NEXOGENESIS
STREAMLINING WATER RELATED POLICIES

# A Practical Guide to Co-Creating WEFE Nexus Governance

**Lead-Authors:** Sabina J. Khan (Helmholtz Centre for Environmental Research – UFZ), Tamara Avellan (Tamara Avellan Consulting)

**Contributing authors:**

WP1: Frank Hüesker (UFZ), Caro Mooren (KWR), Stefania Munaretto (KWR)
WP2: Roberto Roson (CAF), Walter Rossi Cervi (WR), Antonio Trabucco (CMCC)
WP3: Henry Daza (IHE), Sara Masia (IHE), Janez Sušnik (IHE)
WP4: Chaymaa Dkouk (EUT), Lluís Echeverria (EUT), Nuria Nievas (EUT)
WP5: Ingrīda Brēmere (BEF), Silvia Cocuccioni (EURAC), Blaine Haupt (JAWS), Daina Indriksone (BEF), Daniella Kristensen (JAWS), Florentina Nanu (BDG), Chrysaida-Aliki Papadopoulou (NTUA), Maria P. Papadopoulou (NTUA),
WP6: Loïc Charpentier (WE), Svetlana Klessova (G.A.C. Group), Nina Olivier (G.A.C. Group), Lisa Pourcher (G.A.C. Group)



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**The following experts substantially contributed to the development of Nexogenesis' tools, methods and approaches presented in this guidebook:**

*WP1: Frank Hüesker (UFZ), Caro Mooren (KWR), Stefania Munaretto (KWR), Isabelle La Jeunesse (Universite Tours), Eva Sievers (UFZ), Claudia Cirelli (Universite Tours), Ingrid Canovas (Universite Tours), Kaoutar Mounir (Universite Tours);*

*WP2: Roberto Roson (CAF), Walter Rossi Cervi (WR), Antonio Trabucco (CMCC);*

*WP3: Henry Daza (IHE), Sara Masia (IHE), Janez Sušnik (IHE), Nikolaeos Mellios (University of Thessaly), Chrysi Laspidou (University of Theassaly), Alexandra Spuropoulou (University of Thessaly);*

*WP4: Chaymaa Dkouk (EUT), Lluís Echeverria (EUT), Nuria Nievas (EUT);*

*WP5: Ingrīda Brēmere (BEF), Silvia Cocuccioni (EURAC), Blaine Haupt (JAWS), Daina Indriksone (BEF), Daniella Kristensen (JAWS), Florentina Nanu (BDG), Chrysaida-Aliki Papadopoulou (NTUA), Maria P. Papadopoulou (NTUA), Fabio Carelli (EURAC), Stefano Terzi (EURAC), Andrea Müller (AVA), Symon Ryfish (University Uppsala), Beatrice Sambo (Ca' Foscari University of Venice), Claudia Teutschbein (Uppsala University), Jayne Glass (Uppsala University), Malgorzata Blicharska (Uppsala University);*

*WP6: Loïc Charpentier (WE), Svetlana Klessova (G.A.C. Group), Nina Olivier (G.A.C. Group), Lisa Pourcher (G.A.C. Group)*

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# Why this guide?

Managing water, energy, food and ecosystems as separate policy domains can produce avoidable trade-offs and overlook opportunities for joint action. NEXOGENESIS was established to make these interdependencies visible, explore how they may evolve under climate and socio-economic change, and help public authorities and stakeholders identify policy packages that perform across sectors rather than in only one of them.

NEXOGENESIS was a four-year Horizon 2020 research and innovation project (2021–2025) involving 20 consortium partners from Europe and South Africa. Its full title—"Facilitating the next generation of effective and intelligent water-related policies, utilising artificial intelligence and reinforcement learning to assess the water–energy–food–ecosystem nexus"—captures both its policy ambition and its technical core. The project did not begin with a stand-alone software tool. It combined governance and policy research, stakeholder co-creation, scenario analysis, system dynamics modelling, a cross-sector footprint and a decision-support platform in five river-basin settings.

The work unfolded iteratively. Two frontrunner cases, Nestos/Mesta River Basin (Greece/Bulgaria) and Lielupe River Basin (Lativa/Lithuania) applied activities slightly earlier so that practical problems and lessons could inform the follower cases in the Lower Jiu (Romania), Adige (Italy) and Inkomati-Usuthu (South Africa) basins. Across the project, stakeholders helped frame basin problems, test system relationships, reviewed data and assumptions, proposed and validated policies, used the NExus Policy Assessment Tool (NEPAT) to explore policy packages, and translated preferred directions into governance roadmaps and continuation agreements. Technical and governance teams repeatedly exchanged information; no single work package could produce a usable decision on its own.

This guidebook is the culmination of that combined work. It brings the project's methods, tools, case experience and lessons into one implementation route for authorities, researchers, consortia and practitioners. It is not a substitute for the underlying scientific papers, deliverables or NEPAT user guide. Its purpose is to show how the pieces fit together, what each step is trying to achieve, what expertise is required, what outputs should be available, and how those outputs become a defensible policy and implementation pathway.

## For whom is this guide?

River-basin authorities already manage connected systems, even when their legal mandates, budgets and information systems are organised by sector. A decision about irrigation can affect ecological flows and energy demand; a hydropower decision can affect downstream agriculture and ecosystems; climate adaptation in one sector can transfer risks to another. These interactions are often recognised informally but are not consistently represented in policy appraisal, modelling or implementation planning.

The difficulty is not simply a lack of data or tools. Nexus work has to connect several kinds of evidence and authority: scientific projections, sector models, policy and legal analysis, institutional experience, local knowledge, stakeholder values and the practical ability to implement. If these elements are developed separately, the result may be technically sophisticated but institutionally unusable. If technical analysis is omitted, policy dialogue may overlook important feedbacks, future risks or unintended consequences.

NEXOGENESIS responds to this implementation gap by linking stakeholder engagement, governance assessment, policy coherence analysis, future scenarios, system dynamics modelling, the NEPAT and governance roadmaps. The value lies in the connections between these modules. Each produces information needed by the next, and each contains points where authorities and stakeholders can question, validate or redirect the work.

> **THE PRACTICAL PROBLEM** The organisation responsible for the decision needs enough methodological understanding to lead and scrutinise the process. The specialist capabilities may already exist inside a river-basin authority, research consortium or partner organisation; where they do not, they can be commissioned.

This guide is for organisations that want to use a water-energy-food-ecosystems (WEFE) nexus perspective to improve policy development, river-basin planning or cross-sectoral coordination. It does not train readers to become climate modellers, system dynamics specialists or artificial-intelligence developers. Instead, it enables an authority to govern a technically credible and genuinely participatory process.

## How to use the guide?

- **Use it to** define a decision problem and the scope of a nexus assessment.
- **Use it to** understand which activities can be led internally and which require specialist support.
- **Use it to** specify, review and validate the products delivered by technical teams.
- **Use it to** turn model results into stakeholder-validated policy packages, governance roadmaps and commitments.

**THE ORGANISING PRINCIPLE** Every chapter distinguishes three things: what the authority does, what specialists do, and what outputs should be available before moving on.

| Reader | How the guide can be used |
|---|---|
| Primary users | River-basin authorities, ministries, water agencies, regional administrations, transboundary bodies and utilities can use it to lead, commission and quality-assure a nexus process. |
| Supporting practitioners | Governance and policy analysts, facilitators, consultants and technical teams can use it to understand interfaces, handovers and the decision context for their work. |
| Stakeholders and knowledge holders | Sector organisations, civil society, businesses, researchers and affected communities can use it to understand when and how their knowledge should influence the process. |

1. **Choose the route that matches your need.** Use the complete pathway for a full replication, or use individual modules when the immediate need is stakeholder engagement, governance diagnosis, policy coherence or roadmapping.
2. **Read Chapters 1–3 before commissioning models.** They establish the decision question, stakeholder landscape, governance conditions and candidate policy portfolio that give the technical work its purpose.
3. **Use Chapters 5–8 to specify and review specialist work.** The authority does not need to perform the calculations, but it should understand the assumptions, validation points, deliverables and acceptance questions.
4. **Return to Chapter 4 after policy exploration.** Use the preferred policy package, governance findings and stakeholder conditions to build an implementation pathway and commitments.
5. **Use the annex for orientation and transfer.** The case studies show how the approach was applied in different contexts; the one-page sheets support briefings, work-package design and completion checks.

**HOW TO READ IT** Part I groups the authority-led activities. Part II explains the technically specialised activities. The implementation sequence crosses between the two parts: stakeholder engagement and governance assessment come first; governance roadmaps are authority-led but are normally developed after scenario, modelling and NEPAT work.

## How much of the pathway is necessary?

Not every authority needs a full four-year research programme. Stakeholder and governance modules can be used independently to improve coordination or prepare a policy review. Scenario analysis and system dynamics modelling may be proportionate when decisions involve long-time horizons, major cross-sectoral effects or contested assumptions. NEPAT is most useful when a defined set of policies, goals, scenarios and models is ready for structured comparison. The appropriate level of effort should follow the decision risk and intended use—not the availability of a particular tool.

The methods should also be adapted to local governance arrangements, data availability, language, participation cultures and resources. Adaptation is expected; however, the core quality principles should remain: clear ownership, inclusive participation, traceable evidence, transparent assumptions, explicit uncertainty, stakeholder validation and a route from analysis to implementation.

# Abbreviations

The guide minimises abbreviations in the main text. The following short forms recur because they are used in the NEXOGENESIS methods, source documents or software.

| Abbreviation | Meaning | How it is used here |
|---|---|---|
| AI | Artificial intelligence | Broad term for computational methods used in the NEPAT decision-support component. |
| CFNG | Co-Creation Framework for Nexus Governance | The integrated NEXOGENESIS process consolidated in D1.5. |
| CLD | Causal-loop diagram | A qualitative representation of causal direction and feedback. |
| DSS | Decision-support system | NEPAT functions that search for policy combinations against selected goals. |
| IPCC | Intergovernmental Panel on Climate Change | Source framework for the RCP and SSP scenario families used in the project. |
| NEPAT | NExus Policy Assessment Tool | The NEXOGENESIS platform for exploring policies and packages. |
| NXG | NEXOGENESIS | The project acronym. |
| NXGAT | Nexus Governance Assessment Tool | NEXOGENESIS-developed tool for diagnosing governance conditions. |
| PCAT | Policy Coherence Assessment Tool | Structured assessment adapted in NEXOGENESIS to examine cross-sector policy interactions. |
| RCP | Representative Concentration Pathway | IPCC-related climate forcing pathway used to drive climate projections. |
| SDM | System dynamics model | A quantitative stock-and-flow model used to simulate nexus behaviour. |
| SHE | Stakeholder engagement | The project's structured process for identifying, involving and sustaining stakeholders. |
| SSP | Shared Socioeconomic Pathway | IPCC-related narrative and quantitative pathway for socio-economic change. |
| SVPP | Stakeholder-validated policy package | A package selected after technical exploration and stakeholder deliberation. |
| WEFE | Water–energy–food–ecosystems | The four connected domains considered throughout the guide. |

# Mini-glossary

These definitions are deliberately practical. Where a term has several academic meanings, the definition below describes how it is used in this guide.

| Term | Working definition |
|---|---|
| Co-creation | A structured process in which scientific, institutional and experiential knowledge influence problem framing, analysis, option development and validation; it does not mean that every participant has the same mandate. |
| Governance roadmap | A theory-of-change-based pathway that links a preferred policy package to changes in rules, relationships, capacities, resources, implementation practices and responsibilities. |
| Model output | A reviewable product of a modelling step—such as a conceptual map, causal-loop diagram, calibrated SDM or uncertainty result—with an owner, evidence trail and acceptance question. |
| Nexus | A way of examining how decisions and changes in one WEFE domain affect the others, including trade-offs, synergies, feedbacks and distributional effects. |
| Policy instrument | A law, plan, regulation, incentive, investment, programme, operating rule or other intervention that can influence the system. |
| Policy package | Two or more policy instruments assessed together because their combined effects may differ from the sum of their separate effects. |
| Robustness | The extent to which a policy package remains acceptable across plausible future scenarios and relevant uncertainty—not a claim that it will always be optimal. |
| Scenario | A coherent description of plausible future conditions used to test policy performance; it is not a prediction. |
| System / target / transformation knowledge | Knowledge about how the system works; what future is desired; and how change from the current to the desired situation may occur. |
| WEFE Footprint | A NEXOGENESIS cross-sector index and visualisation that summarises changes in water, energy, food and ecosystem performance relative to a reference. |

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# Executive summary

**IN ONE SENTENCE** NEXOGENESIS combines stakeholder and governance work with future scenarios, system dynamics modelling and NEPAT-supported policy exploration, then turns the preferred policy package into an implementable governance roadmap.

## What the project brought together

NEXOGENESIS responded to a familiar implementation problem: public decisions are made through sectoral mandates, yet their consequences travel across sectors and borders. Water allocation affects agricultural production, energy generation and ecosystems. Energy or agricultural policy can alter water demand and quality. Climate change and socio-economic development change several pressures at once. A nexus approach does not abolish sector mandates; it gives decision-makers a structured way to understand and negotiate their interactions.

Over four years, the project combined 20 partner organisations and five case studies into a shared learning process. Governance and policy researchers examined institutional conditions and policy coherence. Engagement teams worked with stakeholders to build system, target and transformation knowledge. Climate, land-use, socio-economic and sector specialists assembled future inputs. System dynamics teams translated relationships into quantitative basin models. The NEPAT team integrated those models, scenarios, policies and goals into an interactive platform. Case teams then used the evidence with stakeholders to validate packages and build governance roadmaps.

The guidebook therefore presents a chain of decisions rather than a catalogue of tools. Each stage reduces a different source of uncertainty: uncertainty about who and what matters; about mandates and policy interactions; about future conditions; about system feedbacks; about the performance of policy combinations; and about whether a preferred package can actually be implemented. The outputs become useful only when they are connected.

**METHOD AND EVIDENCE** *The integrated framework and its evolution across the five cases are synthesised in NEXOGENESIS D1.5 and D5.7. Scientific publications from the project provide method-specific grounding throughout the chapters.* *D1.5* · *D5.7* · *Publications*

## How co-creation develops

The framework uses three connected phases. Co-exploration builds a shared understanding of the problem, stakeholders, governance landscape and plausible futures. Co-design brings stakeholders and specialists together to shape models, assumptions, indicators and policy packages. Co-development validates preferred options and builds the governance pathway for implementation. Engagement is continuous: participation should become deeper as the consequences of choices become clearer.

Co-creation is not a promise that every participant makes every decision. It is a structured process for combining scientific, institutional and experiential knowledge while being explicit about mandates and influence. The level of participation can range from information and consultation to involvement, collaboration and—where participants have the legitimacy and capacity—shared ownership of decisions and actions.

| Knowledge produced | Central question | Examples in the pathway |
|---|---|---|
| System knowledge | What is happening, why, and how are WEFE sectors connected? | Stakeholder and governance maps, policy inventory, scenarios, conceptual models and system behaviour. |
| Target knowledge | What future conditions and policy goals are desirable? | Shared goals, indicators, policy targets, thresholds and criteria for comparing packages. |
| Transformation knowledge | How can the system move from the current situation toward the desired one? | Policy packages, implementation conditions, governance roadmaps, responsibilities and stakeholder commitments. |

The three knowledge types are not produced once. System knowledge expands as stakeholders and modellers identify feedbacks. Target knowledge becomes more specific when goals and indicators are configured in NEPAT. Transformation knowledge becomes credible only when organisations, mandates, resources and implementation conditions are made explicit in the roadmap. Co-creation is therefore an iterative movement between understanding, choosing and acting.

**ITERATION IS EXPECTED** The sequence is a planning aid, not a rigid waterfall. New stakeholders, data gaps, contested assumptions or unexpected model behaviour may require the team to return to earlier stages and revise the scope, policy portfolio or engagement plan.

Figure 1 translates the project into an indicative working sequence; Figure 1 shows the project logic. The figures should not be read as a rigid waterfall. Stakeholder input may require new variables; model results may expose an omitted policy; NEPAT may show that no current package is acceptable; and roadmap work may reveal an implementation barrier that changes the preferred policy. Iteration is part of quality assurance, not evidence that the process failed.

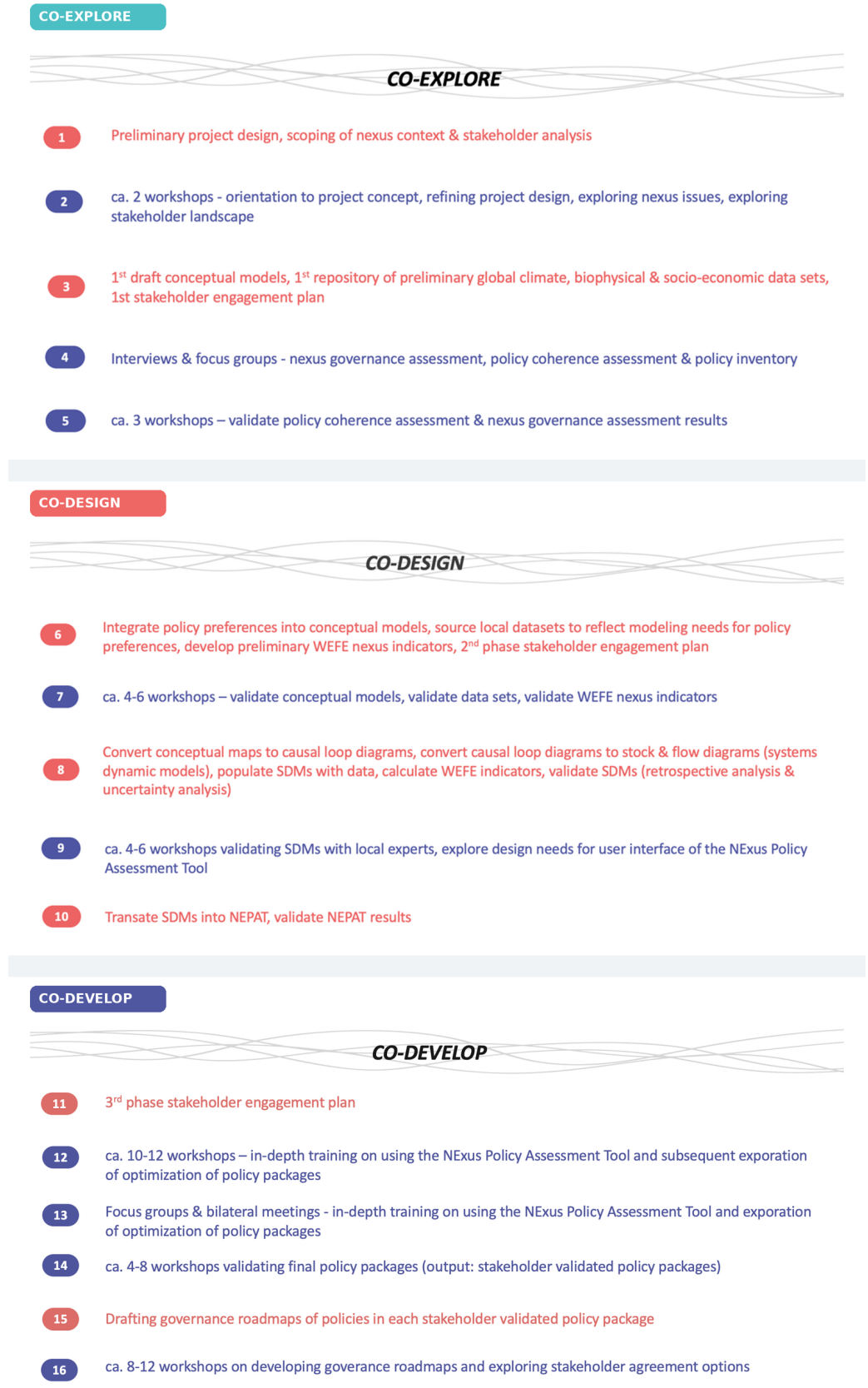



***Figure 1. Indicative implementation sequence across co-exploration, co-design and co-development. Project-team activities and stakeholder activities alternate and overlap; the number of workshops is indicative rather than prescriptive. Source: D1.5.***

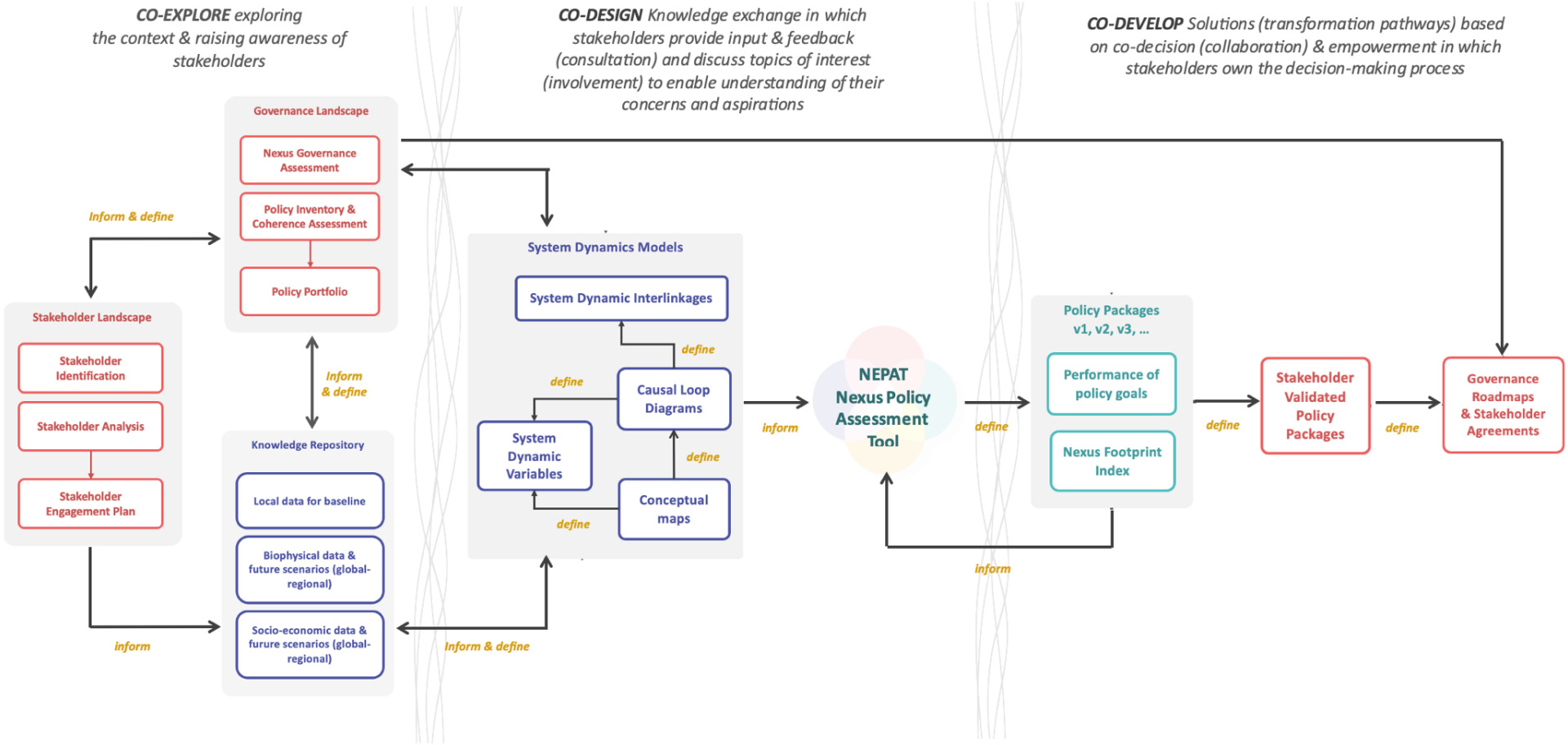



*Figure 2. NEXOGENESIS workflow showing how project activities and outputs connect across the co-creation process. Source: D1.5.*

## The six-stage pathway

The table below is a route map. It should be read from top to bottom as a developing argument. Engagement and governance work define the decision context. Scenarios and modelling create a testable representation of that context under change. NEPAT brings the evidence into a structured comparison of policy packages. The roadmap then returns the analysis to the organisations and relationships that must deliver change.

| Stage | Module | Purpose | Lead arrangement | Co-creation phase |
|---|---|---|---|---|
| 1 | Stakeholder engagement | Build legitimacy, local knowledge and an engagement plan. | Authority-led; facilitation support helpful | Co-explore |
| 2 | Governance and policy assessment | Identify governance barriers, enablers, policy gaps and candidate policies. | Authority-led with governance expertise | Co-explore |
| 3 | Future scenarios | Describe plausible climate, biophysical and socio-economic futures. | Specialist-led; authority specifies needs | Co-explore |
| 4 | System dynamics modelling | Represent nexus relationships and simulate system responses. | Specialist-led; stakeholders co-frame and validate | Co-design |
| 5 | NEPAT policy exploration | Compare policy packages, trade-offs and synergies under scenarios. | Specialist configuration; authority-led use and deliberation | Co-design |
| 6 | Governance roadmaps | Translate a preferred package into outcomes, actions, responsibilities and commitments. | Authority-led with stakeholder facilitation | Co-develop |

The sequence is deliberately asymmetric. Authorities or research consortia should retain ownership of the public decision, but specialist capabilities may be located inside or outside the lead organisation. For example, an authority with its own climate unit may complete much of the scenario work internally; a research consortium may already include system dynamics and software expertise. The important question is not who holds the job title, but whether the required capability, quality assurance and interface with stakeholders are present.

