources and food security in the context of a transition to a low-carbon economy ➢ Explore policies to exploit synergies between reducing greenhouse

	gas emissions and healthy water, land, food and energy systems
Goal	Food security (maintain low food prices)
User	Public Sector, national and EU level (DG AGRI)
Actions	➢ Encourage investments in crop yields ➢ Increase the amount of irrigated areas ➢ Encourage a shift in diets to less meat consumption
Indicator	➢ Price of production of crops and livestock ➢ Quantity of food production of crops and livestock ➢ Volume of abstracted water for irrigation (related to the 1st learning goal) ➢ Total greenhouse gas emissions in agriculture (related to the 2nd learning goal)

Steps in the Serious Game:

1. Compare price of production of crops and livestock in current period to price of production in the initial period (2010).
    - If the price of production of crops and/or livestock is at or below the price of production in the initial period then do nothing.
    - If the price of production of crops and/or livestock is above the price of production in the initial period then the player may take one or more of the following actions: Encourage investments in crop yields; Increase the amount of irrigated areas; Encourage a shift in diets to less meat consumption
2. Display the following indicators at the end of the period:
    - Price of production of crops and livestock
    - Quantity of food production of crops and livestock
    - Volume of abstracted water for irrigation (related to the 1st learning goal)
    - Total greenhouse gas emissions in agriculture (related to the 2nd learning goal)

4.5 Use Cases for the Global Case Study

4.5.1 Global

The Global Case Study, compared to the European one, is lower in detail and higher in integration. It focuses on global challenges such as increasing food demand and international trade features connected to the nexus. It involves policy priorities referring to food security, resource efficiency, low-carbon energy and climate change mitigation, water availability and vulnerability to water stress and floods, water quality, biodiversity and ecosystem services. Impacts of water constraints on food security and human development and impacts of climate change on aggravating and relieving water problems are also explored. Synergies and trade-offs between options in achieving multiple goals are sought.

More specifically, the Global Case Study addresses questions and policy variants having to do with: a) implications of land-based mitigation increased water use of the energy sector on

SDGs related to land, water and food, b) the role that investments can play in innovation and renewable energy development, c) the dynamic of resource material flows in different scenarios, d) the identification of planetary boundaries for water and land, e) the identification of the function of wetlands for the provision of water-related goods and services, f) the effect of increased hydropower on ecosystems, water quality and biodiversity, g) the effect of LULUCF policies and h) the achievement of SDGs.

The learning goals of the Global Case Study focus on how policies targeting indicators for one of the sustainable development goals impact those for other goals; in particular with respect to indicators for renewable energy, water, food security related goals as well as planetary boundaries, in a global context.

The Use Cases designed for the Global Case Study are:

USE CASE G.1	CLIMATE AND ENERGY
Related Learning Goals	Understand synergies and trade-offs of climate and energy policies
Goal	GHG emission reduction and increased renewable energy use
User	Global policy makers (e.g. UNFCCC)
Actions	➢ Introduce carbon pricing ➢ Invest in renewable energy sources ➢ Promote and invest in energy efficiency ➢ Protect forests through REDD+ program
Indicator	➢ Temperature above pre-industrial ➢ Renewable energy share ➢ Energy intensity ➢ Forest area (change)

USE CASE G.2	AGRICULTURE AND FOOD
Related Learning Goals	Understand synergies and trade-offs of agricultural and food policies
Goal	Healthier diets and reduced environmental foot print of food production/consumption
User	National policy makers (e.g. country governments)
Actions	➢ Promote healthier and balanced diets ➢ Promote reduced meat consumption ➢ Invest in improved agricultural efficiency
Indicator	➢ Number of people that are underweight ➢ Number of people that are overweight ➢ Meat consumption ➢ Agricultural productivity per area of land

USE CASE G.3	LAND AND BIODIVERSITY
Related Learning Goals	Understand synergies and trade-offs of biodiversity protection policies
Goal	Reduced loss of biodiversity
User	Global policy makers (e.g. Convention on Biological Diversity)
Actions	➢ Protect key biodiversity areas ➢ Protect forests
Indicator	➢ Mean species abundance (or other biodiversity indicator) ➢ Forest area (change)

