REsilienT water gOvernance Under climate CHange within the WEFE NEXUS

Deliverable D3.3

Policy briefs on the potential of economic instruments for improved water management and governance in Europe

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Nature of the deliverable		
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DEM	Demonstrator, pilot, prototype, plan designs	
DEC	Websites, patents filing, press & media actions, videos, etc.	
OTHER	Software, technical diagram, etc.	

Dissemination Level		
PU	Public, fully open, e.g. web	X
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CI	Classified, information as referred to in Commission Decision 2001/844/EC	

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Executive summary

This set of five policy briefs, developed under Tasks 3.5 and 4.5 of the RETOUCH NEXUS Horizon Europe project, presents a strategy for scaling economic instruments, sustainable financing options, and governance mechanisms for integrated water management within the Water–Energy–Food–Ecosystems (WEFE) nexus. Drawing on six European case studies spanning Mediterranean, Continental, Atlantic, and island settings, the briefs distil methodological lessons into transferable policy recommendations.

Each brief examines how a specific economic or governance instrument — water pricing, drought-adaptation packages, collective strategies for non-conventional water resources, water and energy sustainability in small island economies, and economy-wide water footprint analysis — can be scaled both horizontally (scale out*) and vertically (scale up**). The briefs are organised around five distinct modelling approaches: hydro-economic modelling (Germany and Spain), choice experiments (Netherlands), cost–benefit analysis (Belgium), dynamic sustainability modelling (Malta), and environmentally extended input–output analysis (Slovakia).

The overarching finding is that effective water governance instruments exist and are analytically mature. Their wider adoption, however, depends on three conditions: transparent modelling to build stakeholder trust, sector-sensitive design to avoid unintended distributional impacts, and institutional frameworks that enable cross-sectoral coordination across the WEFE nexus.

*** Scaling Out:** to increase impact by replicating a model in similar contexts, providing flexibility, resilience, and cost-effective growth, often focusing on shared features.

**** Scaling Up:** to increase the coverage, size, capacity, scope, or output of a model to a wider context, essentially making it bigger and more effective. It's about growing substantially, not just linearly, to provide more comprehensive insights.

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2023 2026

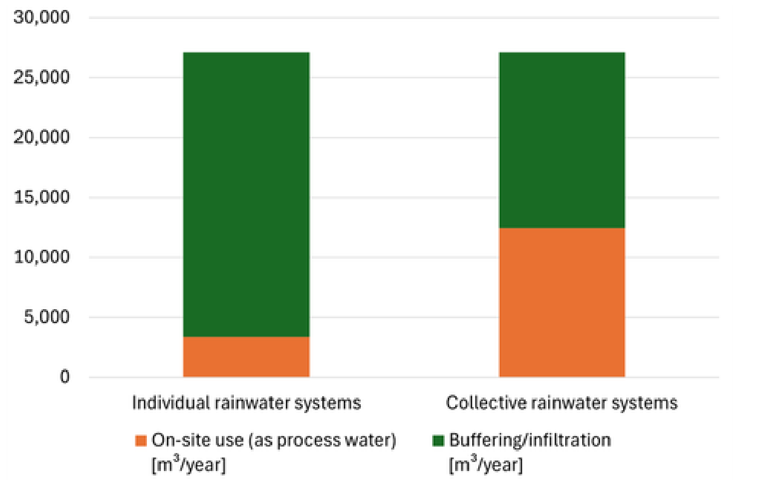
The RETOUCH NEXUS project promotes a cross-sectoral Water–Energy–Food–Ecosystems (WEFE) Nexus approach to support a resilient EU water economy. It ensures that water governance considers ecological, social, and economic dimensions, fostering coherence and effectiveness across sectors and governance levels.

Policy brief | Upscaling of water governance Instruments | Collective & scalable strategies for non-conventional water resources

This policy brief examines methodological approaches to scaling economic instruments and models for water governance.
Case studies are illustrative, and broader application is possible through context-specific analysis.

Introduction: Decentralised solutions of circular water management (e.g. buffering and using rainwater locally or to recharge groundwater) improve household, industrial and/or agricultural water availability, and ecosystem support. However, the business case for these solutions is often unclear, hindering investments.

Modelling Approach: Cost–benefit analysis (CBA) compares the total societal costs and benefits of selected scenarios in monetary terms. For decentralised water solutions, CBA integrates a water balance module, monetary valuation of benefits (and savings), and costs such as investments, land use, maintenance, and operation. Scenarios compare different scales, and sensitivity analysis account for uncertainty in parameters.



Comparing potential rainwater use, buffering and infiltration at a greenfield business park for individual systems vs. a collective solution

RETOUCH NEXUS CASE STUDIES - LESSONS LEARNED

Benefits (+)/costs (–) of collective rainwater use relative to BAU (companies operate individual rainwater tanks). Overall net saving over a 40-year period.