## What authorities can do and what requires support

The division below is indicative rather than prescriptive. “Authority-led” means that the accountable organisation defines purpose, accepts outputs and controls their use. “Specialist” means that a task depends on a technical method or software capability. The same organisation may fulfil both roles, provided responsibilities and review are explicit.

| Usually led by the authority | Usually commissioned from specialists |
|---|---|
| Define the decision problem and geographic scope | Select and downscale climate and socio-economic scenarios |
| Map stakeholders and design engagement | Harmonise and document modelling datasets |
| Convene and facilitate cross-sector dialogue | Build, calibrate and test system dynamics models |
| Assess governance and policy coherence | Configure the models, policy portfolio and scenarios in NEPAT |
| Review assumptions and validate practical relevance | Run technical sensitivity, what-if and uncertainty analyses |
| Develop roadmaps, assign responsibilities and agree actions | Maintain technical architecture, code, data pipelines and model documentation |

The handover between these columns is a recurring risk. A technically correct dataset or model can still be unusable if it answers the wrong question, represents policies at the wrong scale or arrives after the decision window.

Conversely, local preferences cannot replace transparent evidence about system behaviour. Each chapter therefore includes participation points, expected outputs and acceptance questions that keep the two sides connected.

## A typical project team

A workable team needs policy authority, coordination, facilitation, governance analysis, technical modelling and software integration. In smaller applications, one person may cover several roles. In larger or transboundary applications, roles may be distributed across authorities, universities, consultancies and civil-society partners. What matters is that no core responsibility is left implicit.

| Role | Core responsibility |
|---|---|
| Accountable authority / project sponsor | Provides mandate, decides scope, convenes institutions, approves outputs and owns follow-up. |
| Project manager / basin coordinator | Coordinates work packages, timeline, quality gates, risks and interfaces between teams. |
| Governance and policy team | Leads governance assessment, policy inventory and coherence assessment; supports roadmap development. |
| Stakeholder engagement lead/team | Designs inclusive engagement, facilitation, communication, documentation and evaluation. |
| Technical modelling team | Covers climate and socio-economic scenarios, data engineering, domain models, system dynamics and uncertainty. |
| NEPAT specialist | Configures the platform, connects model outputs, tests policy scenarios and supports users. |
| Sector experts and local knowledge holders | Test assumptions, interpret relationships, flag omissions and assess feasibility. |

**MINIMUM VIABLE USE** An authority can use the governance and stakeholder modules without implementing the full technical chain. A full NEXOGENESIS replication requires the six modules to be connected and iterated, not merely completed as separate reports.

## What the reader should expect at the end

A successful application does not end with a model dashboard. It ends with an evidence-backed and stakeholder-tested account of what should change, why, under which future conditions, with which safeguards, and through whose action. The central decision output is the stakeholder-validated policy package. The central implementation output is the governance roadmap: a results chain and action plan that connect policy change on paper with change in practice.

NEXOGENESIS case studies reached different forms of continuation. Nestos/Mesta signatories committed to continue cooperation and promote roadmap policies; Lielupe partners signed a Letter of Intent for cross-sectoral and cross-border collaboration; the Lower Jiu work was connected through agreements with national sustainable-development structures and the basin administration; the Adige Water Fair widened dialogue; and Inkomati-Usuthu stakeholders identified routes for continued collaboration. These differences are a strength: replication should pursue the form of institutional anchoring that fits the local mandate and opportunity.

PART I

# What river basin authorities can lead

The authority provides mandate, local knowledge, legitimacy, convening power and continuity. Specialist facilitation can strengthen these activities, but ownership should remain with the responsible institutions.

01 **Getting started**

02 **Understanding the stakeholder landscape**

03 **Understanding governance and policy**

04 **Developing governance roadmaps**

CHAPTER 1

# Getting started

*Define the decision before selecting the methods.*

| | |
|---|---|
| **What the authority does** | Name the decision problem, set the geographic and institutional scope, appoint a sponsor, define objectives and agree how outputs will be used. |
| **What specialists do** | Advise on feasibility, data needs, methodological options and the technical implications of the chosen scope. |
| **Outputs you should expect** | A project charter, scope statement, initial stakeholder register, decision calendar and agreed quality gates. |
| **Capacity level** | Low to moderate. This should normally be led by the commissioning authority. |

## Start with a decision, not a tool

A nexus assessment becomes useful when it is anchored in an identifiable decision: for example, revising a river basin management plan, comparing drought-response options, coordinating agricultural and energy policies, or testing a package of measures under future climate conditions. Starting from “we want to use NEPAT” or “we need a model” can produce technically interesting work that is poorly connected to an institutional mandate.

Define the problem in a way that makes the interdependencies visible. The statement should identify the affected resources and sectors, the decision-makers, the time horizon and the consequences of taking—or not taking—action. Keep the first scope narrow enough to manage, while documenting important issues that remain outside it.

## Six questions for the project charter

1. **Decision question.** What concrete choice, plan, policy or negotiation will the process inform?
2. **System boundary.** Which basin, sub-basin or administrative area; which WEFE sectors; which time horizon?
3. **Mandate and ownership.** Who commissions the work, who approves outputs and who is responsible after the project?
4. **Stakeholder purpose.** Whose knowledge, interests, authority and consent are needed at each stage?
5. **Evidence standard.** What data, models, uncertainty information and documentation are needed for the decision to be credible?
6. **Use pathway.** Where will the results enter an official planning, budgeting, consultation or policy process?

## Define the scope at four levels

| Scope dimension | Questions to settle | Typical output |
|---|---|---|
| Geographic | Whole basin, sub-basin, transboundary system, municipality or service area? | Map and boundary statement |
| Thematic | Which water, energy, food and ecosystem relationships are material to the decision? | Problem statement and initial causal narrative |
| Institutional | Which authorities have mandates, data, implementation powers or veto points? | Responsibility map and sponsor |
| Temporal | Which baseline, planning horizon and future periods matter? | Decision calendar and scenario horizons |

Scope is a decision about usefulness, not only geography. A whole-basin boundary may be scientifically appealing but too broad for the institution that must act. An administrative boundary may fit a mandate but omit an upstream

driver or downstream effect. Record both the primary decision boundary and the material external relationships. The model and engagement plan can then represent external drivers explicitly without pretending that the lead organisation controls them.

## Match the pathway to the decision risk

Not every problem needs the full NEXOGENESIS chain at the same depth. Proportionality depends on the consequences of error, the irreversibility and cost of the decision, the number of affected sectors and groups, the time horizon, the level of disagreement and the importance of future uncertainty. The scoping group should document why the proposed level of analysis is sufficient.

| Decision situation | Proportionate starting point | Escalate the analysis when |
|---|---|---|
| Coordination or policy-screening question | Stakeholder analysis, NXGAT, policy inventory and a facilitated coherence review. | Important feedbacks, long time horizons or contested quantitative claims emerge. |
| Plan or programme revision | Full governance and policy assessment, targeted scenarios, a fit-for-purpose SDM and structured package comparison. | The plan affects several sectors, major investments or vulnerable ecosystems/groups. |
| Major infrastructure or allocation choice | Full pathway with detailed scenario, model, uncertainty, feasibility and distributional analysis. | The decision is difficult to reverse, crosses borders or depends strongly on future conditions. |
| Research or innovation application | A clearly identified user and decision pathway plus the methods needed to answer the research question. | Tool development begins to outrun policy relevance, access, maintenance or user capacity. |

A modular application should still preserve interfaces. For example, a policy-coherence assessment completed without modelling should record the policy mechanisms and data needs that a future model would require. A stand-alone roadmap exercise should state how the preferred policy was selected and what evidence supports it. Modularity should reduce effort, not break traceability.

## Establish governance for the project itself

A nexus project coordinates multiple disciplines and organisations, so it needs a governance arrangement of its own. Separate accountability for the decision from technical responsibility for analysis. Name the forum that resolves scope disputes, approves changes and accepts cross-work-package handovers. In transboundary work, clarify whether decisions are joint, parallel or advisory and how differences are recorded.

| Project function | Minimum responsibility | Practical arrangement |
|---|---|---|
| Sponsor / accountable owner | Protects the decision link, secures institutional access and accepts the final decision products. | Named senior role with a documented escalation route. |
| Steering or commissioning group | Approves scope, resources, quality gates, major changes and use of results. | Small cross-sector group meeting at defined decision points. |
| Case / project manager | Coordinates schedule, dependencies, issue log, versions, meetings and handovers. | Single operational point of accountability with authority to convene teams. |
| Method leads | Own evidence standards and outputs for engagement, governance, scenarios, SDM and NEPAT. | Named leads and deputies with a shared interface register. |
| Stakeholder or advisory forum | Tests relevance, assumptions, interpretations and implementation conditions. | Purpose and influence defined for each activity; not treated as a substitute steering body. |
| Independent review | Challenges method choices, reproducibility and material conflicts of interest. | Peer review, external expert panel or targeted second-modeller checks. |

Use a simple responsibility matrix for every major output: one accountable owner, named responsible producers, actors to consult and audiences to inform. Avoid assigning accountability to a consortium, working group or “stakeholders” collectively. If no organisation will accept an output, the project has not yet found a use pathway.

## Complete an initial evidence and capability scan

The scan is not a full data assessment. It identifies whether the proposed scope is plausible and which gaps affect schedule, cost or method. Include quantitative datasets, models, legal and policy documents, institutional knowledge, local and Indigenous knowledge where relevant, software, licences, staff capability and existing engagement relationships.

| Scan area | Questions to answer | Scoping decision |
|---|---|---|
| Existing decisions and studies | What plans, models, assessments or consultations already exist, and what can be reused? | Reuse, update or explain why a new analysis is necessary. |
| Data and models | Are important variables available at the required scale, period and licence? Are accepted operational models already in use? | Adjust scope, obtain access, identify proxies or plan targeted development. |
| Institutional and policy evidence | Can the team access policy documents, implementation records and knowledgeable respondents? | Define confidentiality, interview and document-review arrangements. |
| Technical capability | Which scenario, GIS, sector, SDM, uncertainty and software-integration skills exist inside the partnership? | Allocate internal roles, add partners, commission support or narrow the method. |
| Participation conditions | Are affected groups reachable, is there stakeholder fatigue, and what language, access or safeguarding needs exist? | Set engagement resources, timing, formats and inclusion measures. |

**DO NOT CONFUSE "NO DATA" WITH "NO ISSUE"** Missing data may reflect institutional silos, commercial sensitivity or historically excluded sectors. Record the substantive issue and decide whether to collect data, use a transparent proxy, represent it qualitatively or retain it as an explicit limitation.

## Set ethical, data and transparency conditions early

Stakeholder information and model data may be sensitive. Agree consent, confidentiality, personal-data access, data licences, attribution, conflict-of-interest disclosure and publication rules before collection begins. Explain which outputs will be public, which will be shared only in aggregated form and who can request corrections. Participatory modelling also requires transparency about how some perspectives are translated into model structure while others are excluded.

| Condition | Minimum safeguard |
|---|---|
| Consent and participation | Clear purpose, voluntary participation where applicable, withdrawal route and explanation of influence and limits. |
| Personal and sensitive data | Data minimisation, restricted access, retention period and agreed aggregation or anonymisation. |
| Model and data ownership | Licences, editable-file access, version rights, publication conditions and post-project custodian. |
| Conflicts of interest and power | Disclosure, neutral facilitation where needed and a route for minority or dissenting views to be recorded. |
| Transparency of decisions | Decision log linking scope changes, exclusions and accepted/rejected stakeholder or reviewer input to reasons. |

## Design quality gates and an interface register

The implementation sequence crosses organisational boundaries. An interface register prevents silent assumptions from moving downstream. For each handover, name the supplying and receiving teams, required format, version, acceptance test, open issue and date. A quality gate is passed only when the receiving team can use and explain the output—not when the supplying team has merely submitted it.

| Gate | Minimum evidence | Decision if not ready |
|---|---|---|
| Scope to stakeholder/governance work | Charter, boundary, use pathway, sponsor and engagement purpose. | Revise the question or secure ownership before broad engagement. |
| Governance/policy to technical work | Validated problems, goals, policy portfolio, mechanisms, institutional constraints and evidence trail. | Resolve ambiguity or carry explicit alternative interpretations. |
| Scenario data to SDM | Versioned variables, scenario labels, processing metadata, uncertainty and acceptance checks. | Correct, replace or document a justified limitation/proxy. |
| SDM to NEPAT | Accepted model behaviour, policy controls, deterministic/stochastic versions and reproducible test cases. | Do not configure stakeholder comparison until translation matches. |
| NEPAT to roadmap | Validated package, rationale, trade-offs, scenario dependencies, feasibility conditions and objections. | Repeat exploration or revise the portfolio if no package is acceptable. |

**METHOD AND EVIDENCE** *Project start-up draws on established programme, transdisciplinary and data-governance practice. The NEXOGENESIS-specific contribution is the interface sequence connecting co-creation, governance, scenarios, SDM, NEPAT and roadmapping; see D1.5 · D5.7*

## Suggested start-up sequence

1. **Convene a small commissioning group.** Include the responsible authority, policy and engagement leads, and someone able to assess data and modelling implications.
2. **Draft the project charter.** Use existing plans, mandates and known conflicts; record unresolved choices rather than hiding them.
3. **Test the charter with key stakeholders.** Check whether the problem is recognisable, whether important groups or impacts are missing, and whether the intended outputs could influence a real decision.
4. **Issue a technical scoping brief.** Ask specialists to propose a proportionate approach, data plan, uncertainty strategy, timeline and validation points.
5. **Approve quality gates.** Do not let technical work advance until scope, assumptions, stakeholder roles and intended uses are agreed.

**READINESS GATE** Proceed when the sponsor, decision question, scope, stakeholder purpose and intended use are explicit. If any of these remain vague, technical precision will not make the process decision-relevant.

## Project charter — minimum content

| Charter field | What to record |
|---|---|
| Sponsor and owner | The accountable institution, named sponsor and operational project manager. |
| Decision question | The concrete plan, policy, investment or negotiation the work will inform. |
| Scope and exclusions | Geographic, thematic, institutional and temporal boundaries, plus documented exclusions. |
| Outputs and use | Required products, target users and the formal process or decision point they will enter. |
| Stakeholder plan | Who needs to shape, validate, approve or be informed about each stage. |
| Technical interfaces | Specialist tasks, data dependencies, handovers and validation responsibilities. |
| Quality gates | Evidence and sign-off required before the project advances to the next stage. |
| Delivery conditions | Timeline, resources, major risks, ownership, maintenance and update arrangements. |

CHAPTER 2

# Understanding the stakeholder landscape

*Build the relationships and engagement conditions needed for every later stage.*

| | |
|---|---|
| **What the authority does** | Define engagement aims; identify and categorise stakeholders; assess influence, interest and relationships; choose formats; maintain participation; evaluate and update the plan. |
| **What specialists do** | A facilitator or participation specialist can design inclusive processes, manage sensitive dynamics, support consent and data protection, and evaluate participation quality. |
| **Outputs you should expect** | Stakeholder register and map, power-interest matrix, actor-linkage matrix, engagement plan, communication plan and evaluation record. |
| **Capacity level** | Moderate. Policy and facilitation skills are essential; advanced modelling expertise is not required. |

## Why this is needed

Nexus decisions affect organisations and communities with different mandates, knowledge, resources and exposure to risk. Stakeholder engagement helps fill knowledge gaps, identify trade-offs, test whether policies work in practice and build the legitimacy needed for implementation. It is not a single workshop. It is an iterative process that should be reviewed as the project moves from co-exploration to co-design and co-development.

Two choices should be made for every engagement activity (Figure 3). The first is the level of engagement: are participants being informed, consulted, involved in shaping an output, collaborating in its production, or empowered to make or implement a decision? The second is the type of knowledge being sought: system knowledge about what is happening and why; target knowledge about the desired future; or transformation knowledge about how to move from the current to the desired situation. Making both choices explicit prevents a workshop from promising more influence than it can deliver or collecting information that has no route into the analysis.

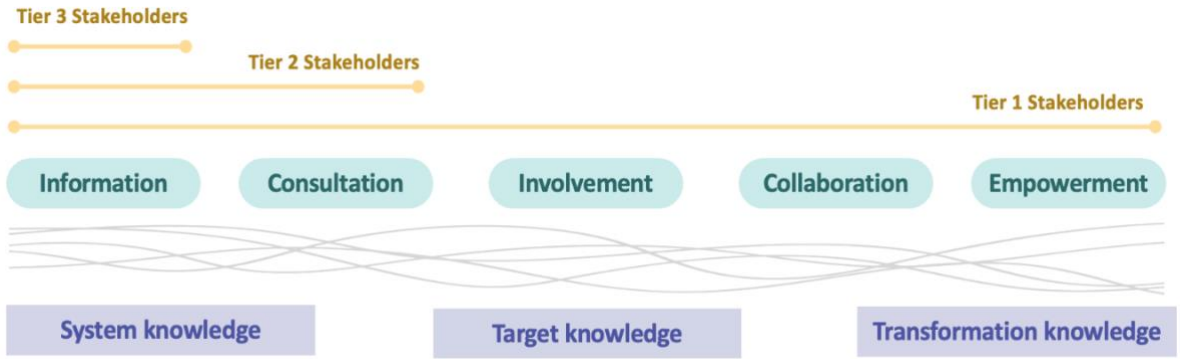



*Figure 3. Relationship between stakeholder tiers, levels of engagement and the generation of system, target and transformation knowledge. The intended level should be chosen for each activity rather than assumed from stakeholder category alone. Source: NEXOGENESIS D1.1/D1.5.*

## Choose the level of engagement deliberately

| Level | What participants can reasonably expect | Typical NEXOGENESIS use |
|---|---|---|
| Information sharing | Receive timely, accessible and relevant information; ask questions and understand what will happen next. | Project orientation, scenario briefings, publication of results and updates between workshops. |
| Consultation | Provide views, evidence or preferences that the team considers and responds to; the accountable body retains the decision. | Interviews, policy and governance validation, review of data gaps and proposed indicators. |
| Involvement | Work directly with the team so concerns and knowledge are reflected in the output, with a visible feedback trail. | Participatory system mapping, review of causal relationships, goal and policy refinement. |
| Collaboration | Share responsibility for producing or validating an output and negotiate differences with other actors. | Co-design of policy packages, NEPAT exploration and governance-roadmap development. |
| Empowerment | Exercise legitimate authority or capacity to decide, commit resources or lead implementation. | Endorsement of a roadmap, formal agreement, delegated action or ownership of follow-up structures. |

Higher engagement is not automatically better. Information may be the appropriate level for a statutory notice; consultation may be appropriate where an elected or legally mandated body must decide; collaboration may be essential where implementation is shared. Empowerment is credible only when participants have the mandate, resources and safeguards to act. The ethical requirement is alignment: the invitation, method, decision rights and feedback should describe the same level of influence.

## Connect engagement to the knowledge needed

| Knowledge type | Practical question | Useful engagement formats | Where it enters the pathway |
|---|---|---|---|
| System knowledge | What is happening, who is affected, and how do WEFE relationships and governance conditions work? | Interviews, mapping, timelines, problem trees, conceptual maps and validation workshops. | Scope, stakeholder analysis, NXGAT, scenarios and conceptual/causal models. |
| Target knowledge | What should improve, for whom, by how much and within which constraints? | Visioning, indicator review, target negotiation, ranking and deliberation. | Policy goals, targets, NEPAT objective settings and package-comparison criteria. |
| Transformation knowledge | Which policies, capacities, relationships and actions can move the system toward the target? | Policy labs, package comparison, theory-of-change work and commitment sessions. | Stakeholder-validated packages, governance roadmaps, agreements and implementation plans. |

**METHOD AND EVIDENCE** *The NEXOGENESIS stakeholder method integrates established co-production and participation literature with case-tested project procedures. Avellán et al. (2025) describes the NXG approach; Papadopoulou et al. (2025) describes the application project's systematic WEFE engagement methodology; D5.1 and D5.7 document implementation and lessons.* *Avellán et al. (2025) · Papadopolou et al (2025) · D5.1/D5.7*

## A practical five-step process

1. **Define engagement aims.** State what the project needs from engagement and what participants should gain. Distinguish information-sharing, consultation, involvement, collaboration and empowerment.
2. **Analyse the stakeholder landscape.** Identify affected and influential actors across WEFE domains and governance levels; assess their interests, power, relationships and possible barriers to participation.
3. **Develop the engagement plan.** Match stakeholder groups to activities, timing, format, level of influence, communication needs and feedback commitments.
4. **Manage and sustain participation.** Maintain contact, close feedback loops, respond to changes, recognise contributions and create realistic opportunities for continued involvement.

5. **Evaluate and adapt.** Review participation, inclusion, learning, influence on outputs and unintended effects at each phase transition.




*Figure 4. Five linked elements of the stakeholder engagement process: aims, analysis, planning, management and sustainment, and evaluation. Source: D5.1.*

The five process steps and the engagement levels answer different questions (Figure 4). The process steps organise the engagement programme over time; the engagement level describes the influence offered in a particular activity. A stakeholder may receive information during project orientation, be involved in conceptual mapping, collaborate in policy-package validation and later be empowered to sign or implement an agreement. Record these transitions in the engagement plan.

## Who should be considered?

Begin with the organisations and people who affect or are affected by the focal nexus problem. Include actors with formal authority as well as groups whose knowledge, livelihoods or rights are material. Relevant categories may include civil society, public initiatives, municipal and national policymakers, agricultural, energy, water and environmental authorities, river basin organisations, businesses and utilities, media and science communicators, and research organisations.

- **Tier 1 — steering and management:** actors whose mandate, authority or technical contribution is central to the process.
- **Tier 2 — active involvement:** actors with a direct interest or strong practical knowledge who should shape or validate outputs.
- **Tier 3 — wider reach:** actors with a general interest who should be informed, consulted selectively or invited to broader events.

