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Policy brief 1: Decision Support Tool

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NBS	Nature-based Solutions
DST	Decision Support Tool

1. Background

European agriculture continues to face significant challenges associated with nutrient losses, soil degradation, and water pollution. The project "transformation for sustainable nutrient supply and management" (trans4num) aims to substantiate and broadly promote Nature-based Solutions (NBS) for sustainable nutrient management through bio-based nutrient sources, sustainable crop rotations and optimisation of nutrient flows. The project applies a systems approach and combines biophysical, technological, economic, social and institutional perspectives.

Although nutrient management decisions are generally made at the farm or field level, their environmental consequences, such as nitrogen (N) leaching into water bodies, often extend across the wider landscape. This spatial mismatch complicates the identification of management strategies that are both environmentally effective and economically viable, particularly when balancing environmental benefits against farm profitability. Addressing these challenges requires decision-support approaches that facilitate the implementation of NBS for nutrient management while explicitly accounting for spatial interactions and cumulative environmental effects at the landscape scale.

2. Introduction

A specific objective of trans4num was to develop and test a nutrient management tool to support decision-making for optimum nutrient supply in diverse agricultural practices and at multiple intervention levels.

The trans4num DST is a user-oriented, spatially explicit, and data-driven optimisation tool that supports collaborative nutrient management at landscape scale by helping stakeholders explore how management strategies and NbS affect environmental and economic outcomes in different geographical contexts. It visualises potential solutions and trade-offs to achieve desired effects, providing an interactive and openly accessible framework that can be adapted to different settings by researchers, advisors and policymakers, including the integration of ESA Sentinel satellite remote sensing information. The DST`s development was inspired by previous tools and models such as NutriGap (developed as a pilot in the H2020 project RELACS), the Danish model CIRKULÆR, as well as by the serious game Dynamix from the H2020 project MIXED. Trans4num Partners collaborated in the development and tested it in their research cases.

This policy brief presents the usefulness of the trans4num DST, its possibilities of use and benefits for different stakeholders, based on the trans4num D3.3, D5.5 and D3.5[1].

[1] Frick Hanna, Bünemann Else K., Birk Morten, Rasmussen Anton, Winther Vestenaa Morten, Vestergaard Odgaard, Morten Graversgaard Mette, Kau Lægsgaard Tidemand August, Strunge Folkmann Pia, and Tommy Dalgaard (2026). Decision-support tool (DST) for the analysis of NbS related, regional nutrient budgets and management optimization. Deliverable 3.5 in the frame of the project "Transformation for sustainable nutrient supply and management (trans4num)".

Vestergaard Odgaard Mette, Birk Morten, Bünemann Else, Frick Hanna, Graversgaard Morten, Rasmussen Anton, Kau Lægsgaard Tidemand August, Winther Vestenaa Morten, Iversen Sara, Strunge Folkmann Pia, and Tommy Dalgaard (2026). Report on the assessment of Decision Support Tool (DST) tool application in NbS. Deliverable 3.3 in the frame of the project "Transformation for sustainable nutrient supply and management (trans4num)".

Qirui Li, Maria Gerster-Bentaya, and Andrea Knierim (2026). Recommendations for transformation pathways. Deliverable 5.5 in the frame of the project "Transformation for sustainable nutrient supply and management (trans4num)".

3. Policy Brief 1:

From Nutrient Targets to Regional Action

Using the trans4num DST to explore where agricultural changes can make a difference

Key messages

- **Where measures are introduced matters.** The environmental benefits and economic costs of changing agricultural practices vary across landscapes. Effective nutrient management requires coordinated action across farms, with measures tailored to local environmental conditions and economic realities.
- **The trans4num DST makes regional choices visible.** It maps alternative ways of introducing NBS and compares their modelled effects on nitrogen losses and agricultural economic performance.
- **Better evidence needs better dialogue.** The DST is designed for joint exploration by farmers, advisors, water managers and regional authorities—not to prescribe decisions or replace local knowledge.

Policy priority: Put spatial scenario analysis, reliable regional data and stakeholder participation at the centre of regional nutrient-management planning.

