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Report on 2nd Hackathon

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1. Introduction

1.1 trans4num objectives & Task 3.4 context

The trans4num project (Transformation for sustainable nutrient supply and management) is a four-year Horizon Europe initiative funded under the EU's "Zero Pollution" call. Coordinated by the University of Hohenheim, the project focuses on developing, validating, and scaling Nature-Based Solutions (NBS) to transition intensive agricultural systems toward circular nutrient management and enhanced ecosystem resilience.

Within this framework, Task 3.4 is dedicated to organizing interactive hackathons that function as collaborative testbeds. Conducted between months M40 and M44, the second hackathon serves as a practical bridge between transdisciplinary research, dynamic nutrient modeling, and stakeholder engagement. Its primary goal is to mobilize young researchers, agronomists, GIS specialists, and rural innovators to evaluate scalable NBS pathways, test regional nutrient balance models, and address the real-world trade-offs faced by intensive farming systems.

1.2 Evolution of the INSPIRE hackathon format

The hackathon builds upon the established **INSPIRE Hackathon format**, developed and refined by Plan4all over the past several years. Departing from traditional, fast-paced programming competitions, the INSPIRE methodology emphasizes open data integration, cross-sectoral collaboration, sustained expert mentoring, and iterative co-creation.

While the first trans4num Hackathon (2024) was hosted as a fully virtual, multi-month event, the second edition was designed as a focused **hybrid event**. Combining in-person working sessions at Aarhus University in Denmark with a structured virtual workspace, this format facilitated direct, place-based analysis while ensuring broad European and international participation without geographic barriers.

The selection of the Limfjord catchment as the central testbed was highly strategic. As one of Denmark's most vulnerable aquatic ecosystems, it is currently the focal point of stringent national debates surrounding the Green Tripartite Agreement. By anchoring the hackathon in a real-world region facing acute pressure to reduce agricultural nitrogen leaching, the event transcended theoretical exercises, forcing participants to grapple with the genuine socioeconomic trade-offs required by the EU Zero Pollution Action Plan.



Figure 1: Danish NBS site - Limfjord catchment



Figure 2: Limfjord catchment - Copernicus Sentinel-2 imagery

1.3 Strategic EU–China collaboration (CAAS & Chinese Consortium)

International cooperation between the European Union and China remains a foundational pillar of the trans4num project. Following the experiences from the first hackathon, collaboration with Chinese partners, including the Chinese Academy of Agricultural Sciences (CAAS) and Tsinghua University, was organized through a dedicated, complementary framework.

Because the Chinese partners had already organized their own dedicated in-situ event in China, they were not requested to co-host or participate directly in the intensive European hacking sessions. Instead, the bilateral cooperation was established around targeted dissemination, cross-promotion, and systemic knowledge transfer:

- **Event and thematic exchange:** The hackathon structure, thematic challenges, and methodology were shared with the Chinese consortium to maintain strategic alignment across project activities.
- **Sharing challenge outcomes & results:** The primary mechanism of collaboration focuses on post-event knowledge sharing, where the concepts, agent-based models, and Nature-Based Solution (NBS) workflows developed during this hackathon are exchanged with the Chinese partners.
- **Comparative insights:** This exchange allows both consortia to compare practical findings, evaluate how data-driven nutrient abatement tools perform across different regulatory and geographic environments, and enrich joint research deliverables within Task 3.4 and the broader project.

1.4 Synergies with sister projects and technical frameworks

To provide participants with operational resources and realistic datasets, the hackathon established technical and methodological synergies with related European initiatives:

- **PoliRuralPlus[1]:** Contributed the **JackDaw GeoAI spatial intelligence agent**, enabling teams to query complex spatial data, regional indicators, and land-use scenarios via natural language.
- **trans4num technical assets:** Teams directly tested and evaluated the **trans4num Decision Support Tool (DST)** alongside regional spatial data layers and Copernicus Sentinel imagery to model nutrient loads and crop rotation impacts.

[1] www.poliruralplus.eu

By integrating these platforms, the hackathon demonstrated the value of reusing interoperable digital infrastructures across research projects to address systemic sustainability challenges.

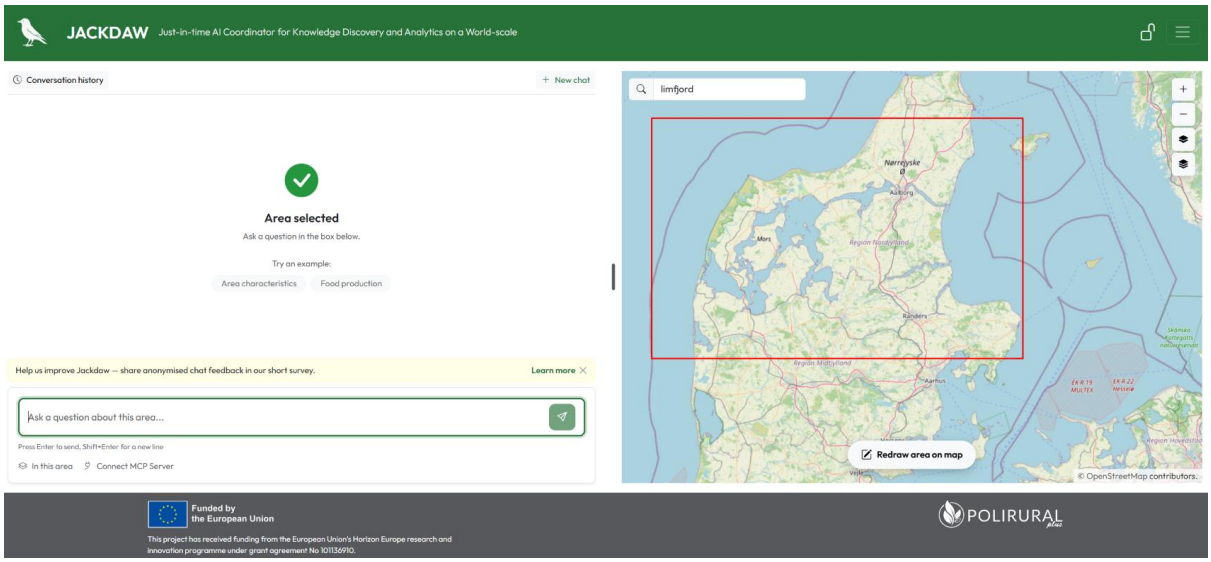


Figure 3: Screenshot of the JackDaw AI Chat Agent



Figure 4: Screenshots of the trans4num Decision Support Tool

1.5 Communication, dissemination, and visual identity

In coordination with communication partner HCC and the host institutions, a comprehensive promotional campaign was deployed across the official trans4num and Plan4all channels.