## Four practical analysis products

| Product | Minimum content | How it is used |
|---|---|---|
| Stakeholder register | Name or organisation, sector, governance level, mandate, location, contact route, interests, expected contribution, consent status and engagement history. | Maintains a traceable and updateable record; access should be restricted where it contains personal data. |
| Tier classification | Tier 1 steering/management, Tier 2 active involvement and Tier 3 wider information or selective consultation. | Matches intensity of engagement to role and relevance; tiers should be reviewed as the project evolves. |
| Power-interest map | Relative ability to influence the issue and level of interest in it, with the evidence or reasoning for placement. | Identifies where tailored engagement, empowerment or careful expectation management may be needed. |
| Actor-linkage matrix | Relationships between pairs of actors, for example cooperation, complementarity, conflict or no established relationship. | Reveals coordination gaps, potential alliances, tensions and where a neutral convenor may be valuable. |

**DO NOT EQUATE POWER WITH IMPORTANCE** Low-power or hard-to-reach groups may be highly affected by decisions. Use the power-interest matrix to plan engagement—not to justify exclusion.

These are living products rather than one-off classifications. Update them after interviews and workshops, when mandates change, when new affected groups emerge, or when the process moves from problem exploration to policy design and implementation. Record uncertainty: an assumed relationship should not be presented as a verified fact.

## Choosing an engagement format

| Format | Best used when | Watch for |
|---|---|---|
| Face-to-face | Trust-building, sensitive dialogue, relationship development and collaborative mapping are central. | Travel, accessibility, neutrality of venue, visas, interpretation and cost. |
| Online | Geographic reach, flexible attendance, recording and rapid information-sharing matter most. | Digital access, distraction, weak informal interaction and limited non-verbal feedback. |
| Hybrid | Inclusion requires both local and remote participation. | Unequal participation between rooms, technical failures and higher facilitation demands. |

**NXG PRACTICE INSIGHT** In the Lielupe case study, informal exchanges during face-to-face breaks helped stakeholders discover potential joint funding opportunities. This illustrates why the value of an engagement format is not limited to the formal agenda.

## Build an engagement plan that can be managed

The plan should connect each activity to a purpose and to an expected use of the information. Avoid inviting the same people to a long sequence of workshops without showing how their input has influenced the work. An overarching schedule can establish milestones, while the detailed design of each workshop should be adjusted to the latest project needs and participant capacity.

| Planning field | Questions to answer |
|---|---|
| Purpose and knowledge need | Is the activity intended to inform, consult, co-design, validate, negotiate or build capacity? What system, target or transformation knowledge is needed? |
| Participants and influence | Who needs to attend, whose voice is at risk of being absent, and what influence will participants have over the output? |
| Format and accessibility | Which venue, language, timing, interpretation, digital access, facilitation and safeguarding arrangements are required? |
| Inputs and outputs | What accessible pre-reading is needed? What decisions, maps, corrections, preferences or commitments should result? |
| Feedback and documentation | Who records the discussion, how will disagreement be represented, and when will participants see how their input was used? |
| Owner and resources | Who is responsible, what staff time and budget are available, and how will follow-up be maintained? |

## Manage, sustain and evaluate participation

Stakeholder fatigue is a delivery risk. It increases when activities are repetitive, highly technical, poorly timed or disconnected from visible decisions. Sustainment begins early: clarify expectations, communicate limits, acknowledge contributions, close feedback loops and create realistic opportunities for participants to continue collaborating beyond the project.

- **Monitor participation, not only attendance.** Check sector, gender, governance-level and affected-group representation, but also who speaks, whose knowledge changes the work and who repeatedly withdraws.
- **Evaluate the quality of co-creation.** Use short surveys, facilitated reflection, interviews or workshop exercises to examine trust, learning, influence, usefulness and unintended effects.
- **Adapt the plan.** Change timing, formats, facilitation, language or participant mix when evidence shows that the process is excluding people or failing to generate usable knowledge.

- **Plan for continuity.** Identify organisations, working groups, agreements, funding opportunities or formal planning processes that can carry relationships and actions forward.

## Communication and exploitation are part of engagement

Communication makes the work understandable and keeps different stakeholder groups informed. Exploitation concerns the practical uptake and continued use of project results. The two should be planned together: a factsheet, dashboard, training session, policy brief or data product is useful only if it is tailored to a real audience, delivered through an appropriate channel and connected to an opportunity for use.

> **CLOSE THE LOOP** After every major engagement activity, tell participants what was heard, what changed, what could not be incorporated and what happens next. Silence after consultation undermines trust and future participation.

## Quality check before moving on

- Stakeholder selection covers all material WEFE domains, governance levels and affected groups.
- Participants know what influence they have and how their contributions will be used.
- Consent, data protection, cultural and accessibility needs are addressed.
- Important disagreements, power imbalances and missing voices are documented.
- The engagement plan has owners, timing, resources, feedback loops and evaluation points.

## NXG resources

- D5.1 Report on Stakeholder Engagement
- D1.1 Stakeholders' co-creation approach for WEFE nexus governance
- D5.7 Recommendations and lessons learned from all case studies

CHAPTER 3

# Understanding governance and policy

*Identify the conditions that enable or block nexus-oriented action.*

| | |
|---|---|
| **What the authority does** | Commission and help conduct the governance assessment, provide policy documents, identify interviewees, interpret institutional realities, validate findings and select candidate policies. |
| **What specialists do** | Governance and policy analysts design interviews and coding, apply NXGAT, assess policy coherence, document evidence and facilitate validation. |
| **Outputs you should expect** | Governance barriers and enablers, validated NXGAT assessment, policy inventory, coherence matrix, policy gaps and a candidate policy portfolio. |
| **Capacity level** | Moderate. This can often be led by ministry or basin staff with independent expert facilitation. |

## Two complementary assessments

The governance assessment asks whether the institutional context supports cross-sectoral coordination and implementation. The policy coherence assessment asks how the content and implementation of policies across WEFE domains reinforce, weaken or overlook one another. Together they provide the institutional and policy baseline for selecting policies, interpreting model results and later designing a governance roadmap.

The two assessments should be interpreted together. A policy may look coherent on paper yet fail because responsibilities, resources or cross-level relationships are weak. Conversely, committed organisations may have little room to coordinate if sectoral objectives and instruments contradict one another. NXGAT explains the governance conditions; the coherence assessment explains the policy interactions. Their combined findings tell the modelling team which interventions matter and tell the roadmap team which institutional changes may be needed.

| Assessment | Core question | Evidence | Main use |
|---|---|---|---|
| Nexus governance assessment (NXGAT) | How supportive is the governance context for integrated WEFE action? | Interviews, documents, institutional experience and stakeholder validation | Identify barriers, enablers and entry points |
| Policy inventory and coherence assessment | How do policy objectives, instruments and implementation arrangements interact? | Policy texts, plans, legal and implementation information, expert judgement | Identify gaps, synergies, conflicts and candidate policies |

## What NXGAT examines

The Nexus Governance Assessment Tool (NXGAT) combines five governance dimensions with five quality criteria. The matrix is used to structure interviews and evidence, not to reduce governance to a single score. Each judgement should be accompanied by a short explanation of the barriers, enabling conditions and leverage points that produced it.

| Governance dimension | Question for the assessment |
|---|---|
| Levels and scales | Are relevant administrative, geographic and ecological levels involved, coordinated and able to adjust to the scale of the nexus problem? |

| Governance dimension | Question for the assessment |
|---|---|
| Actors and networks | Are affected and influential actors included, and are relationships sufficiently cooperative, trusted and adaptable? |
| Problem perspectives and goal ambitions | Are different sectoral problem definitions recognised and translated into mutually compatible nexus goals? |
| Strategies and instruments | Do policies and instruments cover the nexus problem, reinforce one another and create sufficient incentives or pressure for action? |
| Responsibilities and resources | Are mandates, accountability, finance, staff, knowledge and implementation capacity adequate and appropriately coordinated? |

| Quality criterion | Meaning in NXGAT |
|---|---|
| Comprehensiveness | The degree to which relevant WEFE elements are included. |
| Coherence | The degree to which governance elements strengthen rather than weaken one another. |
| Flexibility | The capacity to use different pathways, include new actors or adapt arrangements when conditions change. |
| Intensity of action | The strength of incentives or pressure for nexus-oriented behavioural change or management reform. |
| Fit | The degree to which governance arrangements match ecosystem properties, functions and spatial or temporal dynamics. |

**SCORING WITH EXPLANATION** The original NXGAT uses a four-level scale from very low to very high. Scores are useful for synthesis, but the evidence, reasoning and differences between stakeholder perspectives are more important than the number alone.

**METHOD AND EVIDENCE** *NXGAT was developed within NEXOGENESIS and applied comparatively in the Lielupe and Mesta–Nestos basins. The scientific governance analysis is reported by Mooren et al. (2024) and Moreen et al. (2025); D1.2 and D1.5 contain the operational protocol.* *Moreen et al. (2024) · Moreen et al. (2025) · D1.2 · D1.5*

## Run the governance assessment

1. **Prepare the team and evidence protocol.** Agree the scope, governance dimensions, interview guide, scoring approach, confidentiality arrangements and respondent mix.
2. **Conduct interviews.** Use knowledgeable respondents across sectors and levels. Record the evidence and reasoning behind every assessment—not only a score.
3. **Analyse and interpret.** Compare perspectives, identify consistent patterns and explain why specific governance conditions support or obstruct nexus action.
4. **Assess overall supportiveness.** Synthesize results into barriers, enablers and potential intervention points. Keep disagreement visible.
5. **Validate with stakeholders.** Share an accessible factsheet before the workshop; test the interpretation and revise findings where justified.

## Practical interview and analysis protocol

- **Assemble a mixed team.** Combine governance and policy expertise with local institutional knowledge. Use independent facilitation where political sensitivities or power differences make this valuable.
- **Plan sufficient preparation.** Define the focal nexus problems, adapt the interview guide, identify respondents across sectors and levels, arrange consent and confidentiality, and allow for local languages.
- **Seek breadth and depth.** Approximately 15–20 knowledgeable stakeholders per country as a starting point, adjusted to basin scale, actor diversity and saturation of findings.
- **Allow time for reflection.** NXGAT interviews may require around 90 minutes because respondents need to discuss cross-sector relationships and justify assessments; shorter formats can be used if the scope is narrower.
- **Debrief and triangulate.** Hold team debriefs after interviews, compare notes, use documents and contextual research, and distinguish isolated perceptions from recurring patterns.

- **Retain a stakeholder self-assessment.** Ask respondents for an overall view of cross-sectoral integration, then compare this with the structured matrix assessment.

## Build the policy inventory and assess coherence

1. **Identify relevant policies.** Use the nexus problem and governance assessment to define inclusion criteria across water, energy, food, ecosystems and climate.
2. **Build a structured inventory.** Record objectives, instruments, spatial and temporal scope, responsible institutions, target groups and implementation status.
3. **Assess interactions.** Examine whether policies reinforce, enable, constrain, contradict or fail to address one another. Document the mechanism and evidence for each judgement.
4. **Define a candidate portfolio.** Select policies and policy goals that are decision-relevant, sufficiently specified and—if they will be modelled—measurable and supported by data.

## Make policy-coherence judgements reproducible

The source methodology uses a four-point scale to examine how strongly each policy recognises and addresses expected interactions with other WEFE sectors. At least two policy experts should review the documents independently, record textual evidence for their judgements and reconcile differences. A local expert or stakeholder review then tests whether the interpretation reflects implementation practice rather than policy wording alone.

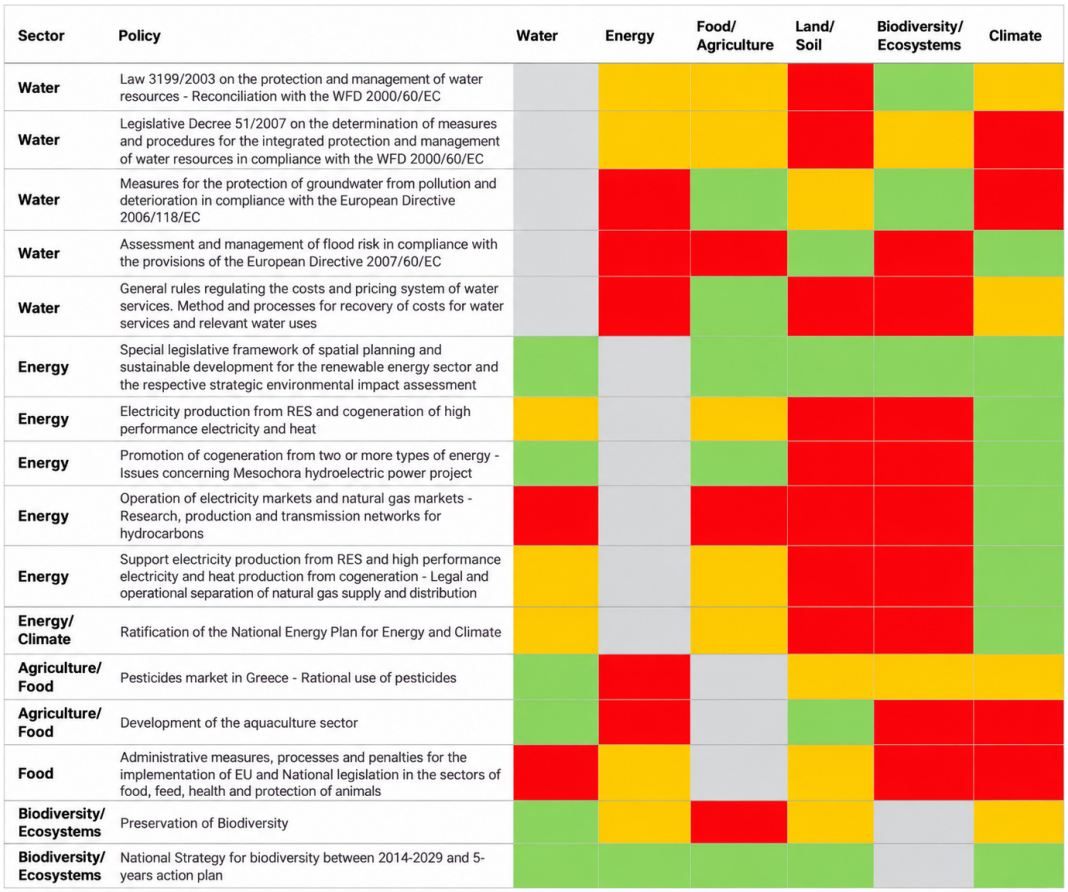
| Evidence level | Interpretation |
|---|---|
| No recognition | The policy does not acknowledge the relevant cross-sector interaction. |
| Recognition | The interaction, trade-off or synergy is mentioned but no operational response is specified. |
| Mechanism or instrument | The policy includes a measure, coordination mechanism or instrument that addresses the interaction. |
| Target or accountable implementation | The interaction is linked to a measurable target, assigned responsibility, implementation provision or monitoring requirement. |

The labels above are a plain-language rendering for this implementation guide. When applying the formal NEXOGENESIS scoring protocol, use the detailed definitions and templates in D1.2 and D1.5 and document any adaptation.

**METHOD AND EVIDENCE** *The NEXOGENESIS policy-coherence assessment adapts an established interaction-scoring lineage: Munaretto and Witmer (2017), Papadopoulou et al. (2020) and Nilsson et al. (2017). Mooren et al. (2025) describes the project's methodological framework for assessing WEFE policy coherence at river-basin level.* *Moreen et al. (2025) · D1.2 · D1.5*

## What results can look like: Nestos policy-coherence assessment

A matrix becomes useful when it helps the reader see a pattern and ask a decision question. In the Greek part of the Nestos/Mesta case, experts compared policy interactions across WEFE domains. The assessment recorded 31 relationships with no coherence, 22 with weak coherence and 27 with strong coherence. Land/soil and ecosystem policies were least aligned with energy policy. Water policies often failed to integrate the implications of other sectors, even where energy, food or biodiversity policies recognised their dependence on water.



| Sector | Policy | Water | Energy | Food/ Agriculture | Land/ Soil | Biodiversity/ Ecosystems | Climate |
|---|---|---|---|---|---|---|---|
| Water | Law 3199/2003 on the protection and management of water resources - Reconciliation with the WFD 2000/60/EC | | | | | | |
| Water | Legislative Decree 51/2007 on the determination of measures and procedures for the integrated protection and management of water resources in compliance with the WFD 2000/60/EC | | | | | | |
| Water | Measures for the protection of groundwater from pollution and deterioration in compliance with the European Directive 2006/118/EC | | | | | | |
| Water | Assessment and management of flood risk in compliance with the provisions of the European Directive 2007/60/EC | | | | | | |
| Water | General rules regulating the costs and pricing system of water services. Method and processes for recovery of costs for water services and relevant water uses | | | | | | |
| Energy | Special legislative framework of spatial planning and sustainable development for the renewable energy sector and the respective strategic environmental impact assessment | | | | | | |
| Energy | Electricity production from RES and cogeneration of high performance electricity and heat | | | | | | |
| Energy | Promotion of cogeneration from two or more types of energy - Issues concerning Mesochora hydroelectric power project | | | | | | |
| Energy | Operation of electricity markets and natural gas markets - Research, production and transmission networks for hydrocarbons | | | | | | |
| Energy | Support electricity production from RES and high performance electricity and heat production from cogeneration - Legal and operational separation of natural gas supply and distribution | | | | | | |
| Energy/ Climate | Ratification of the National Energy Plan for Energy and Climate | | | | | | |
| Agriculture/ Food | Pesticides market in Greece - Rational use of pesticides | | | | | | |
| Agriculture/ Food | Development of the aquaculture sector | | | | | | |
| Food | Administrative measures, processes and penalties for the implementation of EU and National legislation in the sectors of food, feed, health and protection of animals | | | | | | |
| Biodiversity/ Ecosystems | Preservation of Biodiversity | | | | | | |
| Biodiversity/ Ecosystems | National Strategy for biodiversity between 2014-2029 and 5-years action plan | | | | | | |

*Figure 5. Policy-coherence assessment results for the Nestos/Mesta case in Greece. The matrix makes uneven recognition of cross-sector interactions visible and supports selection of priority issues. Source: NEXOGENESIS D1.2.*

The result did not by itself prescribe a policy. It focused the next discussion. Stakeholders selected water quantity as a cross-sector issue because irrigation demand, ecological-flow requirements and hydropower operations all depend on it. The combination of the matrix, implementation evidence and stakeholder interpretation therefore helped define the policy portfolio and the system relationships that later modelling and NEPAT work needed to represent.

**READ A MATRIX AS AN ARGUMENT** Introduce the policy question, explain the strongest pattern, identify important asymmetries, and state what changed in the next step. Do not leave readers to infer meaning from colours or scores alone.

## Prepare the policy portfolio for modelling and NEPAT

The candidate portfolio is the master set of policy instruments that may be evaluated for interactions and impacts. Selection should begin from governance barriers, policy tensions and stakeholder priorities—not from what is easiest to model. For each policy, record whether it is existing, proposed or hypothetical and whether it can currently be represented in the model.

| Policy information | Why it is needed |
|---|---|
| Policy goal and target | Defines the result to be assessed, including target value, direction of change and time horizon where available. |
| Policy instrument and mechanism | Explains what changes in practice and where it enters the WEFE system. |
| Responsible actor and governance level | Connects the modelled intervention to legal authority and implementation capacity. |
| Model translation | Identifies the variables, parameters, equations or rules that represent the policy in the SDM. |
| Constraints and incompatibilities | Records policies that cannot be combined or conditions that limit implementation. |
| Evidence and uncertainty | Documents sources, assumptions, data gaps and confidence in the policy representation. |

**IMPORTANT DISTINCTION** A policy may be institutionally attractive but not immediately modellable. Do not discard it silently. Record whether it is excluded because it is outside scope, lacks data, cannot be represented in the model, or is not supported by the responsible authority.

## What a useful result looks like

- **Specific:** "Responsibilities for drought response overlap between agencies X and Y" is more useful than "coordination is weak."
- **Traceable:** Each judgement can be linked to policy text, interview evidence or validated institutional knowledge.
- **Plural:** Differences between sectors, governance levels and stakeholder groups remain visible.
- **Action-oriented:** Findings identify who could change what, rather than only describing problems.
- **Model-aware:** The candidate policy portfolio distinguishes policy relevance from technical representability.

## Suggested validation workshop

| Step | Purpose | Product |
|---|---|---|
| Circulate a pre-read | Give participants accessible findings, evidence sources and questions before the meeting. | Factsheet and issue log |
| Test the findings | Check whether barriers, enablers and policy interactions are recognisable and specific. | Corrections and confirmed findings |
| Explain disagreements | Record why sectors, levels or groups interpret the same condition differently. | Documented perspectives and uncertainty |
| Prioritise entry points | Select changes with a clear actor, mandate and plausible route to influence. | Ranked governance opportunities |
| Confirm the portfolio | Agree which policies move into modelling, wider deliberation or follow-up analysis. | Candidate portfolio and decisions log |

**VALIDATION IS NOT A VOTE** Revise a finding when new evidence or a stronger explanation warrants it. Preserve material disagreement when consensus would hide a genuine governance constraint.

## NXG resources

- D1.2 Governance and policy assessment in case studies
- D1.5 Consolidated nexus governance framework and guidance

CHAPTER 4

# Developing governance roadmaps

*Translate a preferred policy package into a credible pathway for change.*

**SEQUENCE NOTE** Governance roadmap development is authority-led, but it normally follows Chapter 8: the policy package should first have been explored and validated with stakeholders.

| | |
|---|---|
| **What the authority does** | Confirm goals and preferred policies, convene stakeholders, map institutional changes, assign responsibilities, negotiate commitments and integrate the roadmap into formal planning. |
| **What specialists do** | Governance and facilitation specialists help develop the theory of change, test causal logic, document assumptions and design monitoring and learning arrangements. |
| **Outputs you should expect** | A visual results chain, action plan, stakeholder commitments, implementation responsibilities, timeframe, indicative resources and monitoring approach. |
| **Capacity level** | Moderate. Policy, planning and facilitation expertise are central; technical model-building is not required. |

## What a governance roadmap does

A governance roadmap describes what must change in the governance landscape for a stakeholder-validated policy package to be adopted and implemented. NEXOGENESIS uses a theory-of-change approach and a results chain: local actions support intermediate institutional or behavioural outcomes; these enable adoption and implementation of a policy; the policy contributes to the agreed basin goals.

This is the point where technical choice becomes institutional change. NEPAT may show that a package performs well across WEFE goals and scenarios, but it cannot assign a legal mandate, negotiate a budget, create trust between organisations or ensure that an operating practice changes. The roadmap makes those conditions explicit. It is therefore not an “add-on” after the analysis; it is the implementation half of the decision.

A useful roadmap distinguishes two related forms of change. A change on paper alters the formal policy environment—for example, revising a plan, adopting a regulation, establishing a data-sharing protocol or including a target in a budget. A change in action alters implementation—for example, operating a reservoir differently, maintaining a treatment asset, coordinating inspections, funding an extension service or creating a recurring cross-border working group. All packages require both. A new rule without delivery capacity may remain symbolic; changed practice without formal authority may be fragile or unlawful.

| Change pathway | Typical questions | Illustrative outputs |
|---|---|---|
| Policy / paper | Which law, plan, standard, permit, operating rule or funding instrument must change? Who can initiate, draft, consult, approve and review it? | Draft amendment, ministerial or board decision, revised RBMP measure, budget line, protocol, permit condition or formal agreement. |
| Implementation / action | Which behaviour, service, investment, coordination routine, data flow or operational practice must change? Who delivers and sustains it? | Action plan, operating procedure, coordination group, training, infrastructure work, monitoring arrangement, maintenance plan or funded programme. |

The roadmap should show where the two pathways depend on one another. For example, an irrigation-efficiency programme may need a funding decision and procurement rule on paper, farmer advisory services and metering in practice, and a monitoring arrangement to ensure that saved water supports the agreed ecological or allocation objective rather than enabling additional abstraction.