1. The policy challenge: connecting farm decisions with regional objectives

Europe has set targets to reduce nutrient pollution from agriculture, including through the Water Framework Directive and Nitrates Directive[2]. However, deciding where to take action and how to make changes practical and affordable for farmers remains a challenge. Nutrient losses and the costs of reducing them vary across regions, meaning that a farming practice that works well in one location may be less effective or more costly elsewhere. At the same time, rising fertiliser costs and the need to use nutrients more efficiently add pressure on farmers. Effective nutrient management therefore requires more than setting targets or taking action on individual farms. It also requires understanding where changes could deliver the greatest environmental benefits, what they might cost farmers and how different stakeholders can work together. The trans4num DST was developed to help address these questions by modelling different ways of changing agricultural practices across a region and comparing their potential environmental and economic effects.

2. The trans4num DST: making regional choices visible

The trans4num DST is a digital planning tool that helps stakeholders explore where changes in farming practices could help reduce nitrogen pollution. It combines information on crops, soils and farming conditions with estimates of how different practices may affect nitrogen losses and economic returns. Users can set environmental goals, such as reducing nitrogen entering coastal waters, while considering practical limits, including how much farmland can change or how much economic loss is acceptable. The tool then produces maps and comparisons showing where practices such as different crop rotations, catch crops or perennial grass could be introduced, and how these changes might affect nitrogen losses, agricultural production and regional economic performance. By making these options and their trade-offs visible, the DST helps farmers, advisors, water managers and policymakers discuss possible solutions and identify where coordinated action or additional support may be needed, providing modelled scenarios based on available data and agreed assumptions to support informed discussion and regional planning.

3. What trans4num has demonstrated

Denmark: exploring options for the Limfjord

The DST was developed and demonstrated in the Danish Limfjord region, where nitrogen losses from agriculture contribute to pressures on coastal water quality.

For example, the Limfjord model accounts for differences in soil conditions and how much nitrogen is naturally removed before reaching coastal waters. This allows it to explore where changes in farming practices could have a greater effect on nitrogen entering the fjord. The model also allows users to compare different

[2] Van Doorslaer, B. (2026). Fertilisers Action Plan: Partnership for ensuring availability, affordability and strategic autonomy in home-grown EU fertilisers. European Commission, DG AGRI, presentation, 24 June 2026.

environmental and economic priorities. They can explore how to reduce nitrogen losses while limiting the impact on regional farm income, or set limits on how much an individual farmer's income or agricultural land use may change. Thus, the DST can make both the location of potential improvements and the practical trade-offs more visible.

The key contribution is transparency: instead of debating nutrient-reduction measures only in general terms, stakeholders can examine geographically specific options and their potential trade-offs. These are modelling results, not evidence that the proposed changes have already been implemented or that measured water-quality improvements have occurred.

Beyond Denmark: the importance of local conditions

Trans4num also explored the DST approach through stakeholder workshops in Hungary, the Netherlands and the United Kingdom.

The experience highlighted both the potential and the limits of transferring the tool to other regions. Stakeholders need to agree on meaningful objectives, and suitable geographic and agricultural data must be available. Estimates of how interventions affect nutrient losses and farming outcomes also need to reflect local conditions.

The workshops showed that the DST can help structure discussions between different actors. However, they did not establish fully validated, operational applications in every participating country.

The lesson: Regional decision support cannot be transferred through software alone. It needs local evidence, clearly defined objectives and the involvement of people who understand the landscape.

4. Three priorities for policymakers

- *Target measures where they can make a difference*

Regional authorities and water managers should test spatial scenario analysis when developing nutrient-reduction strategies and catchment-level plans. Rather than assessing management practices only in isolation, authorities can use tools such as the DST to explore combinations of measures across a landscape. By estimating where different measures could deliver greater environmental benefits and at what economic cost, the DST can help identify options for more targeted nutrient management. This could help avoid unnecessary burdens on farms in less critical areas while highlighting where environmental improvements may require additional support or changes in farming practices. However, local validation and stakeholder consultation are needed before modelled scenarios can inform regulatory decisions.