Dedicated graphic packages, visual templates, and targeted web articles supported the Call for Participants across European universities, the Danish agroecological community, and Chinese academic partner networks. Outreach emphasized free, inclusive participation, setting clear expectations for deliverables and collaborative teamwork.

To maximize visibility and ensure a highly targeted applicant pool, the campaign heavily leveraged the established professional and academic networks of the trans4num consortium partners. Direct outreach was conducted through partner-affiliated university faculties, agricultural advisory services, and regional authorities. This decentralized approach ensured the invitation reached a precise demographic of agronomy students, early-career researchers, GIS specialists, and rural innovators.

The digital footprint of the campaign spanned multiple platforms. Structured articles and event registrations were hosted on the core project websites (trans4num, Plan4all) and the host institution's portal (Aarhus University). To reach broader European innovation communities, the hackathon was also syndicated on external environmental and tech-aggregator platforms, including Oppla and Hackathon Hub. This web presence was supported by a coordinated social media push across LinkedIn and Facebook, utilizing targeted hashtags and visual assets to drive continuous engagement leading up to the registration deadline.

Social media campaign	
LinkedIn	https://www.linkedin.com/posts/trans4num_trans4num-hackathon2026-naturebasedsolutions-activity-7508804261049339907-xXQw?utm_source=share&utm_medium=member_desktop&rcm=ACoAAEB2Jr4BVyY2MaMiHb80IkHRMt-sD23hplk
Facebook	https://www.facebook.com/photo/?fbid=1559889456163567&set=a.458175873001603&locale=cs_CZ
LinkedIn	https://lnkd.in/p/dbWpweEe
Facebook	https://www.facebook.com/photo?fbid=1223100629661986 95&set=a.1221377097501986 95&locale=cs_CZ
LinkedIn	https://www.linkedin.com/posts/marketa-kollerova_trans4num-inspire-hackathon-2026-ugcPost-7511010418916716546-Q1-n/?utm_source=share&utm_medium=member_desktop&rcm=ACoAAEB2Jr4BVyY2MaMiHb80IkHRMt-sD23hplk
LinkedIn	https://www.linkedin.com/posts/trans4num_trans4num-hackathon2026-naturebasedsolutions-activity-7513170779090432001-EWjO?utm_source=share&utm_medium=member_desktop&rcm=ACoAAEB2Jr4BVyY2MaMiHb80IkHRMt-sD23hplk

LinkedIn	https://lnkd.in/p/evJZZN3T
LinkedIn	https://lnkd.in/p/d7t2j6w4
LinkedIn	https://lnkd.in/p/dK5Qn9Bc
LinkedIn	https://lnkd.in/p/dsKkSAw7
LinkedIn	https://lnkd.in/p/dU8_JApZ
Facebook	https://www.facebook.com/photo?fbid=1223136903921986 95&set=a.1221377097501986 95&locale=cs_CZ
Websites news	
trans4num	https://trans4num.eu/en/hackathon-2026/
Plan4all	https://www.plan4all.eu/news-and-events/launch-of-the-trans4num-inspire-hackathon-2026-design-the-future-landscape-of-the-limfjord/
Plan4all	https://www.plan4all.eu/inspire-hack/trans4num-inspire-hackathon-2026/
Oppla	https://oppla.eu/event/hackathon-trans4num-inspire-hackathon-2026
Aarhus University	https://agro.au.dk/en/current-news/events/show/artikel/default-d8673561ffee0fb3fff78df36bae3434
Hackathon Hub	https://hackathonhub.eu/events/trans4num-inspire-hackathon-2026-aarhus-2026
Plan4all	https://www.plan4all.eu/news-and-events/empowering-sustainable-landscapes-the-success-of-the-trans4num-inspire-hackathon-2026/
trans4num	https://trans4num.eu/en/news/hackathon-2026-conclusion/
PoliRuralPlus	https://www.poliruralplus.eu/news/ai-meets-agroecology-poliruralpluss-jackdaw-geoai-powers-the-trans4num-inspire-hackathon-2026/

Table 1: Overview of the outreach campaign



Figure 5: trans4num INSPIRE Hackathon 2026 logo



Figure 6: Social media graphics



Figure 7: Social media / website poster

2. Hackathon organization & Implementation

This chapter details the structural framework and operational execution of the second trans4num Hackathon. It outlines the hybrid methodology employed to facilitate international collaboration, the targeted thematic tracks focused on the Limfjord catchment, and the comprehensive mentoring and evaluation processes that guided teams from their initial concepts to the final pitches.

2.1 Challenge definition & thematic tracks

In contrast to the multiple standalone challenges of the first hackathon, the second trans4num hackathon unified all participants around a single overarching objective: **co-designing the future landscape of Denmark's Limfjord catchment**. The catchment serves as a prime European transition area bound by stringent environmental mandates under Denmark's Green Tripartite Agreement and the EU Zero Pollution Action Plan.

Instead of selecting separate, isolated challenges, all interdisciplinary teams worked on this common landscape vision by integrating four key thematic dimensions into their proposed solutions:

1. **Landscape-scale nutrient balances & Nitrogen abatement:** Addressing the severe nitrogen runoff into the vulnerable Limfjord aquatic ecosystem by linking field-level management choices with regional catchment-scale retention targets.
2. **Decision Support Tools (DST) & Geospatial scenarios:** Using spatial evidence to ground landscape designs, specifically by testing and incorporating the *trans4num Decision Support Tool (DST)* and the *JackDaw GeoAI agent* (developed within the project PoliRuralPlus) to simulate crop rotations and land-use allocation.
3. **Circular biomass & Nature-Based Solutions (NBS):** Integrating interconnected nature-based measures, such as perennial grass-clover leys, green biorefinery value chains, wetland restoration, and organic soil amendments, to close regional nutrient loops.
4. **Data-driven policy & Regulatory Sandboxes:** Ensuring systemic feasibility by considering regulatory mechanisms, land consolidation, and practical economic incentives that encourage farmer adoption while meeting strict compliance goals.

By synthesizing these four focus areas within a unified challenge framework, teams were challenged to avoid single-discipline fixes and instead develop holistic, system-level agroecological concepts.