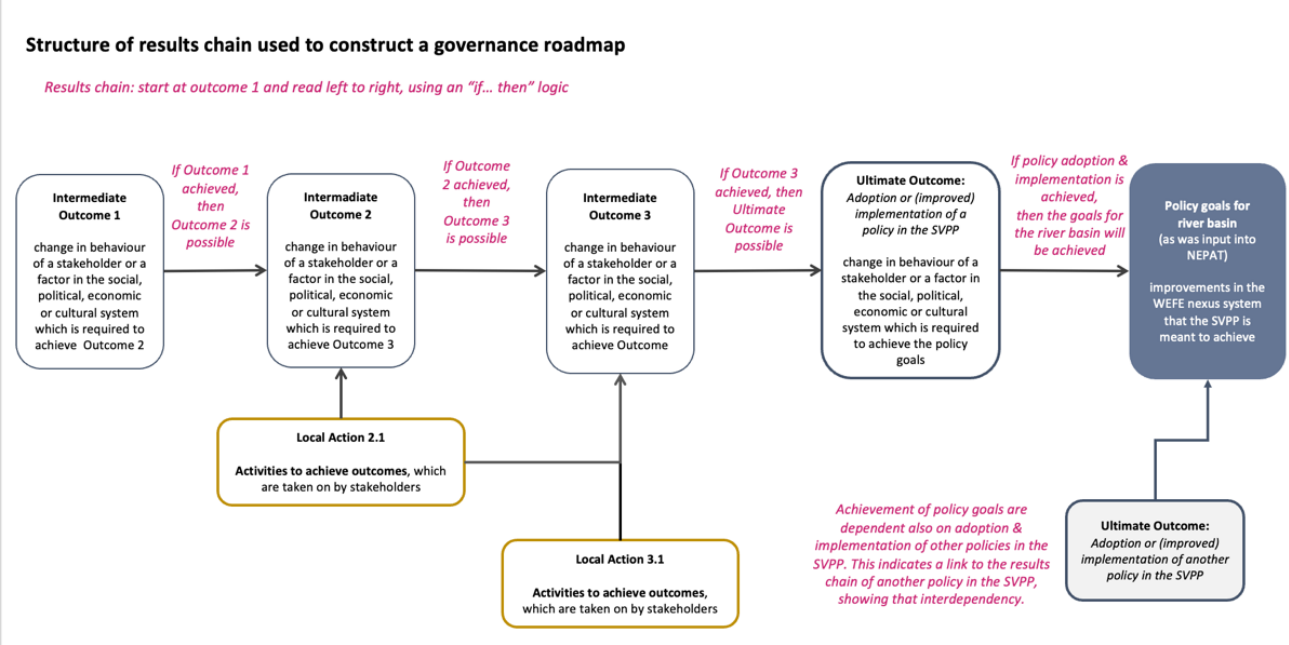



*Figure 6. Structure of a results chain used to develop governance roadmaps. Source: D1.5 and Sabina Khan, NEXOGENESIS Project (2025)., adapted from Margoluis et al. (2013).*

Figure 6 is read from right to left when designing and from left to right when testing. Begin with the basin goal and the policy outcome, then work backwards to identify the changes that must exist immediately beforehand. Once the chain is complete, read it forward as a series of "if–then" propositions. Each arrow is a hypothesis that can be challenged and monitored.

**METHOD AND EVIDENCE** *The NEXOGENESIS roadmap method adapts results-chain and theory-of-change practice, particularly Foundations of Success (2009) and Margoluis et al. (2013). The project used this method to map what structural changes are required in the governance context to successfully implement the validated policy packages and achieve river basin goals.* D1.5 method · D5.7 lessons

## Inputs and readiness for roadmapping

Do not start with an empty diagram. The roadmap workshop should receive a compact evidence pack that enables participants to focus on implementation rather than reopen every earlier analysis. At the same time, the preferred package should not be treated as untouchable. If roadmapping reveals that a policy is unlawful, unaffordable, politically blocked or dependent on an actor who cannot participate, the team should return to NEPAT or the policy portfolio and revise the package.

| Input | What it contributes | Readiness question |
|---|---|---|
| Stakeholder-validated policy package | The policies selected after scenario, impact, uncertainty and stakeholder deliberation. | Is the package sufficiently specified, and are remaining disagreements recorded? |
| NXGAT and coherence findings | Governance barriers, policy tensions, enabling conditions and potential leverage points. | Can participants identify the actor, mandate and mechanism behind each priority finding? |
| Stakeholder and actor-linkage analysis | Influence, interests, relationships, missing voices and possible coalitions. | Are the actors who must own or enable change represented or reachable? |
| Model and NEPAT evidence | Expected effects, important trade-offs, robustness and conditions under which performance changes. | Which conclusions are robust, and which depend on uncertain assumptions or scenario conditions? |
| Mandate, finance and policy-cycle information | Formal decision routes, deadlines, budgets, programme windows and legal constraints. | Is there a plausible institutional entry point and decision window? |

**READINESS GATE** Proceed when there is a sufficiently specified package, an accountable sponsor, the necessary institutional actors, a known decision route and a shared willingness to examine implementation honestly. Return to policy exploration when no credible pathway can be constructed.

## Develop the roadmap in eight working steps

1. **Confirm basin goals and the focal policy.** Use the goals and preferred policy package that emerged from policy exploration. Develop one results chain per focal policy before linking them.
2. **Define the ultimate outcome.** State the adoption, implementation or institutionalisation of the focal policy that the roadmap is intended to enable.
3. **Map intermediate outcomes.** Identify specific changes in mandates, coordination, knowledge, capacity, finance, behaviour or practice needed before the ultimate outcome can occur.
4. **Test the causal logic.** Read the chain from left to right as "if…then" statements; identify missing conditions and remove activities that are incorrectly presented as outcomes.
5. **Identify actions and responsibilities.** For every intermediate outcome, specify practical actions and the lead, supporting and consulted actors.
6. **Add timing, resources and dependencies.** Align milestones with policy cycles and target years; estimate staff, data, expertise, finance and institutional authority required.
7. **Make assumptions and risks explicit.** Record external political, economic, environmental and social conditions that could enable or disrupt the pathway.
8. **Validate, agree, monitor and adapt.** Vet the chain with different stakeholder groups, transfer it into an action plan, define commitments and indicators, appoint coordination and schedule periodic revision.

The eight steps are analytical and political at the same time. Early drafts are often dominated by activities—meetings, studies, training or advocacy—because these are easy to name. The facilitator should repeatedly ask what will be different if an activity succeeds. That answer becomes the intermediate outcome. Activities are then retained only where they have a plausible owner and contribution to that outcome.

## An indicative facilitated workshop sequence

A roadmap can be produced through one intensive process or several shorter sessions. For complex or transboundary packages, several rounds usually produce stronger ownership because participants need time to check mandates, consult colleagues and assess resources. The sequence below is a planning suggestion, not a fixed requirement.

| Session | Main work | Between-session task |
|---|---|---|
| 1. Frame the change | Confirm basin goals, focal policies, decision route, stakeholders and the distinction between paper and action change. | Case team prepares one draft ultimate outcome per focal policy. |
| 2. Build the results chain | Work backwards from the ultimate outcome to intermediate institutional, behavioural and capacity changes. | Named actors verify mandates and missing conditions. |
| 3. Test feasibility and equity | Challenge causal links, costs, distribution, political constraints, dependencies and unintended effects. | Specialists provide targeted evidence; owners assess resources and timing. |
| 4. Convert outcomes into actions | Define actions, owners, supporters, milestones, resources, indicators and decision windows. | Lead actors confirm commitments and identify approval routes. |
| 5. Agree and anchor | Resolve open issues, endorse the roadmap, choose the form of agreement and establish coordination and review. | Integrate actions into plans, budgets, terms of reference or formal decisions. |

One-on-one conversations are often necessary between sessions. Senior decision-makers may not attend every workshop; technical staff may need to verify whether a target can be monitored; marginalised groups may speak more freely in separate formats; and transboundary partners may need national discussions before a joint session. These are not parallel "side processes" if their results are transparently brought back into the roadmap.

## Rules for strong intermediate outcomes

- **One change per box.** Avoid combining several outcomes that have different owners or timelines.
- **Name the actor and the change.** For example: "The basin authority adopts a data-sharing protocol."
- **Describe a result, not an activity.** "Improved inter-agency data access" is an outcome; "hold a workshop" is an action.
- **Make the change observable.** Use language such as adopted, increased, reduced, funded, coordinated or implemented.

- **Check sufficiency and necessity.** Ask whether the outcome is needed and whether additional conditions must also be met.

## Test the complete results chain

| Quality test | Question to ask |
|---|---|
| Causal logic | Does each outcome create a plausible precondition for the next, without unexplained leaps of faith? |
| Completeness | Are institutional, behavioural, financial, technical and political conditions represented where they are necessary? |
| Ownership | Is there an actor with the mandate and capacity to lead each action and own relevant outcome? |
| Feasibility | Can actions be delivered with realistic time, resources and authority, and are dependencies visible? |
| Equity and conflict | Who benefits or bears costs, and could implementation create opposition, exclusion or transferred risks? |
| Adaptability | Are assumptions, risks and indicators explicit enough to support learning and revision? |

The quality tests should be applied to each outcome box as well as to the roadmap as a whole. A chain can look complete while depending on a single weak assumption—for example, that a national ministry will revise a rule, that data will be shared voluntarily, or that farmers will adopt a practice without finance or advisory support. Mark such assumptions visibly and create a response: evidence gathering, advocacy, an alternative pathway or a trigger for revising the package.

## Convert the chain into an action plan

The visual chain explains why change is expected. The action plan explains who will do what and when. Keep the two linked through stable outcome and action identifiers. This makes later monitoring meaningful: the team can see whether an action was completed, whether the intended outcome followed, and whether the causal assumption held.

| Action-plan field | What to record |
|---|---|
| Outcome and action ID | A stable reference linking the action to the results-chain box it is intended to influence. |
| Action and deliverable | An action box, defined scope and tangible completion evidence. |
| Lead / supporting / consulted actors | One accountable lead plus the organisations that enable, advise or are affected by delivery. |
| Mandate and decision route | The legal, administrative or organisational basis and the approvals required. |
| Timing and dependencies | Start, milestone and target dates linked to budgets, planning cycles, permits or preceding actions. |
| Resources and financing | Staff time, technical support, data, procurement, capital/operating finance and likely funding source. |
| Indicator and evidence | How action completion and the intended outcome will be observed, by whom and how often. |
| Risk, assumption and response | Conditions that could prevent progress and the mitigation, contingency or trigger for adaptation. |

Avoid assigning collective ownership to “all stakeholders.” Collective support can be real, but accountability requires a named organisation and usually a named role. Where no actor has a mandate, the roadmap has found a governance gap. The response may be to create a coordination mechanism, seek a formal delegation, redesign the action or escalate it to the level that can decide.

> **KEEP IT ALIVE** A roadmap is a working governance instrument, not the final page of a project report. Review progress, update assumptions, add newly responsible actors and revise the pathway when policies, resources or environmental conditions change.

## Monitor outcomes, not only activities

Roadmap monitoring should answer three questions: are actions being delivered; are the expected intermediate outcomes appearing; and does the pathway still lead toward the policy and basin goals? Activity indicators alone—number of meetings, participants or reports—cannot show whether coordination, behaviour, policy or implementation changed.

| Monitoring layer | Example | What it tells the team |
|---|---|---|
| Delivery | Data-sharing protocol drafted and approved by the two responsible organisations. | Whether the promised action was completed. |
| Intermediate outcome | Agencies exchange agreed datasets on schedule and use them in a joint allocation review. | Whether the action changed institutional practice. |
| Policy / implementation outcome | Revised allocation or operating rule is adopted and applied. | Whether the focal policy change occurred. |
| Basin / WEFE goal | Ecological-flow compliance improves without unacceptable food or energy impacts. | Whether the intervention contributes to the intended system result. |

Set review points around real governance cycles: annual budget preparation, river-basin plan review, seasonal operating decisions or scheduled cross-border meetings. At each review, retain, revise or retire parts of the pathway. If monitoring contradicts the expected causal logic, update the roadmap and—where necessary—return to policy exploration or modelling.

> **NXG PRACTICE EXAMPLE** *The Inkomati-Usuthu case developed a roadmap linking water-supply and wastewater-treatment policies. The roadmap illuminated how institutional capacity issues in the energy sector impacted the ability of the water sector to maintain its infrastructure and the central role of municipalities in planning processes.*

## From roadmap to stakeholder agreement

A stakeholder agreement is a voluntary, co-created commitment to continue working on outcomes or actions that support the preferred policy package. The form should match the mandate, resources and comfort of participants. It may range from an informal working arrangement or recurring dialogue to endorsement of the roadmap, a memorandum of understanding, a formal partnership or incorporation into an official plan.

An agreement should not promise powers that signatories do not have. It can instead specify what each party can credibly do: continue dialogue, promote a policy, seek funding, share defined information, nominate representatives, test an implementation action or advocate at a higher governance level. Where implementation depends on national approval, the agreement can establish a coalition and escalation route rather than pretending that local actors can adopt the policy themselves.

An agreement should not imply authority that participants do not possess. It can document shared intent, clarify contributions, establish a coordination mechanism or commit organisations to pursue actions through their own formal procedures. Record dissent and conditions for participation rather than treating a signature as proof of full consensus.

| Action-plan field | What to record |
|---|---|
| Outcome / action | The specific change or activity and its link to the results chain |
| Lead and supporting actors | Who is accountable, who contributes and who must be consulted |
| Timing and dependency | Start, end, milestones and preconditions |
| Resources | Staff time, expertise, data, finance and institutional authority |
| Progress signal | A small number of observable indicators or milestones |
| Assumptions and risks | Conditions outside direct control and how they will be monitored |

> **NXG AGREEMENT EXAMPLE** In Nestos/Mesta, two agreements committed local signatories to continue cooperation, promote governance-roadmap policies, raise local awareness, identify implementation funding and advance the work through future projects. The agreement reflected what local actors could credibly sustain while recognising that some policy decisions remained national.

## NXG resources

- D1.4 Mooren C., Munaretto S., Khan S. (2025) Governance roadmap and building blocks of a River contract in case studies, Report. NEXOGENESIS project. Available at: https://nexogenesis.eu/wp-content/uploads/2026/09/NXG_D1.4-FINAL.pdf
- D1.5 Consolidated nexus governance framework and guidance
- D5.7 Recommendations and lessons learned from all case studies
- Case-study implementation reports and policy briefs

PART II

# Working with technical experts

The authority remains responsible for the decision questions and use of results. Specialists are responsible for transparent, documented and quality-assured technical work.

05 **When technical support is needed**

06 **Commissioning future scenario analysis**

07 **Commissioning system dynamics models**

08 **Using NEPAT for policy exploration**

CHAPTER 5

# Technical expertise and delivery arrangements

*Locate, combine or commission the capabilities needed for the technical chain.*

**CAPABILITY, NOT ORGANISATIONAL TYPE** Scenario analysis, data harmonisation, system dynamics modelling, uncertainty analysis and NEPAT configuration require specific expertise. That expertise may already exist within an authority, university, consortium or partner organisation, or it may be commissioned. The delivery arrangement should follow capability and accountability—not an assumption that authorities lack technical staff.

This chapter is a capability map. It helps the lead organisation decide which functions are already covered, where independent review would strengthen quality, and where additional partners or contractors may be useful. A large river-basin authority may perform climate or hydrological modelling internally. A research consortium may contain all the relevant technical teams. A smaller authority may commission an integrated service. Each arrangement can work if interfaces, evidence standards, decision ownership and long-term access to the outputs are clear.

## Technical capabilities used in the next three chapters

- Selecting, combining or downscaling climate and socio-economic projections.
- Harmonising datasets with different scales, units, time steps, definitions and uncertainty.
- Developing conceptual models, causal loop diagrams and quantitative stock-and-flow models.
- Calibrating and validating models or running sensitivity, what-if and uncertainty analyses.
- Translating policies into model parameters and configuring policy scenarios in NEPAT.
- Maintaining data pipelines, application interfaces, software, security and reproducibility documentation.

## What the accountable organisation must still own

Locating technical work inside or outside the lead organisation does not change accountability for the public or research decision. The accountable organisation must specify the decision question, confirm scope and policy relevance, provide institutional and local context, convene validation, require transparent uncertainty, and decide how outputs enter a legitimate decision process. Where the lead is a research consortium rather than an authority, it should identify the public body, user organisation or governance process that can legitimately use the results.

## Core technical roles

| Role | Needed for | Minimum evidence of capability |
|---|---|---|
| Climate / biophysical specialist | Scenario selection, impact variables, downscaling and validation | Relevant regional modelling experience and documented uncertainty methods |
| Socio-economic modeller | Population, land use, economy and SSP-consistent projections | Experience linking global scenario families to local variables |
| Data engineer / GIS specialist | Data catalogues, harmonisation, geospatial processing and reproducibility | Versioned workflows, metadata standards and quality control |
| System dynamics modeller | Conceptual maps, stock-flow models, calibration and simulation | Participatory modelling and domain-relevant SDM portfolio |
| Sector/domain experts | Hydrology, agriculture, energy, ecosystems, economics and infrastructure | Ability to test assumptions and interpret local processes |
| NEPAT specialist / developer | Platform configuration, model connection, policy scenarios and technical testing | Knowledge of NEPAT architecture, user views and validation workflow |

The roles can be combined, but the competencies should not be assumed from organisational labels. A hydrologist may not have expertise in socio-economic downscaling; a software developer may not be able to validate a policy mechanism; a system dynamics modeller may need support from domain specialists and facilitators. Ask for evidence that matches the basin, method and intended use.

## Assess capability before choosing a delivery model

Begin with a structured self-assessment across the full chain. Rate capability as available and proven, available but needing support, planned through a partner, or not yet covered. Include availability over time: a specialist who can advise once is not the same as a team that can maintain a model or platform after the project.

| Capability area | Evidence to look for | Questions for the team |
|---|---|---|
| Scenario and impact analysis | Regional climate/impact work, pathway selection, bias correction, downscaling and uncertainty. | Can the team translate global pathways to the variables and scale needed by the decision? |
| Socio-economic and land-use analysis | SSP translation, demographics, economy, agriculture, land use and spatial allocation. | Can narrative assumptions and quantitative variables be kept coherent and locally interpretable? |
| Data engineering and GIS | Metadata, spatial processing, versioned pipelines, quality control and reproducibility. | Can another analyst reproduce every transformation and update the dataset later? |
| Participatory system dynamics | Facilitated mapping, causal and stock-flow modelling, calibration, validation and policy simulation. | Can the modeller work with contested knowledge as well as equations and software? |
| Domain validation | Relevant water, energy, food, ecosystem, economic and infrastructure expertise. | Who can judge whether variables and policy mechanisms correspond to basin practice? |
| NEPAT integration and facilitation | Python/model integration, acceptance tests, user configuration, DSS and workshop experience. | Can the team maintain technical integrity while explaining results to non-technical users? |

Use the assessment to design support rather than disqualify the organisation. An internal team may need a peer reviewer, a short training module or a partner for one submodel. An external team may need embedded authority staff and local experts to understand policy mechanisms and data. The objective is a credible combined capability with a clear handover.

## Choose a delivery arrangement that preserves integration

| Delivery arrangement | Strengths | Conditions to manage |
|---|---|---|
| Primarily internal | Institutional knowledge, continuity, data access and direct connection to operational decisions. | Protected staff time, specialist depth, independent challenge, software support and documentation. |
| Research consortium | Wide disciplinary capability, innovation, peer learning and access to scientific methods. | A real user/authority pathway, consistent versions, post-project ownership and avoidance of work-package silos. |
| Integrated external team | Single contractual interface and coordinated responsibility for technical outputs. | Transparent subcontracting, access to methods/files, independent validation and avoidance of vendor lock-in. |
| Several specialist contracts | Ability to select strong expertise for each task and adapt scope. | Strong integration management, common data standards, aligned assumptions and acceptance tests at every interface. |
| Hybrid embedded team | Combines local continuity with specialist depth and supports capacity transfer. | Clear line management, shared tools, role boundaries, knowledge transfer and retained authority over decisions. |

No arrangement eliminates the need for integration. If teams are procured separately, appoint a technical integrator who understands the end-to-end data and model architecture and has authority to resolve version and interface issues. If one supplier covers everything, retain independent acceptance and require access to the underlying files, not only a hosted interface.

## Plan the interfaces as carefully as the tasks

Many technical failures occur between disciplines: a scenario variable uses a different baseline than the SDM; a policy description cannot be translated into a parameter; a stochastic model is unavailable when NEPAT configuration begins; or a governance finding is reduced to a variable without its institutional meaning. Manage these as explicit interface objects.

| Interface object | Supplier | Receiver | Acceptance evidence |
|---|---|---|---|
| Scenario data vector | Climate, socio-economic and data teams | SDM and domain teams | Version, units, baseline, time step, spatial scale, RCP–SSP label, processing and uncertainty checks. |
| Policy-to-model mapping | Policy/governance and domain teams | SDM and NEPAT teams | Mechanism, controllable setting, actor, timing, constraints, omitted effects and test case. |
| Model integration package | SDM team | NEPAT team | Code/model version, dependencies, variables, deterministic/stochastic modes and matched reference runs. |
| User interpretation pack | NEPAT and technical teams | Facilitator, authority and stakeholders | Plain-language scenario/policy descriptions, limitations, result guide and fallback visuals. |
| Decision evidence pack | Facilitator and case team | Roadmap and accountable authority | Preferred package, alternatives, trade-offs, uncertainty, objections, conditions and rationale. |

## Specify data, software and intellectual-property conditions

Technical continuity depends on rights and practical access. Agree licensing, hosting, security, personal-data handling, software dependencies, model formats, source-code access, update rights, data-provider conditions and publication restrictions before work begins. “Open” should not be promised where third-party licences prevent it; “proprietary” should not be accepted as a reason that decision-critical assumptions cannot be reviewed.

| Contract / agreement topic | Minimum provision |
|---|---|
| Data access and licence | Permitted uses, sharing, derivatives, attribution, sensitive-data controls and post-project availability. |
| Model and code files | Editable formats, source or escrow where appropriate, dependencies, version identifiers and build/run instructions. |
| Reproducibility | Data lineage, parameter register, automated or documented test cases and environment information. |
| Security and continuity | Hosting responsibility, access roles, backups, incident response, service dependencies and retirement/export route. |
| Intellectual property and publication | Background/foreground ownership, reuse rights, scientific publication review and protection of confidential inputs. |
| Maintenance and updates | Named custodian, support period, update triggers, costs, training and procedure for incorporating new data or policies. |

**AVOID LOCK-IN** The accountable organisation should be able to inspect the evidence, reproduce agreed results and export decision records. If long-term operation depends on a supplier, make the dependency, cost and exit route explicit.