Action: Pilot scenario-based, spatially targeted planning in nutrient-sensitive regions, beginning with locally agreed environmental objectives.

- *Make reliable regional data available*

The trans4num experience showed that reliable local data and clear modelling assumptions are essential for exploring regional nutrient management options. The usefulness of the DST depends on information about land use, crop performance, soils, nitrogen losses and how changes in farming practices may affect these outcomes. Building on this lesson, regional authorities, researchers and advisory services should work together to improve data quality, adapt the tool to local conditions and keep information up to date. Establishing regional data partnerships could help organise this cooperation, although this approach has not yet been tested by trans4num. While preliminary estimates can support early discussions, decisions with major economic or regulatory consequences need more reliable data, careful validation and clear explanations of the assumptions used.

Action: Establish regional data partnerships for model adaptation, quality checks and regular updates.

- *Put farmers and advisors at the table*

Regional planning should combine modelled evidence with practical knowledge from farmers, agricultural advisors and other stakeholders.

A technically attractive scenario may still face barriers involving costs, infrastructure, land availability or

willingness to change practices. Discussing these constraints early can improve the relevance of planning and help authorities identify where advice, incentives or further evidence may be needed.

Action: Use facilitated workshops to compare scenarios, discuss feasibility and identify practical steps.

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Policy brief 2:
How to use the AKIS approach for implementing nature-based solutions for circular nutrient management

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Table of Abbreviations

AKIS	Agricultural Knowledge and Innovation System
CAP	Common Agricultural Policy
CNM	Circular nutrient management
DST	Decision Support Tool
EU	European Union
IFSA	International Farming System Association
NBS	Nature-based Solutions
PR	Periodic Report
SET	Social-ecological Transformation
UHOH	University of Hohenheim
WP	Work Package

Policy Brief 2:
How to use the AKIS approach for implementing nature-based solutions (NBS) towards a circular nutrient management

What are nature-based solutions and how does the AKIS matter

European agriculture faces increasing pressure to reduce nutrient losses, protect water and soil resources, adapt to climate change, and reduce its dependence on external inputs. Nature-based solutions (NBS) can contribute to these objectives while also supporting agricultural productivity, economic viability, and regional development (EU 2021[3]; Schulte-Uebbing et al., 2022[4]; Staude et al., 2020[5]).

The trans4num project is an EU-funded, international research and innovation initiative that promotes nature-based solutions (NBS) for sustainable nutrient management in intensive agricultural systems. It brings together 22 partners: researchers, farmers, agricultural practitioners, businesses and policymakers from Europe and China to explore how intensive farming systems can reduce nutrient pollution while maintaining agricultural productivity and environmental sustainability. The project combines field-level experimentation, interdisciplinary research, stakeholder engagement, and the development of practical decision-support tools. Over a period of four years (2022-2026), 20 innovations across seven regions (4 in Europe, 3 in China), including bio-based fertilisers, crop rotations and improved nutrient management practices were tested.

Building on the knowledge and experience gained through these trials, the core concern is how these solutions can be scaled up and their adoption promoted more widely across various agricultural systems. Scaling innovations requires more than simply transferring individual technologies from research into practice (Wigboldus et al., 2016[6]). As NBS are embedded in complex agricultural contexts, they need to be developed and implemented with a systemic approach that considers the interactions between technologies, farming practices, and the wider socio-economic and institutional context.

