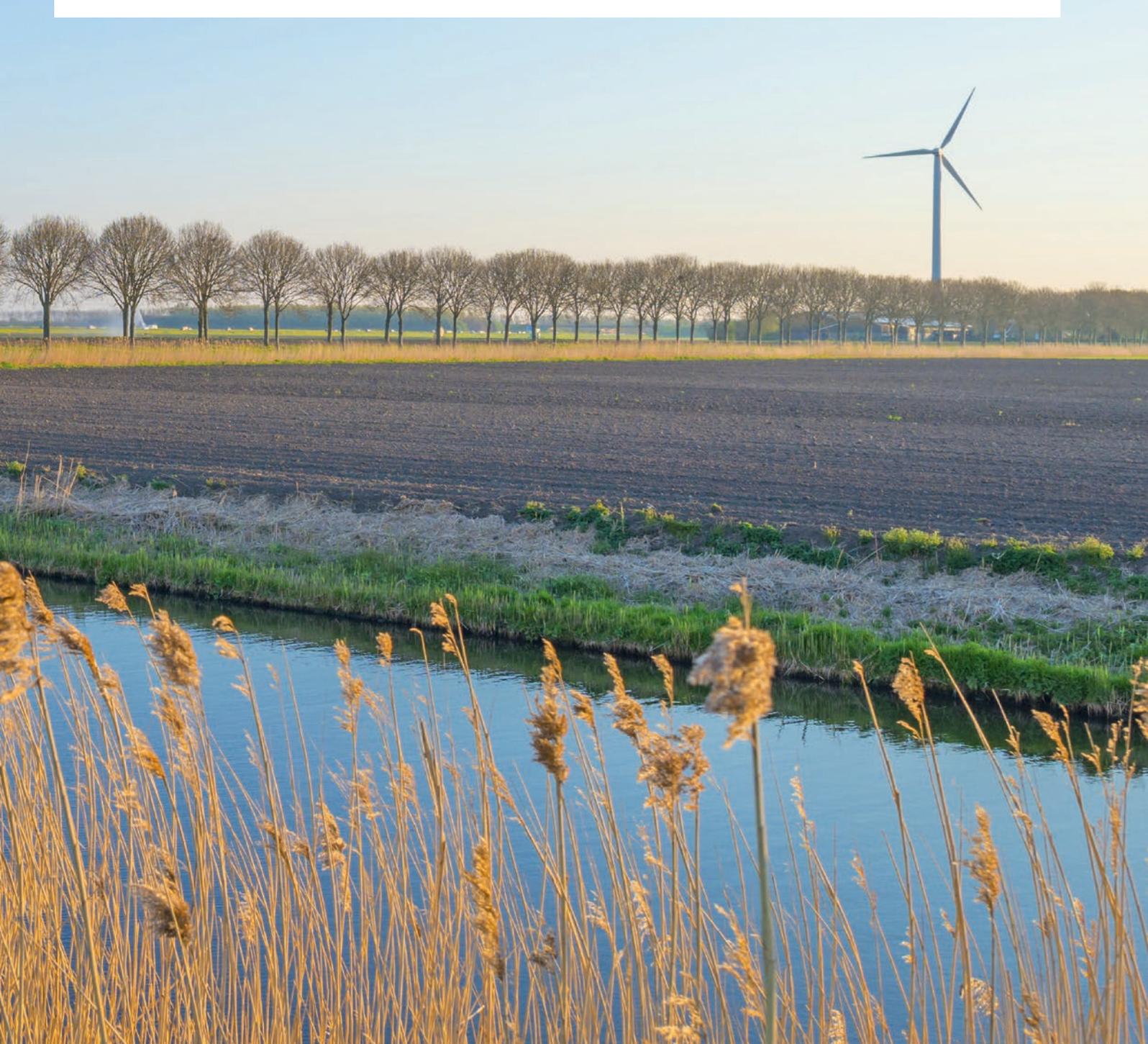


# How to secure the efficient use of our scarce natural resources?

Findings from SIM4NEXUS – Sustainable Integrated Management FOR the NEXUS of water-land-food-energy-climate for a resource-efficient Europe



## Contact us

**Project Scientific coordinator:** Dr. Floor BROUWER, Wageningen Research

**Email:** SIM4NEXUS@wur.nl



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## Welcome

We are pleased to introduce SIM4NEXUS, acronym of the project 'Sustainable Integrated Management FOR the NEXUS of water-land-food-energy-climate for a resource-efficient Europe'. SIM4NEXUS is a Research and Innovation Action, implemented between June 2016 and June 2020. The project received funding from the European Union's Horizon 2020 research and innovation programme. The brochure takes stock of the products and findings from 49 months of our interdisciplinary work.

### Our observations

The integrated management of the Nexus of water-land-food-energy-climate is critical to secure efficient and sustainable use of resources.

More coherent and integrated management strategies are needed in the domains of water, energy, food, land and climate.

Support is needed to implement Nexus-compliant practices in real cases.

### Our responses

SIM4NEXUS searched for new scientific evidence on sustainable and integrated management of resources (water, land, energy and food) in Europe and elsewhere.

The consortium adopted the Nexus concept in testing pathways for a resource-efficient and low-carbon Europe.

SIM4NEXUS applied the Nexus concept in 12 case studies, implemented at different scales: regional, national, transboundary, European and global. The diversity of case studies allowed to better understand interlinkages of decision making across spatial scales, and support decision making in the short-, medium- and long-term (up to 2030, 2050 and beyond).

The Nexus concept evolved during the past couple of years. It was a fairly new concept when SIM4NEXUS was designed in 2015. The consortium is pleased to see the Nexus concept has matured since then. The more than 30 papers from the project, which have been published in peer-reviewed journals, have contributed to this development. The project also showed evidence of the successful implementation of a pool of innovations to test the Nexus concept. The collaboration with practitioners from policy, business and civil society has been critical to reach this.

SIM4NEXUS has benefited from the synergies created with other Nexus research and the Nexus Project Cluster (<http://www.nexuscluster.eu>) has been an important initiative for science-policy interactions and public debates on the Nexus. Moreover, our exploitation strategy will offer solid ground for knowledge development, training and learning on the Nexus.

We appreciate your feedback and look forward to continuing to collaborate with you.



**George Beers**  
(Project Coordinator)



**Floor Brouwer**  
(Scientific Coordinator)

# Project partners

SIM4NEXUS brings together a multidisciplinary team of 26 partners from 15 countries.



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PEOPLE AND WATER

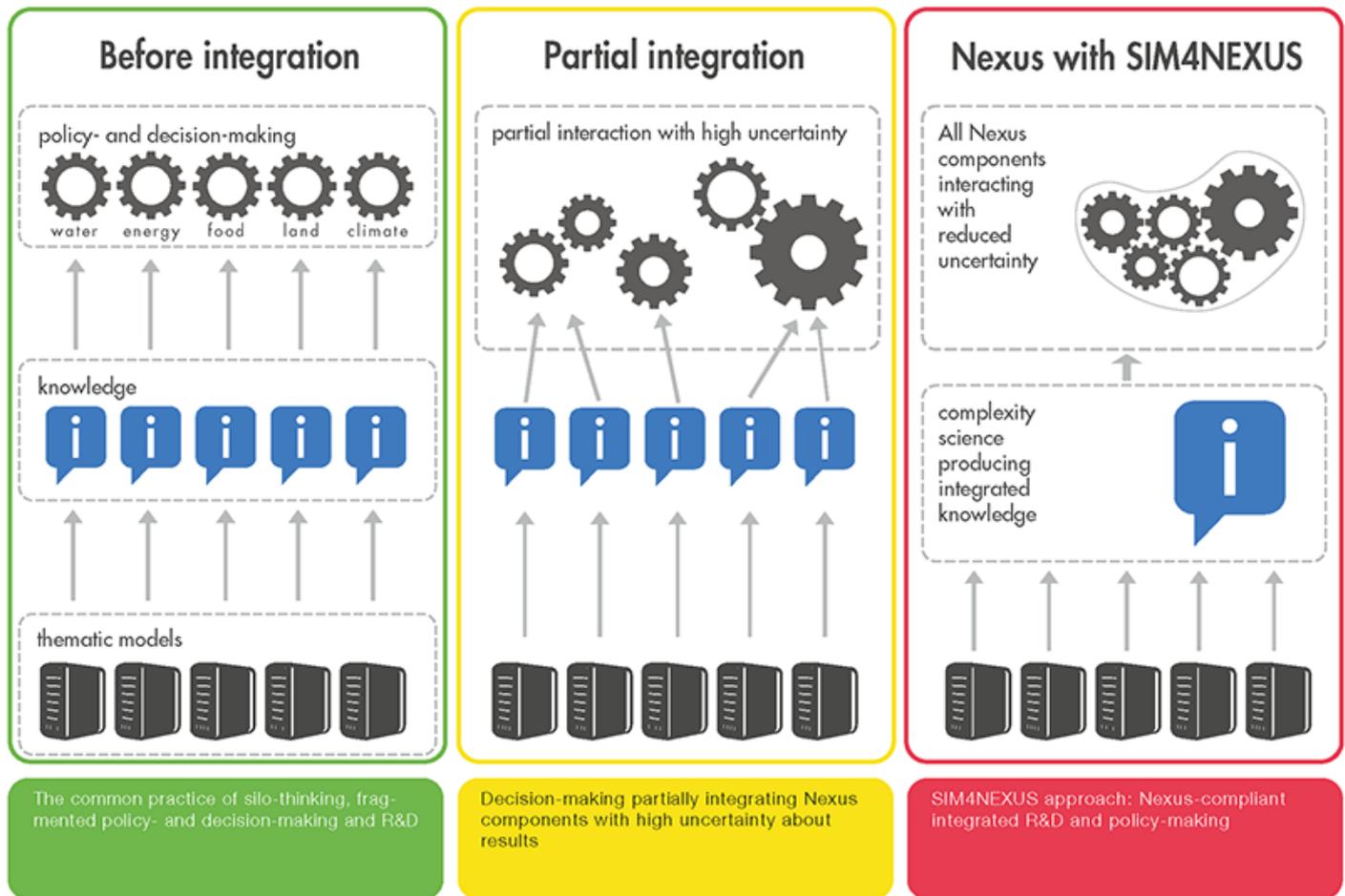


WATER EUROPE

# SIM4NEXUS in a Nutshell

**Why?** Water, land, food, energy, and climate are interconnected, comprising a coherent system (the 'Nexus'), dominated by complexity and feedback. Putting pressure on one part of the Nexus can create pressures on the others. Management of the Nexus is critical to securing the efficient use of our scarce resources.