2.2 Methodology: The Innovation Canvas Framework

To structure participant contributions and ensure tangible, high-quality deliverables within a condensed timeframe, the organizers introduced a standardized **trans4num Innovation Canvas**[2]. Each multidisciplinary team was guided to produce two explicit end-products:

- **Product 1: Future Landscape Concept (Slide 3):** A spatial design presented as a GIS map, spatial diagram, or visual storyboard illustrating *where* and *how* targeted NBS interventions are allocated across the Limfjord landscape.
- **Product 2: Innovation in One View (Slides 4–13):** A synthesized, 1-page canvas structured around five foundational pillars:
    1. *The Problem:* Clear identification of the specific catchment pressure and affected stakeholders (farmers, municipalities, aquatic ecosystems, bio-industries).
    2. *The Solution:* The concrete portfolio of nature-based solutions and their systemic interconnections.
    3. *The Benefits:* Quantification of multi-benefits (N-reduction, biodiversity, carbon sequestration, farm income) alongside mitigation of operational trade-offs and bottlenecks.
    4. *The Farmer:* Practical adoption incentives (new commercial revenue, input cost savings, CAP eco-schemes) and strategies to overcome the primary barrier to adoption.
    5. *The Transition:* Deployment of digital tools/spatial data (DST and JackDaw) combined with top-3 strategic recommendations across farm, market/cooperative, and policy levels.

2.3 Call for Participants, Demographics & International Engagement

The Call for Participants successfully mobilized a highly diverse, multidisciplinary cohort, bringing together 33 individuals encompassing active hacking participants, expert mentors, organizing staff, and jury members. The hybrid format enabled the event to transcend geographic boundaries, resulting in a rich cross-pollination of academic, cultural, and professional perspectives.

Participant diversity and global reach

The hackathon attracted an exceptionally international group of participants spanning multiple continents. The participant roster featured early-career researchers, agronomists, and GIS specialists originating from Denmark, Germany, Great Britain, Portugal, Japan, India,

[2] Available at: trans4num_innovation_canvas.pptx

Iran, and Morocco. This global representation ensured that the proposed Nature-Based Solutions and landscape designs were informed by a wide array of international agroecological perspectives.

Complementing the international virtual and traveling participants was a strong, dedicated cohort of on-site students from Aarhus University (AU). This local academic engagement provided the teams with crucial on-the-ground context regarding Danish agricultural practices and Limfjord-specific environmental challenges.

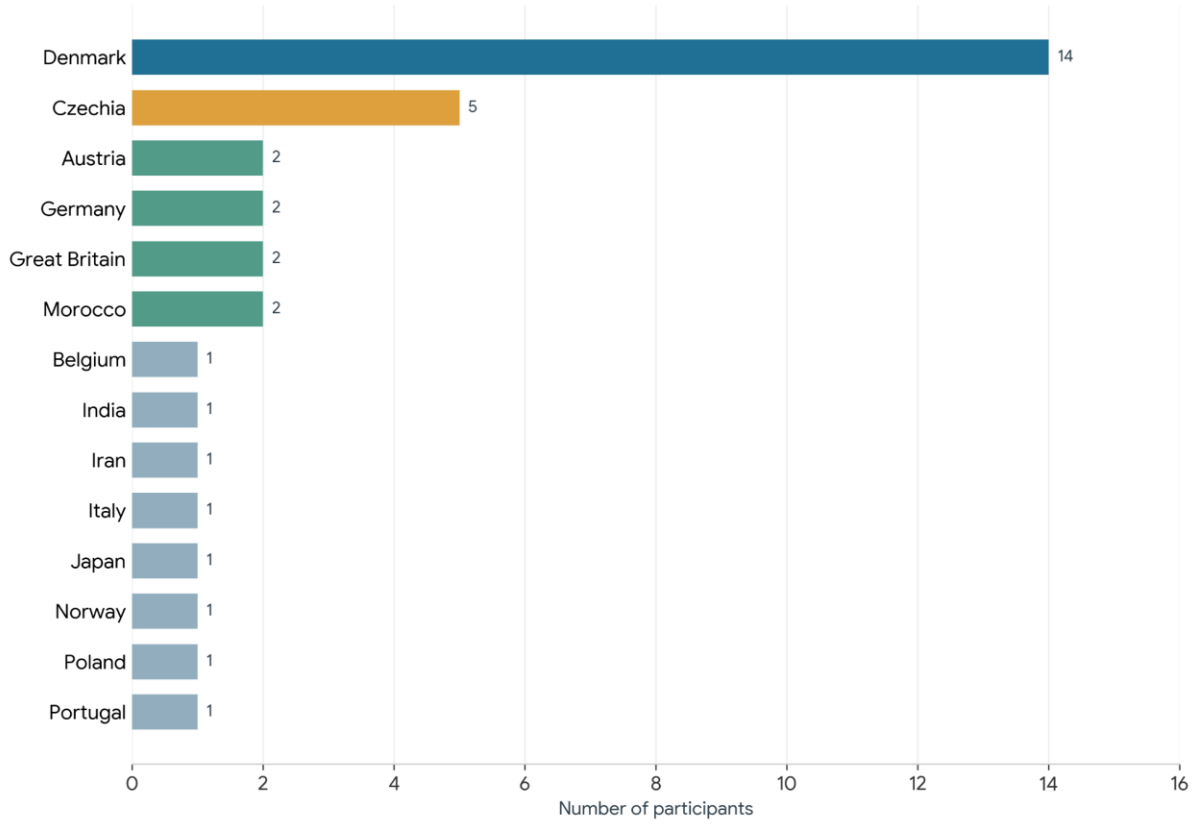


Figure 8: Hackathon participants by country

Extended outreach and vocational networks

Beyond the direct participants, the hackathon concept and methodology were communicated extensively across transnational European networks. A key aspect of this outreach was the targeted dissemination to the EU network of vocational agricultural schools, coordinated by project partners. This strategic distribution ensured that the hackathon's challenge framework reached future agricultural practitioners and educators, significantly amplifying the educational impact of the trans4num project.

The organizing, mentoring, and evaluation team

The successful execution of the hackathon was underpinned by a coalition of organizers, technical mentors, and jury members drawn from across the trans4num consortium and allied networks. This backbone of experts provided continuous guidance, spatial data support, and rigorous evaluation throughout the two-day event. Key institutional representation included:

- **Aarhus University:** Tommy Dalgaard, Nele Lohrum, Morten Graversgaard, Morten Winther Vestenaa provided core agronomic mentoring, local catchment data, and event hosting.
- **Plan4all:** Markéta Kollerová, Filip Leitner, František Zadražil, Karel Charvát, and Tomáš Mildorf managed the hackathon methodology, the JackDaw GeoAI agent, and the overarching INSPIRE framework.
- **University of Hohenheim:** Li Quiriui supported international participant coordination and broader EU network dissemination.
- **Industry & Advisory Experts:** Morten Birk (Cordulus) led the technical onboarding for the Decision Support Tool (DST), while Morten Winther Vestenaa (ICOEL) provided critical insights into organic farming regulations and practical farmer adoption.