Successful implementation at scale requires changes beyond individual technologies. They may involve adjustments to farm management practices, land use, infrastructure, market structures, regulatory frameworks, and institutional cooperation. Understanding how these factors interact is essential to creating the conditions for successful and sustained adoption. Effective knowledge exchange, access to timely information and support to learning and innovative behavior are key conditions that help farmers and related stakeholders to prepare for and go ahead with such changes. The Agricultural Knowledge and Innovation Systems (AKIS) concept broadens the perspective on the range of concerned stakeholders and their networks —at the operational, local, and regional levels—that are essential for the long-term

[3] Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions. Pathway to a Healthy Planet for All. Brussels, COM(2021) 400final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0400&qid=1623311742827

[4] Schulte-Uebbing, L. F., Beusen, A. H., Bouwman, A. F., & De Vries, W. (2022). From planetary to regional boundaries for agricultural nitrogen pollution. *Nature*, *610*(7932), 507-512.v

[5] Staude, I. R., Waller, D. M., Bernhardt-Römermann ... & Baeten, L. (2020). Replacements of small-by large-ranged species scale up to diversity loss in Europe's temperate forest biome. *Nature ecology & evolution*, *4*(6), 802-808.

[6] Wigboldus, S., Klerkx, L., Leeuwis, C. *et al.* Systemic perspectives on scaling agricultural innovations. A review. *Agron. Sustain. Dev.***36**, 46 (2016). https://doi.org/10.1007/s13593-016-0380-z

implementation of innovative NBS on a broad scale (EU SCAR-AKIS 2026[7]).

To whom do we address this Policy Brief?

This policy brief addresses those actors (organisations and individuals) who influence the set-up and functions of the Agricultural Knowledge and Innovation system, and in this way impact the capacity of the AKIS to contribute to disseminating NBS and thus achieving transition towards circular nutrient management. These actors include policymakers and regulating bodies at the regional, national and EU levels in the first place, and research bodies, formal and non-formal education bodies, advisory services at various levels as well as private sector actors engaged in knowledge exchange and innovation support.

Short presentation of the four cases

The trans4num NBS cases illustrate a range of approaches to circular nutrient management, differing in their spatial scope and organisational complexity. The cases in the Netherlands, Hungary and the UK focus mainly on interventions at field and farm level, albeit with considerable variation in practices and experimental designs. In contrast, the Danish case adopts a broader regional perspective, examining biomass and nutrient flows across production, processing, logistics and multiple value-chain actors.

We studied the AKIS features along these four European cases:

The Limfjord case in **Denmark**, adopts a regional value-chain perspective, linking crop production, biorefineries, energy systems and regulatory innovation. Perennial crop rotations, such as grass–clover, can reduce nitrate leaching, improve soil quality, and provide biomass for protein, feed and bioenergy. Bio-based fertilisers derived from biorefinery residues and recycled nutrients support nutrient circularity and reduce reliance on synthetic fertilisers. The case also highlights the importance of stakeholder collaboration, value-chain development, adaptive regulatory frameworks and context-specific solutions for achieving environmental targets without land abandonment.

In the **Netherlands**, Planty Organic, a plant-based farming system, derived from short- and long-term crop rotation experiments with plant-based fertilisation (lucerne and grass clover pellets, green manures, cover crops, and plant-based nutrient strategies) indicate that NBS can maintain crop performance while reducing reliance on external inputs, even though short-term effects are limited. Field trials with organic amendments, such as straw, grass and clover, show yields and most soil indicators comparable to conventional treatments.

In Hungary, the NBS innovations include a combination of rotations, bio-fertiliser, bio-stimulants, and reduced tillage with the potential to reduce reliance on synthetic fertilisers and manure while maintaining crop nutrient supply in the particularly sensitive Szigetkös plain. In parallel, huge efforts put in developing training material, conducting demonstrations and field days proved effective to create awareness and understanding of soil conservation related NBS innovations.

In the United Kingdom, the long-term experiments centred around reduced tillage, the use of organic amendments, and rotations. The primary systemic contribution is the evaluation of whole-system trade-offs and the targeting of nature-based solutions (NBS) across different soil types, supported by evidence generated through long-term research experiments (LSRE). A second NBS innovation focussed on the use of an alternative phosphorus-based fertiliser

[7] EU SCAR-AKIS (2026), *Enhancing EU AKISs: From Knowledge to Impact*, Brussels.

made from abattoir waste (bones, blood), named Thallo in cooperation with a private company.

