trans4num DECISION SUPPORT TOOL

Summary

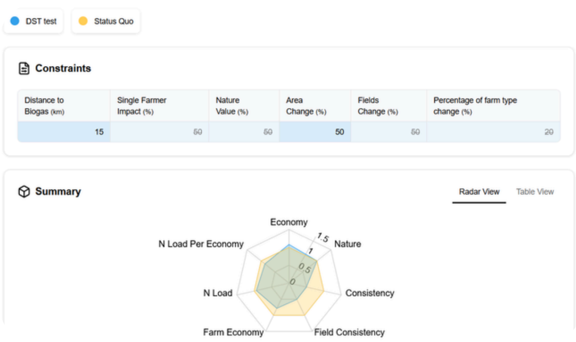
The trans4num Decision Support Tool (DST) helps bridge the gap between farm-level nutrient management and its broader environmental impacts. By linking field-level actions to landscape-scale outcomes, it supports farmers, advisors, and policymakers in planning and optimising nature-based solutions, visualising trade-offs, and collaboratively finding efficient, regionally adapted strategies for sustainable agriculture.

The need

The need for the trans4num Decision Support Tool (DST) primarily stems from a critical mismatch in scale between agricultural decision-making and its environmental impacts. While decisions regarding nutrient management are usually made at the individual farm or field level, the resulting environmental consequences, such as nitrogen leaching, water pollution, biodiversity loss, and soil degradation, manifest at a much broader landscape scale.

Because of this disconnection, a clear need was identified for a tool that could address the following challenges:

- Bridging the gap between field actions and landscape outcomes
- Visualizing trade-offs between multiple environmental targets and agronomic productivity on various spatial scales
- Planning and operationalizing Nature-Based Solutions (NBS) at landscape level
- Fostering active collaboration both between farmers, advisors, policy makers and the broader bioindustry



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The benefits

Benefits for farmers and farmer associations

- **Connecting actions to outcomes**: Shows how field-level management choices impact broader landscape outcomes, making the green transition more tangible
- **Identifying new value chains**: Alternative scenarios can reveal economic opportunities. For example, perennial grass or catch crops that reduce nutrient losses while opening access to green biorefining markets
- **Flexible, realistic scenarios**: Evaluates full crop rotations rather than single-year crops, with recommendations kept within practical limits rather than unrealistic farm-type overhauls
- **Collaborative problem-solving**: Empowers cooperatives and farmer clusters to jointly find efficient, economically viable solutions across a shared landscape

Benefits for agricultural advisors

- **Facilitating strategic dialogue**: Supports communication between farmers, policymakers, and water managers to collaboratively plan and implement nature-based solutions
- **Visualising trade-offs**: Helps demonstrate the balance between environmental targets and regional economic returns, making efficient solutions easier to identify
- **Enhancing the advisory role**: Advisors act as trusted facilitators, translating technical outputs into practical language, which has been shown to improve farmer understanding and uptake

Benefits for regional planners and policymakers

- **Supporting collaborative policy development**: Provides a shared platform for planners, policymakers, and farmers to jointly explore and co-design solutions in multi-stakeholder settings
- **Assessing feasibility of policy options:** Helps evaluate which interventions are realistic under actual farming conditions, improving the practicality of proposed measures

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trans4num solution

How the DST works: technical background

The DST is a spatially explicit, data-driven optimisation tool that captures both the impact of NBS implementation under geographically varying conditions.

- Optimisation engine: Uses mixed-integer programming to evaluate and allocate alternative crop rotations and management strategies across all fields within a defined landscape
- Transition matrices: Lookup tables that quantify the effects of shifting from one management practice to another — such as nitrogen leaching, yield, and economic return — based on local soil types. These must be developed case-specifically from field experiments, expert knowledge, or regionally adapted process-based models
- Geographic variability: Spatial variability is captured at field level using crop code and soil type, allowing the model to reflect how NbS effectiveness varies across the landscape — for example, differences in nitrogen retention between fields
- Software architecture: A React-based frontend and Python backend connected via a REST API. The model engine processes multiple data formats, including tabular data (CSV, JSON) and spatial files (GeoTIFF, GeoJSON, Shapefile)

How the DST works: user experience

The DST does not prescribe decisions or predict exact outcomes. Instead, it starts from a desired effect and visualises possible ways to achieve it — serving as a basis for discussion and collaborative solution-finding among diverse stakeholders.