**What?** SIM4NEXUS (Sustainable Integrated Management FOR the NEXUS of water-land-food-energy-climate for a resource-efficient Europe) aims to address knowledge and technology gaps and thereby facilitate the design of policies within the Nexus. The project will deliver Serious Games, which are cloud-based and integrated tools to support and learn about the Nexus in real cases.



**Where?** 12 case studies at regional, national, continental and global scales have served as test-beds for the models and the integration methodologies. The case studies analysed Nexus trade-offs and possible Nexus-compliant practices for the future, engaging local stakeholders and decision makers. The Serious Games are important outcomes for training and learning.

**Who?** SIM4NEXUS brings together a multidisciplinary team of 26 partners from 15 countries.

**When?** SIM4NEXUS has been implemented between 1 June 2016 and 30 June 2020.

**How much?**

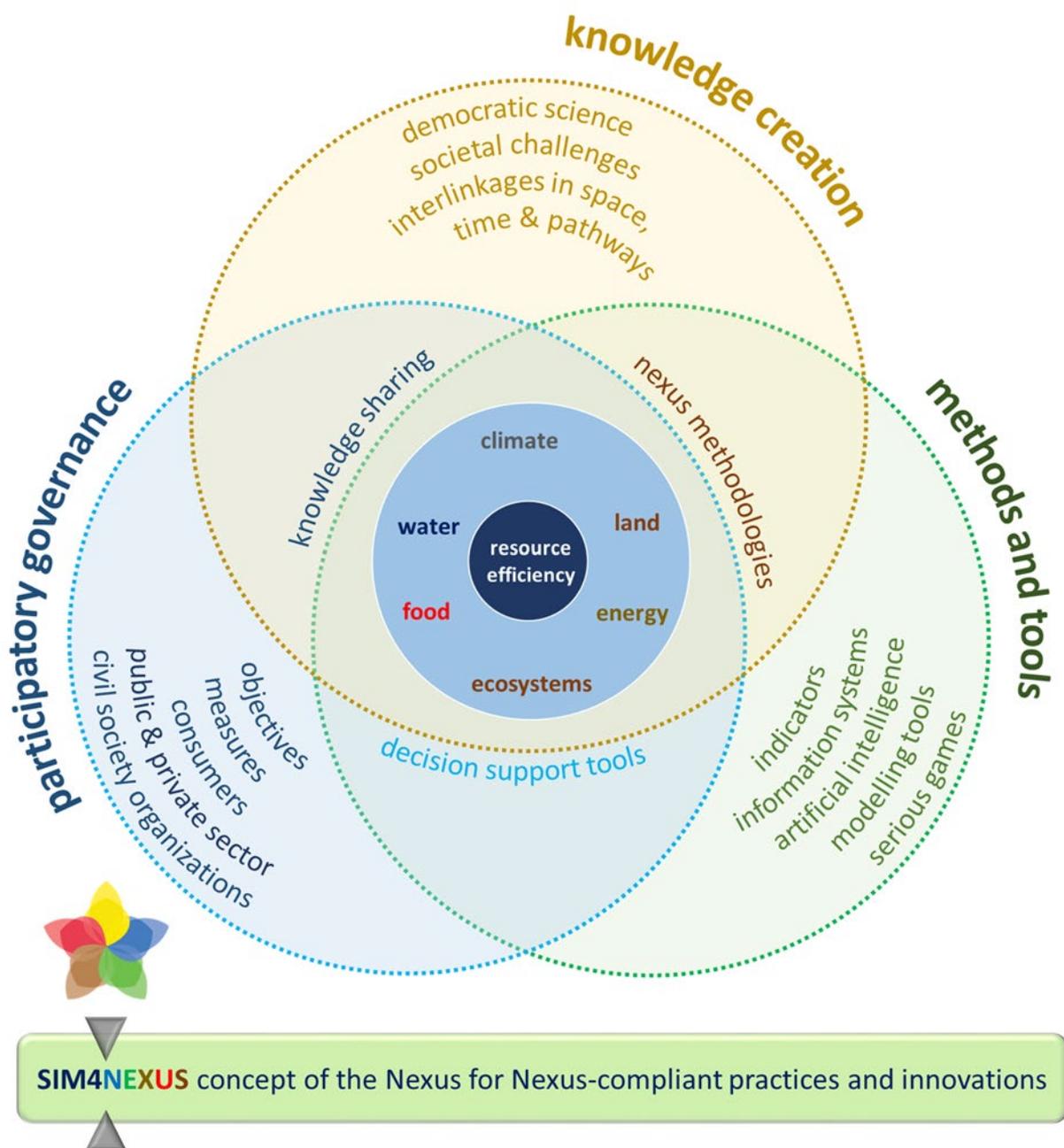
The grant amount is EUR 7,895,657.50.

**How?** 7 Work Packages have explored and developed interconnected activities to improve the scientific basis, capacity building and set the ground for the exploitation of the products after the project period.

# Reflecting on the highlights from SIM4NEXUS

SIM4NEXUS increases the understanding of how water management, food production and consumption, energy supply and land use policies are linked together, and how they relate to climate action. Our findings build on 12 case studies at regional, national, transboundary, European and global scales. The national case studies in Sweden, Latvia, the Netherlands, Greece and Azerbaijan regard the transition to a low carbon economy as driver of change in the other Nexus

sectors. Interlinkages between water, energy and agriculture are a common focus of the regional case studies in Spain, Italy and the UK. Both transboundary cases are clustered around river basins, with a focus on climate and its relation to land use (Germany-Czech Republic-Slovakia) and on energy related to land use (France-Germany). The European case is targeted at a low-carbon economy and the global case links the Nexus to achieving the Sustainable Development Goals.



SIM4NEXUS is a Research and Innovation Action, and made progress in both respects:

- SIM4NEXUS has a strong research dimension. SIM4NEXUS advanced in the understanding and assessment of the Nexus in various contexts. A framework for the assessment of the Nexus is developed to facilitate future research assessing the impacts of interventions from a Nexus perspective. Moreover, interlinkages between water, land, food, energy and climate are now made operational, identifying both the most influential and vulnerable resources. The degrees of interlinkages are defined, including direct and indirect pathways from one Nexus component to another. The Greek case study for example, proves the food sector is the one with the most influence on other Nexus dimensions, while water is the most affected and vulnerable resource (Laspidou et al., 2019).
- System Dynamics Modelling (SDM) is our methodology of integration, including the modelling of multiple feedback and interaction among resources in the Nexus. SDM dates back from the 1960s. Used for studying feedback problems in industrial processes, it aims to understand how a system behaves and responds to incentives and changes. It proved to be a strong innovative methodology to test the Nexus concept. The project builds on well-known and scientifically established existing models, each to simulate different themes of the Nexus. System Dynamics Modelling is used, integrating public domain data and metadata for decision and policy making. Serious Games are developed as an enhanced interactive visualisation tool, providing an immersive experience to decision- and policy-makers. They assist the users (as players) in better understanding and visualising policies at various geo-/spatial scales and from a holistic point of view, towards a better scientific un-

derstanding of the Nexus. This is the first time a Serious Game with this complexity has been built on the theme of the Nexus. A Serious Game approach combines a learning objective with a fun activity to increase the potential for learning uptake (Sušnik et al., 2018).

The research activities offered solid ground on the benefits of using a Nexus approach, primarily to exploit and create synergies between policies and avoid conflicts between policies. European policies for water-land-energy-food-climate sectors reckon with trade-offs in other sectors. However, opportunities for synergies are less explored and there is no institutionalised procedure for a comprehensive Nexus assessment of new policies. New integrating themes (e.g., circular and low-carbon economy related to resource efficiency and planetary boundaries) can stimulate a Nexus approach.

Our results and products contribute to the legacy of SIM4NEXUS, including knowledge and products to be used for training (i.e., universities, policy, business and civil society organisations). Commercial applications and training courses are planned to ensure follow-up actions. A combined for-profit and non-profit exploitation strategy is developed to ensure the largest project impact, among others to contribute to policy support and future assessments, including those of the Intergovernmental Panel on Climate Change (IPCC). Side-events were organised during COP23 (Bonn, November 2017) and COP24 (Katowice, December 2018) to present progress on the Nexus and climate action.

SIM4NEXUS will seek to partner with international fora in Europe and beyond (e.g. Nexus Project Cluster), to team up for increased and more impactful communication and dissemination of the Nexus concept.



Laspidou, C.S.; Mellios, N.; Kofinas, D. Towards Ranking the Water–Energy–Food–Land Use–Climate Nexus Interlinkages for Building a Nexus Conceptual Model with a Heuristic Algorithm. *Water* 2019, 11, 306.

Sušnik, J., Chew, C., Domingo, X., Mereu, S., Trabucco, A., Evans, B., Vamvakieridou-Lyroudia, L., Savić, D.A., Laspidou, C., Brouwer, F. 2018. Multi-stakeholder development of a serious game to explore the water-energy-food-land-climate nexus: the SIM4NEXUS approach. *Water* 2018, 10(2), 139; doi:10.3390/w10020139.