Category	Benefits (+) & Costs (-) in €
Groundwater extraction & tarrif costs	-72,335
Drinking water prodution costs	106,845
Wastewater treatment costs	-18
Flooding costs	0
CAPEX	142,644
OPEX	65,672
Collective vs individual systems	**242,808**

RETOUCH NEXUS CASE STUDY

The Flanders (Belgium) case study applies CBA to the Keiberg Vossem greenfield business park demonstration site, comparing a business-as-usual scenario, that complies with Flemish legislation and guidelines vs. an innovative collective rainwater harvesting system over a 40-year horizon with a 4% real discount rate. Benefits are valued using avoided costs: wastewater treatment (€0.30/m³), drinking water production (€0.59/m³), and groundwater-related costs (€0.40/m³). The analysis supports the Flemish Blue Deal policy framework.

Preliminary results show the increased cost-effectiveness of collective rainwater systems vs individual or no infrastructure. Benefits span hydrological, economic, environmental, and resilience dimensions. Surplus rainwater contributes to groundwater recharge, supporting ecosystems and agriculture - a critical WEFE co-benefit.

Indicators (data requirements and resulting insights)

- Net present value and benefit-cost ratio of rainwater management scenarios.
- Volumetric indicators: rainwater captured, reused, infiltrated, and overflowed per scenario.
- Treatment, production, abstraction costs/benefits.
- WEFE co-benefits: groundwater recharge rates, ecosystem support, agricultural water availability.

Governance mechanisms

- Flemish Blue Deal as policy framework for water resilience.
- Multi-actor governance for coordination between businesses, municipalities, water utilities (De Watergroep), and VITO.
- Contractual set up for collective rainwater trading and distribution.
- Phased implementation strategies to manage infrastructure scale-up efficiently.

Implications for WEFE Nexus framework

- Decentralised rainwater solutions reduce energy need for treatment, enhance agricultural water availability, support ecosystems by groundwater recharge.
- Policy frameworks should recognise cross-sectoral benefits to justify collective investments.
- Actor-based distributional analysis is needed to design equitable cost-sharing mechanisms.

Potential Economic Instruments

- Incentives (e.g. pricing), subsidies, legislation supporting collective rainwater infrastructure (tanks, pipes, pumps).
- Avoided-cost pricing: monetising the societal value of decentralised water management.
- Cost-sharing by beneficiaries (businesses, municipalities, utilities).
- Groundwater abstraction tariffs as a complementary incentive for rainwater reuse.

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SCALING OUT

TO INCREASE IMPACT BY REPLICATING A MODEL IN SIMILAR CONTEXTS, PROVIDING FLEXIBILITY, RESILIENCE, AND COST-EFFECTIVE GROWTH, OFTEN FOCUSING ON SHARED FEATURES.

MODELLING STRATEGY

CBA methodology for decentralised rainwater management

The CBA framework can be replicated at other business parks, industrial zones, and residential areas in Flanders and across similar European water-stressed regions. The core methodology (water balance + avoided-cost valuation) is retained while adapting site-specific parameters.

Example: Apply the same CBA to the two other Belgian demonstration sites (industrial and household contexts) and then to similar sites in the Netherlands, northern France, or western Germany.

Scaling out general framework.

Assumptions & potential Risks:

- Benefits are highly location-specific (e.g., flood risk determines buffer value).
- Treatment, production, abstraction costs differ across sites.
- Non-monetary benefits are harder to transfer.

Mitigation measures:

- Sensitivity analysis to provide a range of outcomes.
- Clear governance guidelines for collective rainwater systems to support replication.

SCALING UP

TO INCREASE THE COVERAGE, SIZE, CAPACITY, SCOPE, OR OUTPUT OF A MODEL TO A WIDER CONTEXT, ESSENTIALLY MAKING IT BIGGER AND MORE EFFECTIVE. IT'S ABOUT GROWING SUBSTANTIALLY, NOT JUST LINEARLY, TO PROVIDE MORE COMPREHENSIVE INSIGHTS.

Scaling up general framework.

ECONOMIC INSTRUMENT

Regional/national circular water financing framework

Scaling up means expanding from a single business park (~20 businesses) to parks with 100+ businesses, and then from site-level to regional or national programmes. This involves larger pipe diameters, higher infrastructure investments, and more complex governance.

Example: Integrating decentralised rainwater systems into the Flemish Blue Deal at regional level, with standardised incentive structures, permitting procedures, and cost-sharing models applicable across Flanders.

Assumptions & potential Risks:

- Increasing complexity with scale.
- Governance structures become more complex.
- System design must remain within efficient scale to avoid diminishing returns.

Mitigation measures:

- Sensitivity analysis to identify efficient system sizes.
- Clear governance and contractual frameworks.
- Phased implementation to ensure cost-effectiveness as scale increases.

Conclusions / Final Remarks

- **Collective systems create value:** Shared rainwater infrastructure can be cost-effective, while improving water supply resilience.
- **System-wide cost savings:** Each cubic meter harvested can reduce pressures on different water uses.
- **Stronger planning choices:** Applying multi-benefit cost–benefit analysis supports evidence-based infrastructure decisions