## Build capacity through participation in the work

Training is most effective when tied to real project products. Pair authority or consortium staff with specialists during scenario framing, model walkthroughs, acceptance tests and NEPAT rehearsal. Produce role-based guidance: decision-makers need interpretation and limitations; analysts need data and model operation; administrators need configuration, access and maintenance procedures.

| Learning objective | Suggested activity | Evidence of transfer |
|---|---|---|
| Scenario literacy | Review pathway choices, local translation and uncertainty with the scenario team. | Staff can explain what RCP/SSP labels mean and what transformations affect local inputs. |
| Model literacy | Walk through conceptual, causal and quantitative outputs using one policy mechanism. | Staff can trace a result from policy control through model relationships to an indicator. |
| NEPAT facilitation | Rehearse a user-defined and DSS-supported package comparison. | Facilitators can explain views, uncertainty, limits and record a decision rationale. |
| Technical administration | Repeat installation/configuration and reference test runs from documentation. | A second person can reproduce the accepted configuration without the original developer. |
| Decision use | Translate a result into a briefing and roadmap input with the accountable authority. | The evidence enters a real planning, policy or governance process in an appropriate form. |

**METHOD AND EVIDENCE** *This capability-centred approach reflects the NEXOGENESIS experience that effective uptake depends on technical skill, institutional memory, facilitation and durable ownership—not on whether expertise is labelled internal or external. D5.7 ; Policy Brief 3*

## A short internal work specification or commissioning brief should require

- **Decision link:** the decisions and users each output will support.
- **Tasks and boundaries:** what is included, excluded and dependent on other teams.
- **Data plan:** sources, licensing, metadata, quality checks, gaps and ownership.
- **Method and alternatives:** why the proposed method is proportionate and what simpler or stronger options exist.
- **Participation points:** when authority staff and stakeholders will frame, review and validate.
- **Uncertainty and limitations:** how they will be analysed, communicated and carried into decisions.
- **Deliverables and acceptance criteria:** formats, documentation, editable data/code where appropriate, visual outputs and sign-off gates.
- **Continuity:** handover, training, maintenance and conditions for reuse or update.

The same specification can be used for an internal technical unit, a university partner or a contractor. It creates a common basis for review and prevents assumptions from remaining hidden simply because colleagues work in the same organisation. Independent review can be proportionate: peer review of a method note, replication of selected runs, a code and data audit, or review by a second modeller may be enough.

## Evaluate proposals or internal plans against the same criteria

Selection should test whether the proposed team can connect methods to the decision, not merely whether it has delivered similar software or reports. Require a short method and integration response that names assumptions, alternatives, interfaces, acceptance tests, participation points and post-project ownership. Where price is a major criterion, assess lifecycle cost as well as initial delivery.

| Evaluation criterion | Evidence in the response | Reason for weighting |
|---|---|---|
| Understanding of the decision | Restated use case, users, scale, key WEFE relationships and material institutional constraints. | Prevents a generic technical solution from driving the scope. |
| Method fitness and alternatives | Rationale for scenario, modelling, uncertainty and platform choices, including proportionate alternatives. | Shows that complexity follows the question rather than habit. |
| Integrated capability | Named staff, roles, availability, domain coverage, facilitation and responsibility for cross-team integration. | Reveals gaps hidden by organisational credentials or broad team descriptions. |

| Evaluation criterion | Evidence in the response | Reason for weighting |
|---|---|---|
| Evidence and reproducibility | Data plan, metadata, code/model documentation, version control, tests and independent review. | Protects transparency, updateability and confidence in results. |
| Participation and communication | Co-framing/validation points, accessible outputs, feedback trail and treatment of power or disagreement. | Connects technical quality to legitimacy and local relevance. |
| Continuity and value | Training, maintenance, licences, hosting, update route, exit/export and whole-life cost. | Avoids unusable tools, hidden dependencies and post-project loss. |

## Manage delivery with short integration routines

Long work packages need frequent, lightweight coordination. A monthly technical report is not a substitute for seeing the current data, model and decision implications together. Use short demonstrations and shared registers so that problems surface while they are still reversible.

| Routine | Purpose | Minimum record |
|---|---|---|
| Interface review | Check upcoming and completed handovers across governance, scenarios, SDM and NEPAT. | Version, owner, receiver, acceptance result, open issue and due date. |
| Model/data demonstration | Show current behaviour and transformations rather than report percentage complete. | Demonstrated build/run, questions, agreed changes and reference files. |
| Decision-relevance check | Confirm that outputs still answer the intended question and policy window. | Scope change, consequence for methods/timeline and sponsor decision. |
| Stakeholder feedback review | Track how engagement changed assumptions, data, policies, models or facilitation. | Input, response, rationale, version and feedback to participants. |
| Risk and dependency review | Identify data access, staff, software, policy-cycle and approval risks. | Owner, response, trigger, contingency and escalation. |

Use change control proportionately. A spelling correction does not need steering approval; changing the basin boundary, scenario set, policy portfolio, model structure or DSS objective may alter the meaning of results and should be recorded and accepted by the relevant owner. Freeze versions for stakeholder workshops and retain the ability to reproduce exactly what participants saw.

## Acceptance meeting: five questions

- Does the output answer the agreed decision question at the right scale?
- Can users trace the data, assumptions, methods and changes made after validation?
- Were authority staff and stakeholders able to challenge the work before finalisation?
- Are uncertainty and important limitations carried into the conclusions?
- Are ownership, editable files, handover, maintenance and update responsibilities clear?

CHAPTER 6

# Commissioning future scenario analysis

*Develop plausible futures that are fit for the decision and the model.*

| | |
|---|---|
| **What the authority does** | Specify the decision question, local variables and planning horizons; provide local data and context; review scenario assumptions; validate whether outputs are plausible and usable. |
| **What specialists do** | Select climate and socio-economic scenario families, process and downscale data, harmonise variables, document provenance, perform retrospective checks and characterise uncertainty. |
| **Outputs you should expect** | Scenario framing note, data catalogue, regional projections, harmonised model inputs, validation report, uncertainty analysis and accessible visual summary. |
| **Capacity level** | High for the technical work. Authority staff need sufficient literacy to interrogate assumptions and interpret uncertainty. |

## Why scenario analysis is needed

A policy that performs well under current conditions may fail under a warmer climate, altered land use, population change or different economic development. Scenario analysis does not predict a single future. It assembles a transparent set of plausible futures so that policies can be tested for robustness, trade-offs and unintended effects.

The project used internationally established scenario frameworks rather than inventing its own climate or socio-economic futures. Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathways (SSPs) were developed through the climate-research community under the auspices of the Intergovernmental Panel on Climate Change (IPCC). NEXOGENESIS selected a purposeful subset and translated it into basin-relevant variables.

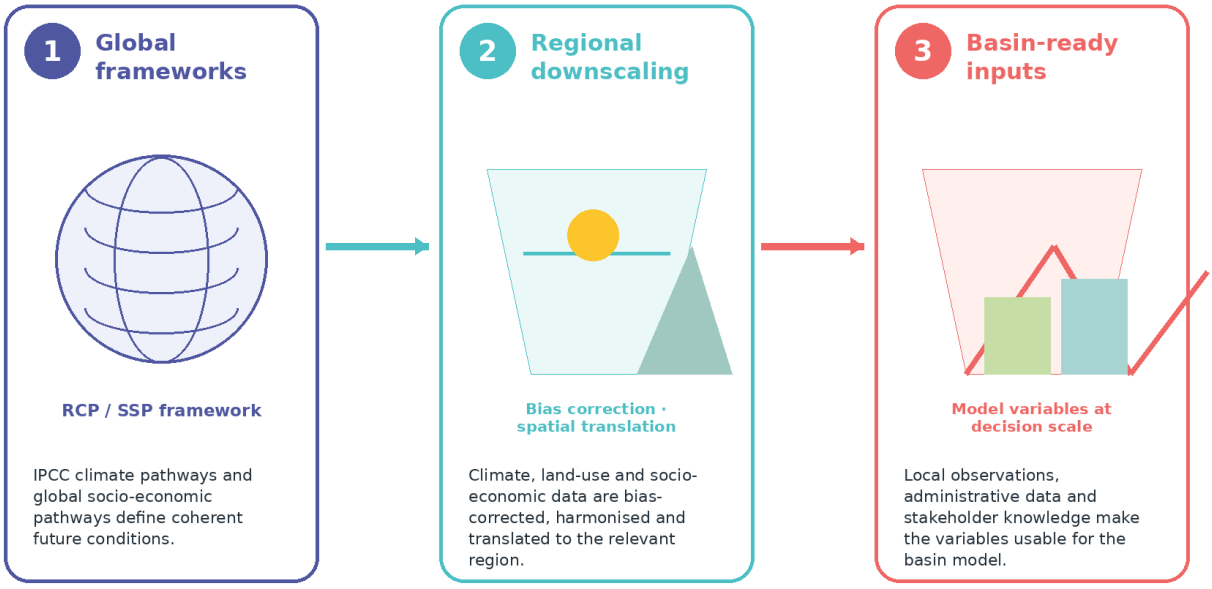



*Figure 7. Complete scale-translation concept: global IPCC-related pathway assumptions are downscaled and harmonised, then combined with local data and knowledge to create basin-ready inputs. Source: OpenAI 2025; D2.1–D2.5.*

Figure 7 emphasises that downscaling is not simply an enlargement of a global map. It is a chain of transformations. Each transformation—bias correction, spatial allocation, temporal aggregation, local calibration or variable mapping—

adds assumptions that should be documented and reviewed. Traceability must work in both directions so that a surprising local result can be followed back to the source scenario and processing choice.

## Three connected types of future information

| Type | What it describes | Examples relevant to WEFE decisions |
|---|---|---|
| Climate scenarios | Alternative trajectories of greenhouse-gas forcing and the resulting climate conditions. | Temperature, precipitation, drought, extreme events and seasonal shifts. |
| Biophysical projections | How climate, land use and other drivers affect physical and ecological processes. | Runoff, river flow, crop yield, irrigation demand, biomass, soil carbon, water quality and biodiversity. |
| Socio-economic projections | Alternative pathways for population, economy, technology, land use and resource demand. | Population, GDP, sector production, energy demand, agricultural markets, land-use change and technology uptake. |

## The subset used by NEXOGENESIS

For climate, NEXOGENESIS used RCP2.6 and RCP8.5. RCP2.6 represents a strong-mitigation, low-forcing pathway; RCP8.5 represents a high-emissions, high-forcing pathway. The project used the pair to span a broad low-to-high response space, particularly because climate trajectories diverge more clearly after mid-century. This does not imply that only these futures are possible, that RCP8.5 is a forecast, or that every current application should make the same choice.

For socio-economic conditions, NEXOGENESIS used SSP2 (“Middle of the Road”) and SSP4 (“Inequality” or “A Road Divided”). SSP2 describes development broadly following historical patterns with uneven progress; SSP4 describes increasing inequality within and across countries, with unequal access to resources, technology and adaptive capacity. Combining the two RCPs and two SSPs created four contrasting RCP–SSP test conditions for policy analysis, while case teams translated the global narratives into variables relevant to their basins.

| Project pathway | Short interpretation | Why it was included |
|---|---|---|
| RCP2.6 | Strong mitigation / low radiative forcing. | Provides a lower climate-change trajectory against which policy performance and residual risk can be tested. |
| RCP8.5 | High emissions / high radiative forcing. | Provides a high-stress climate trajectory and broadens the range of possible system responses. |
| SSP2 | Middle-of-the-road development with incomplete and uneven progress. | Provides a continuation-like socio-economic pathway that is neither strongly sustainable nor highly fragmented. |
| SSP4 | High inequality and unequal capacity, technology and resource access. | Tests distributional and implementation challenges that may not appear under aggregate growth assumptions. |

The selection was proportionate to a four-year multi-case project and the computational burden of repeated SDM and NEPAT runs. A new application may select other pathways, newer scenario products or a different number of combinations. It should preserve the analytical principle: choose a set that is scientifically defensible, internally coherent, relevant to the decision horizon and different enough to reveal vulnerabilities and trade-offs.

**METHOD AND EVIDENCE** *Use the IPCC synthesis and the NEXOGENESIS data deliverables to distinguish the international scenario framework from project-specific selection, downscaling and basin translation. D2.1–D2.5 document sources, processing, validation and uncertainty.* IPCC synthesis · NXG D2 resources

**SCENARIO COHERENCE** A climate pathway, socio-economic pathway and policy assumption should form a plausible combination. If elements are mixed for stress-testing, label this clearly and explain the analytical purpose.

## Typical data sources used in NEXOGENESIS

| Source family | Potential contribution |
|---|---|
| ISIMIP | Harmonised cross-sector climate-impact simulations for water, agriculture, ecosystems and related domains; useful for multi-model comparison. |
| CORDEX | Regional climate projections that improve spatial detail compared with global climate-model outputs. |
| Copernicus Climate Change Service | Climate and hydrology-related datasets and indicators, including regional information and historical observations. |
| SIMETAW-GIS and crop models | Crop water requirements, irrigation needs and agricultural responses to climate and soil conditions. |
| GLOBIO and biodiversity models | Biodiversity and ecosystem indicators related to land use, fragmentation, climate and other pressures. |
| CGE and land-use models such as G-RDEM/MagnetGrid | Socio-economic and agricultural projections translated into spatial land-use patterns. |
| Local observations and statistics | Calibration, retrospective validation, bias assessment, local variables and interpretation of regional relevance. |

The source list is illustrative, not mandatory. Specialists should select sources according to the decision question, geography, period, licensing, update cycle and required variables. Local observations remain essential even when global or European datasets are used.

## What specialists should do

1. **Identify target variables.** Start from the decision question and system model: for example precipitation, temperature, runoff, crop water requirements, energy demand, population, GDP, land use or technology.
2. **Screen suitable sources.** Select harmonised, quality-controlled datasets and models with appropriate coverage, resolution, time periods and scenario families.
3. **Define a coherent scenario set.** Combine climate and socio-economic assumptions explicitly; avoid mixing incompatible pathways without explanation.
4. **Downscale for regional relevance.** Translate global or regional outputs to the spatial and temporal scale needed by the basin model, while documenting added assumptions and uncertainty.
5. **Harmonise and format.** Align units, definitions, grids, boundaries, time steps, baselines and missing-data treatment for integration into the SDM.
6. **Validate retrospectively.** Compare modelled historical conditions with observations and local statistics to identify bias, plausibility issues and limitations.
7. **Analyse and communicate uncertainty.** Use ensembles or ranges where appropriate, distinguish scenario from model, parameter and data uncertainty, and retain the information through later modelling stages.
8. **Populate and label the system models.** Provide scenario-specific data vectors to the SDM team, document every transformation and ensure model versions can be compared consistently.
9. **Validate and iterate with specialists and stakeholders.** Test the first simulations against scientific and local knowledge, revise datasets where justified and document unresolved limitations.

## Downscaling and harmonisation add assumptions

Global projections are generally too coarse for basin decisions. Statistical or dynamical downscaling, spatial allocation and disaggregation can improve regional relevance, but they do not create certainty. Choices about correction methods, administrative boundaries, local station data, crop types, land suitability and temporal aggregation can materially affect results. These transformations should be documented and reviewed with local experts.

In NEXOGENESIS, local input led to the inclusion of regionally important crops that were absent from generic datasets—for example grape and apple production in the Adige basin and macadamia and citrus production in Inkomati-Usuthu. This illustrates how stakeholder knowledge can improve technical relevance without replacing quality-controlled modelling.

## How to interpret uncertainty

| Uncertainty source | What it means for the decision |
|---|---|
| Scenario uncertainty | Different future climate and socio-economic pathways can change policy performance; compare conclusions across plausible futures. |
| Model structural uncertainty | Models represent processes differently; use multiple models or explain why a selected model is appropriate. |
| Parameter and input uncertainty | Values, measurements and assumptions may be imprecise; test influential parameters and report plausible ranges. |
| Downscaling and processing uncertainty | Regionalisation and harmonisation introduce additional assumptions that should remain traceable. |
| Decision uncertainty | Preferences, implementation behaviour, costs and political conditions may not be captured by technical projections. |

Multi-model ensembles help show where projections converge and where they diverge. Means or medians should be accompanied by ranges, quantiles and relevant outliers. A wide range is not a modelling failure; it may indicate that flexible, precautionary or adaptive policies are needed.

## What the authority should decide

- Which decisions and risks require future information—and which do not.
- Which planning horizons correspond to real policy, infrastructure or investment cycles.
- Which local thresholds, vulnerable groups, ecosystem conditions or service standards matter.
- Which scenarios are credible enough to test and sufficiently different to reveal vulnerabilities.
- How uncertainty will influence decisions—for example through robustness, precaution or adaptive pathways.

## Deliverables and acceptance questions

| Deliverable | Acceptance questions |
|---|---|
| Scenario framing note | Are pathways, time horizons, combinations and exclusions clearly justified? |
| Data catalogue | Can every variable be traced to source, version, unit, resolution, processing and licence? |
| Regional projections | Do they cover the needed geography, periods and system variables? |
| Validation report | Are historical performance, bias and data gaps reported—not only the best-performing result? |
| Uncertainty analysis | Are uncertainty sources separated and presented in a form decision-makers can interpret? |
| Model-input package | Can the SDM team reproduce and use the data without undocumented transformations? |

**QUALITY PRINCIPLE** Do not ask which scenario is “most likely” before asking which futures could materially change the decision. The purpose is to test policy robustness, not to create false certainty.

## NXG resources

- D2.1 Consolidated data across nexus dimensions
- D2.2 Biophysical data vectors
- D2.3 Socio-economic data vectors
- D2.4 Grid-level socio-economic dataset
- D2.5 Retrospective analysis and uncertainty assessment

CHAPTER 7

# Commissioning system dynamics models

*Co-create a useful representation of the system, then test it transparently.*

| | |
|---|---|
| **What the authority does** | Co-frame the model purpose, participate in mapping, provide institutional and local knowledge, challenge assumptions, identify important policies, validate whether relationships and outputs make sense, and interpret results. |
| **What specialists do** | Develop conceptual maps, causal loop diagrams and quantitative stock-and-flow models; integrate data and sectoral models; calibrate, validate and document; run sensitivity, what-if and uncertainty analyses. |
| **Outputs you should expect** | Validated conceptual map and causal loop diagram, documented SDM, data and parameter register, calibration/validation results, scenario simulations, uncertainty outputs and policy-effect summaries for NEPAT. |
| **Capacity level** | High for model development; moderate for informed participation and interpretation. |

## What the model is for

System dynamics modelling represents feedbacks, delays, accumulations and cross-sector relationships in the WEFE system. It enables the project to explore how policies and external drivers may change system behaviour over time. The model should be as simple as possible while still answering the agreed decision questions. It is a decision-support representation—not a complete replica of the basin.

Participatory modelling has value before any simulation is run. Building a shared representation requires participants to explain causal assumptions, recognise dependencies outside their sector and identify where evidence is missing or contested. Conceptual maps and causal-loop diagrams therefore act as boundary tools between disciplines, organisations and knowledge systems.

## The modelling pathway

1. **Purpose and boundary.** Agree the decision question, spatial and temporal boundary, intended users, exclusions and criteria for judging whether the model is fit for purpose.
2. **Evidence base.** Map data and scenario inputs, assumptions, proxies, scale mismatches, uncertainty, ownership and important knowledge gaps.
3. **Conceptual map.** Agree the main WEFE components, external drivers, policies and material or information relationships; use the map as a boundary object for discussion.
4. **Causal-loop diagram.** Express causal direction, delays and reinforcing or balancing feedbacks; test the logic with stakeholders and domain experts.
5. **Quantitative SDM.** Translate the accepted structure into stocks, flows, equations, parameters and time steps; connect thematic models only where this adds decision value.
6. **Calibration and validation.** Compare behaviour with observations, accepted patterns, extreme-condition tests and stakeholder/domain knowledge; document revisions and remaining limitations.
7. **Policy and uncertainty runs.** Represent policies as parameter or rule changes, run the agreed scenarios, and complete sensitivity, what-if and uncertainty analysis.
8. **NEPAT handover.** Provide tested model versions, variables, policy controls, scenario labels, uncertainty information, metadata and reproducible acceptance cases.

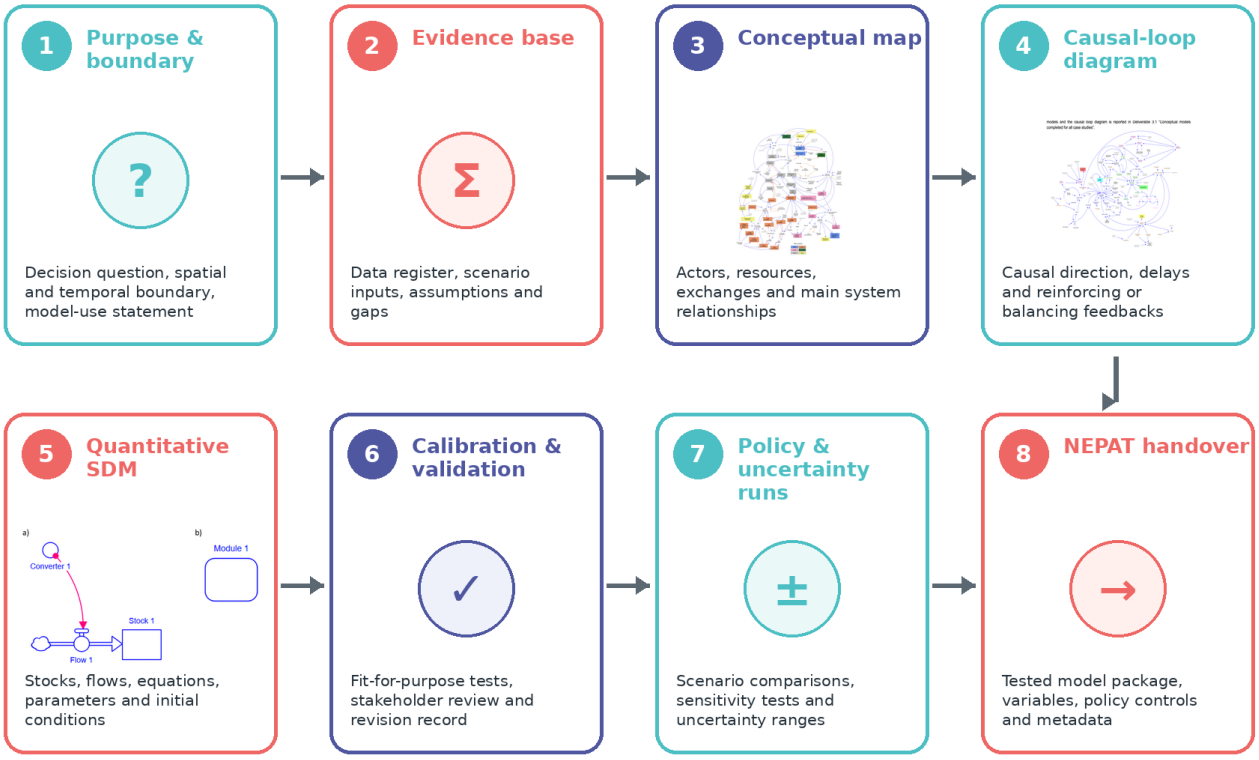



*Figure 8. The eight-step modelling pathway and its aligned modelling outputs. Source: OpenAI 2025; reconstructed from NEXOGENESIS D3.1–D3.6.*

Figure 8 shows the purpose and evidence base that prevent the model from becoming a technically elegant answer to the wrong question. Calibration, uncertainty and a controlled NEPAT handover prevent the quantitative model from being treated as complete merely because it runs.