# Policy coherence



## Agriculture and Food are key sectors to increase the sustainability of natural resource use

### Key outputs

- Coherence assessment of policies at [European, international, national and regional](#) level for water, land, energy, food and climate. (Munaretto & Witmer, 2017; Munaretto et al., 2018).
- [List of success factors for a Nexus governance process.](#)
- [Overview of factors hindering the implementation of European policies: regulatory gaps, ambiguities and inconsistencies.](#)
- [Inventory of formal and informal cross-sector cooperation arrangements.](#)
- [Policy coherence recommendations to the European Green Deal](#)

### Findings

Climate change, climate change mitigation, and adaptation put pressure on agriculture and food security. At the same time, the agro-food chain can offer solutions for these problems, for example, by **replacing animal with vegetable proteins in the diet** and increasing resource efficiency in the agro-food chain.

European Common Agricultural Policy can support the transition to more resource-efficient agriculture, e.g., by encouraging farmers to grow less water-demanding or non-irrigated crops, to use technologies for precision irrigation and to reduce emissions of nutrients and pesticides. To protect and restore the soil, water, biodiversity, ecosystems and the landscape, Good Agricultural and Environmental Conditions (GAEC) and Greening measures should be stricter and better maintained, and direct payment should be linked to public services instead of agricultural land area.

Successful Nexus policy has many dimensions and is multi-scale. It concerns the whole policy cycle and depends on political will, mindset, a common vision, knowledge management and careful organisation of the process, which is complex and uncertain. Pilots and scenario analyses are helpful, and monitoring of progress and results is vital, as well as collaboration between researchers, stakeholders and policymakers from the start to end of the process. Long-term engagement and financing must be part of the deal, as no sector or sectoral institution feels responsible for the Nexus between sectors. Thematic approaches stimulate a Nexus approach, such as the European 'From Farm to Fork' and 'Circular Economy' initiatives.



**Dr. Maria WITMER**  
PBL Netherlands Environmental  
Assessment Agency  
✉ [maria.witmer@pbl.nl](mailto:maria.witmer@pbl.nl)

# Serious Game Development



Illustration & Video by: Grady Klein/ www.gradyklein.com

## Serious Gaming provides disruptive experience to understand policy impacts and the interlinkages between the Nexus components

### Findings

- **Serious Game** is available for different case studies: Greece, Azerbaijan, Latvia, Netherlands, United Kingdom, Sardinia, and more to come! Available at <https://seriousgame.sim4nexus.eu>
- Applied **Artificial Intelligence** provides autonomous and optimal policy implementation.
- The Nexus concepts are **standardised** and common understanding is provided thanks to the SIM4NEXUS ontology and Semantic Repository, which relies upon and extends the ETSI SAREF ontology.

### Our work

The SIM4NEXUS Serious Game provides impressive user experience and state of the art technology to allow users to learn about the Nexus concepts while playing. To that end, the game relies on four main elements.

The **Graphic User Interface** provides beautiful infographics and a control panel to interact with

the game while learning about the complex connections between the Nexus elements. The main aim is to create a realistic virtual environment where players can interact with the proposed Case Studies to reach an objective Nexus health status. The Nexus health status relies on multi-criteria objectives, which are tailored to each Case Study.

The interactions of players in the game are enabled by the policy implementations they decide to activate on each turn of the game. To compute the consequences of those policy implementations, the SIM4NEXUS Serious Game makes use of the **Knowledge Elicitation Engine**. The Knowledge Elicitation Engine embeds the **Game Logic** and the Nexus Knowledge and databases. The Game Logic mixes the simulation runs from the models needed to reach the next status of the case study, feeding and retro-feeding from the **Nexus repositories**: the SIM4NEXUS ontology, the Semantic Repository and the SIM4NEXUS databases. This impact is showcased in the User Interface and, therefore, the interlinkages and implications are highlighted while playing.

Finally, the Nexus repositories are generated with three main objectives:

- Aggregate general knowledge about the Nexus
- Standardise and provide semantic meaning to the different concepts of the Nexus: the SIM4NEXUS ontology as an extension of ETSI SAREF
- Collect specific information about the case studies and user interactions to enable further analysis

**Xavier DOMINGO**  
EURECAT

✉ [xavier.domingo@eurecat.org](mailto:xavier.domingo@eurecat.org)

**Lluís ECHEVERRÍA**  
EURECAT

✉ [lluis.echeverria@eurecat.org](mailto:lluis.echeverria@eurecat.org)

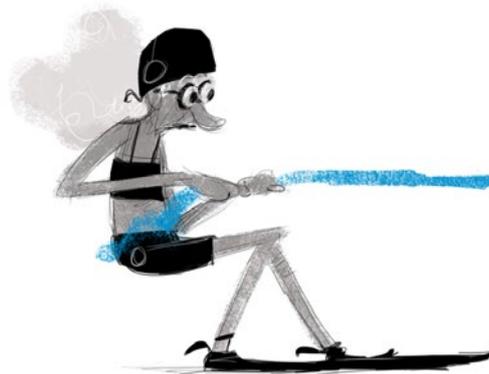
**Mehdi KHOURY**  
UNEXE

✉ [mehdi.khoury@gmail.com](mailto:mehdi.khoury@gmail.com)

# Serious Game



SIM4NEXUS has developed a Serious Game. The Serious Game is a computer game that aids learning about the Nexus by helping users to understand and explore the interactions between water, energy, land and food resources management under a climate change context, divides the problem into manageable interventions, and allows participants to learn by doing. The ultimate goal of game development is to create a fun and interactive capacity-building tool to be used in research, educational settings and management.



## Features

- Enables players to implement policies in a **gameplay environment** and explore how policies affect different Nexus components
- **Summary information** is given about policy actions, assigned costs and potential benefits; this facilitates scorekeeping according to both financial and social capital metrics.
- Costs are tallied against benefits, which are revealed as gameplay progresses. This allows a player to measure progress and compare to others.
- Built upon system dynamics models with a sound scientific basis

## Includes

- A **strategy map** that facilitates comparison of policy impacts in different regions
- A **virtual card table** in which policy cards can be applied through a drag-and-drop interface
- A **visualization system** that shows the impacts of users' decisions on the model



**Xavier DOMINGO**  
EURECAT

✉ [xavier.domingo@eurecat.org](mailto:xavier.domingo@eurecat.org)

**Lluís ECHEVERRÍA**  
EURECAT

✉ [lluis.echeverria@eurecat.org](mailto:lluis.echeverria@eurecat.org)

**Mehdi KHOURY**  
UNEXE

✉ [mehdi.khoury@gmail.com](mailto:mehdi.khoury@gmail.com)

Illustration & Video by: Grady Klein / [www.gradyklein.com](http://www.gradyklein.com)

# SIM4NEXUS Space



## Looking into the Nexus future from Space

### Key product

SIM4NEXUS-Space is an extension and an exploitation activity of SIM4NEXUS. Results to be uploaded on SIM4NEXUS-Space web site.

### Our work

SIM4NEXUS-Space consists of an innovative extended approach within SIM4NEXUS that builds upon, replaces, and enhances the technologies employed in the project. More specifically, the goal is to replace SIM4NEXUS input datasets with data derived from publicly available and retrievable databases. These databases (primary or synthetic) may include:

1. Satellite data (Copernicus, MODIS, NPP VIIRS etc.) which have sufficient spatial and temporal resolution to cover SIM4NEXUS needs.

2. Thematic data (CORINE Land Use/Land Cover, EEA, EUROSTAT, other international readily-available databases)

SIM4NEXUS-Space was implemented in the Sardinia case study. The model input parameters replaced by satellite and thematic data are:

- Various crop areas (from CORINE LULC 2018)
- Evapotranspiration (from MODIS satellite sensor)
- Population (from NPP VIIRS satellite Nightlights)
- Temperature (from MODIS satellite sensor)
- Precipitation (CHIRPS inventory)

MORE INFORMATION HERE:  
[www.sim4nexus-space.com](http://www.sim4nexus-space.com)



Image Source: CLC 2018, "<https://land.copernicus.eu/>"

**Prof. Markos BONAZOUNTAS**

EPSILON Malta, Ltd.

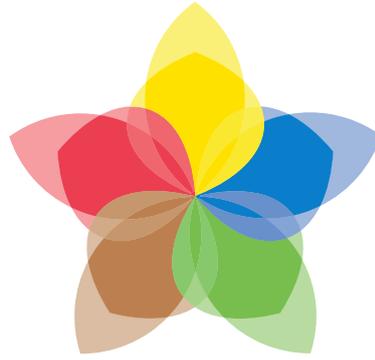
✉ [bonazountas@epsilon.gr](mailto:bonazountas@epsilon.gr)

**Ms. Pelagia KOUTSANTONI**

EPSILON Group

✉ [rtd-projects@epsilon.gr](mailto:rtd-projects@epsilon.gr)