RETOUCH NEXUS

RETOUCH NEXUS 2023 2026

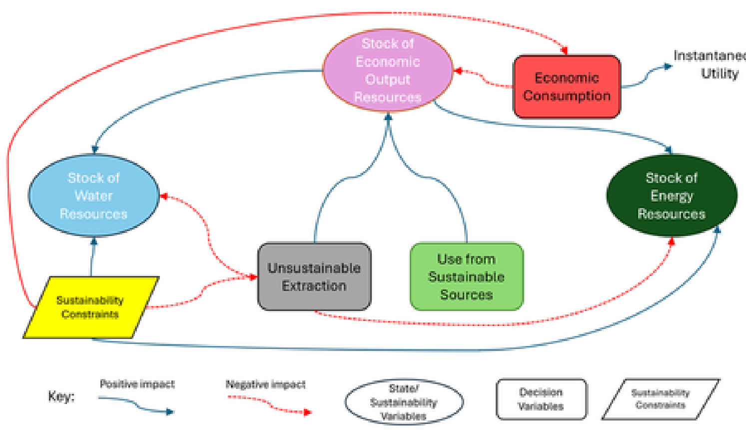
The RETOUCH NEXUS project promotes a cross-sectoral Water–Energy–Food–Ecosystems (WEFE) Nexus approach to support a resilient EU water economy. It ensures that water governance considers ecological, social, and economic dimensions, fostering coherence and effectiveness across sectors and governance levels.

Policy brief | Upscaling of water governance Instruments | Water and energy sustainability in small island economies

This policy brief examines methodological approaches to scaling economic instruments and models for water governance.
Case studies are illustrative, and broader application is possible through context-specific analysis.

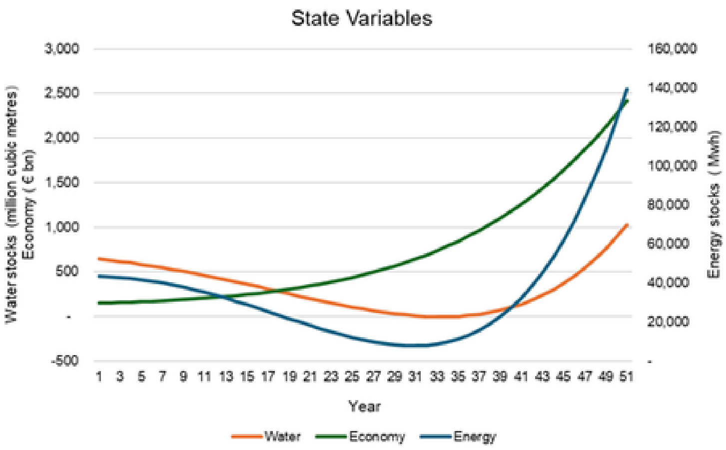
Introduction: desalination and wastewater treatment are energy-intensive processes that generate trade-offs between water and energy security. Economic and population growth can further aggravate the depletion of these resources, undermining long-term development. How should policymakers invest in sustainable water and energy sources, to foster growth and avoid critical resource thresholds?

Modelling Approach: dynamic modelling tracks key sustainable and unsustainable resource stocks (water, energy, and capital), feedback loops, and constraints through a system of equations. A production function links economic output to inputs used. Running Monte Carlo simulations over 50 years, we study the impact of the output share reinvested in sustainable resources, extraction rates caps, and pricing instruments.



Conceptual flow diagram.

RETOUCH NEXUS CASE STUDIES - LESSONS LEARNED



Dynamic behavior of simulated state variables.

RETOUCH NEXUS CASE STUDY

Malta faces significant water scarcity compared to other EU members, relying on energy-intensive desalination to meet its water needs. As a result, economic activity depends on both energy and water inputs, sourced from a mix of sustainable and non-sustainable systems. Given its limited land availability to support population needs, ecosystems, energy generation, and food production, Malta illustrates the complex trade-offs within the Water–Energy–Food–Ecosystem (WEFE) nexus.

The simulations show that economic growth becomes potentially unsustainable within 3 decades. Malta's existing Water Table stakeholder platform and Inter-Ministerial Committee provide a governance foundation, but their scope needs to expand from the current water-energy focus to a full WEFE nexus approach.

Indicators (data requirements and resulting insights)

- Dynamic sustainability trajectories: stock levels of water, energy, and economic capital over time.
- Sustainable-to-unsustainable resource use ratios.
- Full-cost recovery ratios for water services (financial + resource + environmental costs).
- WEFE integration metrics: cross-sector policy coherence indicators.

Governance mechanisms

- Inter-Ministerial Committee (IMC) for cross-sectoral water policy implementation.
- National Water Table stakeholder platform (government, utilities, NGOs, private sector) – to be expanded to full WEFE scope.
- Centralised administration advantage: Malta's small size enables effective coordination, but formalisation is needed as WEFE scope broadens.

Implications for WEFE Nexus framework

- Water and energy sustainability are deeply coupled in island systems; pricing instruments must reflect this interdependence.
- Without deliberate reinvestment policy, economic growth leads to resource depletion within a generation.
- Expanding the model to include food and ecosystem components will strengthen WEFE policy coherence.

Potential Economic Instruments

- Stepwise water tariffs with high financial cost recovery (via economic regulator REWS).
- Full-cost recovery pricing incorporating resource and environmental costs (currently only qualitative).
- Renewable energy subsidies integrated with water pricing (solar-powered desalination).
- Irrigation subsidies and tariffs for reclaimed/second-class water.

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SCALING OUT

TO INCREASE IMPACT BY REPLICATING A MODEL IN SIMILAR CONTEXTS, PROVIDING FLEXIBILITY, RESILIENCE, AND COST-EFFECTIVE GROWTH, OFTEN FOCUSING ON SHARED FEATURES.