This collaborative organizational structure ensured that participants were not only challenged to innovate but were fully supported by leading experts in spatial intelligence, agroecology, and rural policy.

Participants were accommodated via a hybrid setup:

- **On-site track:** Teams based at Aarhus University (Department of Agroecology) working in dedicated collaborative rooms.
- **Virtual track:** Remote teams and individual contributors collaborating via online platforms, video sessions, and shared workspaces.

The hybrid format necessitated a highly structured digital workspace to ensure parity between on-site teams in Aarhus and remote participants. This was managed through dedicated virtual channels for mentor dispatch, real-time Q&A, and file sharing. This setup not only democratized access for international students who could not travel, but also successfully simulated the modern, distributed nature of international European research consortia.

Team matching was initiated during the preparation phase and finalized during the plenary opening, grouping complementary skills (e.g., pairing agronomic and environmental science backgrounds with GIS developers and spatial modelers).

2.4 Mentoring process & Technical support

To ensure teams were fully operational from day one, participants were provided with comprehensive onboarding packages, including Limfjord geospatial datasets, agronomic profiles, and user guides for the core software. Mentors drawn from Aarhus University, Plan4all, and ICOEL provided dedicated guidance throughout the process:

- **Agronomy & Nitrogen Mentor:** Tommy Dalgaard & Morten Graversgaard provided context on local soil variations, nitrogen retention percentages, crop rotations, and livestock densities.
- **Nature-Based Solutions Mentors:** Morten Winther Vestenaa and Tommy Daalgard advised on green biorefinery feedstock parameters, wetland placement, and perennial grass-clover performance.
- **Policy & Economic Mentor:** Morten Graversgaard supported teams in navigating the Green Tripartite framework, CAP subsidy schemes, and farmer business viability.
- **Digital & AI Tool Mentors:** Filip Leitner and Morten Birk guided participants through API queries, spatial layers, scenario simulation in the DST, and prompt engineering in the JackDaw GeoAI agent.

2.5 The Digital Toolbox: JackDaw and the trans4num DST & ABM handout

To ground their proposed landscape designs in spatial evidence and realistic trade-offs, participants were provided with a dedicated digital toolbox. While the use of these tools was not strictly mandatory - teams were encouraged to prioritize systemic thinking over software usage - the toolbox served as a critical research and validation asset to support the "Transition" pillar of their Innovation Canvas. The toolbox consisted of two primary platforms:

trans4num Decision Support Tool (DST)

The trans4num DST is a spatial, data-driven planning tool designed to evaluate how agricultural management strategies influence nutrient losses, water quality, crop production, and farm economics at a landscape level. With the first prototype explicitly developed for the Limfjord region, the DST allowed participants to evaluate Nature-Based Solutions such as diversified crop rotations, perennial crops, catch crops, and green biorefining.

Teams navigated the DST using a structured four-step workflow:

1. **Define a Goal:** Selecting an optimization target, such as maximizing economic performance while reducing nitrogen losses by a specific metric.
2. **Add Constraints:** Defining practical limits, such as restricting specific crop changes, maintaining realistic farm types, or setting maximum distances to relevant bio-industries.

3. **Generate Alternative Scenarios:** Allowing the tool to calculate possible landscape configurations that satisfy the goals and constraints.
4. **Explore the Results:** Extracting evidence via interactive maps (showing field-plot based changes in crop rotations and yields) and charts (comparing regional nitrogen balances and economic returns).

Importantly, the DST was positioned not to prescribe decisions, but to help teams jointly explore alternative scenarios, visualize trade-offs between environmental targets and economic viability, and identify practical pathways forward. The resulting maps and data summaries provided the concrete evidence required for the teams' Future Landscape Concept and Innovation Canvas presentations.

JackDaw GeoAI Assistant

Developed within the Horizon Europe PoliRuralPlus project, JackDaw acts as a GeoAI spatial assistant that combines artificial intelligence with geographic and spatial datasets. It allows users to query complex spatial data using natural language. During the hackathon, teams utilized JackDaw to:

- **Explore the Landscape:** Identify dominant crops, land uses, and baseline characteristics across the Limfjord catchment.
- **Investigate Spatial Patterns:** Locate vulnerable areas and determine optimal placements for Nature-Based Solutions (e.g., wetlands or buffer areas) based on surrounding environmental features.
- **Query Policy and Evidence:** Access relevant planning information and challenge their own agronomic assumptions.

Participants were guided to use JackDaw as an interactive research partner through a structured workflow: Ask simple questions, Explore the landscape, Check evidence against assumptions, Connect findings to their goals, and Design the future landscape. JackDaw outputs served as evidence to inform team thinking rather than acting as final decision-makers.

Alongside the digital toolbox, participants were equipped with localized, high-resolution datasets to ensure their landscape models were grounded in reality. This data package included regional soil type maps, historical nitrate leaching metrics, dominant crop rotation patterns in the Limfjord area, and proximity layers to existing biogas and green biorefinery infrastructure. By providing this curated data environment, teams could immediately focus on scenario building rather than spending the limited hacking time hunting for baseline statistics.

Agent-Based Model (ABM) Handout

In addition to the interactive software tools, participants were provided with a prepared background handout detailing the ADAPtES Agent-Based Model (ABM). Developed specifically for the Limfjord catchment, this model simulates the complex socio-economic dynamics of transitioning arable land to perennial grass-clover for green biorefining or biogas production. Rather than just mapping environmental data, the ABM illustrates the behavioral and logistical aspects of the transition, specifically, how individual farmer decisions, area payments, and proximity to processing plants influence one another. By studying the model's findings, such as the reality that a farmer's willingness to convert land does not result in actual delivery without sufficient local processing capacity, teams were able to critically evaluate the practical feasibility of their proposed Nature-Based Solutions. The handout prompted participants to answer crucial "what-if" questions and consider the importance of cooperative structures, pooled supply, and spatial logistics when designing the 'Farmer Adoption' and 'Transition' pillars of their Innovation Canvas.

2.6 Evaluation framework & Jury composition

A multidisciplinary jury of international experts evaluated the submitted deliverables. The panel included senior representatives from agricultural engineering, geoinformatics, agroecology, and research management. The evaluation adhered to a structured multi-criteria rubric:

- **Novelty & Systemic thinking (25%):** Originality of the proposed solution and how effectively individual interventions function together as an interconnected agroecological system.
- **Environmental & Agroecological impact (25%):** Plausibility and scale of nitrogen abatement, ecosystem restoration, soil carbon benefits, and biodiversity gains.
- **Farmer viability & Practical feasibility (20%):** Realism of the farm business case, market readiness, and mitigation of critical bottlenecks/trade-offs.
- **Use of spatial evidence & Digital tools (15%):** Quality of the Future Landscape Concept and meaningful integration of the trans4num DST, JackDaw, or open geospatial data.
- **Pitch & Delivery quality (15%):** Adherence to the 8-minute presentation format, clarity of the final "Innovation in One View" canvas, and responsiveness during the 2-minute jury Q&A.