# Team SIM4NEXUS



# SIM4NEXUS



The Hague



Barcelona



Riga



Exeter



Athens

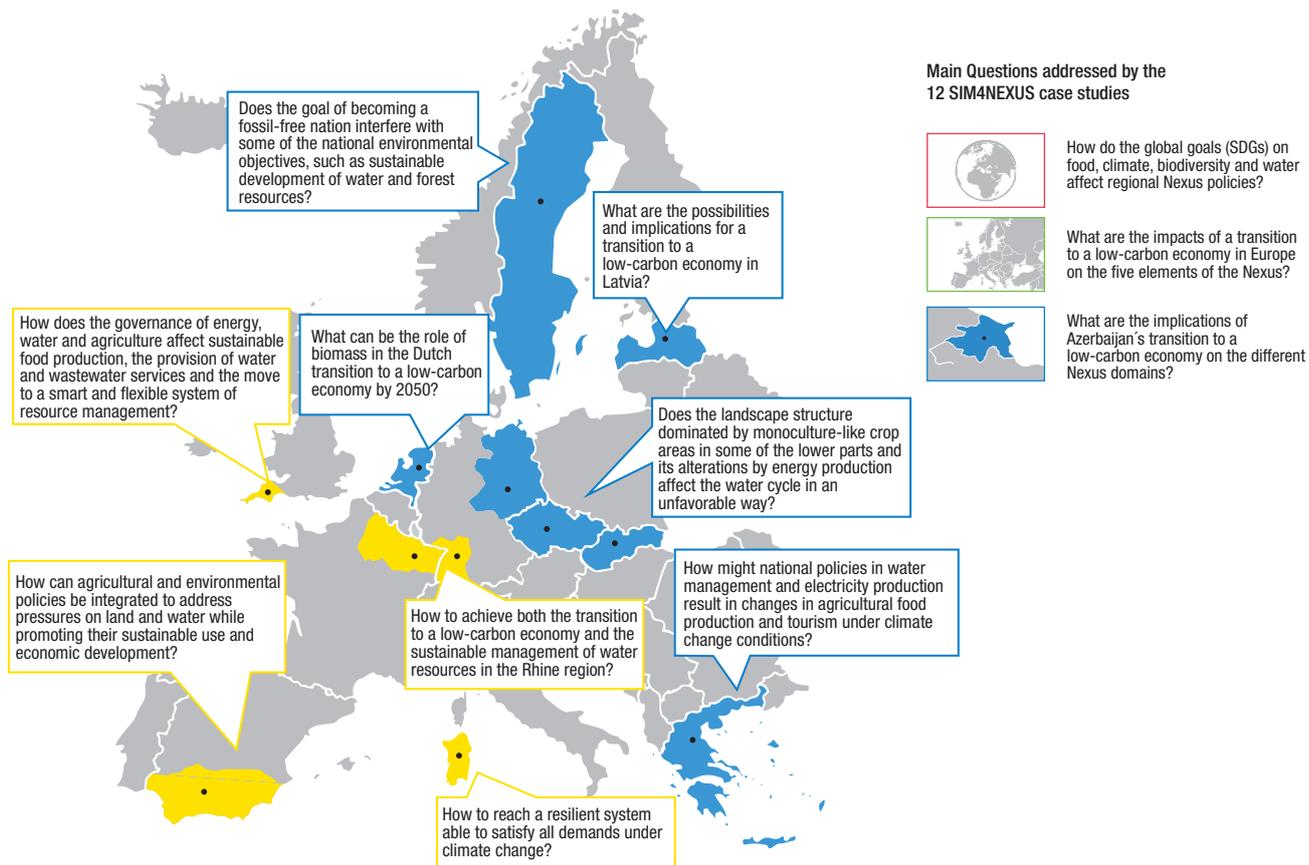


Vienna



Trebon

# Case studies & stakeholder engagement



## Main Questions addressed by the 12 SIM4NEXUS case studies

-  How do the global goals (SDGs) on food, climate, biodiversity and water affect regional Nexus policies?
-  What are the impacts of a transition to a low-carbon economy in Europe on the five elements of the Nexus?
-  What are the implications of Azerbaijan's transition to a low-carbon economy on the different Nexus domains?

## 12 case studies successfully implemented the SIM4NEXUS tools and methods and engaged a cross-sectoral dialogue with local stakeholders

### Key achievements

- Stakeholders involved from 14 different countries, covering all 5 Nexus domains
- Stakeholders gained knowledge on the Nexus and their countries' Nexus issues.
- Stakeholders actively participated in the identification of Nexus challenges, the data collection and scenarios development, and the formulation of policy recommendations.
- Stakeholders mobilized through a diversity of means: workshops, interviews, surveys, Serious Game tests or field trips in an iterative process with SIM4NEXUS researchers.

### Key products

Guidance documents to organize and evaluate case study workshops

Test-beds for the SIM4NEXUS approach and tools

Outputs contributing to SIM4NEXUS' policy recommendations and Nexus framework

### Our work

Methodologies and tools to integrate the Nexus components have been tested with real-life challenges in 12 case studies at regional, national, European and global scales.

The SIM4NEXUS Partners worked in close collaboration with relevant stakeholders to (a) specify the Nexus challenges they face; (b) apply the tools developed by SIM4NEXUS; (c) investigate the applicability and relevance of these tools for supporting decisions and raising awareness; (d) develop effective policy adaptation and implementation that supports a resource-efficient Europe. The science-policy participatory and iterative process established has successfully led to policy recommendations.

An amazing wealth of data has been collected, both from local sources and thematic models, and connected through the specific System Dynamic Models. Policy interventions have been tested through the Serious Game and best possible combinations towards Nexus-compliance have been identified.



**Floor BROUWER**

Wageningen Research

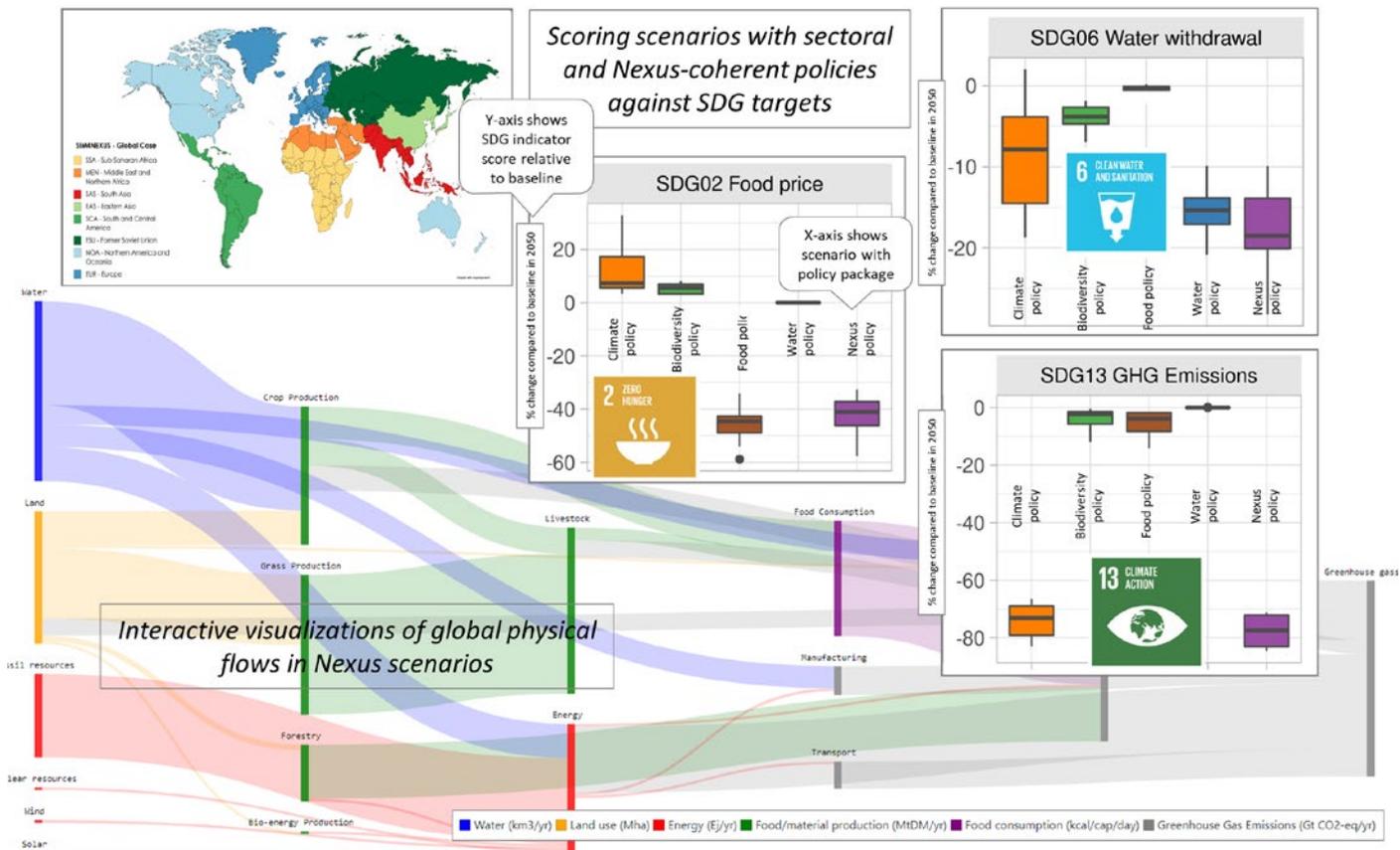
✉ [floor.brouwer@wur.nl](mailto:floor.brouwer@wur.nl)

**Maïté FOURNIER**

ACTeon

✉ [m.fournier@acteon-environment.eu](mailto:m.fournier@acteon-environment.eu)

# Global Nexus assessment



## Reducing meat consumption is a win-win strategy for climate, food, biodiversity and water

### Key achievements

- Development of harmonized scenarios with multiple models on sectoral and Nexus-coherent policy
- Investigated synergies and trade-offs of climate, biodiversity, food and water policies and their relationship with the sustainable development goals
- Improved interaction and cooperation between modelling teams on Nexus research

### Our work

The SIM4NEXUS global case study brings together a team working with large, complex modelling tools on the global scale investigating interactions between the human system and the environment. For the first time, scenarios quantifying synergies and trade-offs across Nexus sectors are co-developed with multiple models. This allows quantification of the Nexus while also taking model uncertainties into account.

The replacement of animal proteins by plant-based proteins is a strategy with high synergies across climate, food, biodiversity and water. In contrast, climate mitigation policies with substantial land requirements such as bio-energy could have negative impacts on food production or biodiversity and therefore should only be implemented if food security and nature protection are guaranteed.