Although similar in the overall objective and intention, the four cases differ in their innovation focus, regional context and stage of development. The Danish case draws on more than 35 years of experience with perennial grass as an environmental measure, although its integration with green biorefining is more recent. Planty Organic began in 2012, and the UK Thallo case has also developed over roughly 15 years. The LSRE case (UK) has even several decades of experiences, and included new rotation components in the project. The Szigetköz case in Hungary appears to be a more recent initiative according to the available material. These differences in maturity provide important context for interpreting the cases, as actors, support structures and coordination arrangements around an innovation change as it develops over time.

AKIS features strengthening NBS nutrient management

With our comparative case-study approach, we explore how a number of AKIS features matter for successful nutrient management NBS implementation and spreading. The comparison examines three AKIS dimensions: actor constellations, knowledge and financial infrastructures, and coordination mechanisms (Birke et al. 2026[8]). It considers which actors are involved in each case, what resources support the innovation, and how activities are linked across actors, sectors and levels. The aim is to identify similarities and differences in how these dimensions are configured, rather than to rank the cases or assume that one arrangement would be appropriate in every context.

Actor constellations: who is involved, and what do they contribute?

Actor constellations refer to the organised actors involved in or relevant to an innovation. These may include public authorities, research and education organisations, private-sector businesses and advisers, farmer-based organisations, and NGOs (Birner et al., 2009[9]; Knierim et al., 2015[10]). This section examines the range and composition of actors around each NBS, distinguishing those actively involved in the specific innovation from those present in the wider AKIS. The starting point of an innovation often shapes which actors are closely involved. Across the cases, no single actor constellation appears of equal importance for each of the NBS innovations. The configurations that stand out are those that bring together the actors needed for the innovation's particular stage and purpose.

- Research–farmer constellations, often supported by an intermediary, are important for developing and testing practice-based innovations. This is especially clear in Planty Organic, where farmers, Biowad, researchers and SPNA jointly shaped and tested the farming system. Denmark also has strong research–advisory–farmer links. These constellations help ensure that research responds to practical questions and that innovations are tested under farming conditions.

[8] Birke, F. M., Knierim, A., Bae, S., & Gerster-Bentaya, M. (2026). How to comparatively analyse the AKIS across European countries – conceptual foundations and application. *The Journal of Agricultural Education and Extension*, *32*(5), 697–721. https://doi.org/10.1080/1389224X.2025.2559583

[9] Birner, R., K. Davis, J. Pender, E. Nkonya, P. Anandajayasekeram, J. Ekboir, A. Mbabu, et al. 2009. "From Best Practice to Best fit: A Framework for Designing and Analyzing Pluralistic Agricultural Advisory Services Worldwide." *Journal of Agricultural Education and Extension* 15 (4): 341–355. https://doi.org/10.1080/13892240903309595.

[10] Knierim, A., K. Boenning, M. Caggiano, A. Cristóvão, V. Dirimanova, T. Koehnen, P. Labarthe, and K. Prager. 2015. "The AKIS Concept and Its Relevance in Selected EU Member States." *Outlook on Agriculture* 44 (1): 29–36. https://doi.org/10.5367/oa.2015.0194.

- Cross-sector constellations become important when an innovation depends on a new value chain or changes beyond the farm. The Danish grass biorefinery stands out: research, advisory services and farmers are joined by municipalities, biogas and processing actors, and other value-chain partners. Klimafonden Skive helps connect some of these groups. This broader configuration reflects the need to coordinate biomass production, processing, regional objectives and market development.
- Company–research constellations can drive technical development but may need additional actors to support uptake. Thallo developed through a close partnership between Elemental Digest Systems and Rothamsted Research. Rothamsted helped extend the start-up's initially narrow actor base by linking it to other researchers and introducing the innovation to farmers widening the network beyond the company's immediate circle. However, limited early farmer involvement and weak connections to advisory, regulatory and commercial actors constrained broader embedding.
- Advisory- and public-sector-oriented constellations can provide channels for implementation, but their presence does not guarantee that a specific NBS is integrated into them. In Hungary, the wider AKIS includes research, advisory services, farmer organisations and public authorities, with advisory services as a potentially important interface with farmers. Yet theSzigetköz NBS itself appears only partially connected to these actors. The case therefore highlights the difference between the actors available in the wider system and those actively involved around a particular innovation.