MODELLING STRATEGY

Dynamic model for water–energy–economy interactions

The methodology can be applied to other small island developing states or water-stressed city-regions with similar water–energy coupling. The core model structure (state variables, production function, sustainability constraints) is portable; coefficients and data inputs need recalibration.

Example: Apply to other Mediterranean islands (Cyprus, Crete, Sardinia, Balearic Islands) or water-stressed coastal cities dependent on desalination (e.g., Barcelona, Almeria, coastal Gulf states).

Scaling out general framework.

Assumptions & potential Risks:

- Need to fine-tune equations for each context.
- Data availability may be limited.
- Outsourced model development requires proper documentation for transferability.

Mitigation measures:

- Develop a step-by-step calibration manual.
- Prepare a minimum data requirements template specifying variables, units, time horizons, and data sources.
- Ensure transparency and comparability across applications.

SCALING UP

TO INCREASE THE COVERAGE, SIZE, CAPACITY, SCOPE, OR OUTPUT OF A MODEL TO A WIDER CONTEXT, ESSENTIALLY MAKING IT BIGGER AND MORE EFFECTIVE. IT'S ABOUT GROWING SUBSTANTIALLY, NOT JUST LINEARLY, TO PROVIDE MORE COMPREHENSIVE INSIGHTS.

Scaling up general framework.

ECONOMIC INSTRUMENT

Comprehensive WEFE pricing and investment framework

Scaling up means integrating additional policy domains: renewable energy subsidies, agricultural/irrigation policy, ecosystem protection measures. The model transitions from energy–water–economy to a full WEFE nexus framework including local food production and ecosystem components.

Example: Expanding Malta's model to explicitly include agricultural water allocation, ecosystem water requirements (groundwater-dependent terrestrial ecosystems), and renewable energy investment scenarios.

Assumptions & potential Risks:

- Model complexity increases.
- More detailed data inputs required.
- Current Excel-based platform may become limiting.

Mitigation measures:

- Transition from Excel to R or Python.
- Maintain user-friendly interface.
- Modular design allowing incremental expansion.

Conclusions / Final Remarks

- **Hidden risks:** Energy-intensive water supply can mask long-term depletion in water-scarce regions.
- **Mainstream constraints:** Water sustainability indicators should be integrated into economic and territorial planning as binding constraints, not ancillary environmental considerations.
- **Assess long-term compatibility**: Dynamic modelling can support policymakers in testing whether current development trajectories are consistent with long-term water security goals.

RETOUCH NEXUS

The RETOUCH NEXUS project promotes a cross-sectoral Water–Energy–Food–Ecosystems (WEFE) Nexus approach to support a resilient EU water economy. It ensures that water governance considers ecological, social, and economic dimensions, fostering coherence and effectiveness across sectors and governance levels.

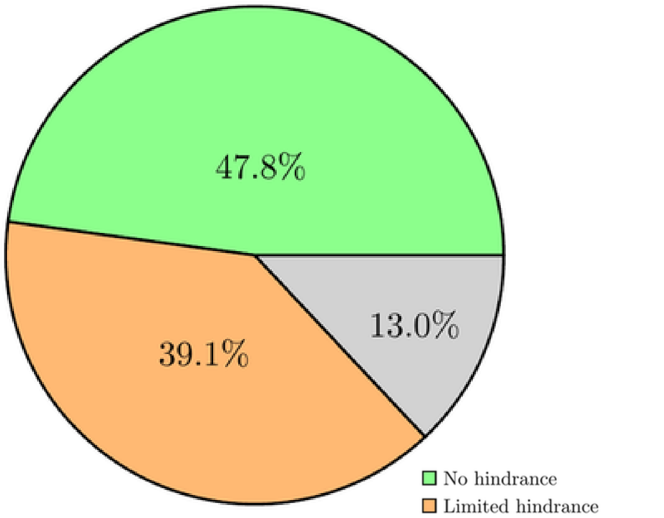
RETOUCH NEXUS 2023 2026

Policy brief | Upscaling of water governance Instruments | Drought-adaptation packages

This policy brief examines methodological approaches to scaling economic instruments and models for water governance.
Case studies are illustrative, and broader application is possible through context-specific analysis.

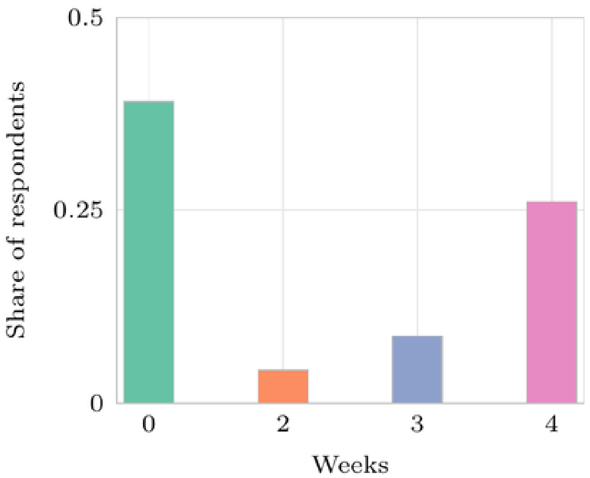
Introduction: Despite increasing water scarcity, farmer investment in adaptation has remained limited, reflecting financial barriers, behavioural biases, coordination challenges, and continued reliance on public water authorities. To address this, we need to develop drought-adaptation instruments (targeted storage subsidies, abstraction regulations, and cooperative schemes) aligned with farmer needs and incentives.