### Key product

[Development of interactive visualization of scenarios to share results with the public](#)

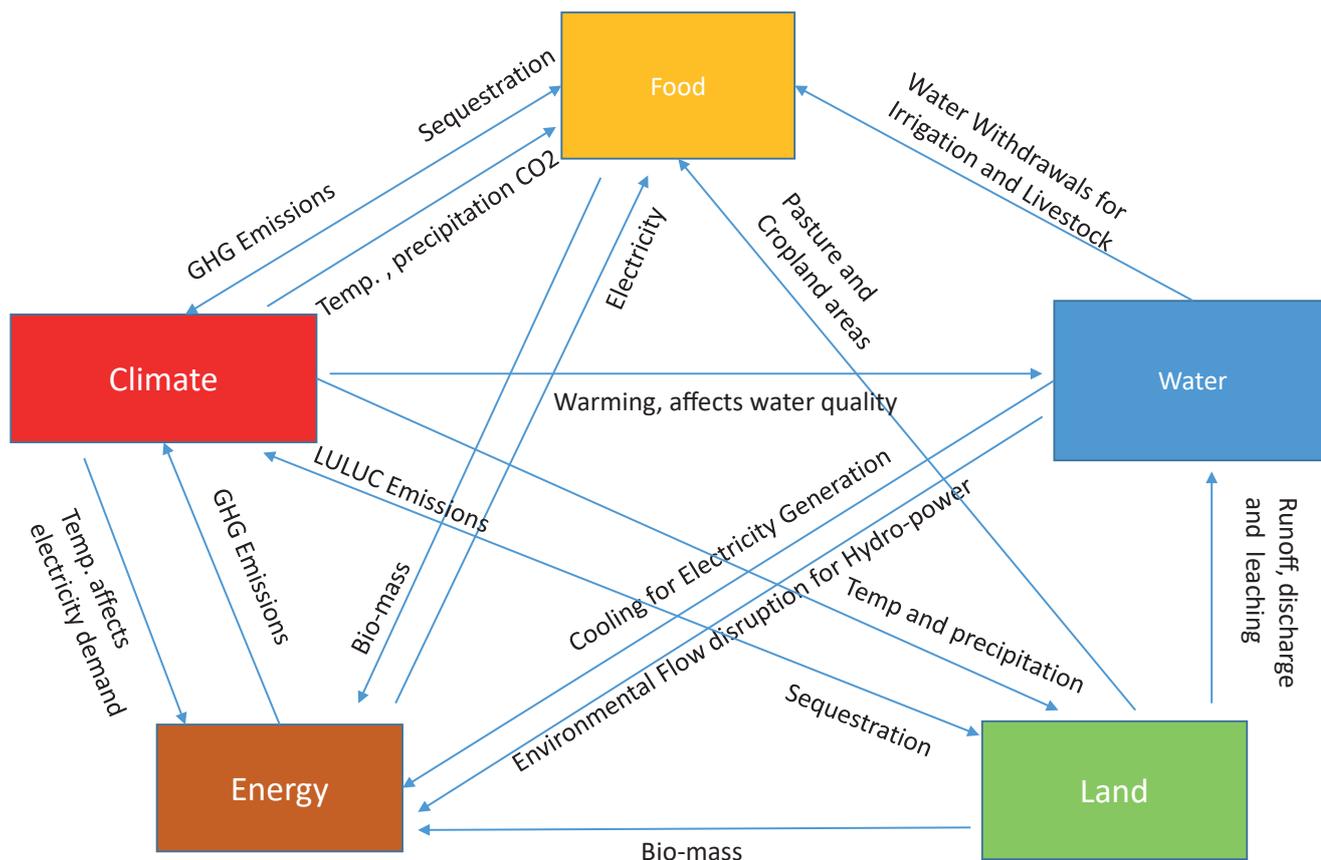


**Jonathan DOELMAN**

PBL Netherlands Environmental Assessment Agency

✉ [jonathan.doelman@pbl.nl](mailto:jonathan.doelman@pbl.nl)

# EU transition to a low-carbon economy



## The essentials: Energy saving, energy efficiency & changing human diets

### Findings

- Raising resource-efficiency awareness with consumers stimulates a healthy diet and the purchase of energy-saving technologies. This strategy will help to reduce greenhouse gas emissions while maintaining lower energy and food prices rather than by putting the obligation solely on the producers of energy and food.
- Bio-electricity combined with carbon capture and storage (CCS) technology is an important component in the low-carbon economy transition, particularly in Eastern Europe. However, a large amount of bio-electricity can have an impact on land use for nature and agriculture.
- A large increase in renewable energy can increase energy prices and land use. Energy efficiency and savings are then central to reduce greenhouse gas emissions while limiting the amount of renewable energy needed to replace fossil fuels.
- Healthy diets with less meat consumption and food waste combined with an agriculture carbon tax are in line with climate goals and will lead to more resource-efficient agriculture in Europe.
- A policy that encourages flexible land use and incentives to mitigate greenhouse gases in European agriculture can increase crop production for human consumption even with an increased burden of mitigation. Crop farmers can use some land and other resources unused in a smaller livestock sector. However, increased cropland use might increase water usage as it is often more water-intensive, e.g., irrigation in Southern Europe.

### Presentations

“Projections for Europe and the World to 2050, through the lens of the Water, Land, Energy, Food and Climate Nexus” – Scenarios Forum 2019, Denver, US

[“Nexus in Europe” – EU Green Week 2019](#)

**Jason LEVIN-KOOPMAN**

Wageningen Research

✉ [jason.levin-koopman@wur.nl](mailto:jason.levin-koopman@wur.nl)

# Republic of Azerbaijan case study



## A Nexus perspective for integrated solutions

### Key achievements

- Conceptual System Dynamics Model of the Nexus of Azerbaijan
- [Open source electricity sector model in OSeMOSYS](#)
- Serious Game for an indicative Nexus assessment of sectoral policies (water, energy, land, food, climate) of Azerbaijan

### Our Work

SIM4NEXUS mapped the interlinkages in the Nexus of water, energy, land, food and climate in the case of Azerbaijan and identified key challenges.

The starting point was a review of the Nexus systems in Azerbaijan, which guided the development of a conceptual model. A sectoral policy analysis was also performed. This was reviewed and discussed with local stakeholders at a workshop in Baku in September 2018. In parallel modelling took place: the Open Source energy Modelling SYstem – OSeMOSYS – was applied for the energy modelling with input from the macroeconomic model E3ME, and the Modular Agricultural GeNeral Equilibrium Tool – MAGNET – was used to explore the effects of climate change mitigation measures on agriculture.

Scenarios were modelled: a baseline; a “bad” scenario, with unmitigated climate change impacts; and a ‘good’ scenario, incorporating mitigation and adaptation measures.

The gamification of the Nexus provides an opportunity to national stakeholders, e.g., from academia or ministries, for exploring the impacts of different sectoral policies on the Nexus. The Serious Game of Azerbaijan will be used in the exploitation of SIM4NEXUS as an entry example in workshops, education and similar.

The Case Study team would like to thank Anar Nuriyev, from the Baku State University, and Dr. Farhad Mukhtarov, from the Erasmus University Rotterdam, for their valuable contribution to the case study.

The views expressed in this brochure and the outputs of SIM4NEXUS concerning the Azerbaijan study are those of the authors and do not necessarily reflect the views of the stakeholders consulted in the case study nor the Republic of Azerbaijan.



**Viktoria MARTIN**

KTH Royal Institute of Technology  
✉ [viktoria.martin@energy.kth.se](mailto:viktoria.martin@energy.kth.se)

**Hauke HENKE**

KTH Royal Institute of Technology  
✉ [haukeh@kth.se](mailto:haukeh@kth.se)

**Georgios AVGERINOPOULOS**

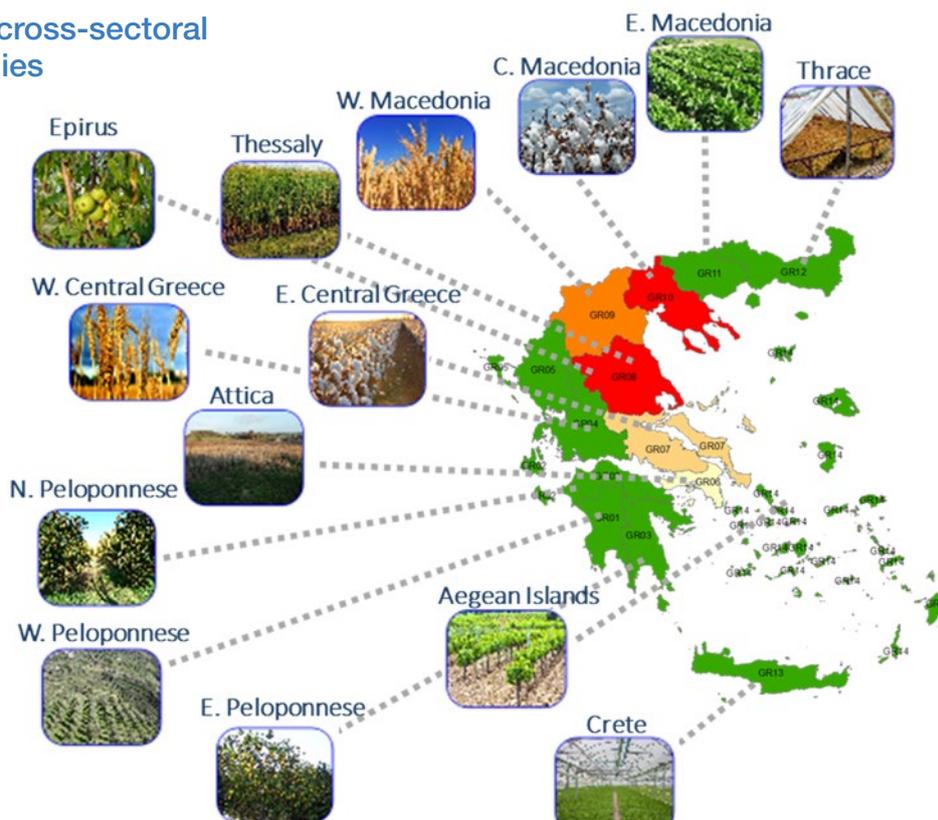
KTH Royal Institute of Technology  
✉ [georgios.avgerinopoulos@desa.kth.se](mailto:georgios.avgerinopoulos@desa.kth.se)

# Greece: See the big picture!

## The Nexus forces us to think about cross-sectoral implications of single-sector strategies

### Key achievements

- Developed a System Dynamics Model that maps sector-specific data from major published databases and scenario models for the national case study of Greece
- Disaggregation algorithms were employed on annual national-scale data and turned them into spatial and temporal datasets by converting them to monthly values spread among all 14 River Basin Districts (RBDs)
- Quantified interlinkages among Water, Energy, Food, Built Environment, Natural Land and greenhouse gas (GHG) emissions on a national and RBD scale
- Policy coherence analysis revealed that policies on climate and food can have positive effects on energy, water and land policies, showcasing the cross-sectoral synergies of Nexus-coherent policy making.