A diverse actor constellation can support both the development of an innovation and wider interest in alternative nutrient management. Planty Organic illustrates this through its connections among various farmers and farmer organisations, researchers, civial society organisations and some regional authorities. The Danish grass biorefinery builds on a similarly broad base, but extends across more sectors, bringing in advisory services, municipalities and value-chain actors as well. The cases further support that diversity is most likely to broaden knowledge exchange and build a wider community of interest when actors are meaningfully connected to the innovation (Garforth et al., 2003[11]; Klerkx, van Mierlo, and Leeuwis, 2012[12]; Labarthe et al., 2013[13]). Another cross-cutting finding is the value of complementarity: research needs links to farming practice; practice-based learning may need an intermediary or trial organisation; and innovations that depend on markets, regulation or cross-sector change need relevant public and private actors involved as well. The appropriate constellation depends on what the innovation requires—not simply on how many actor categories are represented.

Enabling knowledge and financial infrastructures: continuity supports learning

Knowledge infrastructures provide the resources and capacities needed to develop and test an innovation. They include research and advisory organisations, trial and demonstration

[11] Garforth, C., B. Angell, J. Archer, and K. Green. 2003. "Fragmentation or Creative Diversity? Options in the Provision of Land Management Advisory Services." *Land Use Policy* 20 (4): 323–333. https://doi.org/10.1016/S0264-8377(03)00035-8.

[12] Klerkx, L., B. van Mierlo, and C. Leeuwis. 2012. "Evolution of Systems Approaches to Agricultural Innovation: Concepts, Analysis and Interventions." In *Farming Systems Research into the 21st Century: The new Dynamic*, edited by I. Dornhofer, D. Gibbon, and B. Dedieu, 457–483. Springer Dordrecht.

[13] Labarthe, P., M. Caggiano, C. Laurent, G. Faure, and M. Cerf. 2013. *Concepts and Theories Available to Describe the Functioning and Dynamics of Agricultural Advisory Services*. Learning for the Iinventory (PRO AKIS WP3): Deliverable WP2-1 (Pro AKIS: Prospect for Farmers' Support: Advisory Services in European AKIS; WP2: Advisory services within AKIS: International debates).

sites, monitoring, data and practical tools. Financial infrastructures provide the funding and investment needed to maintain these activities and, where relevant, move towards implementation (Birke et al. 2026[6]).

A particularly strong role plays long-term experimentation, which supports cumulative learning. At SPNA, Planty Organic trials have generated evidence on yields, soil fertility and nutrient balances over 14 years. In Denmark, research and advisory capacities build on established experience with perennial grass, while trials and demonstrations support further development of the biorefinery system. Both cases show how a continuing knowledge base can inform adaptation beyond a single experiment or project. Thallo highlights the limits of knowledge infrastructures when other resources are missing. Rothamsted's trials helped establish the product's agronomic performance, but scientific validation did not resolve the high capital needs and limited early revenue that constrained commercial-scale production. In Hungary, public and advisory structures offer potential channels for knowledge, but they haven't been consistently mobilised for the specific Szigetköz activities.

Financial infrastructures point to differences in the continuity and diversity of support. Planty Organic has depended on project funding, regional support and the efforts of key organisations to assemble resources. Thallo faced a particularly demanding financing gap between proof of concept and commercial production. The Danish NBS innovation benefits from a wide mix of research, sector-based, public and regional funding, though the long-term commercial viability of its emerging value chain remains uncertain.

The implication is that support should extend beyond initial trials. Long-term experimentation, accessible advice and funding arrangements that allow for adaptation are important where innovations need time to demonstrate their practical and economic value. Support may also need to address the transition from evidence to implementation, especially where commercial investment or new value-chain arrangements are required.