USE CASE G.4	WATER
Related Learning Goals	Understand synergies and trade-offs of water policies
Goal	Reduce water use and improved water quality
User	National or regional policy makers (depending on river basin size)
Actions	➢ Promote improved water use efficiency ➢ Invest in improved irrigation systems ➢ Invest in sanitation systems ➢ Educate farmers to improve fertilizer use efficiency
Indicator	➢ Proportion of water with good quality ➢ Water withdrawal as a proportion of available water ➢ Quality of water-related ecosystems

It should be mentioned that in the case of the Global Case Study, steps in the Serious Game have not been added as the Global CS is not constructing a Serious Game in the same way as the other CSs. It only focuses on an interactive visualisation based on a number of different scenarios.

5 Conclusions

In this deliverable case-specific Use Cases, appropriate for the particular expectations of each Case Study, were presented. Such Use Cases were adapted to the generic ones delineated in deliverable D1.2 ‘Use Cases for SIM4NEXUS’ reflecting the specific needs, characteristics and developmental perspectives of each CS as well as the interests of its stakeholders as to the nexus issues addressed. Use Cases were also adjusted to the policy scenarios having been defined by each CS in terms of policy objectives and policy instruments, setting the framework for the management of the several nexus sectors. Policy goals correspond to the respective goals of Use Cases while policy instruments (interventions) are in line with the actions the player may trigger in the SG environment. Indicators, measuring the performance of actions and the overall accomplishment of a goal, were defined according to the numerical data included in the SDM of each CS.

Use Cases for S4N CSs were directly related to the learning goals of each CS. This is of utmost importance as the implementation of Use Cases in the SG environment aims at providing the player with ‘new knowledge’ which stresses the ‘learning by playing’ dimension of the SG.

The design of Use Cases provided an opportunity to Case Studies to better conceptualise their Serious Games and enabled their active participation in the development of the SG (Papadopoulou et al., 2019). As already mentioned, case-specific Use Cases are compliant to the objectives of each CS, correspond to stakeholders’ interests and put an additive value to the quantification of policies through their connection to the SDM.

Briefly, the general steps towards the development of Use Cases by each Case Study include:

- The selection of the nexus sectors involved in each CS, the identification of interlinkages existing among such sectors and the definition of the relevant nexus challenges.
- The definition of the Case Study’s learning goals.
- The engagement of interested stakeholders.
- The design of a conceptual model, delineating all critical interlinkages and challenges.
- The development of a SDM containing all nexus-related variables and allowing for the estimation of indicators, measuring the accomplishment of the goals set.
- The identification of the nexus-critical objectives and instruments, reflecting current and future policy priorities of the CS.
- The quantification of policies and their connection to the SDM / ‘Translation’ of policies into model terms.
- The determination of indicators based on the SDM’s data.

After the accomplishment of such general steps, each CS identified the goal of each Use Case, the user/player, possible actions through which the goal of the Use Case will be pursued and a list of indicators measuring the performance of the goal.

68 Use Cases were developed by the SIM4NEXUS CSs. Such Use Cases concern the efficient use of water resources, the modernisation of the energy sector, the sufficient production of food (especially agricultural and livestock products), the protection and sustainable management of land and the adaptation to climate change impacts. Each CS focused on its

specific needs and future perspectives as well as on the interests of the engaged stakeholders. Accordingly, regional, national, trans-boundary, continental and global Use Cases were designed and incorporated in the Serious Games developed for each CS.

Conclusively, the process of developing Use Cases was rather complex due to the amount of information that should be integrated and inter-connected. Goals should be connected to the CSs learning goals while, corresponding actions towards the achievement of the Use Case's goal should be determined. Then, the actions should be combined with the respective indicators, representing the level of the goal's accomplishment. The goal of each Use Case reflects relevant policy goals and the actions are in close relationship to policy interventions. Finally, the additive value of Use Cases to the Serious Game is if utmost importance as, Use Cases represent the way that the user interacts with the game and takes decisions as to the management of the nexus.

6 References

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