Modelling Approach: Choice experiments ask respondents to choose between hypothetical policy options, while Random Utility Models quantify marginal utilities and willingness to pay for individual components. The results reveal trade-offs across heterogeneous groups and provide quantitative evidence on behavioural and economic drivers of adaptation uptake.



Reported drought hindrance among respondents.

RETOUCH NEXUS CASE STUDIES - LESSONS LEARNED



Desired bridging time from own storage among respondents (NA responses are omitted from the figure).

RETOUCH NEXUS CASE STUDY

The HHNK case study in Noord-Holland (Netherlands) applies a CE among farmers in a low-lying, supply-constrained region, varying four attributes: weeks of abstraction ban, bridging with own storage, cooperation mode (none / with water authority / with other farmers), and annual cost per hectare. Results are linked to farm characteristics and drought experience to capture preference heterogeneity.

Results show that many farmers remain hesitant to undertake lumpy storage investments, even when willingness to pay for measures reducing the cost and risk of on-farm storage is clear. Cooperation and collective solutions should mitigate transaction costs and preserve farm autonomy. Abstraction bans are acceptable only when combined with adequate bridging support.

Indicators (data requirements and resulting insights)

- Willingness-to-pay estimates, with uncertainty caveats.
- Estimated effects of abstraction bans, storage bridging, cooperation, and cost.
- Farm differences: sector, soil, drought experience, salinisation, and existing storage.
- WEFE linkages: water availability, pumping/storage energy use, crop resilience, and ecosystem impacts.

Governance mechanisms

- Water authority-farmer dialogue on feasible drought-adaptation packages.
- Clear operating rules for drought periods and abstraction bans.
- Cooperative storage or sharing arrangements where locally feasible.
- Targeted follow-up with key sectors; co-design of policy packages.

Implications for WEFE Nexus framework

- Farmer preferences are an important input for WEFE policy design.
- On-farm storage has co-benefits.
- Policy packages need to address feasibility, trust, and risk, not only cost.

Potential Economic Instruments

- Targeted support for feasible on-farm or collective water storage.
- Cost-sharing schemes that reduce investment risk.
- Conditional abstraction rules combined with clear communication.
- Advisory services and demonstrations to reduce uncertainty.

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SCALING OUT

TO INCREASE IMPACT BY REPLICATING A MODEL IN SIMILAR CONTEXTS, PROVIDING FLEXIBILITY, RESILIENCE, AND COST-EFFECTIVE GROWTH, OFTEN FOCUSING ON SHARED FEATURES.

MODELLING STRATEGY

Choice experiments for drought-management policy design

The choice experiment (CE) methodology can be replicated in other water-authority regions across the Netherlands and similar European low-lying or drought-prone agricultural areas. The core design (fixed core CE plus local calibration step) is retained while adapting attribute levels to local conditions

Example: Replicate the same CE across 10 neighbouring water board jurisdictions in the Netherlands, or in similar EU regions (Belgian polders, northern German lowlands, East Anglian fens in the UK).

Scaling out general framework.

Assumptions & potential Risks:

- Attribute levels may need local calibration.
- Samples may not be directly comparable across regions.
- Governance differences in collaboration arrangements may affect interpretation.

Mitigation measures:

- Use a fixed core CE plus local calibration step.
- Run short pretests in each region.
- Report both regional and pooled models to enable cross-regional comparison.

SCALING UP

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Scaling up general framework.

ECONOMIC INSTRUMENT

Comprehensive drought-adaptation investment framework

Scaling up means broadening sample coverage to the full HHNK area and multi-basin comparisons across the Netherlands; adding policy scenarios; linking CE outputs to basin-level hydrological indicators; and estimating segmented models to capture heterogeneity by sector and area.

Example: Expanding from the pilot HHNK survey to a national-level stated-preference study feeding into the Dutch Delta Programme's drought adaptation strategy.

Assumptions & potential Risks:

- Data harmonisation across basins.
- Governance complexity across institutions.
- Risk of losing local realism with strong standardisation.

Mitigation measures:

- Use a two-tier setup: common core + optional local modules.
- Maintain interactive dashboard for HHNK and partners to explore alternative policy designs.

Conclusions / Final Remarks

- **Preferences drive uptake:** Farmers invest in adaptation when policies reflect what they value.
- **Combined policies outperform**: Integrated packages work better than isolated instruments.
- **Evidence before spending**: Preference studies help calibrate subsidies and cost-sharing.
- **From guesswork to evidence:** Data-driven design improves adaptation outcomes.