Jury members:



Tommy Dalgaard is a Professor in the Department of Agroecology at Aarhus University, where he leads research in Agricultural Systems and Sustainability. With an extensive academic background in agroecology, spatial land-use modeling, and nitrogen management, his work focuses on transforming European agrifood systems through the integration of Nature-Based Solutions, agroforestry, and sustainable landscape planning. As a driving force within the trans4num project and a core mentor during the hackathon, Professor Dalgaard provides critical expertise in balancing regional nitrogen abatement with practical agronomic realities and ecosystem services in the Limfjord catchment.



(Stein) Runar Bergheim manages Research and Development at Avinet, a leading digital services and consultancy firm in Norway. With a strong academic and professional background in landscape management, spatial planning, and GIS, he brings extensive international experience to the panel. Having managed more than two hundred information technology and spatial planning assignments across twenty countries, Runar specializes in bridging the gap between complex technical solutions and non-technical stakeholders. His expertise provides the jury with a crucial perspective on the practical application, design, and deployment of digital tools in land management and rural development.



Karel Charvát represents Plan4all bringing extensive expertise in open data, AI-enhanced geospatial analysis, and rural development. As a driving force behind the INSPIRE Hackathon methodology over the past several years, he has guided numerous international challenges focused on digital agriculture, spatial intelligence, and environmental sustainability. His involvement in the trans4num project ensures a strong focus on utilizing geospatial tools and collaborative innovation to solve complex agroecological challenges.



Morten Winther Vestenaa is a Senior Advisor and Special Consultant at the Innovationscenter for Økologisk Landbrug (ICOEL). Holding an M.Sc. in Agronomy from the University of Copenhagen, he specializes in organic plant production, nutrient management, and circular ecology. His professional expertise encompasses optimizing organic crop nutrition, navigating environmental regulations, and developing circular agricultural models, including plant-based biogas solutions and multi-stakeholder research initiatives.

2.7 Pitching, final event & deliberation

The hackathon concluded with a plenary pitching session bringing on-site and remote participants together:

- **Pitching format:** Each team had about 8 minutes to present their landscape concept and canvas slides, followed by 2 minutes of direct Q&A with the jury.
- **Jury deliberation:** The panel convened in a closed session to aggregate scoring sheets, debate borderline evaluations, and establish consensus rankings.
- **Awards & Recognition:** The event ended with the presentation of awards (Gold, Silver, Bronze) and certificates, accompanied by feedback from the jury highlighting the direct applicability of the outputs to ongoing trans4num pilot deliverables and stakeholder sandboxes.

The event concluded with the announcement of the top teams, recognizing their exceptional contributions and innovative solutions.

Gold Award: Team Meguri - Sofia Vila Verde, Marie Nishino, Komal Kumari

A Farmer-First Landscape Transition

Silver Award: Team Low-Hanging Fruit - Dave Peacock, Jeppe Munk, Katharina Jentzsch

Topographical Gradient Strategy

Bronze Award: Regenerative Agriculture - Fran Jonckheere & xxx

Healthy Soils for Vibrant Waters

3. Results, Solutions & Project impact

3.1 Summary of team solutions and pitches

The second trans4num Hackathon produced diverse and innovative approaches to the Limfjord challenge, emphasizing systemic landscape changes, circular nutrient flows, and farmer-centric transition models. The jury awarded the top three solutions based on their integration of environmental impact, practical feasibility, and spatial evidence.

Gold Award: Team Meguri – A Farmer-First Landscape Transition (Sofia Vila Verde, Marie Nishino & Komal Kumari)

Team Meguri presented an integrated, bottom-up landscape approach focused on tackling nitrogen pollution at its source while actively protecting farmers' livelihoods and economic viability.

- **The Core Solution:** The team designed a targeted spatial distribution of nature-based solutions: placing grass-clover rotations and lowering livestock density on vulnerable arable fields to increase nitrogen retention, while implementing legume-cereal intercropping on highly productive fields to reduce synthetic fertilizer dependency.

- **Landscape Integration:** Their landscape concept strategically positioned constructed mini-wetlands in lowland depressions for denitrification, integrated carbon farming along field boundaries, and deployed agroforestry clusters to increase biodiversity and generate alternative timber revenue.
- **The Transition & Farmer Focus:** Recognizing that farmers cannot bear the financial risk of environmental transitions alone, the team emphasized overcoming the initial investment barrier through targeted subsidies, CAP eco-schemes, and simplified financial support. They advocated for a participatory, farmer-centric approach that provides technical training and strengthens local supply chains (e.g., green biorefineries).