Coordination mechanisms: how actors organise joint work

Coordination mechanisms are the arrangements or activities through which actors align decisions, responsibilities or actions. They may use existing networks or construct them through coordination (Klerkx et al., 2012[10]). Across the cases, coordination commonly relied on intermediaries. However, the lead actors and the reach of coordination differed: some cases had mechanisms that connected several sectors, while in others coordinated activity mainly occurred within the inner innovation group.

The Danish case illustrates two complementary coordination functions. Vertically, Aarhus University generates research on perennial crops and biorefining, while SEGES Innovation and local advisory centres help translate this knowledge into farm-level decisions; farmers contribute practical feedback through trials and demonstrations. Horizontally, Klimafonden Skive acts as a regional intermediary, helping bring agricultural, research, municipal and private-sector perspectives into discussions about bioeconomy and land use. However, these functions do not yet ensure effective coordination across every part of the innovation: links between municipalities responsible for water-quality measures and private actors needed for processing and value-chain development remain a challenge. Strengthening those links is important for moving from regional experimentation towards implementation and market development.

Planty Organic is coordinated mainly within its farmer–research group. Farmers and Biowad helped shape the initiative, while SPNA supported and sustained the trials. These

arrangements enable practical questions and research activities to inform one another. The initiative's wider contacts with other farmers and organisations demonstrate network reach, but the evidence does not indicate that all those contacts are part of a jointly coordinated structure. Coordination remains strongest among farmers, researchers and closely connected organisations, with weaker links to private advisory and commercial actors.

In the UK, Rothamsted provided a specific bridging function for the development of Thallo. It connected the company to other research organisations and introduced the innovation to farmers through institutional engagement activities. This helped extend coordination beyond the start-up's immediate network, but the evidence points to a limited bridging role rather than a broad or formal coordination mechanism. Links to wider advisory services, public authorities and commercial actors remained limited.

In Hungary, advisory services appear to be the main operational coordinators facilitating farmer-to-farmer exchange and cooperative learning. The wider AKIS offers potential links between research, advice and practice, but these structures have not yet been consistently mobilised around the innovation; bridging appears to depend partly on individual relationships and project-based cooperation.

Our comparison also indicates that the three dimensions should be considered separately, so that specific strengths and effects can be fairly acknowledged: Denmark has a broad actor constellation and specific mechanisms for cross-sector coordination. Planty Organic has a varied set of contacts but coordination concentrated mainly within its farmer–research group. Rothamsted helped extend Thallo's company-centred network, while its coordination role remained relatively limited. In Hungary, advisory services provide an operational coordination function, but the innovation is not yet firmly connected to the wider AKIS.

Policy recommendations

1. Recognise AKIS infrastructures embedding NBS support

AKIS infrastructures provide the conditions in which an NBS can be developed, tested and taken up. The cases show that relevant features include knowledgeable, dedicated actors who with a long-term perspective mobilise repeatedly forces and resources, and make use of established and new ways and channels to address complex nutrient management challenges with practical answers. While we recognize various routes through which knowledge reaches practice, access to sustained experimentation and institutional funding is common denominator in three out of the four cases.

National and regional innovation programmes, including relevant EU-funded projects, should therefore assess how an NBS is connected to supportive AKIS infrastructures and related to established knowledge networks. The diagnosis should identify active and missing actors and organisations with a particular focus on the interface between farming practice and applied research, besides funding arrangements, regulatory constraints and coordination gaps. It should be revisited as the innovation develops: actor needs and bottlenecks can change between initial experimentation, validation and wider uptake. Repeated diagnosis can help programmes adjust their support rather than assume that the conditions identified at the outset remain unchanged.

2. Fund intermediation and coordination explicitly

Some NBS initiatives need an intermediary organisation that can respond flexibly to changing support needs—not only provide a single service, but connect actors, identify gaps and help

organise activities as the innovation develops. Organisations with a broad remit can have more room to act in this way than actors whose responsibilities are limited to formal advisory provision.

The cases illustrate this potential. Klimafonden Skive helps connect agriculture, research, municipalities and private-sector actors around regional innovation and bioeconomy activities. In Planty Organic, SPNA supported the trials and worked with the farmer group that initiated the innovation, helping to maintain links between experimentation and farming practice. These examples suggest that intermediary functions may be performed by regional organisations, research or trial organisations, or civil-society bodies—not only by advisory services.