- Two-step input process: Users first select a regional optimisation goal, then apply constraints to limit options and ensure realistic scenarios
- Exploring trade-offs: The model identifies the most efficient spatial allocation to meet defined goals. If a goal is too ambitious or constraints too restrictive, the model signals this — providing valuable insight into what is realistically achievable
- Visual outputs: Results include spatial maps comparing the status quo with the optimised alternative field by field, pie charts showing crop shares before and after optimisation, and radar views for comparing economic and environmental performance across model runs. The nitrogen balance of the whole region is also reported.

What were the challenges / limitations in the implementation process?

- High complexity and need for facilitation: as the tool targets landscape settings, its intended use is primarily in facilitated workshop settings rather than as a standalone tool for individual farmers.
- Case-specific adaptation and data requirements: Applying the DST to new regions requires substantial local data input, with transition matrices in particular often proving difficult to obtain.

What kind of resources do you need to implement the proposed solution?

- Spatially explicit agricultural data
- Defined goals for a region
- Defined effect of an NBS that varies geographically due to spatially varying data.
- Data describing effects of an introduced NBS
- A trusted facilitator (modeller, researcher or advisor)

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More information

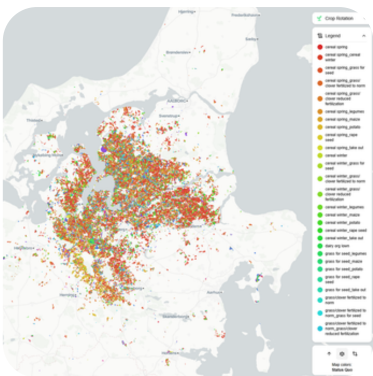
Transferability of the DST

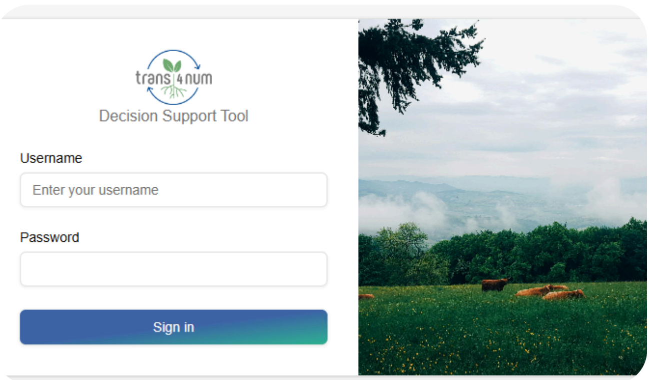
- The DST was developed for the Limfjord, Denmark, but its structure is transferable to other regions. Adaptation is required, including a clear regional optimisation target, appropriate constraints, and relevant data inputs such as transition matrices and geospatial datasets.

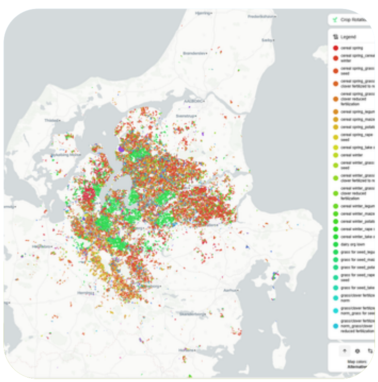
How the DST was developed

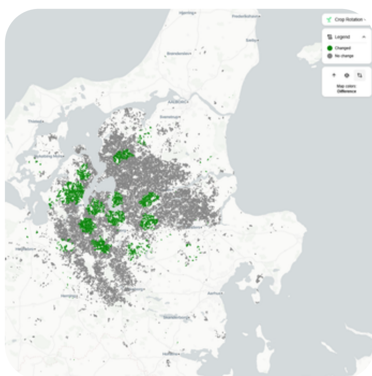
- Development was collaborative and iterative, bringing together researchers across agronomy, soil sciences, spatial data science, and social sciences. Through this process, a key gap in existing tools was identified - the need to link field-level actions to landscape-scale outcomes.
- Co-design: Transdisciplinary workshops with farmers, advisors and regional planners in Denmark shaped key refinements, including evaluation of full crop rotations and constraints to prevent unrealistic farm-type changes.
- Iterative testing through DST workshops in Hungary, the Netherlands, and the UK demonstrated the tool's value in facilitating discussion across diverse landscape settings and governance structures.

- Explore the DST
- Find more Practice Abstracts: https://trans4num.eu/library/?type=ABS









Learn more about the project at https://trans4num.eu/en/

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