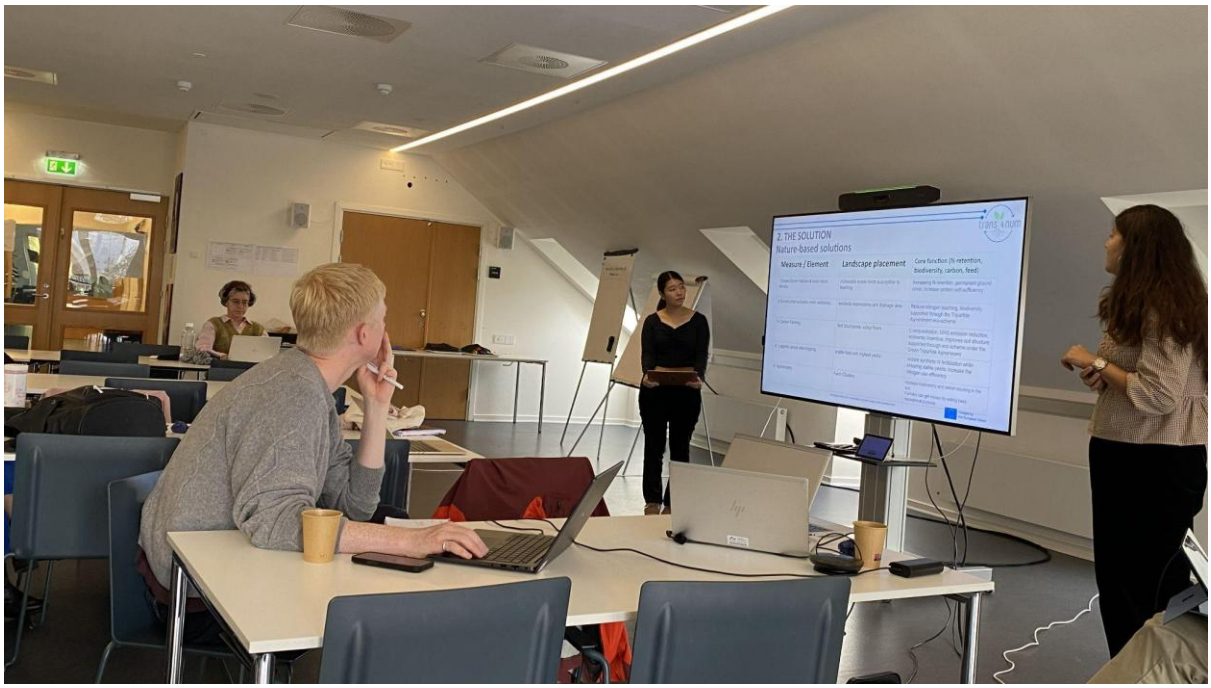


Figure 9: Team Meguri presenting their Innovation Canvas

Silver Award: Team Low-Hanging Fruit – Topographical Gradient Strategy (Dave Peacock, Jeppe Munk & Katharina Jentzsch)

Team Low-Hanging Fruit developed a spatial, sub-catchment scale strategy that works directly with the natural topography and water flow of the Limfjord to catch, utilize, and filter nutrients.

- **The Core Solution:** The team conceptualized a three-tiered "terraced" landscape model:

- *Uplands (Source Control):* Utilizing runoff retention basins to harvest excess runoff and implementing precise, split nitrogen applications.
- *Midlands (Biological Sponge):* Transitioning to deep-rooted grass-clover fields harvested three times a year for regional biorefineries, which scavenges residual nutrients and improves stable soil carbon.
- *Lowlands (Final Filter):* Constructing wetlands, rewetting drained organic soils, and reconnecting stream meanders to provide natural denitrification before water reaches the fjord.

- **Impact & Adoption:** This systemic flow reduces overall nitrogen leaching and boosts biodiversity through stream remeandering, while cutting CO2 emissions in the lowlands. To address trade-offs, they proposed empowering farmers through shared sub-catchment nitrogen responsibilities, cooperative models for biorefineries, and utilizing CAP Pillar II funding to compensate lowland farmers.



Figure 10: Team Low-hanging Fruit presenting their Innovation Canvas

Bronze Award: Regenerative Agriculture – Soil Health for Vibrant Waters (Fran Jonckheere & Emma-Sophie Tossmann)

The Bronze-winning concept focused on implementing regenerative agriculture principles across the Limfjord catchment to reduce nitrogen leaching by fundamentally restoring soil health and ecosystem functions.

- **The Core Solution:** The proposal centered on a matrix of interconnected field practices to build soil organic matter and enhance nutrient cycling.

- **Key Interventions:**
  - *Cover Crops & Diverse Rotations:* Keeping living roots in the soil year-round to capture residual post-harvest nitrogen, while alternating crops with varying rooting depths to maximize nutrient use efficiency and soil structure.
  - *Reduced Tillage:* Minimizing soil disturbance to protect microbial communities and improve soil aggregation, thereby directly reducing nutrient runoff.
  - *Buffer Strips & Wetlands:* Installing vegetated zones between active fields and waterways to filter surface runoff and capture nutrients before they enter the fjord.
- **Impacts:** The strategy demonstrated that healthier, carbon-rich soils inherently provide better water infiltration and nutrient retention, translating to reduced coastal eutrophication, improved drought resilience for farmers, and lower input costs.



Figure 11: Team Regenerative Agriculture presenting their Innovation Canvas

The concepts generated by the top teams provide direct, usable inputs for ongoing project tasks. For example, Team Meguri's farmer-centric eco-scheme proposals offer empirical case studies for Work Package 4 (Socio-economic and Policy frameworks), while the topographical gradient model proposed by Team Low-Hanging Fruit provides new scenario archetypes that can be further simulated by the technical teams in Work Package 2.

3.2 Contributions to trans4num objectives

The second hackathon directly advanced the core scientific, technical, and policy objectives of the trans4num project by moving theoretical frameworks into applied, localized stress tests. The outcomes contributed to the project in three primary ways:

Advancement of the trans4num DST through practical user stress-testing and scenario mapping

The hackathon served as a critical real-world testing ground for the trans4num Decision Support Tool (DST). By deploying the tool in a time-constrained, multidisciplinary environment, the consortium gathered invaluable feedback on its usability, processing demands, and scenario-mapping capabilities. For instance, participant teams stress-tested the tool by attempting complex regional simulations - such as modeling a 20% land-use change with a 5% economic impact margin on farmers. While the intensive processing time for such complex regional calculations highlighted areas for technical optimization, the exercise confirmed the DST's fundamental value: empowering users to compare alternative farming practices and visually map how specific management changes affect landscape-level nitrogen losses. This user feedback will directly inform the next iteration of the tool's interface and processing architecture.

Practical validation of the JackDaw GeoAI agent in complex hydrological and agronomic scenarios

The event provided a unique environment to validate the JackDaw GeoAI spatial assistant outside of its initial PoliRuralPlus testing parameters. Participants explored its potential to rapidly visualize spatial differences in nitrogen loss risks and identify suitable geographical placements for nature-based solutions. The hackathon demonstrated that, despite the steep learning curve inherent in mastering spatial AI prompts within a single day, JackDaw holds significant promise as a "bridge" technology. Teams noted that user-friendly digital tools like JackDaw are essential for translating abstract scientific knowledge and environmental problems into actionable, site-specific realities for farmers and regional planners.

Actionable strategies for nutrient circularity and compliance under national and EU environmental mandates

A core objective of trans4num is to align Nature-Based Solutions with stringent policy mandates, specifically the EU Zero Pollution Action Plan and regional frameworks like Denmark's Green Tripartite Agreement. The hackathon generated highly actionable, localized strategies that bridge the gap between regulatory compliance and farm-level economic viability. The proposed solutions, ranging from sub-catchment "terraced" filtration models to participatory, farmer-first eco-schemes, demonstrated how targeted subsidies and cooperative market structures (e.g., local green biorefineries) can successfully incentivize the adoption of perennial grasses, wetlands, and reduced tillage. By explicitly linking environmental nitrogen abatement with new commercial income streams and CAP subsidy

eligibility, the hackathon provided the trans4num consortium with realistic business cases for nutrient circularity that can be scaled across other European and Chinese pilot regions.