### Findings

The Greece Nexus assessment showed that the highest degree of coherence was attained within policies of the same sector. Significant **positive policy interactions** also exist among policies concerning different Nexus sectors, e.g., climate and energy policies. Climate change adaptation and resilience, combating climate change impacts and sustainable development of agriculture are the most influencing policy objectives.

Finally, Nexus Informatics develops the science of recognising and quantifying Nexus interlinkages. A **System Dynamics Model** maps sector-specific data, and quantifies interlinkages among water-energy-land-food-climate for Greece. Data availability and scale are core **constraints** to make the Nexus concept operational. Nexus Directional Chord plots were developed as an **innovative visualisation** tool, which reveals Nexus hotspots and strong interlinkages among sectors, facilitating stakeholder awareness.

The Nexus is simulated as a holistic multi-sectoral system that provides insights into the vulnerability of resources to future socio-economic scenarios. The analysis shows that to move from a general nexus thinking to an operational nexus concept, it is important to focus on data availability and scale. Nexus Directional Chord plots are developed as an innovative visualisation tool, which reveals Nexus hotspots and strong interlinkages among sectors, facilitating stakeholder awareness.

### Key outputs

[Laspidou C., N. Mellios & D. Kofinas \(2019\) Towards Ranking the Water–Energy–Food–Land Use–Climate Nexus Interlinkages for Building a Nexus Conceptual Model with a Heuristic Algorithm. \*Water\*, 11, \(2\), 306; Munaretto et al., 2018\).](#)

[Laspidou C., N. Mellios, A. Spyropoulou, D. Kofinas & M.P. Papadopoulou \(2020\) Systems thinking on the resource Nexus: Modeling and visualisation tools to identify critical interlinkages for resilient and sustainable societies and institutions. \*Science of Total Environment\*, Vol. 717, 137264.](#)

[Papadopoulou C.A., M.P. Papadopoulou, C. Laspidou, S. Munaretto & F. Brouwer \(2020\) Towards a Low-Carbon Economy: A Nexus-Oriented Policy Coherence Analysis in Greece. \*Sustainability\*, Vol. 12, Issue 1,](#)

[Serious Game for Greece, both at national scale and at RBD scale](#)

[Dataset: Mellios, N.; Laspidou, C. \(2020\). “Water–Energy–Food–Land–Climate Nexus data for the Case Study of Greece: National and River Basin District Scale”, Mendeley Data.](#)



**Chrysi LASPIDOU**

University of Thessaly

✉ [laspidou@uth.gr](mailto:laspidou@uth.gr)

**Maria P. PAPAPOPOULOU**

National Technical University of Athens

✉ [mpapadop@mail.ntua.gr](mailto:mpapadop@mail.ntua.gr)

# Cross-sectoral collaboration in Sweden



Boosting cross-sectoral collaboration is the key to raising awareness of societal Nexus challenges that fosters capacity building and optimizes policy making.

## Key achievements

- Established a dialogue with stakeholders across all 5 Nexus sectors
- Performed a policy analysis of the Swedish Nexus and disentangled the complex interlinkages
- Co-developed a conceptual model of the Swedish Nexus together with stakeholders
- Collected data from different sectors to support drawing a comprehensive picture of the Swedish Nexus
- Translated the conceptual model into an operational System Dynamics Model
- Developed final policy recommendations (based on the policy analysis, inputs from stakeholders and results from the System Dynamics Model) that can help improve resource efficiency and carbon neutrality in Sweden

## Findings

The Nexus challenges in Sweden are linked to forestry, water, energy, food and climate sectors. Major challenges are knowledge gaps and considerable **uncertainties** on how environmental systems will change and what their impacts will be. SIM4NEXUS has led to two key conclusions:

1. A Nexus approach is necessary to handle current challenges societies are facing, particularly about addressing climate change and efficient resources use. System Dynamics Modelling and Serious Gaming proved to be important tools for simulating the complex cross-sectoral interlinkages and more importantly for learning purposes. Nevertheless, due to data limitations and the related complexity of the Nexus system, such tools were suggested to be better **utilised for educational purposes** than for real-life decision making.
2. Adopting such a Nexus approach is a complex endeavour that requires comprehensive changes in the current policy-making and decision-making systems. **Interaction with stakeholders from different sectors**, including face-to-face cross-sectoral meetings (workshops), is necessary to increase awareness of Nexus issues and build the capacity of the different sectors for future improvements.

## Key products

[Policy analysis report](#)

[Popular science article in Biodiverse magazine](#)

[Article in Ecosystem Services](#)

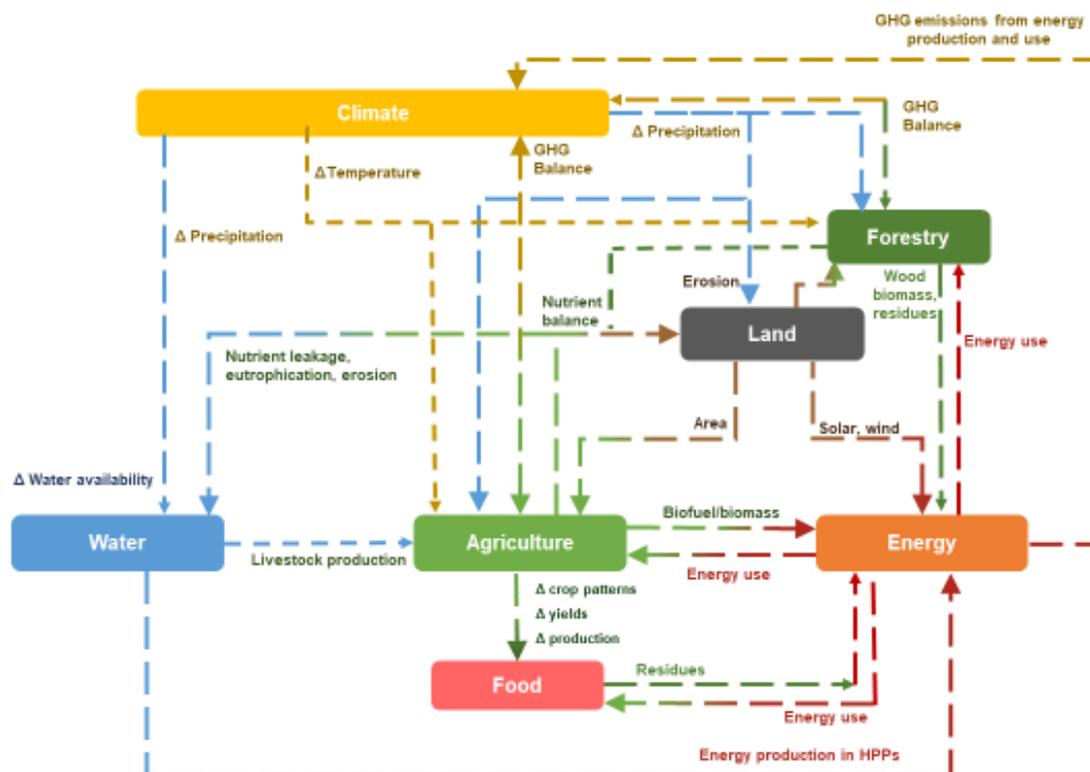
**Dr. Claudia TEUTSCHBEIN**

Department of Earth Sciences, Uppsala University  
✉ [claudia.teutschbein@geo.uu.se](mailto:claudia.teutschbein@geo.uu.se)

**Dr. Malgorzata BLICHARSKA**

Department of Earth Sciences, Uppsala University  
✉ [malgorzata.blicharska@geo.uu.se](mailto:malgorzata.blicharska@geo.uu.se)

# Biomass and sustainable land-use in Latvia



## Pathways towards low-carbon development and resource-efficiency require Nexus interaction

### Key achievements

- The case study has addressed different Nexus domains
- Stakeholders thinking beyond the sector silos dimension
- Biomass is a local resource in Latvia now and in the future
- Resource-efficiency requires diversification of land use
- Innovative technologies are essential for low-carbon development
- The applied approach is transferrable to the countries in the Baltic Sea Region

### Our work

The Latvia case study explores the possibilities and implications of low-carbon development and resource-efficiency policies. We interacted with stakeholders at the national, regional and local levels to provide information, build understanding, obtain feedback and engage to participate in testing of the project outputs. The SIM4NEXUS approach was acknowledged by stakeholders as appropriate to tackle the complex issues and to promote cross-sectoral thinking going beyond the silos dimension. The key Nexus issues in Latvia concern biomass as a local resource, sustainable land use and innovative technologies in application.