Funding programmes should therefore support organisations or partnerships with a clear mandate to provide flexible intermediation. Depending on the needs of an NBS, eligible activities could include convening relevant actors, supporting farmer–researcher exchange, connecting projects with regional authorities or value-chain partners, and identifying emerging coordination needs. The aim should be to give intermediaries room to respond to the innovation's changing requirements, while making their responsibilities and resources sufficiently clear to sustain that work.

3. Involve to whom it matters

NBS initiatives benefit when concerned actors help define the problem, shape the experiments and interpret what they learn. This joint process can ensure that research addresses relevant practical questions and that proposed solutions are assessed against the needs and conditions of those expected to use them. Depending on the innovation, this may involve farmers, researchers, advisers, trial organisations and—where relevant—businesses, public authorities or water managers.

The process can also gain momentum when it reaches beyond the initial group to connect more widely with farmers and organisations working on similar challenges. Planty Organic illustrates this: exchange among farmers, farmer organisations, researchers and other interested organisations brought in different perspectives and helped the idea become more established, although links to private advisory and commercial actors remained limited. Programmes should therefore support both sustained collaboration within an initiative and wider exchange through farmer study groups, site visits, demonstrations and peer learning. The aim is not simply to increase participation, but to enable actors to learn together and adapt an innovation to their own contexts.

4. Connect local innovation to advisory and education systems

Project-based learning is less likely to reach a wider audience if its findings remain within the project network. Where evidence is sufficiently mature, programmes should support its translation into formats that farmers, advisers and learners can use. Options include advisory materials, adviser training, vocational and agricultural education, demonstration-farm networks, farmer organisations and digital advisory tools.

Planty Organic provides an example of knowledge being shared beyond its trials through talks, seminars and visits involving agricultural apprentices and students. This suggests a practical route for connecting long-term experiments to education, although it does not establish how far the approach has been integrated into formal curricula or routine advisory provision. Denmark's research and advisory structures, and Hungary's advisory system, may offer potential routes for embedding knowledge. Support should therefore be based on the capacities

and gaps identified in each case, rather than assuming that national or regional systems already provide an effective pathway.

5. Establish feedback loops between local practice and policy

As a practical policy option, programmes can complement written project reporting with regular exchanges between initiative participants and relevant authorities. These discussions can provide an opportunity to consider what has worked, what remains uncertain and whether changes to policy, funding or regulation could support further experimentation.

The cases suggest complementary approaches. In the Netherlands, links between funded activities and the funding authority can provide a formal route for reporting and reviewing results, while direct contact with regional actors supports discussion of local development. In Denmark, intermediaries such as Klimafonden Skive engage with policy actors to help shape conditions for regional innovation and value-chain development. Such exchanges can also help authorities recognise that experimentation takes time and does not always produce the intended result. A trial that does not lead to adoption or prove viable can still generate useful evidence about constraints and future options.

Regional or national programmes should therefore establish clear responsibility for convening these exchanges and connecting them to relevant policy processes. The purpose should be two-way learning: initiatives share evidence and implementation challenges, while authorities explain constraints and consider whether policy or support arrangements should respond. This approach treats NBS projects as experiments with uncertain outcomes, rather than judging them solely by whether they deliver immediate, successful uptake.

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This brief draws on Deliverable D2.4 of the trans4num project, which applied an innovation-centred AKIS diagnosis to four nutrient-management-related innovation cases in Denmark, Hungary, the Netherlands and the United Kingdom. The analysis combined contextual and policy review, actor mapping, expert interviews and cross-case analysis of knowledge and financial infrastructures and coordination mechanisms.

The evidence is qualitative and based on four context-specific cases with different innovation types, development stages and numbers of interviewees. It does not establish a statistically representative or causal relationship between particular AKIS configurations and uptake. Rather, it identifies recurring enabling conditions and bottlenecks that can inform the design of context-sensitive policy support.