



ARSINOE

The ARSINOE Multi-System Dynamic Modelling Framework



Introduction

Within the framework of the ARSINOE project, we introduced the Dynamic Multi-System Resilience Modelling and Assessment Framework (DMRM&AF) – also known as the ARSINOE wheel – as a conceptual framework to integrate diverse modelling approaches in support of climate resilience analysis. This framework was developed and applied across nine case studies to support decision-making under climate-related hazards. The framework was designed to be sufficiently generic and flexible, allowing the case studies to develop both computational and systems' models using a vast array of modelling methodologies, enabling its application across diverse regional contexts and stakeholder needs.



The DMRM&AF Framework and its application

The ARSINOE framework offers a flexible structure that enables each case study to build a tailored modelling architecture. Organised into five modelling tiers and supported by four foundational pillars, the framework is deliberately non-prescriptive, allowing interdisciplinary teams to adapt it to the specific challenges, systems, and data availability of each region.

The five modelling tiers include:

1. Future Society and Socio-economic scenarios (Tier 1)
2. Climate and Socio-economic Projections (Tier 2)
3. Environmental and Biophysical Systems Models (Tier 3)
4. Human and Operational Systems Model (Tier 4)
5. Strategic Response Models (Tier 5)

The five modelling tiers are supported by four ARSINOE pillars and which map to the life cycle of a computational/systems' model. The four pillars are:

- System Innovation Approaches, e.g., co-creation, participatory modelling, and Living Labs;
- Data and Logic, e.g., primary and secondary data, integration of datasets, deployment of expert knowledge, citizen science, and semantic structures;
- Resilience Assessment, e.g., risk and sensitivity analysis tailored to each case;
- Stakeholder Decision-making, e.g., interfaces such as dashboards, visualisations and VR tools.



Key insights

The application of the DMRM&AF framework across nine ARSINOE case studies demonstrated its effectiveness as both a conceptual model and an advanced modelling architecture. It enabled the design of hybrid, multi-tiered systems to address climate challenges by integrating environmental, operational, and strategic models aligned with socio-economic and climatic scenarios. This approach facilitated a deeper understanding of intersectoral dynamics and how systems respond to future stress scenarios.

A key strength of the framework is its flexibility. Each case study tailored its modelling approach using the ARSINOE Wheel, selecting modelling methodologies and tools, data, techniques used for the assessment of resilience, and method of communication of the results (to the stakeholders) suited to the local context, while ensuring cross-case comparability. The structured framework also enhanced documentation, transparency, and knowledge exchange among interdisciplinary teams, strengthening the overall impact of ARSINOE's resilience modelling strategy.

Challenges & future directions

Despite its strengths, the implementation of the ARSINOE Wheel revealed several operational challenges. One major difficulty lies in the calibration and harmonisation of diverse models, especially when linking environmental simulations with behavioural or strategic decision-making tools. Many case studies also faced limitations related to data availability, interoperability of software platforms, and the need for computational resources when developing distributed or high-resolution simulations. Furthermore, the integration of stakeholder input into technically complex modelling processes remains an area where further guidance and methodological refinement are needed.

Looking ahead, the ARSINOE project plans to extend the capabilities of the framework by integrating newer climate data, refining model interactions and integration, and enhancing user accessibility through visualisation dashboards and digital twins. There is also growing interest in expanding the framework to include additional models, for example, for modelling cascading impacts, equity aspects, or longer-term transformation pathways. Continued co-creation with stakeholders and alignment with emerging local priorities will be essential to ensure the relevance, usability, and uptake of the framework beyond the project's duration.

Conclusion

The ARSINOE Multi-System Dynamic Modelling Framework (D3.8) provides a robust, co-created structure for integrating complex models into climate resilience planning. By linking scientific modelling with stakeholder needs, it empowers regional actors across Europe to navigate uncertainty and design evidence-based adaptation strategies. The implementation of the ARSINOE wheel for resilience assessment for all the nine case studies will be presented as part of D6.7.



To learn more about the ARSINOE Multi-System Dynamic Modelling Framework, read our corresponding deliverable: [HERE](#).

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The ARSINOE consortium



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