### Key products

[Serious Game for the Latvia case study](#)  
[Brouwer F., L. Vamvakeridou-Lyroudia, E. Alexandri, I. Bremere, M. Griffey & V. Linderhof \(2018\), The Nexus Concept Integrating Energy and Resource Efficiency for Policy Assessments: A Comparative Approach from Three Cases. Sustainability 2018, 10, 4860; doi:10.3390/su10124860](#)



**Ingrida BREMERE**

Baltic Environmental Forum – Latvia

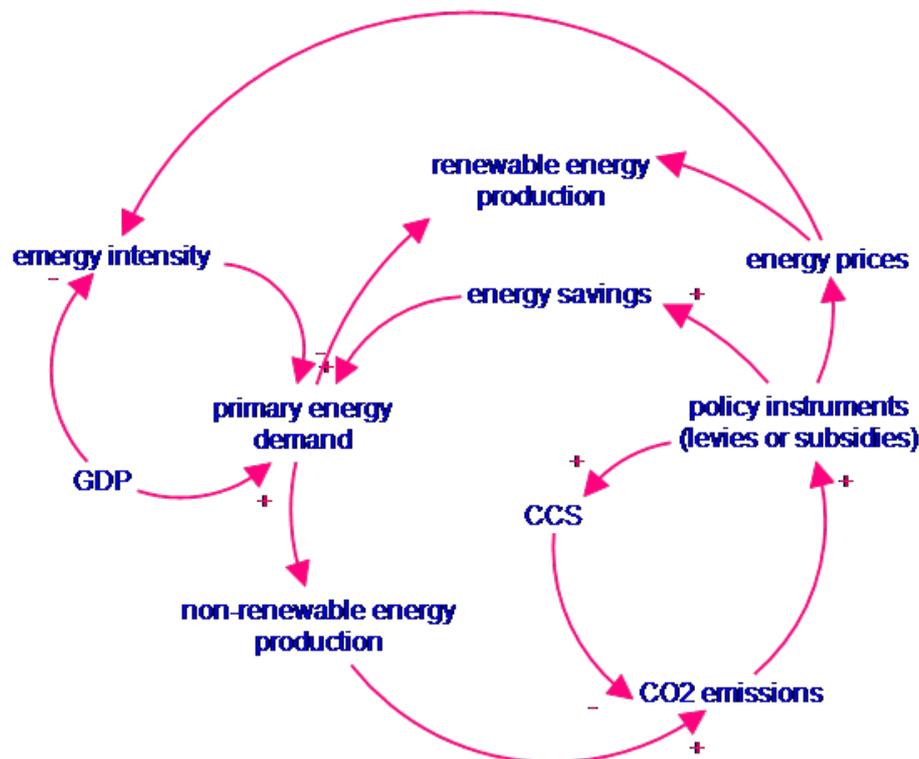
✉ [ingrida.bremere@bef.lv](mailto:ingrida.bremere@bef.lv)

**Daina INDRIKSONE**

Baltic Environmental Forum – Latvia

✉ [daina.indriksone@bef.lv](mailto:daina.indriksone@bef.lv)

# The Netherlands: bio-based and circular economy



## Trade-offs between biomass for renewable energy and (food and non-food) resource efficiency

### Key findings

1. The perception of biomass for energy is persistently negative among many stakeholders and the usage of biomass for energy is heavily debated.
2. Up until 2020, biomass policy implementation is often seen as fragmented and incoherent.
3. By playing the Dutch Serious Game, stakeholders can learn how the need for different types of biomass as a renewable energy source may conflict or have synergies with the creation of a bio-based and circular economy.
4. There are still knowledge gaps concerning the heterogeneity and sustainability of biomass and the best application of the different types, e.g., imported woody biomass or manure.
5. The Dutch Serious Game allows investigating different pathways towards a low-carbon and resource-efficient economy embedded within separate learning experiences on policies you can apply.

The Netherlands aims for a low-carbon and resource-efficient economy in 2050. The use of biomass for energy was identified as an alternative with a significant potential contribution to the realisation of these goals. Many types of biomass could be used for energy, like wood, manure, wastewater, organic waste, etc. Also, growing biomass for energy or other new uses like bio-based products would require land, which is already scarce in the Netherlands. Moreover, other types of renewable energy require land as well (solar power parks, and wind power turbines). These competing claims lead to trade-offs between land used for food and non-food production and land used for renewable energy production. The key question addressed is: what is the potential role of biomass in the pathway to a low-carbon and resource-efficient economy in the Netherlands?

### Outputs

[Linderhof, V., N. Polman, J. Susnik, S. Masia, K. Dekkers & M. Witmer \(2019\) How to achieve a low-carbon economy in the Netherlands in 2050: the system dynamics model approach. Presentation at the 2nd International Conference on Energy Research and Social Science: "Energy and Society in Transition", Arizona State University, Tempe \(AZ\), USA, 28-31 May 2019.](#)

[Brouwer, F., L. Vamvakeridou-Lyroudia, E. Alexandri, I. Bremere, M. Griffey & V. Linderhof \(2018\) The Nexus concept integrating energy and resource efficiency for policy assessments: A comparative approach from three cases. Sustainability, 10\(12\), 4860.](#)

**Vincent LINDERHOF**

Wageningen Research

✉ [vincent.linderhof@wur.nl](mailto:vincent.linderhof@wur.nl)

**Nico POLMAN**

Wageningen Research

✉ [nico.polman@wur.nl](mailto:nico.polman@wur.nl)

# The Water-Energy-Food Nexus in Andalusia (Spain)



## Water-efficient irrigation does not automatically save energy



### Key achievements

- Identification of water-agriculture-energy inter-relationships in Andalusia, through collaboration with stakeholders
- Assessment of public policies related to the water-energy-food Nexus
- Application of thematic models to simulate alternative futures that take into account foreseen socioeconomic and environmental trajectories (simulation scenarios)
- Development of a System Dynamics Model (SDM) of the Nexus in Andalusia

### Key products

System Dynamics Model of the Nexus in Andalusia, developed in close collaboration with regional stakeholders. The model helps to understand synergies and trade-offs between Nexus sectors and supports Nexus-coherent decision making.

[Martinez P., M. Blanco & B. Castro-Campos \(2018\) The Water-Energy-Food Nexus: A Fuzzy-Cognitive Mapping Approach to Support Nexus-Compliant Policies in Andalusia \(Spain\). \*Water\* 10 \(5\): 664](#)

[Martinez P. & M. Blanco \(2019\) Sensitivity of Agricultural Development to Water-Related Drivers: The Case of Andalusia \(Spain\). \*Water\*, 11\(9\), 1854](#)

**Maria BLANCO**

Technical University of Madrid (UPM)

✉ [maria.blanco@upm.es](mailto:maria.blanco@upm.es)

# Sardinia's adaptation to climate change



## Sustained socio-economic development in Sardinia requires sustainable use and optimal allocation of limited resources

### Key achievements

- The development of a System Dynamics Model for Sardinia with a strong focus on energy-water resources analysing possible future pathways
- Development of methane deployment and distribution across the island appears as a must to reduce energy costs, but its implementation is controversial in terms of reaching carbon neutrality
- Water management rules must be re-elaborated and distribution systems restructured to adapt to climate change and the strong climate variability.
- Coordination at the governance level requires implementation of a Nexus approach and policies.

### Findings

Reaching resource efficiency, carbon neutrality and water sustainability under Climate Change scenarios in Sardinia faces challenges by a fast-decreasing population and a relatively low income per capita. The assessment revealed that sustainable use of water resources can be reached, also under climate change projections, by implementing relatively few technological and governance solutions.

Investing in the development of the forestry sector will be beneficial for reaching carbon neutrality. However, present national and regional policies need to be deeply re-elaborated as they pose severe restrictions to the sector. To reach carbon neutrality, Sardinia must increase the energy efficiency of buildings and accelerate power generation from renewable resources.

### Key publications

[Masia S., J. Sušnik, S. Marras, S. Mereu, D. Spano, A. Trabucco \(2018\) Assessment of irrigated agriculture vulnerability under climate change in Southern Italy. \*Water\*, 10\(2\), 209.](#)

[Sušnik J., C. Chew, X. Domingo, S. Mereu, A. Trabucco, B. Evans, L. Vamvakieridou-Lyroudia, D. Savić, C. Lapidou, F. Brouwer \(2018\) Multi-stakeholder development of a serious game to explore the water-energy-food-land-climate Nexus: the SIM4NEXUS approach. \*Water\*, 10\(2\), 139.](#)

[Regional Strategy of Adaptation to Climate Change—Sardinia Regional Ministry of Environment](#)

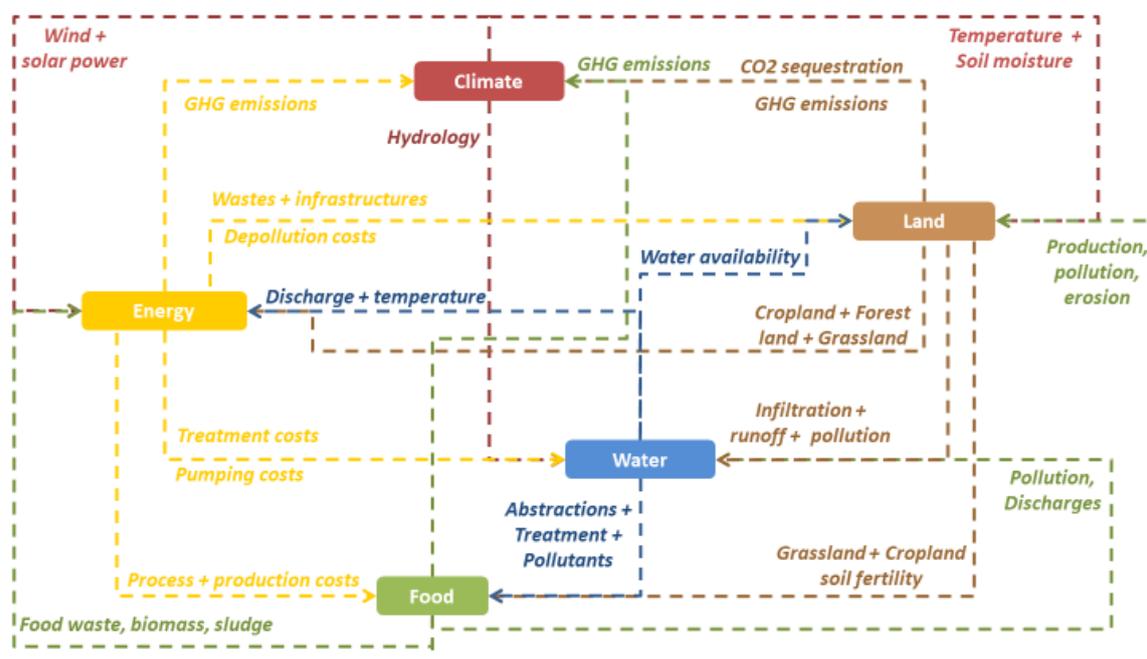


**Donatella SPANO**  
UNISS/CMCC  
✉ [spano@uniss.it](mailto:spano@uniss.it)

**Simone MEREU**  
UNISS  
✉ [smereu@uniss.it](mailto:smereu@uniss.it)

**Antonio TRABUCCO**  
CMCC  
✉ [antonio.trabucco@cmcc.it](mailto:antonio.trabucco@cmcc.it)

# Energy transition in the Upper-Rhine (France-Germany)



## A Nexus approach contributes to mitigating the impacts of the energy transition on water, land and food resources in the Upper-Rhine region

### Key achievements

- Policy assessment of (in)coherences across the Nexus in the Upper-Rhine region
- Conceptual visualization of the Nexus interlinkages in the Upper-Rhine region
- Datasets and evolution trends of the sectors from 2010 to 2050 in Grand Est and Baden-Württemberg
- Identification of policy recommendations to improve resource efficiency and make energy transition “Nexus-compliant” in Grand Est and Baden-Württemberg
- Transboundary and cross-sectoral workshops organized with French & German stakeholders

### Presentations

[Fournier & al. \(2018\) “Introducing the Nexus concept to better manage and adapt large-rivers basins: an example from the Upper-Rhin”, at I.S. Rivers \(Lyon, France\).](#)

### Findings

The France-Germany transboundary case study focuses on the links and synergies between energy policy and the transition to a low-carbon economy on one side, and the management of natural resources (in particular water) on the other side.