RETOUCH NEXUS

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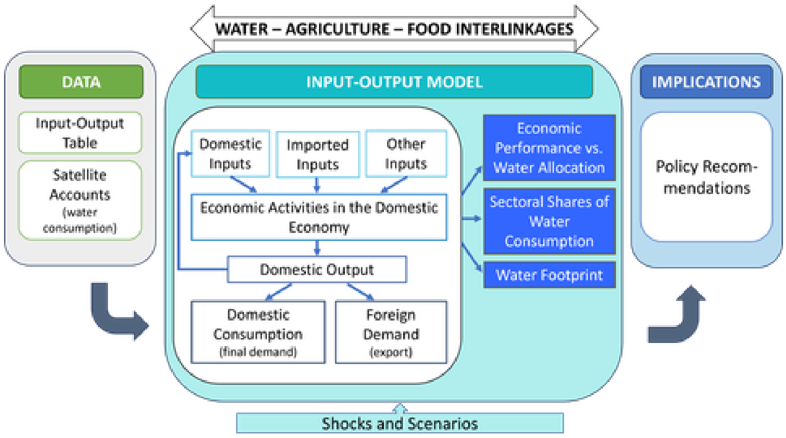
RETOUCH NEXUS 2023 2026

Policy brief | Upscaling of water governance Instruments | Economy-wide water footprint analysis

This policy brief examines methodological approaches to scaling economic instruments and models for water governance.
Case studies are illustrative, and broader application is possible through context-specific analysis.

Introduction: water consumption can be concentrated in a small number of sectors that contribute a relatively modest share of total economic output and employment. However, water is embedded in complex supply chains, so that constraints on one sector (e.g., agricultural water restrictions) propagate indirectly through the food industry, manufacturing, and services via intermediate inputs. Traditional water policy, which focuses on direct water users, often overlooks these indirect, economy-wide effects.

Modelling Approach: environmentally extended input–output (EEIO) analysis can reveal the full picture of water dependencies across an economy, trace virtual water flows through supply chains, and inform targeted, sector-sensitive policy interventions that improve water efficiency without causing disproportionate economic disruption. The approach is particularly relevant for designing policies that integrate water, food, and trade considerations within the WEFE nexus.



Analytical Framework of Environmentally Extended Input-Output Model.

RETOUCH NEXUS CASE STUDIES - LESSONS LEARNED

Scenario 4 – economy-wide water constraint.

% change rel. to baseline	**Total economy**	**Agriculture**	**Food industry**	**Manufacturing**	**Services**
Output	-0.02%	-0.07%	-0.62%	0.00%	0.00%
Value added	-0.02%	-0.09%	-1.28%	0.00%	0.00%
Employment	-0.04%	-0.09%	-1.03%	0.00%	-0.03%
Water consumption	-5.00%	-0.08%	-30.24%	-0.04%	-0.65%

RETOUCH NEXUS CASE STUDY

In Slovakia, agricultural output generated ~$2.1 billion in added value (~2% of total) while accounting for roughly 123 million m³ of blue water consumption (~ 29% of sectoral total). Similarly, the food industry generated about $1.2 billion in added value and consumed 69 million m³ of blue water.

Applying an EEIO framework representing the economy with 39 subsectors, plus a blue water consumption satellite account, four scenarios were tested: 1) changes in food demand composition, 2) improved agricultural water efficiency, 3) water-use restrictions in agriculture, 4) economy-wide water constraints. Results show:

- Plant-based foods are less water-intensive during processing, but increase water consumption during production.
- Efficiency improvements yield cost-effective reductions without compromising output.
- Agricultural water restrictions produce concentrated impacts on food processing supply chains.
- Economy-wide water rationing disproportionately affects water-intensive food sectors.

Indicators (data requirements and resulting insights)

- Sectoral water footprints (direct and supply-chain embedded virtual water).
- Water intensity ratios (m³/$ output) by sector.
- Economic output and employment impacts of water policy scenarios.
- Cross-sectoral multiplier effects of water constraints.

Governance mechanisms

- Inter-ministerial multi-stakeholder platforms for dialogue across water, agriculture, environment, and land-use sectors.
- Aligning spatial development and sustainable water-resource management.
- Adaptive management through regular policy reviews with monitoring and stakeholder input.
- Unified, interoperable water data platform for evidence-based decision-making.

Implications for WEFE Nexus framework

- Economy-wide water footprint analysis reveals hidden dependencies and supply-chain vulnerabilities.
- Dietary shifts must be paired with efficiency measures to avoid unintended water-use increases.
- Sector-sensitive water allocation strategies are essential to avoid disproportionate disruptions.
- Water governance reform in Slovakia requires integrated spatial planning and WEFE-aligned incentives.

Potential Economic Instruments

- Subsidies for water retention and regenerative agriculture.
- Tiered tariffs reflecting scarcity conditions.
- Cooperative leasing of water abstraction infrastructure by farmers.
- Carbon–water banks and public–private partnerships for infrastructure and ecosystem restoration.
- Water footprint metrics integrated into food and agricultural policy.

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SCALING OUT

TO INCREASE IMPACT BY REPLICATING A MODEL IN SIMILAR CONTEXTS, PROVIDING FLEXIBILITY, RESILIENCE, AND COST-EFFECTIVE GROWTH, OFTEN FOCUSING ON SHARED FEATURES.

MODELLING STRATEGY

EEIO modelling with water satellite accounts

The EEIO framework is inherently replicable: any country with national input–output tables and water-use statistics can apply the same methodology. Eurostat and international project initiatives provide harmonised data for all EU member states.