## Review the output of every modelling step

| Step and modelling output | Main purpose | Acceptance question |
|---|---|---|
| 1. Purpose and boundary note | Connect the model to a decision, users, scale, exclusions and required performance. | Would the proposed model answer the agreed decision question at the right scale? |
| 2. Evidence and assumptions register | Make data, scenarios, proxies, gaps, confidence and ownership traceable. | Can reviewers see what is known, assumed, transformed or missing? |
| 3. Conceptual map | Frame components, actors, external drivers, policies and material/information exchanges. | Are important sectors, actors, cross-border effects and policy entry points represented? |
| 4. Causal-loop diagram | Express causal direction, delays and reinforcing or balancing feedbacks. | Does the proposed cause-and-effect logic reflect evidence and experience? |
| 5. Quantitative SDM | Represent accumulations, rates, equations and time so policies and scenarios can be simulated. | Do the equations and policy controls correspond to how the system operates? |
| 6. Calibration and validation record | Demonstrate fit for purpose and document revisions, limitations and stakeholder review. | Which behaviours are credible, weakly supported or outside the model's capability? |
| 7. Policy and uncertainty results | Compare packages and reveal influential assumptions, ranges and conditional conclusions. | Which conclusions remain stable and which depend on scenarios or parameters? |
| 8. NEPAT integration package | Transfer tested model versions, controls, variables and metadata reproducibly. | Do agreed test cases produce the same behaviour after integration? |

**METHOD AND EVIDENCE** *System dynamics is an established method. Core foundations include Forrester's work and Ford (2009); participatory modelling is discussed by Voinov and Bousquet (2010) and others. NEXOGENESIS applications and methodological contributions are described by Amorocho-Daza et al. (2024) and Sušnik and Mellios (2025). Amorocho-Daza et al. (2024) · Sušnik and Mellios (2025) · NXG D3 resources*

## Use data availability to refine—not silently dictate—the model

Data mapping should begin while the conceptual model is still being discussed. For every proposed connection or variable, record potential global and local sources, ownership, scale, time period, quality, uncertainty and processing needs. The team then makes an explicit choice: retain the variable with a suitable dataset; use a justified proxy; develop a thematic model; represent the relationship qualitatively; collect new data; or exclude it and document the limitation.

| Data situation | Transparent response |
|---|---|
| Several credible sources | Compare definitions and behaviour; select or combine sources with a documented rationale and uncertainty treatment. |
| Only a global or coarse source | Assess whether downscaling is credible and whether local validation can support its use. |
| Only local expert knowledge | Use it to frame hypotheses or parameter ranges, record provenance and seek triangulation. |
| Important process but insufficient data | Consider a simplified or qualitative representation, a thematic model, targeted data collection or an explicit exclusion. |
| Available data but weak decision relevance | Do not add a variable merely because it exists; apply the minimum-model test. |

## When thematic models are useful

A basin may contain a process that requires more detail than the core SDM can provide—for example hydrology, crop water demand, ecosystem-service flows or a specific energy system. A thematic model can be developed in another tool and connected to the SDM. Stakeholders and modellers should first confirm that the additional detail is necessary for the decision, then agree data needs, validate outputs and document how the models exchange information. NEXOGENESIS used thematic modelling in the Adige and Nestos/Mesta cases to complement the system models.

## Calibrate and validate for the intended use

Validation is an argument that the model is credible enough for a defined purpose—not proof that it is a true replica of the basin. A model used to compare the direction of policy effects may need a different level of numerical fit from one used to support an operational allocation. State the intended claims first, then choose tests that can support or limit those claims.

| Test family | What it examines | Evidence to retain |
|---|---|---|
| Structural review | Whether equations and connections reflect accepted theory, domain knowledge and policy mechanisms. | Equation/assumption review, source references, expert comments and resolution log. |
| Dimensional and boundary checks | Whether units, conservation relationships, initial conditions and external inputs are coherent. | Automated or documented checks, balance tests and identified boundary assumptions. |
| Historical behaviour | Whether the model reproduces important observed patterns, trends, events or ranges over an appropriate period. | Plots, fit statistics where meaningful, comparison periods, data quality and residual limitations. |
| Extreme-condition tests | Whether the model behaves plausibly when inputs or parameters take very low, high or limiting values. | Defined test cases, expected direction and actual response. |
| Sensitivity and uncertainty | Which parameters and structures influence conclusions and how outcomes vary across plausible values. | Sampling design, ranges, influential factors and stability of policy conclusions. |

| Test family | What it examines | Evidence to retain |
|---|---|---|
| Stakeholder/domain validation | Whether the system logic, policy representation and simulated behaviour are recognisable and decision-relevant. | Annotated outputs, disagreement, revisions and reasons for retaining contested assumptions. |
| Integration regression tests | Whether translation to Python/NEPAT preserves accepted model behaviour. | Reference input–output cases, tolerances, software versions and test results. |

Avoid reporting only the best-fitting variable or period. A transparent validation record shows where the model performs well, where it is weak and what kinds of inference are not supported. If a variable is poorly reproduced but does not affect the decision conclusion, explain why. If it materially affects package ranking or a vulnerable group, improve the evidence, redesign the model or qualify the decision.

## Keep stakeholder input traceable

Participatory modelling should leave an auditable record of influence. After each mapping or validation activity, record the proposed change, evidence or perspective, the team's response and the resulting model version. "Not incorporated" is a legitimate response when the proposal is outside scope, contradicted by stronger evidence or cannot yet be quantified—provided the reason and consequence are visible.

| Stakeholder input record | Example content |
|---|---|
| Source and context | Stakeholder group or role, activity/date, consent and whether the statement represents experience, preference or formal evidence. |
| Proposed implication | Add a variable, change a causal direction, refine a policy setting, alter a parameter range or flag an omitted effect. |
| Technical assessment | Evidence reviewed, data availability, scale, model relevance and possible representation choices. |
| Decision and rationale | Incorporated, partly incorporated, retained qualitatively, deferred or excluded—with reason. |
| Version and consequence | Model/output changed, acceptance test repeated and any effect on results or limitations. |

**MODEL MINIMUM** Every additional variable, submodel or feedback should answer a decision need, address a material risk or improve credibility enough to justify its data, validation and maintenance burden.

## Participation points that should be mandatory

| Gate | Stakeholder / authority question | Evidence of completion |
|---|---|---|
| Model purpose and boundary | Does the proposed model answer the decision question at the right scale? | Signed-off model scope and exclusions |
| Conceptual structure | Are important actors, resources, feedbacks, delays and cross-border effects represented? | Annotated conceptual map and issue log |
| Data and assumptions | Are sources credible and are proxies or gaps acceptable? | Data/parameter register with confidence notes |
| Behaviour and validation | Does the model reproduce important observed or expected patterns? | Calibration and validation report |
| Policy representation | Does the modelled change correspond to how the policy works in practice? | Policy-to-parameter translation table |
| Results and uncertainty | Which conclusions are robust, conditional or unsupported? | Scenario comparison and uncertainty summary |

## How to judge model quality without becoming a modeller

- **Purpose fit:** The model answers the agreed question and does not add complexity without decision value.
- **Transparency:** Variables, equations, parameters, data sources and assumptions are documented and explainable.
- **Behavioural credibility:** The model is tested against observations, known events, expected patterns and expert knowledge.
- **Uncertainty honesty:** Ranges and limitations are carried into the results rather than hidden behind a single line.
- **Stakeholder traceability:** The team records how stakeholder input changed—or did not change—the model and why.
- **Reusability:** Files, versions, dependencies, ownership and update procedures are clear.

**ETHICAL PRACTICE** Participatory modelling can amplify some perspectives and exclude others. Facilitation should make power differences, contested assumptions and the consequences of model choices visible.

## Sensitivity, what-if and uncertainty are different questions

| Analysis | Question answered | Use in policy dialogue |
|---|---|---|
| Sensitivity testing | Which parameters or assumptions most strongly influence model outputs? | Identifies influential policy levers, fragile conclusions and priorities for better evidence. |
| What-if testing | How would the system respond to a specified event or extreme assumption? | Supports stress-testing, exploration of thresholds and discussion of events that may be plausible but are not part of the standard scenario set. |
| Uncertainty testing | What range of outcomes follows from uncertain parameters, data, models or scenarios? | Shows whether a conclusion is robust, conditional or too uncertain to support a specific decision. |

These analyses should not end with a technical plot. Specialists should explain which conclusions remain stable, which depend on particular assumptions and which interventions could perform acceptably across a range of futures.

## Prepare a controlled handover to NEPAT

In NEXOGENESIS the system dynamics models were translated from Stella Architect into Python for integration with NEPAT. An authority does not need to manage this conversion, but it should require a controlled and tested handover. The NEPAT team needs the deterministic and uncertainty-enabled model versions, policy goals and targets, policy instruments, entry points, model variables, assumptions, scenario labels and footprint indicators. Translation tests should confirm that the integrated model reproduces the accepted SDM behaviour.

## NXG resources

- D3.1 Conceptual models completed for all the case studies
- D3.2 Final report on the complexity science and integration methodologies
- D3.3 Final report on the application of biophysical models and stakeholder recommendations
- D3.4 Complexity science models implemented for all the Case studies Prototypes and explanatory report manual for each Case study methodology
- D3.5 Sensitivity and uncertainty analysis
- D3.6 Sensitivity and uncertainty analysis report
- D3.7 Final report on the WEFE Nexus Index methodology and visualisation

CHAPTER 8

# Using NEPAT for policy exploration

*Use the tool to structure dialogue—not to automate a public decision.*

| | |
|---|---|
| **What the authority does** | Confirm goals and candidate policies, review assumptions and scenarios, use the interface to explore packages, interpret trade-offs, bring feasibility and distributional concerns into discussion, and document stakeholder validation. |
| **What specialists do** | Configure NEPAT, connect system models and scenarios, translate policies into model settings, test the platform and explain outputs, uncertainty and technical limitations. |
| **Outputs you should expect** | Configured case, policy portfolio, scenario set, simulation outputs, WEFE Footprint comparisons, AI-supported recommendations, deliberation record and stakeholder-validated policy package. |
| **Capacity level** | Moderate for use and interpretation after configuration; high for implementation, integration and maintenance. |

## What NEPAT does

The NEPAT is the place where the different strands of the NEXOGENESIS process become visible together. It connects a chosen climate and socio-economic future, represented by an RCP–SSP combination, with the basin system model, the available policy instruments, the policy goals to be achieved and the WEFE Footprint. Users can therefore examine a future basin through two complementary lenses: they can test what they think should be done, or they can specify what they want the future to achieve and ask the decision-support system which policy package performs best against those priorities.

NEPAT is not a single score, forecast or optimisation screen. Its main workspace is the Simulation View (Figure 9). At the top, the Policy Package Summary shows each package being examined: the selected RCP–SSP reference scenario; the policy instruments included; their start, duration and end years; goal-achievement flags; the WEFE Footprint Index; and qualitative information on implementation cost and social acceptance where these have been configured. A package can contain one policy or several policies acting together. Users can add packages for side-by-side comparison, run or rerun them after a change, save and exchange a simulation, and generate a report.

Below this summary, users move between connected views. The *Global View* recalls the basin and scenario context. *Policy Instruments* is where measures and their settings are assembled into packages. *Policy Goals* shows whether the simulated system reaches the selected targets and how performance changes through time. *Nexus Footprint* reveals wider effects across water, energy, food and ecosystems. *Detailed View* opens the underlying model variables and time series so that users can investigate why a headline result occurs. The *Decision Support System* (DSS) reverses the direction of the enquiry: instead of starting from a package, it starts from selected goals or Footprint variables and searches for policy combinations that perform well against them. These views are intended to be read together. A green goal flag, a high average achievement score or a positive overall Footprint should never be interpreted without opening the sectoral and detailed results underneath it.

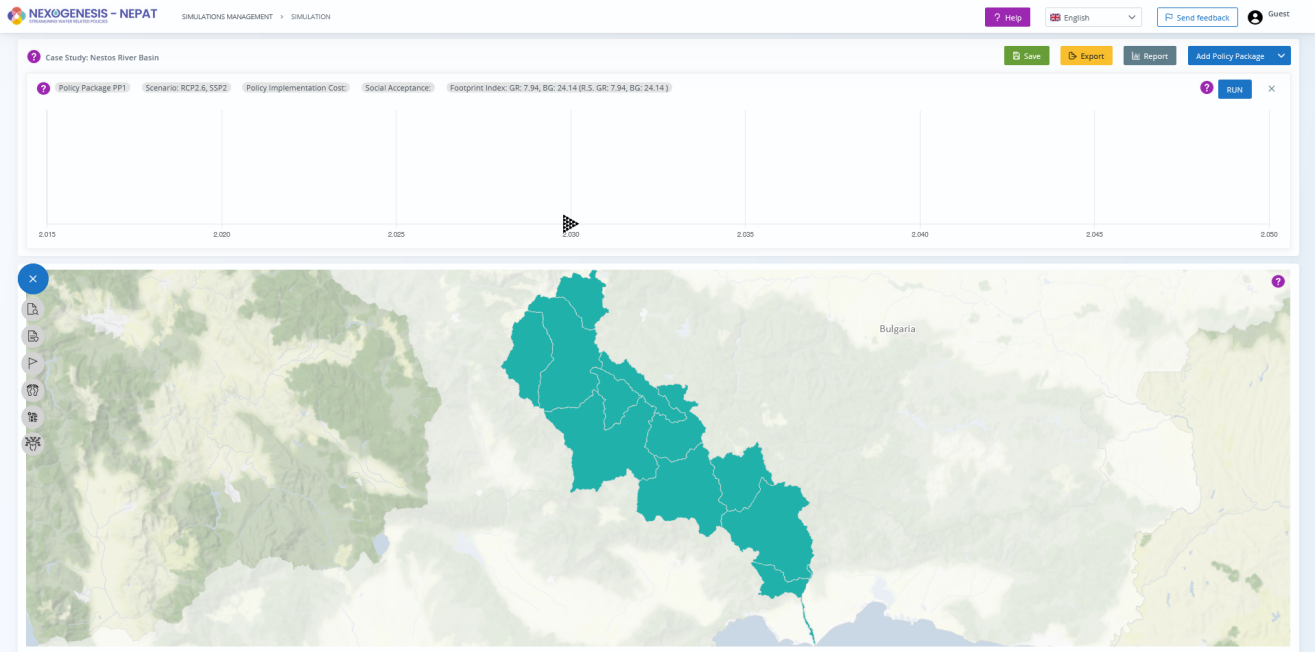



*Figure 9. The plain view of NEPAT showing the Nestos/Mesta River Basin Case. Source: [https://nepat-dev.nexogenesis.eu/](https://nepat-dev.nexogenesis.eu/).*

**NEPAT DOES NOT DECIDE** The tool can reveal trade-offs, synergies and technically strong combinations. It does not automatically resolve political priorities, rights, distributional impacts, implementation capacity, legal constraints or direct economic costs. Those remain matters for evidence-based and legitimate deliberation.

**METHOD AND EVIDENCE** *NEPAT and its decision-support workflow were developed within NEXOGENESIS. Technical design, simulation-policy integration and final validation are documented in D4.1, D4.3 and D4.5; the 57-page User Guide provides step-by-step interface instructions.* *NEPAT User Guide · D4.3 · D4.5*

## What users need to understand

The interface supports a movement from configuration to interpretation. Users should not stop at the first green flag or aggregate index. The views answer different questions and are most useful when used as a sequence: confirm what was run; inspect goal performance; inspect cross-sector side effects; examine detailed variables; then ask the decision-support system for alternatives under explicit constraints.

| View / feature | What it helps users examine | Interpretation question |
|---|---|---|
| Policy Package Summary | The scenario, policies, timing, high-level indicators and whether the latest configuration has been run. | Am I comparing the intended package and an up-to-date simulation? |
| Global View | High-level case and simulation context. | Is the case, reference scenario and overall configuration correct? |
| Policy Instruments | Policies included in a package and their settings or parameters. | Do the settings reflect a plausible implementation of the instrument? |
| Policy Goals | Progress toward targets, including detailed, scaled and normalised views. | Which goals are achieved, improving, stagnant or moving away from target? |
| Nexus Footprint | Annual change across water, energy, food and ecosystems relative to the baseline. | Where are the main synergies, trade-offs and missing indicators? |
| Detailed View | Time series for model variables over the 2015–2050 simulation period. | Which system mechanism or timing explains the headline result? |
| Decision Support System | AI-supported recommendations under selected goals and constraints. | What objective and constraints produced the recommendation—and what is omitted? |
| Comparison / report | Side-by-side packages and an exportable evidence record. | Can stakeholders explain why one package is preferred to another? |

### A possible six-step stakeholder workflow

1. **Prepare the policy exploration.** Agree the policy goals, candidate instruments, scenarios, baseline, model version and questions for participants.
2. **Orient users.** Explain the interface, the underlying system model, the WEFE Footprint and the limits of the decision-support component before asking for choices.
3. **Explore packages.** Begin with participant-selected packages; compare their results across goals, footprint indicators, scenarios and detailed variables.
4. **Use decision support critically.** Compare AI-supported recommendations with participant choices. Discuss why they differ and which feasibility, distributional or political factors the tool does not represent.
5. **Reconfigure if no package is acceptable.** Add, remove, sequence or adjust policies and rerun the model. Where stakeholders identify a desirable measure that is not yet in the portfolio, record it as a hypothetical policy for later modelling rather than forcing a choice among inadequate options.
6. **Validate and document.** Record the preferred package, remaining disagreements, conditions for support, uncertainties, rejected alternatives and implications for the governance roadmap.

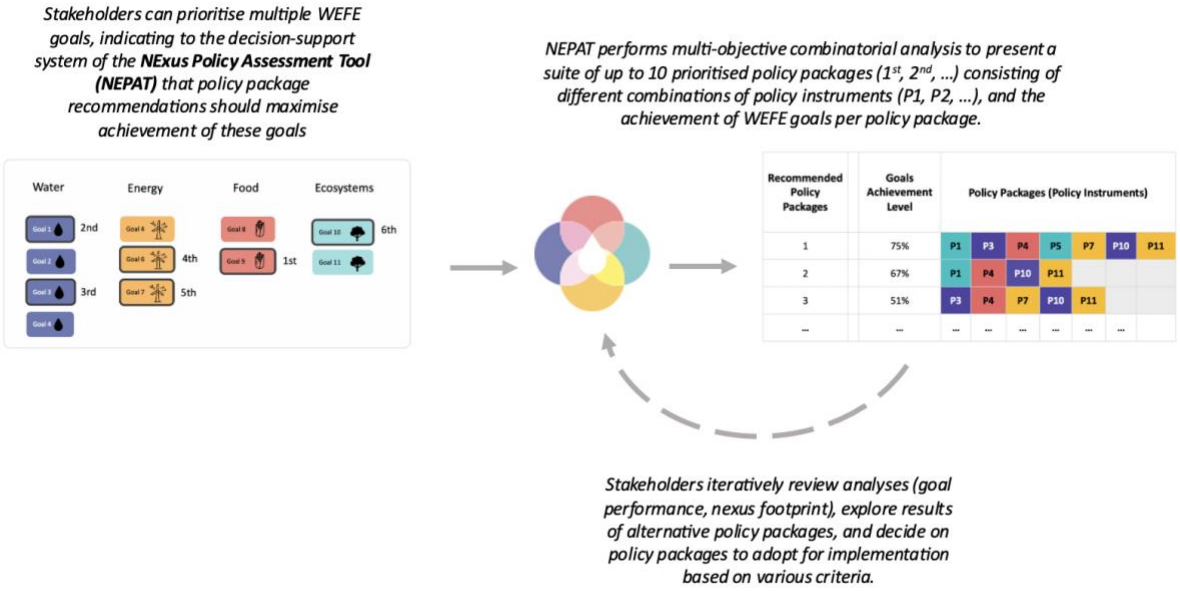



*Figure 10. Iterative exploration of policy packages with stakeholders. A package is proposed, simulated, interpreted and revised until an acceptable, evidence-backed package can be validated—or the process returns to the policy portfolio and model.*
*Source: D1.5*

Figure 10 captures the core logic: comparison is iterative and socially interpreted. A “better” package in the DSS may be rejected because it relies on an unlawful instrument, creates unacceptable distributional effects, exceeds capacity or optimises goals that stakeholders did not prioritise. That rejection should be documented as decision evidence. It may lead to new constraints, safeguards, sequencing or an additional policy that was not initially modelled.

> **THE LOOP IS A RESULT, NOT A FAILURE** If no package meets the agreed goals and feasibility conditions, document why, revise the policy portfolio or assumptions and repeat the exploration. The rationale for changes is part of the evidence trail.

## Readiness gate: what must be connected

The platform should not be used for substantive policy comparison until the minimum case configuration is stable enough to interpret. “Stable” does not mean final or certain; it means that versions, meanings and known limitations are controlled. The checklist below is also the contract between the governance, modelling and NEPAT teams.

| Configuration element | Minimum requirement before deliberation | Owner / verifier |
|---|---|---|
| Reference scenario | Named RCP–SSP combination, time horizon and basin translation, with assumptions explained in plain language. | Scenario team / case lead |

| Configuration element | Minimum requirement before deliberation | Owner / verifier |
|---|---|---|
| System model | Accepted version, baseline behaviour, policy controls, uncertainty mode and tested Python integration. | SDM and NEPAT teams |
| Policy goals | Clear indicator, direction, target or achievement rule, target year and rationale. | Authority/stakeholders with technical support |
| Policy instruments | Readable description, mechanism, controllable parameter, application range and known omissions. | Policy and SDM teams |
| WEFE Footprint | Available pillars/indicators, baseline, direction of benefit, aggregation and missing variables documented. | Footprint/SDM team |
| Decision-support settings | Objective, constraints, maximum policies, sectors and any required pre-existing package made visible. | NEPAT facilitator and decision owner |

**GO / REVISE** Proceed when the case can reproduce agreed test runs and participants can understand the configuration. Revise when a key policy cannot be represented, goal definitions are ambiguous, or the platform and accepted SDM produce different results.

## The WEFE Footprint inside NEPAT

The WEFE Footprint is the cross-sector lens within NEPAT. NEXOGENESIS developed the index and visualisation to summarise change across four pillars—water, energy, food and ecosystems—while allowing users to drill down to sub-pillars and indicators (Figure 11). In the project implementation, the hierarchy included four pillars, nine sub-pillars and sixteen indicators, although not every indicator was available for every case.

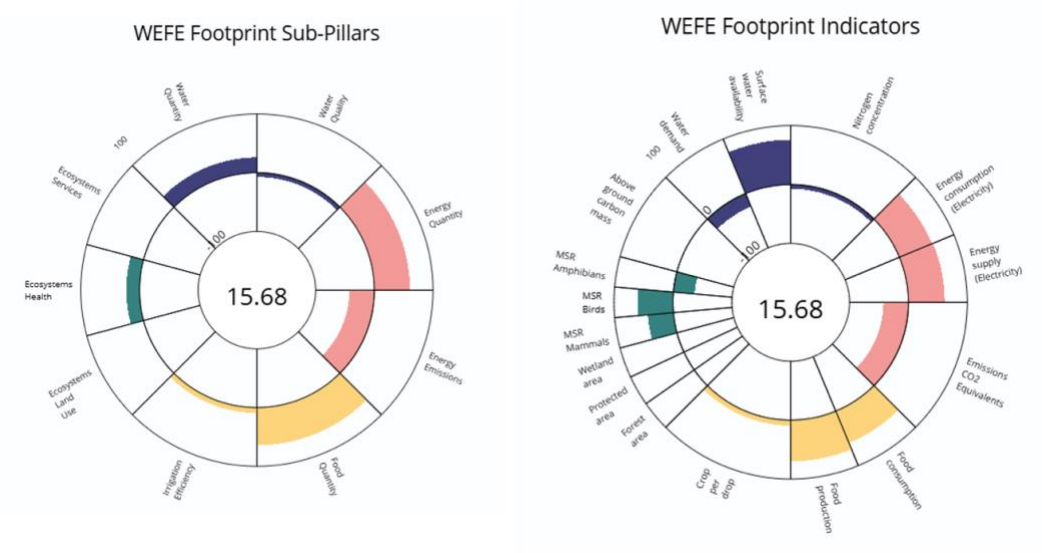



*Figure 11. Example WEFE Footprint profiles used in NEPAT to compare a reference and policy future. Water is blue, energy red, food yellow and ecosystems green; users can move from the central index to pillars, sub-pillars and indicators. Source: D1.5 and NEPAT User Guide.*

The Footprint is expressed on a scale from −100 to +100 relative to the 2015 baseline in the NEXOGENESIS implementation. Positive values indicate improvement relative to that baseline; negative values indicate decline. Zero therefore means no change from the reference point, not “good” performance. A positive overall index can coexist with a serious negative result in one pillar or indicator, so the aggregate should always be opened and interpreted alongside the underlying variables.

| Reading move | What to look for | Common misinterpretation to avoid |
|---|---|---|
| Overall index | Broad direction and differences between packages or years. | Treating one number as a complete welfare or sustainability judgement. |

| Reading move | What to look for | Common misinterpretation to avoid |
|---|---|---|
| Four pillars | Whether gains are concentrated in one sector while another deteriorates. | Assuming a positive average means every WEFE domain improves. |
| Sub-pillars and indicators | The variables driving the result, including greyed-out or unavailable indicators. | Reading missing indicators as zero impact or no concern. |
| Time and scenario | Whether performance is temporary, delayed or sensitive to the RCP–SSP reference scenario. | Comparing values from different scenarios or years as if they were identical conditions. |
| Stakeholder interpretation | Distribution, local thresholds, rights, costs and practical meaning beyond the index. | Assuming aggregation removes value judgements or implementation questions. |

Indicator selection and aggregation are substantive methodological choices. Across the five cases, teams sought a common footprint structure, but basin-scale data were not always available and some indicators required proxies or were omitted. The Footprint should therefore be accompanied by a data-availability note, direction-of-benefit logic, and an explanation of how aggregation and weighting were applied.