The development of **bioenergy** (especially biofuel production and energy generation based on methanation) as substitutes for fuel products will change land use and put pressure on water quality and quantity. Therefore, stronger conditions should be set for the development of energy crops. Energy transition’s development of **solar energy** shall also be managed by safeguard measures to minimize land take and direct it towards “low value” land.

In addition, policy recommendations are made to enhance transboundary governance, cross-sectoral cooperation and science-policy dialogue between France and Germany for achieving jointly set policy objectives in a more cost-effective manner and as pre-conditions for a transboundary energy transition.



**Emeline HILY**

ACTeon

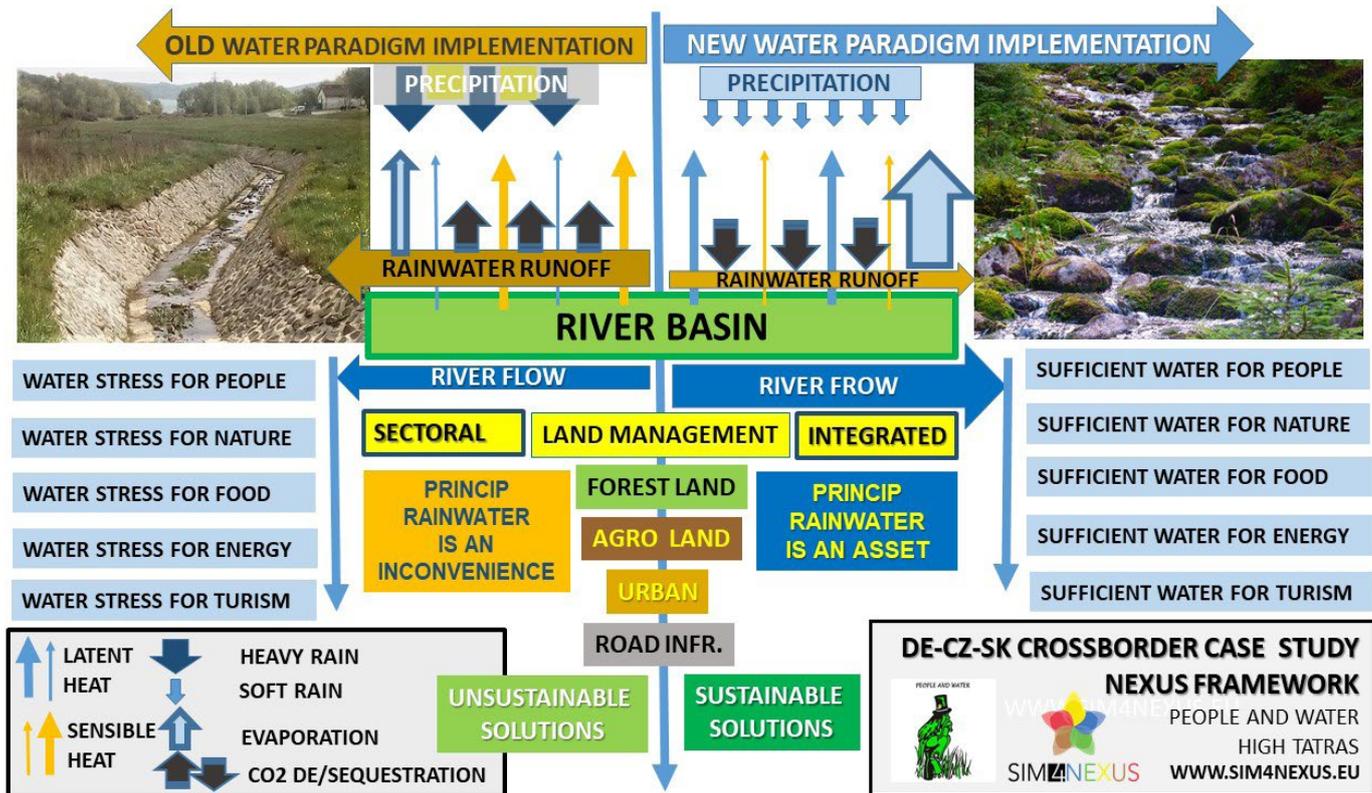
✉ [e.hily@acteon-environment.eu](mailto:e.hily@acteon-environment.eu)

**Pierre STROSSER**

ACTeon

✉ [p.strosser@acteon-environment.eu](mailto:p.strosser@acteon-environment.eu)

# Climate-resilient landscapes in Eastern Europe (Germany, Czech Republic, Slovakia)



All pictures: Author and Foto: M. Kravčík

## Rainwater retention is a driving force of climate-resilient landscapes

### Key achievements

- Landscape restoration programme for Eastern Slovakia
- Regular communication with the Ministry of Environment (CZ)
- Regular communication with the Commission “Drought – SUCHO” (CZ)
- Awareness for the electrical load balancing problem under increasing shares of volatile renewable sources; communications with the environmental department of Vattenfall (DE)

### Key products

[Policy brief – landscape restoration](#)

### Findings

Landscape restoration based on retention of water through the involvement of new forests, seepage grass strips, wetlands and ponds are recommended, accompanied by improving soil quality. By retaining rainwater in damaged ecosystems, the renewal of vegetation begins, carbon sequestration, soil and groundwater reserves improve, springs are renewed, water vapour is increased and solar energy is transformed into latent heat that is transferred to higher, cooler layers of the atmosphere. There, at the dew point, this latent energy is transformed into sensible heat. The generated rainfall returns to the ground and feeds the ecosystems, stimulates vegetation growth, carbon sequestration and thermoregulation in the landscape. Clouds reduce the entry of solar radiation. This functional model can be quantified and implemented at the individual, local, regional and global levels.



An example of the landscape restoration of damaged agricultural land by the retention of rainwater on slopes by contoured bell by the unemployed in 2004 in Eastern Slovakia village Torysa

**Jan POKORNÝ**

ENKI, o.p.s. Třeboň, Czech Republic

✉ [pokorny@enki.cz](mailto:pokorny@enki.cz)

**Michal KRAVČÍK**

People and Water, Košice, Slovakia

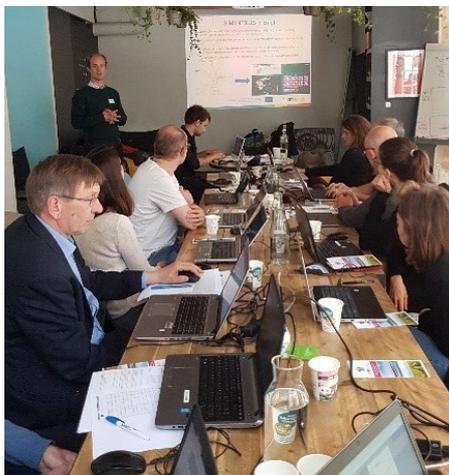
✉ [kravcik.michal@gmail.com](mailto:kravcik.michal@gmail.com)

**Tobias CONRADT**

Potsdam Institute for Climate Impact Research (PIK), Germany

✉ [conradt@pik-potsdam.de](mailto:conradt@pik-potsdam.de)

# How to “Nexus” after the project life?



## Key achievements

- Analyze the Serious Gaming market
- Design a smooth collaboration and ‘exploitation strategy’
- Prepare the ground for a spin-off creation

## Key products

- Full commercialisation plan for the Serious Game software (e.g., definition of commercial packages, software maintenance, commercial pipelines, first clients, business plans, partners’ involvement, creation of a legal structure)
- Start-up development plans for the first 5 years

## Our work

Stage 1 – An extensive market study was carried out to determine the potential customers and competitors of the SIM4NEXUS Serious Game. Different types of actors were approached (public, private, public authorities, associations, NGOs). The aim was to determine the needs of end-users in terms of Serious Game use.

Stage 2 – Exploitation strategy and business models were agreed to enable collaborations after the project end. This includes a 2-year trial and commercialisation plans for a start-up creation, including customer training at several levels.

Stage 3 – Test-playing of the Serious Game at “customer feedback workshops” to enable product improvement.



**Alexandre BARRET**

Strane Innovation

✉ [alexandre.barret@strane-innovation.com](mailto:alexandre.barret@strane-innovation.com)

**Nathalie VALLEE**

Strane Innovation

✉ [nathalie.vallee@strane-innovation.com](mailto:nathalie.vallee@strane-innovation.com)

**Alexandra JAUNET**

Strane Innovation

✉ [ajaunet@strane-innovation.com](mailto:ajaunet@strane-innovation.com)

**Stefania MUNARETTO**

KWR Water Research Institute

✉ [Stefania.Munaretto@kwrwater.nl](mailto:Stefania.Munaretto@kwrwater.nl)