Example: Apply the same EEIO framework to other Central and Eastern European economies with similar agricultural water intensity (Czech Republic, Hungary, Poland, Romania) to enable cross-country comparison and EU-level policy recommendations.

Scaling out general framework.

Assumptions & potential Risks:

- Requires national IO tables with sufficient sectoral disaggregation.
- Water-use satellite data may be incomplete or use different definitions across countries.

Mitigation measures:

- Standardise definitions (blue water, virtual water).
- Use harmonised input–output tables (e.g., from Eurostat).
- Develop automated preprocessing tools for all EU member states.

SCALING UP

TO INCREASE THE COVERAGE, SIZE, CAPACITY, SCOPE, OR OUTPUT OF A MODEL TO A WIDER CONTEXT, ESSENTIALLY MAKING IT BIGGER AND MORE EFFECTIVE. IT'S ABOUT GROWING SUBSTANTIALLY, NOT JUST LINEARLY, TO PROVIDE MORE COMPREHENSIVE INSIGHTS.

Scaling up general framework.

ECONOMIC INSTRUMENT

Comprehensive sector-sensitive national water policy framework

Scaling up involves increasing sectoral detail (60+ sector disaggregation), adding multi-regional IO analysis to capture trade flows and transboundary virtual water, and integrating dynamic IO modelling to capture temporal evolution of economic structure and water consumption.

Example: Linking Slovakia's EEIO with neighbouring country models (Czech Republic, Hungary, Austria) to analyse Danube basin-wide virtual water flows and transboundary policy coherence.

Assumptions & potential Risks:

- Multi-regional models require consistent data across countries.
- Computational and methodological complexity increases.
- Political coordination for transboundary policy is challenging.

Mitigation measures:

- Use multi-regional input-output databases (e.g. Exiobase).
- Focus on key bilateral trade flows.
- Engage through existing Danube basin governance structures (ICPDR).

Conclusions / Final Remarks

- **One-size rules fail:** Blanket water restrictions can place high burdens on some sectors, while delivering limited overall savings.
- **Efficiency delivers savings:** Targeted agricultural efficiency measures can deliver significant water savings at low economic cost.
- **Check impacts early:** Policymakers should assess sector-specific effects before applying restrictions.

RETOUCH NEXUS

RETOUCH NEXUS
2023 2026

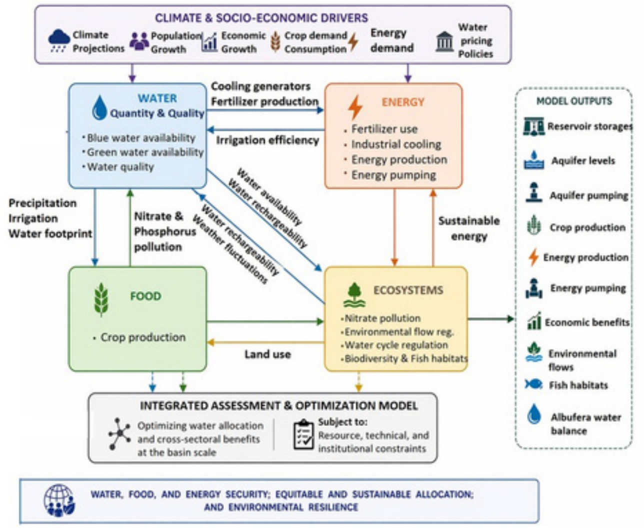
The RETOUCH NEXUS project promotes a cross-sectoral Water–Energy–Food–Ecosystems (WEFE) Nexus approach to support a resilient EU water economy. It ensures that water governance considers ecological, social, and economic dimensions, fostering coherence and effectiveness across sectors and governance levels.

Policy brief | Upscaling of water governance Instruments | Water pricing

This policy brief examines methodological approaches to scaling economic instruments and models for water governance.
Case studies are illustrative, and broader application is possible through context-specific analysis.

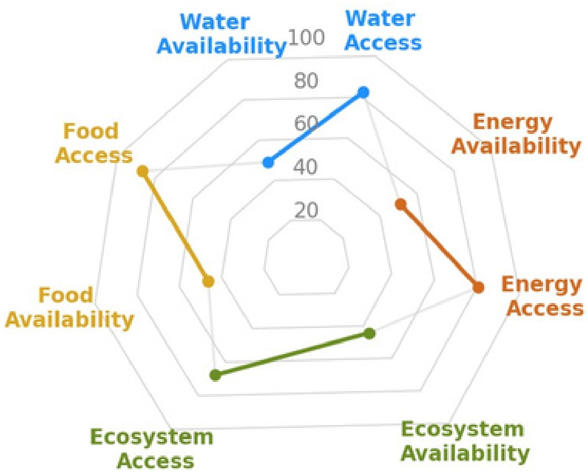
Introduction: traditional water allocation rules fail to reflect the true marginal value of water under scarcity at the river basin scale. As a result, allocation is inefficient, inequitable, and environmentally harmful. Water pricing turns physical scarcity into decision-relevant signals for users and policymakers, incentivising efficient use, supporting ecosystem protection, and revealing the cross-sectoral trade-offs in the WEFE nexus.