**METHOD AND EVIDENCE** *The WEFE Footprint was developed in NEXOGENESIS and is documented in D3.7 and the NEPAT User Guide. Related scientific grounding includes Simpson et al. (2022).* *D3.7 · NEPAT User Guide · Simpson et al. (2022)*

## Interpret stochastic uncertainty

When advanced functionality and stochastic simulation are enabled, NEPAT can run the uncertainty-enabled SDM repeatedly. Detailed goal and variable views then display the first quartile (Q1), median (Q2) and third quartile (Q3) of the simulated distribution. The deterministic baseline remains useful as a reference, but it should not be mistaken for the only plausible outcome.

| Pattern in results | Interpretation | Decision response |
|---|---|---|
| Narrow quartile range and stable package ranking | The result is relatively insensitive to the uncertainty represented in the run. | Focus deliberation on feasibility, distribution and omitted factors. |
| Wide range but consistent direction | Magnitude is uncertain, but improvement or deterioration is comparatively robust. | Consider precaution, adaptive implementation and monitoring thresholds. |
| Range crosses the reference or target | The conclusion is conditional; the package may succeed or fail under plausible parameter values. | Identify drivers, seek better evidence, add safeguards or compare alternatives. |
| Package ranking changes | The “best” package depends on uncertain assumptions. | Avoid a single winner; consider robust or flexible packages and document the trade-off. |

## Designing the use experience

| User perspective | Primary tasks | What a good experience requires |
|---|---|---|
| Policy and stakeholder users | Select goals and policies, compare packages, inspect trade-offs, question assumptions and record conditions for support. | Plain language, a short orientation, facilitated interpretation, visible uncertainty and enough time to discuss why results differ. |
| Technical and administrative users | Configure the case, connect model versions, map policy controls to parameters, load scenarios, test calculations and maintain the platform. | Version control, reproducible test cases, documented mappings, error handling, access management and a clear handover procedure. |

A technically correct installation can still fail as a decision-support process if policy users do not understand what they are seeing. Conversely, a polished workshop cannot compensate for an undocumented or incorrectly translated model. Commissioning should therefore include both platform acceptance and user-session design.

### Prepare and test before a stakeholder session

1. **Freeze the workshop version.** Record the case configuration, model and data versions, scenario set, policy portfolio, goal definitions and footprint weights that will be used.
2. **Run technical acceptance tests.** Check baseline behaviour, policy-to-parameter mappings, extreme and missing values, scenario switching, optimisation constraints, result reproducibility and export functions.
3. **Prepare policy-readable descriptions.** For each instrument, explain the intended mechanism, implementation setting, time horizon and any important effects that the model does not represent.
4. **Rehearse the facilitation.** Use a small internal group to test timing, terminology, navigation, display legibility and the questions that will connect model outputs to institutional feasibility.
5. **Prepare a fallback.** Keep static result summaries or screenshots for agreed packages so that substantive discussion can continue if connectivity or platform performance fails.

**SHOW UNCERTAINTY WITHOUT PARALYSING THE DISCUSSION** Explain the range and source of uncertainty, whether package rankings change, and which conclusions remain stable. Avoid presenting a single optimisation result as a forecast or guarantee.

### Design a sequence of explorations

Users learn more from a deliberate progression than from unrestricted clicking. Begin with a known reference and a small number of participant-proposed packages. Once participants can explain the goal and Footprint results, introduce the decision-support system and more advanced constraints. This preserves agency and makes differences between user judgement and algorithmic recommendation discussable.

| Exploration | Question it helps answer | Useful facilitation move |
|---|---|---|
| Single-policy run | What mechanism and side effects does one instrument create? | Ask participants to predict the direction of effects before revealing the result. |
| Participant-defined package | How do locally preferred instruments interact? | Record the reason for each selected instrument and compare expectations with results. |
| Maximise one goal or WEFE domain | What trade-offs emerge when one objective dominates? | Use the result to expose the consequences of a narrow mandate. |
| Meet several targets with fewer policies | Can a smaller package achieve an acceptable balance? | Discuss administrative simplicity, cost and implementation capacity. |
| Constrained DSS recommendation | What package is suggested when sectors, policy count or existing instruments are restricted? | Make every constraint visible before interpreting the recommendation. |
| Compare across RCP–SSP scenarios | Which packages remain acceptable under contrasting futures? | Distinguish robustness from the best result in any single scenario. |
| Build on an existing package | Which additional instrument improves an already supported direction? | Preserve political feasibility while searching for complementary measures. |

The NEPAT can be used in a multitude of ways. Below, we show two main modalities that help in its exploration.

### Modality 1 — policy-first exploration: “This is what we think we should do”

In this first modality, stakeholders, authorities or experts define a policy package themselves. They select one or more instruments, specify their implementation settings and timing, choose the RCP–SSP future under which the package will be tested, and run the connected system dynamics model. NEPAT then shows how the package performs against the agreed policy goals, how its effects evolve over the simulation period and what wider positive or negative changes appear in the WEFE Footprint and detailed system variables. Multiple packages can be placed beside one another, including a single-policy package that helps explain a mechanism and more complex packages that reveal interaction, reinforcement or interference between instruments.

This is a policy-led “what if?” enquiry: if we implement this package under these future conditions, what is likely to happen? It is particularly useful for testing proposals already under discussion, comparing stakeholder preferences, examining an existing strategy, or challenging assumptions about a familiar instrument. Participants should state what they expect before running the package and then compare that expectation with the simulated result. A policy assumed to be a powerful lever may have only a modest effect on the chosen goal, may take longer than expected, or may create collateral benefits and harms elsewhere in the nexus. The value of the result lies as much in explaining these surprises as in ranking packages.

### Modality 2 — goal-first exploration: "This is how we want the future to look"

In this alterantive modality, users begin with the desired outcome rather than a preferred policy package. They choose the RCP–SSP future, select the policy goals—or, in a separate search, WEFE Footprint variables—to prioritise, and assign their relative importance. Where the advanced functions are available, users can also constrain the search: for example, by retaining policies from an existing package, limiting the maximum number of instruments or restricting the sectors from which instruments may be selected. The AI-supported DSS then searches across the configured policy combinations and returns ranked recommendations, including the policies in each package and their estimated achievement of the selected goals. In the standard interface, the DSS can optimise against selected goals or selected Footprint variables in one request, but not both simultaneously; the recommended packages must therefore be inspected across all other goal, Footprint and detailed views before they are considered credible.

This is a goal-led "what would it take?" enquiry: given this future and these priorities, which modelled policy package most closely produces the conditions we want? It can identify combinations that participants had not considered, show that a smaller package performs nearly as well as a larger one, or demonstrate that the configured portfolio cannot fully achieve every target. The DSS may return up to ten recommendations rather than one inevitable answer. If it finds no better package, that is also information: the goals, constraints, policy portfolio or underlying system relationships may need to be reconsidered.

> **TWO COMPLEMENTARY LENSES ON THE FUTURE** Modality 1 moves from policies to consequences: "If we do this, what happens?" Modality 2 moves from desired consequences to policies: "If we want this future, what would it take?" Using both makes the assumptions in human preferences and algorithmic recommendations visible and contestable.

### What the two modalities make discussable

Moving between the two modalities creates a structured space for conversations that are often difficult to hold with conventional policy documents. First, it makes competing goals explicit. If all goals cannot be achieved equally, participants must discuss which shortfalls are acceptable, whether minimum thresholds should be protected and whether sequencing or safeguards could improve the balance. The DSS weighting is not a technical detail: it expresses a choice about what counts as success.

Second, NEPAT connects ambition to implementation capacity. A modelled package may look attractive but contain more instruments than authorities can finance, administer, monitor or enforce. Conversely, a smaller package may be institutionally feasible but insufficient to reach the goals. These observations should feed directly into the distinction made in Chapter 3 between policy on paper and policy in action, and into the roadmap's assignments of mandate, finance, capacity, timing and accountability.

Third, the exercise reveals questions of voice and power. Who selected the goals, target levels and relative weights? Who defined the policy portfolio from which the DSS is allowed to choose? Which sectors or groups are represented in the model, and whose costs, rights or knowledge remain outside it? A recommendation may be computationally strong while relying on an instrument that shifts burdens to a group with little influence in the workshop. NEPAT makes such choices easier to see, but only an inclusive and well-facilitated process can address them.

Fourth, the comparison can challenge established policy beliefs. Participants may discover that a favoured instrument does little for the intended goal, that two policies largely duplicate one another, or that progress in one domain produces an unexpected loss in another. These are not reasons to dismiss the model automatically or to accept it uncritically. They are prompts to inspect the detailed variables, question the causal assumptions and data, consider complementary measures, and decide how unavoidable trade-offs should be governed.

The two modalities are therefore not competing operating modes from which a team chooses only one. A strong session normally begins with participant-defined packages, uses the DSS to expose alternatives, compares the recommendations with stakeholder expectations, and then returns to a revised participant-defined package. This movement preserves human agency while allowing computational search to broaden the option space. The outcome is not "the package chosen by NEPAT," but an evidence-backed and stakeholder-validated package whose performance, limitations, distributional implications and implementation conditions are understood well enough to enter the governance roadmap.

### Questions for a good deliberation

- Which goals or sectors improve, and which experience trade-offs?
- Do results change materially across climate and socio-economic scenarios?
- Which model assumptions or parameters drive the result?
- Who benefits, who may bear costs, and whose interests are not represented in the model?
- Can the package be implemented under current mandates, budgets, capacities and legal conditions?
- Would sequencing, safeguards or complementary measures reduce the trade-offs?
- What evidence or consultation is still needed before the package can be endorsed?

## Validate a policy package—not only a score

A stakeholder-validated policy package (SVPP) is the main decision output from this chapter. Validation should be based on a recorded set of criteria, not a show of hands after one simulation. NEXOGENESIS practice considered performance against goals and the Footprint, robustness across RCP–SSP conditions, trade-offs, leverage, stakeholder priorities and feasibility. A new application can add legal, rights-based, cost, equity or political criteria as long as they are explicit.

| Validation criterion | Evidence to record |
|---|---|
| Goal and Footprint performance | Which targets improve, which WEFE indicators decline and how the package compares with the reference. |
| Robustness | Whether conclusions and package preference remain acceptable across scenarios and uncertainty ranges. |
| Trade-offs and safeguards | Who or what is negatively affected and which complementary measure, limit or sequencing condition is needed. |
| Feasibility | Mandate, legal fit, institutional capacity, indicative finance, technical practicality and policy-cycle opportunity. |
| Legitimacy and distribution | Whose priorities are represented, whose are missing, who bears costs and how disagreement was handled. |
| Decision rationale | Why the package was preferred, which alternatives were rejected and what evidence could trigger revision. |

**NO ACCEPTABLE PACKAGE** Do not force validation. If every modelled package violates a critical condition, revise the portfolio, policy settings, constraints or model and repeat the exploration. The absence of an acceptable package is a substantive result.

## Outputs to carry into the governance roadmap (→ Chapter 4)

- The preferred policy package and the policy goals it is expected to support.
- A concise explanation of major synergies, trade-offs and scenario dependencies.
- Uncertainty and limitation notes that must remain visible in later decisions.
- Stakeholder conditions, objections and feasibility considerations.
- Policies or measures excluded from modelling but still relevant to implementation.
- Priority governance barriers and enabling conditions to address in the roadmap.

## NXG resources

- Explore NEPAT (guest login available)
- NEPAT step-by-step user guide
- Guidance for using NEPAT in teaching and facilitated exercises
- D4.1 Technical design
- D4.3 Simulation policy framework
- D4.5 Final engine and validation

# Closing the loop: from nexus evidence to sustained action

This guide ends where implementation begins. The purpose of the NEXOGENESIS pathway is not to complete a sequence of assessments or produce a technically impressive platform. It is to help a group of actors move from fragmented understandings and sectoral policies towards a shared account of the system, explicit goals, transparent choices and an implementable pathway for change. The final products are therefore not only a model, a NEPAT simulation or even a preferred policy package. They are the relationships, capacities, commitments and governance arrangements that make coordinated action more likely after the analytical work has ended.

Across five river basins, NEXOGENESIS demonstrated that the co-creation framework can connect stakeholder engagement, governance and policy analysis, future scenarios, system dynamics modelling, AI-supported policy exploration and governance roadmaps in a coherent process. The cases did not produce one universal “best” policy or one institutional form that can simply be copied elsewhere. They produced a tested way of asking better questions: what futures must policy withstand; what goals are being prioritised; which synergies and trade-offs are hidden by sectoral planning; who benefits or bears costs; and what must change in mandates, resources, relationships and implementation practice for a preferred direction to become real?

## What changed in the NEXOGENESIS cases

The clearest outcomes were not identical across the cases, because each process entered a different governance landscape. In the Nestos/Mesta River Basin, structured Greek–Bulgarian dialogue helped actors move from different national concerns—such as ecological flow, irrigation and solid-waste management—towards common priorities for the shared river. Stakeholders validated policy packages explored through NEPAT, endorsed governance roadmaps and incorporated shared actions into two final agreements. The agreements were not an endpoint; they created a basis for continuing co-creation, mobilising finance and developing the policies further through local institutions and follow-on initiatives.

In the Lielupe River Basin, Latvian and Lithuanian participants used national focus groups and a final transboundary workshop to discuss NEPAT packages and roadmap activities for water-quality improvement. The process generated practical ideas around data exchange, economic assessment of measures, joint projects, site visits and continued stakeholder meetings. A Letter of Intent formalised the intention to continue cross-sectoral and cross-border collaboration, with a coordinating organisation identified to maintain contact. The result illustrates that a voluntary commitment can be valuable when it has a clear agenda, an institutional home and identifiable next steps.

In the Jiu River Basin case, the process helped connect basin-level experience with national sustainable-development and policy-working-group discussions. Stakeholders explored how WEFE methods could inform Romanian policy processes and education, while agreements and roadmap work created entry points for continued collaboration. The case also exposed a recurring limitation: local and basin actors may understand the nexus problem well but still have limited influence over national policy. River basin committees, sustainable-development bodies and other intermediaries therefore matter as channels through which local evidence can travel upwards.

In the Adige River Basin, basin diversity and strong provincial identities made a single basin-wide river contract unrealistic within the project period. The case therefore shifted towards the Adige Water Fair and a shared intentions process, using modelling and NEPAT primarily to support awareness, dialogue and the formulation of priorities such as common monitoring, comparable hydrological information and improved data protocols. This was not a lesser result. It demonstrated the importance of adapting the form of commitment to what actors can credibly support, rather than forcing a legally or politically over-ambitious agreement.

In the Inkomati-Usuthu River Basin, workshops and NEPAT visualisations made inter-sectoral synergies and trade-offs more discussable, while policy validation and governance roadmaps were linked to existing catchment-management structures. The case highlighted both the value of practical visualisation for non-specialists and the difficulty of representing sectors such as mining and energy when data and participation are limited. Continuation through catchment forums and established authorities is therefore as important as the original analysis: without an institutional process that can update evidence, invite missing actors and revisit the package, the technical tool will gradually lose relevance.

> **A REALISTIC DEFINITION OF SUCCESS** Success is not that every goal is fully achieved or every stakeholder agrees. It is that trade-offs and exclusions are visible; the evidence can be questioned; a legitimate group can explain why a direction was preferred; responsibilities and barriers are explicit; and there is an institutional route for continuing the work.

## What the cross-case experience teaches

First, co-creation is an infrastructure, not a workshop technique. Early stakeholder mapping, trusted local intermediaries, impartial facilitation and repeated interaction created the conditions for participants to share knowledge and revise positions. Participation had to remain flexible: bilateral meetings, focus groups, newsletters, online formats and sector-specific conversations often sustained involvement when a standard workshop could not. Deliberate attention to low-power, high-interest actors improved the evidence base, while early links to concrete policy processes helped attract decision-makers.

Second, nexus work must be framed beyond water. Several cases struggled to engage energy, mining or other actors when the process was presented mainly through water-management concerns. Sector-specific champions and narratives can translate the nexus into the priorities, incentives and language of reluctant sectors. The same applies to ecosystems: NEXOGENESIS showed that “ecosystems” cannot be assumed to mean the same thing to everyone. Their local meaning, indicators and relationship to ecosystem services, biodiversity, land and water should be made explicit before they are reduced to the variables available in a model.

Third, digital decision support becomes useful only when people, data and institutions can sustain it. NEPAT’s quantitative outputs and visualisations helped non-specialists discuss complex effects, but data gaps, model granularity, usability and training constrained its application. A platform configured once during a project will become obsolete unless responsibilities for data updates, model maintenance, user support and interpretation are anchored and financed. Open and interoperable data, transparent assumptions, local ownership and practical capacity-building are therefore governance requirements, not merely technical preferences.

Fourth, the governance roadmap and stakeholder agreement are the bridge between evidence and action. They convert a preferred package into changes in mandates, behaviour, coordination, finance, information and implementation practice. The agreement need not always be legally binding: its value depends on whether it names a shared direction, identifies who will continue the work and connects to a policy cycle, river basin body, budget process or other durable institutional arena. Roadmaps should likewise remain living documents that are monitored, challenged and adapted as assumptions, political conditions and environmental pressures change.

Finally, lasting impact must be designed from the start. D5.7 found that project-based relationships can quickly weaken when funding ends, even after productive workshops. Institutional anchoring, long-term finance, sector champions, training, open tools and explicit feedback channels between local and national levels should therefore be discussed during project design—not deferred to the final event. D1.5 also cautions that multi-case initiatives can stretch engagement and specialist capacity too thin. Scaling should retain a common methodological spine while allowing meaningful local adaptation and enough time for iteration.

## Carry the process forward

For an authority, consortium or research team reaching the end of this guide, the immediate task is to convert the validated direction into an operating cycle. The following actions help prevent the work from becoming a static report:

1. **Name an institutional home.** Identify the authority, river basin body, working group, partnership or forum that will convene the next review and hold the evidence trail.
2. **Translate the package into mandates and resources.** Link each roadmap action to an accountable actor, legal or policy instrument, budget route, implementation capacity and monitoring responsibility.
3. **Keep the coalition open.** Retain existing participants while creating routes for missing sectors, affected communities and lower-power actors to enter future deliberations.
4. **Maintain the evidence base.** Assign responsibility for data, model and NEPAT updates; record assumptions and versions; and preserve policy-readable explanations of what the tools do and omit.
5. **Monitor both nexus outcomes and governance change.** Track selected WEFE indicators alongside the intermediate changes—coordination, capacity, finance, rules and behaviour—that the roadmap assumes will deliver them.
6. **Create triggers for reconsideration.** Agree when a package, target or roadmap must be reopened, for example after a major drought or flood, new legislation, a material data update, an unacceptable distributional impact or persistent failure to reach a threshold.

The NEXOGENESIS contribution is ultimately a disciplined way to keep the policy conversation open without making it directionless. Models and AI broaden what can be explored; stakeholders and governance analysis establish what is legitimate and feasible; roadmaps and agreements make action and accountability concrete. Used together, these elements allow authorities and communities to treat nexus governance as an adaptive public process: one that can learn, revise and continue as the future unfolds.

> **FINAL TAKEAWAY** Do not end with the preferred policy package. End with a capable coalition, an owned roadmap, a maintained evidence base and a scheduled next decision.

ANNEX

# Case studies and quick-reference sheets

Five basin profiles show how the common pathway was adapted in practice. Six one-page sheets then support briefings, work-package design and completion checks.

1 **Five NEXOGENESIS case studies**

2 **Six module quick-reference sheets**

## Annex Part 1 — Five NEXOGENESIS case studies

NEXOGENESIS applied the pathway described in this guidebook in five contrasting river-basin contexts. Each case combined stakeholder engagement and governance analysis with future scenarios, system dynamics modelling, policy exploration and a governance roadmap. The sequence and intensity were adapted to the decision context, available evidence, institutional relationships and stakeholder capacity. The Nestos/Mesta and Lielupe River Basin cases acted as frontrunner cases, allowing early methods and lessons to inform later application elsewhere.

The cases did not converge on one identical agreement or policy. They converged on a common process for moving from local problem knowledge to cross-sector evidence, package deliberation and an institutional route forward. The formal result depended on local opportunity: signed transboundary or cross-level agreements in some cases, a public dialogue and charter process in another, and commitments to use results in existing catchment structures elsewhere.

| Case study | Distinctive nexus setting | Transfer question |
|---|---|---|
| Nestos/Mesta | Transboundary river, hydropower and irrigation, protected delta and coastal pressures. | How can two countries create a shared agenda while working through different national institutions? |
| Lielupe | Transboundary agricultural basin with nutrient, water-quality and wetland pressures. | How can flexible engagement turn technical collaboration into a durable cross-border commitment? |
| Lower Jiu | Energy transition, irrigated agriculture, wetlands, floods and droughts. | How can basin action connect with national sustainable-development and water institutions? |
| Adige | Hydropower, intensive agriculture, tourism, ecological flows and a vulnerable delta. | How can upstream and downstream interests examine locally specific trade-offs together? |
| Inkomati-Usuthu | Transboundary water allocation, mining, agriculture, energy reliability, ecosystems and equity. | How can technical options be paired with capacity, legitimacy and fair access? |

**READ THESE AS APPLICATION NOTES** The profiles highlight context, methods, key policy or agreement results and lessons. They are not impact evaluations and do not imply that one basin's preferred policies can be transferred unchanged to another.

# Five case-study settings—and what the process led to

The common pathway was adapted to different transboundary, institutional and sectoral realities.




Five contrasting basins allowed the methods to be tested across borders, governance systems and resource pressures. Nestos/Mesta and Lielupe were frontrunners; lessons from them informed the three follower cases.

**WHAT "CULMINATION" MEANT**

The endpoint was not one universal policy. It was a locally validated package, a governance pathway and a concrete form of continuation—agreement, institutional link, public forum or commitment to keep collaborating.



### Nestos/Mesta

Two agreements committed signatories to continue cooperation, promote roadmap policies, raise awareness and seek implementation funding.



### Lielupe

A Letter of Intent established continued cross-sectoral and cross-border collaboration around water quality, data exchange and joint activities.