Figure 12: Hackathon participants with AU & ICOEL team

3.3 Lessons Learned and Comparison with the 1st Hackathon

The design and execution of the second trans4num Hackathon built directly upon the structural feedback and limitations identified during the first hackathon (as documented in Deliverable D3.2). By adapting the methodology, the organizing team successfully addressed previous operational bottlenecks:

Focused thematic challenges directly tied to core project deliverables

During the first hackathon, the broad call for diverse challenges resulted in some tasks misaligning with the project's core objectives, leading to uneven engagement (e.g., the cancellation of the web-scraping challenge due to a lack of participants). The second hackathon overhauled this approach by unifying all participants around a single, highly relevant regional testbed: the Limfjord catchment. Instead of isolated, disparate tasks, teams tackled interconnected thematic pillars, landscape-scale nitrogen abatement, Nature-Based Solutions, and data-driven policy, ensuring that every proposed solution directly contributed to trans4num's primary goals of regional nutrient circularity and DST validation.

Improved participant onboarding through structured canvas templates

A key limitation of the first hackathon was the occasional gap between mentor expectations and the participants' technical expertise, which sometimes led to diluted focus. To solve this, the second hackathon introduced a highly structured workflow via the **trans4num Innovation Canvas**. By providing a standardized 14-slide template, a clear 4-step workflow for digital tools, and explicit requirements for two deliverables (the *Future Landscape Concept* and the *Innovation in One View* summary), participants were immediately oriented. This scaffolding prevented teams from getting bogged down in software engineering and kept them strictly focused on systemic agroecological problem-solving and realistic farmer business cases.

Redefined framework for EU-China knowledge exchange

While the initial ambition for the second hackathon was to host synchronous, joint participation with the Chinese Academy of Agricultural Sciences (CAAS) and Chinese researchers, direct participation during the intensive hacking sessions did not materialize. Because the Chinese partners organized their own dedicated in-situ activities, the collaboration framework was pragmatically adapted. Rather than forcing asynchronous active hacking, the strategy shifted to post-event knowledge transfer. The highly structured results of the Limfjord hackathon, including the agent-based mitigation concepts, spatial landscape models, and the Innovation Canvas methodology itself, are designated to be shared with the Chinese consortium. This ensures that the solutions generated in the European context can still provide comparative insights and inform parallel nutrient management strategies within the Chinese pilot regions.

3.4 Exploitation and next steps (Task 5.2 Integration)

The outcomes of the second trans4num Hackathon extend beyond the event itself, serving as foundational inputs for the project's broader exploitation strategy under Task 5.2 (Integration). The conceptual landscape models, validated Nature-Based Solutions, and localized farmer business cases generated by the participating teams will directly feed into upcoming trans4num dissemination deliverables. Furthermore, the empirical feedback gathered on the Decision Support Tool (DST) and the proposed systemic transition strategies will provide concrete case studies for future scientific papers and targeted policy briefs addressing agricultural sustainability.

To ensure these results and impacts reach a wide and relevant audience, a comprehensive, structured article detailing the hackathon activities, the Innovation Canvas methodology, and the winning solutions will be published on the official trans4num website.

This publication will serve as the primary vehicle for post-event outreach and will be actively distributed across multiple channels. It will be shared directly with all project partners, the

universities and schools originally invited to participate, and the broader extended professional networks of each consortium member. Crucially, this structured dissemination package will also be shared with the Chinese consortium partners, fulfilling the bilateral knowledge exchange objective and ensuring that the actionable insights generated in the Limfjord catchment can inform parallel nutrient management strategies and research activities in China.

4. Annexes

Annex 1: The trans4num Hackathon Handbook including Innovation Canvas Guidelines

Annex 2: Student Background Package

Annex 3: Agent-based Mode Handout

Annex 4: Presentations by hackathon mentors

Annex 5: Participant List

Annex 6: Evaluation Matrix & Scoring Sheets

Annex 7: Awards certificates created by HCC

4.1 The trans4num Hackathon Handbook including Innovation Canvas Guidelines

1. Welcome Package

Welcome to the trans4num INSPIRE Hackathon 2026
22–23 October 2026 | Aarhus, Denmark

Welcome!

Welcome to the final **trans4num Hackathon**, where you will work in interdisciplinary teams to imagine how the agricultural landscape around the Limfjord could look in the future.
During two days, you will explore a real-world challenge at the intersection of **agriculture, nitrogen management, biodiversity, climate, digital technologies and the future of rural landscapes**.
You do not need to be a programmer or an expert in agriculture. We are looking for different perspectives, creative ideas and realistic solutions.

What is trans4num?
trans4num – Transformation for sustainable nutrient supply and management is a four-year EU-funded Horizon Europe project bringing together partners from Europe and China to explore how **Nature-Based Solutions (NBS)** can contribute to more sustainable nutrient management in

agriculture.
The project focuses particularly on solutions such as **sustainable crop rotations, bio-based fertilisers and improved nutrient management**, while also looking at the wider social, economic and environmental conditions needed for their successful implementation.
A key ambition of trans4num is to understand how agricultural systems can move towards more sustainable nutrient management and how decision-support tools, modelling and stakeholder cooperation can support this transition.
The project works across four European NBS sites, including **Denmark**, where the focus is on the Limfjord catchment in Northern Jutland. Around 63% of the selected Danish NBS site is agricultural land, making it a representative setting for exploring the challenges and opportunities of sustainable nutrient management.

Why the Limfjord?

The Limfjord region illustrates a fundamental challenge: agriculture needs to remain productive and economically viable, while nutrient losses – particularly nitrogen – need to be reduced to protect water quality, biodiversity and the wider environment.
The Danish trans4num site therefore explores how different measures can work together, including changes in crop rotations, perennial and biomass crops, bio-based fertilisers and improved nutrient management.

The Denmark Hackathon

What is the challenge?

Your challenge is to **design a future agricultural landscape for the Limfjord region**.
Your solution should explore how the landscape could:

- substantially reduce nitrogen losses;
- maintain productive and economically viable farming;
- improve biodiversity and ecosystem functioning;
- contribute to climate mitigation and adaptation;
- make use of Nature-Based Solutions;
- support farmers and advisors in making transition decisions; and
- be realistic enough to work in practice.

You will be given background information about the Limfjord region and access to a **toolbox of digital and modelling tools**, including Jackdaw and the Decision Support Tool (DST).
The tools are there to support your thinking – **they are not the solution and you are not required to use them**.
You are encouraged to think beyond the tools and develop your own ideas, approaches and combinations of solutions.

Our key message

Your task is not to build software. Your task is to design innovative, realistic solutions that help farmers navigate the transition towards sustainable landscapes.

Think about the landscape as a **system**. A successful solution is not only environmentally effective – it also needs to make sense for farmers, communities and the wider food system.

What will you produce?

Each team will prepare **two outputs**.