Modelling Approach: hydro-economic models integrate hydrological process with economic optimisation evaluating how alternative pricing instruments affect water allocation, sectoral performance, and ecosystem status at the basin scale. Climate projections and socio-economic scenarios provide the forcing conditions. System dynamics further capture feedback loops and non-linear responses across interconnected sectors.



Integrated hydro-ecnomic modelling framework from a WEFE perspective.

RETOUCH NEXUS CASE STUDIES - LESSONS LEARNED



Water Pricing Impact of WEFE Nexus Performance.

RETOUCH NEXUS CASE STUDY

The Júcar River Basin (Spain) uses a hydro-economic optimisation model coupling TETIS hydrology, AQUACROP/CAPRI agronomics, CMIP6 climate scenarios, and habitat suitability curves, testing uniform and dynamic water pricing.
Uniform Water Pricing delivers strong but unequal environmental gains. Dynamic Water Pricing linked to reservoir storage levels and marginal resource opportunity costs achieves a more balanced trade-off. Water pricing strengthens aquatic species resilience.

The Upper Main River Basin (Germany) uses SWAT+ hydrology with system dynamics and stochastic frontier analysis, incorporating shadow pricing.
Shadow water prices increase steadily from 2000 to 2050 across all water demand scenarios. Water quality degradation compounds quantity scarcity, reducing production potential by up to 10–15%.

Indicators (data requirements and resulting insights)

- Scarcity indicators: water scarcity ratio, groundwater depletion rates, reservoir storage levels, WEFE index.
- Marginal water prices to quantify economic scarcity.
- Species resilience metrics: frequency ratio, mean/max duration of habitat stress, severity index.
- Water quality indicators (nitrate concentration) linked to agricultural intensity.

Governance mechanisms

- Basin-wide coordination frameworks aligning WEFE objectives.
- Cross-sector stakeholder platforms for co-decision on allocation rules.
- Adaptive management cycles: regular policy reviews based on monitoring and stakeholder input.
- Shared data systems and open-access dashboards for transparency.

Implications for WEFE Nexus framework

- Water pricing is a key for WEFE integration
- Dynamic pricing better preserves cross-sectoral balance than rigid uniform tariffs.
- Climate uncertainty demands robust, adaptive pricing rather than static tariff schedules.
- Water quality must be explicitly integrated into pricing frameworks to avoid underestimating true scarcity costs.

Potential Economic Instruments

- Volumetric water tariffs (transparent, strong environmental signal, but equity concerns for low-value crops).
- Dynamic/scarcity-based water pricing (tariffs linked to reservoir storage or marginal opportunity cost; more balanced trade-offs).
- Shadow pricing as a planning tool to reveal the marginal value of water under constraints.
- Source-specific tariffs (surface vs. groundwater) and sector.

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MODELLING STRATEGY

Hydro-economic modelling with dynamic water pricing

The modular structure of both models enables replication across other European river basins facing similar WEFE challenges.

Example: The dynamic pricing design from the Júcar (storage-based tariffs linked to marginal resource opportunity costs) could be replicated in other Mediterranean basins (e.g., Ebro, Guadalquivir, Segura in Spain; Arno, Po in Italy; Axios in Greece) that share surface-groundwater interactions, irrigated agriculture, and seasonal scarcity.

Scaling out general framework.

Assumptions & potential Risks:

- Assumes availability of comparable hydrological, agricultural, and ecological data.
- Key risks include data gaps, institutional differences in water rights and regulatory frameworks, limited computational capacity, and stakeholder resistance to pricing reforms.

Mitigation measures:

- Build modular model versions that can run with limited data.
- Use proxy or regional datasets where local data are unavailable.
- Engage stakeholders early.
- Provide training and technical support for local teams.
- Apply sensitivity analyses to account for uncertainty.

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Scaling up general framework.

ECONOMIC INSTRUMENT

Comprehensive basin-wide water pricing framework

For the Júcar-style model, farm-level decision-making could be added, along with renewable energy integration, additional species, detailed habitat connectivity, and groundwater-dependent ecosystems; increasing temporal and spatial resolution. The System dynamic model can be extended from the Upper Main to the full Main River basin, or multi-basin comparisons.

Example: moving from basin-specific pricing to a national framework where prices are differentiated by scarcity, environmental externalities, and basin-level objectives. Revenues are reinvested in basin management, infrastructure, and ecosystem protection. Governance shifts from local implementation to system-level coordination.

Assumptions & potential Risks:

- Resolution requires detailed datasets.
- Computational complexity increases significantly.
- Calibration and validation become more demanding.
- Interpretation of results and communication becomes harder.

Mitigation measures:

- Simplify or aggregate non-critical components.
- Employ high-performance computing.
- Apply systematic calibration procedures.
- Focus on key indicators and visualisation tools.

Conclusions / Final Remarks

- **Water pricing** is effective, but only when designed to reflect scarcity.
- River basins with established monitoring systems are well suited for early pilots, and advance modelling can help **identify distributional effects before implementation.**
- **Transparency** is critical for acceptance. Public dashboards linking prices to real-time water availability help build trust.
- The Water Framework Directive enables **cost recovery**, while **hydro-economic modelling** provides the necessary evidence base for sound policy design.