### Lower Jiu

Two agreements linked the work to Romania's sustainable-development structures and the Jiu Water Management Administration.



### Adige

The Adige Water Fair broadened dialogue and laid foundations for a shared charter of intent and future collaboration.



### Inkomati-Usuthu

Stakeholders validated policy directions and committed to carry NEXOGENESIS outputs into catchment-management forums and future cooperation.

Sources: NEXOGENESIS D1.5, case factsheets, D5.5, D5.7, Policy Brief 3 and the project's case-study achievements page.

*Figure 12. Locations, official case-study imagery and the principal continuation outcome in each NEXOGENESIS case. Sources: NEXOGENESIS D1.5, D5.5, D5.7, Policy Brief 3, case factsheets and the project's case-study achievements page.*

CASE STUDY 1 | GREECE AND BULGARIA

# Nestos/Mesta River Basin

**WHY THIS CASE MATTERS** A 5,479 km² transboundary basin links upstream reservoirs and hydropower with irrigation, farming and livestock, and a downstream delta protected under Ramsar and Natura 2000. Its 243 km river crosses different national governance systems before reaching the Aegean Sea.

## Nexus challenges

- Balancing hydropower operations, irrigation demand, ecological flows and water quality across the border.
- Managing flood risk, sediment and coastal erosion while protecting high-value delta ecosystems.
- Building cooperation around climate adaptation despite different institutions, data and policy processes.

## How the NEXOGENESIS pathway was used

The frontrunner case combined systematic stakeholder mapping, national and transboundary engagement, governance and policy assessment, climate and socio-economic scenarios, participatory system mapping, quantitative system dynamics models and NEPAT policy-package exploration. Stakeholders identified shared priorities including reducing water losses and increasing renewable-energy generation, while national discussions retained concerns such as ecological flow, irrigation, waste and coastal pressures. Preferred directions were translated into governance roadmaps before the sixth transboundary workshop.

## What was decided or carried forward

**KEY RESULT** Two agreements were signed. A Bulgarian agreement was signed by the mayors of Gotse Delchev and Nestos; a Greek agreement added Greek Civil Protection and the Nestos Farmers' Association. Signatories committed to continue cooperation, promote the governance-roadmap policies in local communities, raise awareness, identify funding opportunities and advance implementation through future projects. The agreements recognised that modernising irrigation and some other measures still depend on national decisions.

## Lesson for replication

Transboundary co-creation benefits from parallel national work, deliberate cross-border moments and a concrete shared commitment. The roadmap should distinguish what local coalitions can deliver from what they must advocate to national actors; it should not average away different priorities or mandates.

**Open the NEXOGENESIS Nestos/Mesta River Basin case-study page** · Case lessons and agreements (D5.7)

CASE STUDY 2 | LATVIA AND LITHUANIA

# Lielupe River Basin

**WHY THIS CASE MATTERS** The 17,788 km² transboundary Lielupe basin supports about 800,000 people. Roughly 60% is agricultural land and about 30% forest, with important wetlands and floodplain meadows. Agricultural intensification makes nutrient management and water quality central nexus issues.

## Nexus challenges

- Reducing nutrient losses while sustaining agricultural production and rural livelihoods.
- Coordinating water, food, ecosystem and climate priorities across two countries and multiple administrative levels.
- Maintaining stakeholder participation beyond formal project workshops and avoiding duplication with other initiatives.

## How the NEXOGENESIS pathway was used

As a frontrunner case, Lielupe tested the stakeholder, governance and policy-assessment methods early. Local and cross-border actors helped frame nutrient and water-quality pressures, validate upstream–downstream system relationships, examine nature-based and land-use measures, explore policy packages and shape a governance roadmap. National focus groups and the sixth workshop connected NEPAT results with practical options for joint Latvian–Lithuanian work.

## What was decided or carried forward

**KEY RESULT** Stakeholders signed a Letter of Intent for Cross-sectoral and Cross-boundary Collaboration in the Lielupe River Basin District. It reaffirmed cooperation around improved water quality and identified practical routes including environmental-data exchange, collaborative projects, site visits, stakeholder meetings, online tools, economic assessment of measures and continued review of the legal framework. Baltic Environmental Forum assumed a coordinating/contact role.

## Lesson for replication

Durable cooperation grows through both structured workshops and informal relationship-building. A letter of intent is stronger when it names a coordinator and a practical agenda, yet it still requires institutional anchoring and finance. Linking to existing projects and networks can reduce fatigue and help the roadmap find a home.

**Open the NEXOGENESIS Lielupe River Basin case-study page** · Case lessons and agreements (D5.7)

CASE STUDY 3 | ROMANIA

# Lower Jiu River Basin

**WHY THIS CASE MATTERS** The 16,759 km² Jiu basin connects upstream coal and lignite areas with downstream agriculture, irrigation, hydropower and Natura 2000 wetlands. The lower basin has experienced extensive wetland loss and faces drought, flooding and erosion alongside the social and economic implications of energy transition.

## Nexus challenges

- Managing water needs and land-use pressures while restoring or protecting wetland functions.
- Addressing drought, flood and erosion risks under changing climate conditions.
- Connecting regional transition and basin priorities with national sustainable-development and water-governance processes.

## How the NEXOGENESIS pathway was used

All case studies used six workshops to connect local knowledge and institutional analysis with four RCP–SSP test conditions, system dynamics modelling and policy-package discussion. Results made both synergy and trade-off visible: afforestation supported climate mitigation, while expansion of irrigated agriculture could increase nitrogen leaching. The roadmap focused on institutional capacity, training, the use of nexus approaches in education and links to energy-transition and sustainable-development processes.

## What was decided or carried forward

**KEY RESULT** Two agreements connected the project's legacy to organisations at complementary levels: Romania's Department for Sustainable Development and the Jiu Water Management Administration. The intended continuation was not only further modelling; it included using existing governance platforms, strengthening cross-sector coordination, building basin-authority capacity and embedding nexus thinking in academic and professional education.

## Lesson for replication

A basin roadmap gains traction when it connects complementary levels. National sustainable-development structures can support policy coherence and energy-transition entry points, while the basin administration anchors implementation where resource interactions occur. Training and institutional memory are implementation actions, not merely dissemination.

**Open the NEXOGENESIS Lower Jiu River Basin case-study page** · Case lessons and agreements (D5.7)

CASE STUDY 4 | ITALY

# Adige River Basin

**WHY THIS CASE MATTERS** The 409 km Adige drains a 12,100 km² basin from the Alps to the Adriatic. Sixty-one hydropower stations, intensive apple production, vineyards and cereals, tourism, river ecosystems and delta wetlands create strong upstream–downstream interdependencies. The coast also faces saline intrusion and erosion.

## Nexus challenges

- Coordinating hydropower, irrigation, ecological-flow and tourism needs along a highly regulated river.
- Representing locally specific crops, seasonal demand and mountain-to-delta processes in scenarios and models.
- Including downstream wetlands and coastal vulnerability in decisions dominated by upstream water uses.

## How the NEXOGENESIS pathway was used

Stakeholders and specialists developed a basin-specific system understanding, assembled climate, land-use and socio-economic inputs, modelled cross-sector dynamics and explored policy effects. Local input led the technical work to represent regionally important apple and grape production. The case also exposed a scale problem: basin-wide results were not always detailed enough for provincial policymakers, so credibility depended on connection with trusted local hydrological evidence and institutions.

## What was decided or carried forward

**KEY RESULT** The two-day Adige Water Fair created a visible forum for actors to discuss water-management barriers, needs and solutions and to lay foundations for a shared charter of intent. The culmination was therefore a widened and more public basin dialogue rather than a claim that one final policy package had already secured formal adoption.

## Lesson for replication

Broad basin dialogue works best when technical variables remain recognisably local and the scale of results matches the jurisdictions expected to act. Public events can widen ownership and create a shared agenda, but follow-up needs a named institutional route and stakeholder requests must be paced to avoid fatigue.

**Open the NEXOGENESIS Adige River Basin case-study page** · Case lessons and agreements (D5.7)

CASE STUDY 5 | SOUTHERN AFRICA

# Inkomati-Usuthu Water Management Area

**WHY THIS CASE MATTERS** The Inkomati-Usuthu system connects South Africa, Eswatini and Mozambique. Mining in upper catchments, high-value irrigated agriculture, conservation areas including Kruger National Park, energy needs and diverse urban and rural water users make allocation, quality, ecosystem health and equity inseparable.

## Nexus challenges

- Responding to over-allocation, uneven access and competing demands across users and borders.
- Addressing mining-related water-quality pressures, treatment needs and ecosystem protection.
- Managing links between irrigation, food production, unreliable energy supply, biodiversity and climate risk.

## How the NEXOGENESIS pathway was used

The case combined stakeholder and governance assessment with future scenarios, participatory mapping, system dynamics and policy exploration. Stakeholders used NEPAT to identify a starting set of policies and validated three instruments, with a fourth food-related instrument under consideration. The governance assessment found a restrictive context shaped by weak cross-sector communication and accountability, but also identified short-term flexibility and some water–ecosystem policy coherence as leverage points.

## What was decided or carried forward

**KEY RESULT** Draft roadmaps were prepared for maintenance and repair of water-treatment infrastructure and for securing Strategic Water Source Areas. Stakeholders identified potential forms of agreement and committed to continued collaboration, including carrying NEXOGENESIS outputs into catchment-management forums. Further bilateral work was required to finalise responsible actors and agreements; the result is a concrete continuation pathway, not a completed formal accord."

## Lesson for replication

Technical optimisation is insufficient where access, trust, mining-data gaps and institutional capacity are central. Replication should clarify who bears costs and benefits, create neutral multi-sector spaces, obtain the participation of powerful actors, and connect basin action with transboundary allocation and national implementation systems.

**Open the NEXOGENESIS Inkomati-Usuthu Water Management Area case-study page** · Case lessons and agreements (D5.7)

# Annex Part 2 — Six module quick-reference sheets

The following sheets condense the six technical modules described in Parts I and II. They are designed for short briefings, procurement or work-package discussions, and completion checks. They should be used together with the fuller chapters, particularly where methodological choices or public decisions require a traceable evidence record.

| Sheet | Module | Primary use |
|---|---|---|
| A | Stakeholder engagement | Plan legitimate and sustained participation. |
| B | Governance assessment | Diagnose institutional and policy conditions. |
| C | Governance roadmaps | Turn a policy package into owned actions. |
| D | Future scenarios | Commission decision-relevant future inputs. |
| E | System dynamics modelling | Represent feedbacks and simulate policy effects. |
| F | NEPAT | Explore policy packages and deliberate over trade-offs. |

ANNEX A | QUICK REFERENCE

# Stakeholder engagement

*Create the legitimacy, knowledge exchange and relationships that the whole process depends on.*

**WHAT IS BEING DONE HERE?** The team identifies affected and influential actors, chooses the appropriate level of engagement for each activity, and generates the system, target and transformation knowledge required by later decisions.

### WHY IS IT NEEDED?

To identify affected and influential actors, fill knowledge gaps, surface trade-offs, test practical relevance and build ownership.

### WHEN IS IT NEEDED?

Throughout the process. Start before scope is fixed; review the plan at each transition from co-explore to co-design to co-develop.

### WHERE DOES INFORMATION COME FROM?

Existing networks and registers, snowball identification, sector and mandate mapping, interviews, workshops, local knowledge and engagement records.

### WHAT PROCESS DOES IT INFORM?

Problem framing, governance assessment, model design and validation, policy exploration, roadmap development and stakeholder commitments.

### WHAT THE AUTHORITY DOES

Sets engagement aims; convenes; confirms representation; closes feedback loops; protects consent and confidentiality; sustains participation.

### WHAT SPECIALISTS DO

Facilitation design, power and relationship analysis, inclusive methods, documentation, participation evaluation and adaptation.

### CAPACITIES NEEDED

Policy knowledge, facilitation, communication, conflict sensitivity, inclusion, data protection and monitoring/evaluation.

### OUTPUTS

Stakeholder register/map, influence-interest and actor-linkage analysis, engagement and communication plan, evaluation record.

### HANDOVER TO THE NEXT STEP

Provide the stakeholder map, engagement levels, knowledge needs, participation risks and feedback commitments to the governance, modelling and NEPAT teams.

### QUALITY CHECK

Are affected low-power groups represented? Do participants know their influence? Is there evidence that input changed the work?

**NXG resources**

- D5.1 Report on Stakeholder Engagement
- D1.1 Co-creation approach
- D5.7 Lessons learned

ANNEX B | QUICK REFERENCE

# Governance assessment

*Understand how institutions and policies enable—or obstruct—integrated WEFE action.*

**WHAT IS BEING DONE HERE?** The team applies NXGAT and policy-coherence analysis to explain mandates, relationships, resources, barriers, enabling conditions and cross-sector policy interactions, then validates the interpretation with stakeholders.

### WHY IS IT NEEDED?

To move beyond technical solutions and identify mandates, coordination conditions, policy interactions and implementation barriers.

### WHEN IS IT NEEDED?

Early in co-exploration, after the initial problem and stakeholder scope are defined; validate before selecting the policy portfolio.

### WHERE DOES INFORMATION COME FROM?

Interviews, policy and legal documents, plans, implementation experience, institutional data, expert interpretation and stakeholder validation.

### WHAT PROCESS DOES IT INFORM?

Candidate policy selection, model scope, interpretation of results, feasibility assessment and later governance roadmap.

### WHAT THE AUTHORITY DOES

Provides mandate and documents; identifies respondents; participates in analysis; tests findings; validates priorities and candidate policies.

### WHAT SPECIALISTS DO

Apply NXGAT, code and synthesise evidence, build the policy inventory, assess coherence, facilitate validation and document rationale.

### CAPACITIES NEEDED

Governance analysis, policy analysis, interviewing, qualitative coding, institutional knowledge and workshop facilitation.

### OUTPUTS

Validated barriers/enablers, policy inventory, coherence matrix, gap analysis, candidate policy portfolio and evidence trail.

### HANDOVER TO THE NEXT STEP

Provide priority nexus problems, policy goals and instruments, governance constraints, model-relevant mechanisms and unresolved disagreements to the technical teams.

### QUALITY CHECK

Can every judgement be explained? Are disagreements visible? Are policy relevance and technical modellability distinguished?

**NXG resources**

- D1.2 Governance and policy assessment
- D1.5 Consolidated framework
- NXG case-study reports

**Completion test** Can a decision-maker see what was done, why it matters, what remains uncertain, and what decision the output supports?

ANNEX C | QUICK REFERENCE

# Governance roadmaps

*Turn a preferred policy package into outcomes, actions, responsibilities and sustained commitment.*

**WHAT IS BEING DONE HERE?** Stakeholders work backwards from a preferred policy package to define the policy-on-paper and implementation-in-action changes, intermediate outcomes, owners, resources and commitments needed for delivery.

### WHY IS IT NEEDED?

A technically strong policy package will not implement itself. The roadmap connects policy choice to institutional and behavioural change.

### WHEN IS IT NEEDED?

During co-development, after stakeholders have explored and validated a preferred policy package.

### WHERE DOES INFORMATION COME FROM?

Policy goals, validated package, governance assessment, stakeholder and actor maps, local experience, mandate and resource information.

### WHAT PROCESS DOES IT INFORM?

Implementation planning, coordination, budgeting, partnership formation, monitoring, learning and formal or informal agreements.

### WHAT THE AUTHORITY DOES

Convenes roadmap work; confirms goals; assigns owners; negotiates commitments; integrates actions into official processes; coordinates follow-up.

### WHAT SPECIALISTS DO

Facilitate theory-of-change development, test causal logic and assumptions, document the action plan and design monitoring.

### CAPACITIES NEEDED

Strategic planning, facilitation, institutional analysis, negotiation, budgeting and monitoring/evaluation.

### OUTPUTS

Visual results chain, action plan, responsibilities, timeframe, indicative resources, assumptions, indicators and stakeholder commitments.

### HANDOVER TO IMPLEMENTATION

Integrate agreed actions into plans, budgets, mandates, agreements and review cycles; name a coordinator and preserve links to the validated policy package.

### QUALITY CHECK

Are outcomes observable and owned? Are actions resourced? Is a coordinating body named? Is the roadmap reviewed and adaptable?

**NXG resources**

- D1.5 Consolidated framework
- D5.7 Lessons learned
- Case-study implementation reports

**Completion test** Can a decision-maker see what was done, why it matters, what remains uncertain, and what decision the output supports?

ANNEX D | QUICK REFERENCE

# Future scenarios

*Test policies against plausible climate, biophysical and socio-economic conditions.*

**WHAT IS BEING DONE HERE?** Specialists select a defensible subset of IPCC-related RCP and SSP pathways, downscale and harmonise them, and combine them with observations and local knowledge to create traceable basin-model inputs.

### WHY IS IT NEEDED?

To reveal whether policies remain effective and equitable under changing climate, land use, population, economy and resource demand.

### WHEN IS IT NEEDED?

After decision variables and planning horizons are agreed, before quantitative SDM simulations are finalised.

### WHERE DOES INFORMATION COME FROM?

Climate models and scenario pathways, SSP-consistent socio-economic projections, global and regional datasets, observations and local statistics.

### WHAT PROCESS DOES IT INFORM?

System dynamics model inputs, policy stress-testing, NEPAT scenario comparison and robustness-oriented decision-making.

### WHAT THE AUTHORITY DOES

Defines decision needs, time horizons and local thresholds; supplies context; reviews assumptions; validates plausibility and usability.

### WHAT SPECIALISTS DO

Select pathways, downscale, harmonise and document data, validate retrospectively, quantify and communicate uncertainty.

### CAPACITIES NEEDED

Climate and impact modelling, socio-economic modelling, GIS, statistics, data engineering, metadata and uncertainty analysis.

### OUTPUTS

Scenario framing, data catalogue, projections, harmonised inputs, validation report, uncertainty analysis and accessible visuals.

### HANDOVER TO THE NEXT STEP

Supply versioned, scenario-labelled model inputs and a plain-language note on RCP–SSP assumptions, processing, uncertainty and limitations to the SDM team.

### QUALITY CHECK

Are scenarios coherent and decision-relevant? Can variables be traced? Are bias, gaps and multiple uncertainty sources visible?

**NXG resources**

- D2.1 Data sources
- D2.2-D2.4 Data vectors and downscaling
- D2.5 Validation and uncertainty

**Completion test** Can a decision-maker see what was done, why it matters, what remains uncertain, and what decision the output supports?

ANNEX E | QUICK REFERENCE

# System dynamics modelling

*Represent cross-sector feedbacks and simulate how policies may change system behaviour.*

**WHAT IS BEING DONE HERE?** The team moves through eight controlled outputs—from purpose and evidence to conceptual and causal models, a quantitative SDM, validation, policy/uncertainty runs and a tested NEPAT handover.

### WHY IS IT NEEDED?

To connect WEFE relationships, delays and feedbacks and assess policy effects over time rather than in isolated sectors.

### WHEN IS IT NEEDED?

In co-design, once the decision boundary, core relationships, policy portfolio and scenario inputs are sufficiently clear.

### WHERE DOES INFORMATION COME FROM?

Stakeholder and expert knowledge, conceptual maps, sectoral models, scenario datasets, observations, policy mechanisms and literature.

### WHAT PROCESS DOES IT INFORM?

Policy simulations, sensitivity/what-if analysis, WEFE Footprint calculation, NEPAT configuration and stakeholder deliberation.

### WHAT THE AUTHORITY DOES

Co-frames purpose and boundary; joins mapping; tests assumptions and policy representation; validates relevance; interprets uncertainty.

### WHAT SPECIALISTS DO

Build maps and equations, integrate data/models, calibrate and validate, run simulations and uncertainty tests, document and hand over.

### CAPACITIES NEEDED

System dynamics, sector modelling, data science, statistics, participatory modelling, facilitation and software/version management.

### OUTPUTS

Conceptual map, causal loop and stock-flow models, data/parameter register, validation, simulations, uncertainty and NEPAT-ready outputs.

### HANDOVER TO THE NEXT STEP

Transfer tested model versions, policy controls, scenario labels, uncertainty settings, metadata and reference test cases to the NEPAT team.

### QUALITY CHECK

Does the minimum model answer the decision question? Are assumptions traceable? Which conclusions are robust or conditional?

### NXG resources

- D3.1 Conceptual models
- D3.4 Implemented models
- D3.5-D3.6 Uncertainty
- D3.7 WEFE Nexus Index

**Completion test** Can a decision-maker see what was done, why it matters, what remains uncertain, and what decision the output supports?

ANNEX F | QUICK REFERENCE

# NEPAT

*Explore policy packages and make trade-offs visible in a structured stakeholder dialogue.*

**WHAT IS BEING DONE HERE?** Users combine an accepted system model, RCP–SSP scenario, policy goals and instruments; compare user-defined and DSS-supported packages through goal, Footprint and detailed views; and validate an acceptable package for roadmapping.

**WHY IS IT NEEDED?**

To compare policies across WEFE goals and scenarios, visualise synergies and trade-offs and support transparent deliberation.

**WHEN IS IT NEEDED?**

After policy goals, instruments, system models and scenarios are configured; before developing governance roadmaps.

**WHERE DOES INFORMATION COME FROM?**

Policy portfolio, SDM simulations, climate and socio-economic scenarios, WEFE indicators and user-selected objectives.

**WHAT PROCESS DOES IT INFORM?**

Policy-package exploration, AI-supported recommendation, stakeholder validation, feasibility discussion and roadmap selection.

**WHAT THE AUTHORITY DOES**

Confirms goals and policies; explores packages; interrogates results; brings feasibility, rights and distribution into discussion; documents validation.

**WHAT SPECIALISTS DO**

Configure and test the platform, connect models, translate policy settings, maintain the architecture and explain technical limitations.

**CAPACITIES NEEDED**

Policy analysis, model literacy, facilitation and data visualisation for users; software, API and model integration for implementers.

**OUTPUTS**

Configured case, scenario and policy comparisons, footprint and goal views, DSS recommendations, deliberation record and validated package.

**HANDOVER TO THE NEXT STEP**

Provide the validated package, trade-offs, scenario and uncertainty dependencies, feasibility conditions, objections and excluded measures to the roadmap team.

**QUALITY CHECK**

Are recommendations linked to stated objectives? Are uncertainty and omitted costs/impacts visible? Is the decision rationale documented?

**NXG resources**

- Explore NEPAT
- NEPAT user guide
- NEPAT teaching/facilitation guide
- D4.1-D4.5 technical resources

**Completion test** Can a decision-maker see what was done, why it matters, what remains uncertain, and what decision the output supports?

# Selected NEXOGENESIS resources

This guide deliberately routes detailed replication methods to the underlying project resources. The official NEXOGENESIS downloads page is the most reliable entry point for public deliverables, case-study reports, factsheets and policy briefs.

**Open the NEXOGENESIS downloads page**

## Framework, governance and co-creation

- D1.1 Stakeholders' co-creation approach
- D1.2 Governance and policy assessment
- D1.5 Consolidated governance framework and guidance
- D5.1 Report on Stakeholder Engagement
- D5.7 Recommendations and lessons learned

## Future scenarios and data

- D2.1 Consolidated data sources
- D2.2 Biophysical data vectors
- D2.3 Socio-economic data vectors
- D2.4 Grid-level socio-economic data
- D2.5 Retrospective validation and uncertainty

## System dynamics and WEFE Footprint

- D3.1 Conceptual models
- D3.4 Implemented models and manuals
- D3.5 Sensitivity and uncertainty
- D3.6 Sensitivity/uncertainty report
- D3.7 WEFE Nexus Index

## NEPAT

- NEPAT platform
- NEPAT step-by-step user guide
- NEPAT teaching and facilitation guide
- D4.1 Technical design
- D4.3 Simulation policy framework
- D4.5 Final engine and validation

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