1. Future Landscape Concept

Create a visual representation of your proposed future landscape.
You can choose the format that best communicates your idea, for example:

- landscape map;
- transition roadmap;
- conceptual system map;
- infographic;
- working diagram;
- storyboard.

Your concept should show the main landscape elements, Nature-Based Solutions, agricultural production systems and the expected benefits for the environment, farmers and society.

2. Trans4num Innovation Canvas

You will also complete a short standardised canvas explaining your solution.
It will ask you to consider:
Challenge → Nature-Based Solutions → Impacts → Farmer Adoption → Digital Tools → Barriers & Enablers → Recommendations
In particular, consider the effects of your solution on:

- nitrogen reduction;
- biodiversity;
- climate mitigation and adaptation;
- farm economy;
- social acceptance.

Pitching Your Solution

*On Day 2, each team will present their work directly to the expert jury and other participants in an 8-minute pitch followed by 2 minutes of Q&A. Your presentation should bring your **Future Landscape Concept** and **trans4num Innovation Canvas** together into a compelling story: clearly explain your vision, highlight the main nature-based measures, demonstrate the benefits for farmers and the environment, and explain how the transition can realistically happen.*

Hackathon at a glance

Day 1 – Explore & Create | 22 October

09:30-10:00: Registration and coffee

10:00–12:00 | Plenary session
https://teams.microsoft.com/meet/3736039687552142?p=Mu8a1pxVSURuTadigz

- 10:00 - 10:10 Welcome and introduction - Tommy Dalgaard
- 10:10 - 10:30 Inspiration from Nature-Based Solutions: Background & Vision - Morten Graversgaard & Tommy Dalgaard
- 10:30 - 11:00 The Limfjord challenge - Morten Winther Vestenaa & Morten Graversgaard
- 11:00 - 11:10 Canvas & Future landscape concept introduction - Markéta Kollerová
- 11:10 - 11:30 Introduction to the toolbox - Morten Birk & Filip Leitner
- 11:30 - 11:45 Extra tool - video by Geoffrey Groom
- Introduction to other possible materials - Tommy Dalgaard

12:00–13:00 | Lunch

13:00–16:00 | Team work

- Explore the challenge
- Develop your future landscape
- Use the available tools and information where useful
- Discuss feasibility, impacts and implementation

Day 2 – Present & Reflect | 23 October

10:00–11:30 | Team presentations
https://teams.microsoft.com/meet/3475093844282287?p=pRSVw5E7XEsAIDstBC

- 8-minute presentation per team (5-10 teams)
- 2 minutes for questions

11:30–12:00 | Jury deliberation & closing

- Jury discussion

12:00–12:30 | Lunch

12:30-13:00 | Award ceremony and concluding remarks

- Reflections
- Wrap-up

Who can help you?

You will have access to mentors with different areas of expertise throughout the hackathon.

Area	Mentor / Support
Jackdaw & AI / spatial data	Filip Leitner – Plan4all
Decision Support Tool (DST)	Morten Birk – Cordulus
Agriculture & nitrogen management	Morten Winther Vestenaa & Morten Graversgaard - AU
Nature-Based Solutions	Tommy Dalgaard - AU
Policy & regulation	Danish experts
General hackathon support	Plan4all & Aarhus University

Don't hesitate to ask questions. Mentors are there to help you explore possibilities, understand the available tools and challenge your assumptions – **not to design the solution for you**.

Main contacts

Aarhus University / Danish team
Tommy Dalgaard, Aarhus University - tommy.dalgaard@agro.au.dk
Morten Birk, Cordulus - DST - mb@cordulus.com

Plan4all
Markéta Kollerová – Hackathon coordination - marketa.kollerova@plan4all.eu
Filip – Jackdaw tool - filipleitner@gmail.com

Be curious. Think across disciplines. Think beyond the obvious.
There is no single correct future landscape.
Your team is invited to explore ***what could work, why it could work, and what would be needed to make it happen****.*

2. Challenge Brief

CHALLENGE BRIEF: Designing the Future Landscape of the Limfjord

1. The Regional Context

The Limfjord catchment in Northern Jutland (covering ~260,000 ha, of which 63% is agricultural land) is one of Denmark's most productive agricultural regions. However, it also faces an acute environmental crisis:

- **Severe Aquatic Degradation:** According to the latest River Basin Management Plans, only **1 out of 109 Danish coastal waters** currently achieves "good ecological status" under the EU Water Framework Directive.
- **Massive Nitrogen Leaching:** Agricultural nitrogen (N) losses in Denmark amount to **50,000–60,000 tonnes per year**, making farming the single largest source of aquatic nutrient pollution. In the shallow Limfjord, excess N causes severe eutrophication, toxic algal blooms, and critical oxygen depletion (hypoxia).

2. The Core Challenge

"Design a future agricultural landscape for the Limfjord region that substantially reduces nitrogen losses while maintaining productive, economically viable farming and delivering clear benefits for climate, biodiversity, and local communities."

Your task is not to write code or build software. Your goal is to develop an **innovative, realistic systemic concept** that supports farmers, advisors, and regional authorities in navigating the green transition.

3. Key Dimensions to Address

A successful concept considers the landscape as an **interconnected system** across five core pillars:

1. **Nitrogen & Water:** How does your design reduce N leaching and restore the aquatic environment?
2. **Productive Agriculture:** How can food, feed, or biomass production remain viable and competitive?
3. **Nature & Biodiversity:** Where and how do **Nature-based Solutions (NbS)** (e.g., perennial grass-clover rotations, constructed wetlands, peatland rewetting, buffer strips) fit into the landscape?
4. **Climate Mitigation & Adaptation:** How does the design sequester carbon, reduce greenhouse gases, or protect against extreme weather?
5. **Farmer Adoption & Economics:** Why would farmers adopt your solution? What are the financial incentives, new value chains (e.g., green biorefineries, biogas), or advisory tools that make it practical?

4. Available Toolbox (Inspiration, Not a Constraint)

You will have access to supporting digital and modelling tools:

- **Jackdaw:** A GeoAI spatial assistant to explore catchment data, map soil risks, examine land use, and query policy documents.
- **Decision Support Tool (DST):** Practical decision-support workflows for farm-level nutrient planning.

Note: You are free to use any combination of these tools, external data, maps, or conceptual models. The tools are there to support your thinking—not to restrict your imagination.

5. Required Deliverables

Each team will deliver **two interconnected outputs**:

1. **Future Landscape Concept:** A visual presentation of your solution (landscape map, transition roadmap, system diagram, or infographic) showing the spatial layout, main NbS measures, and transition pathway (Today → Transition → Future).
2. **trans4num Innovation Canvas:** A completed structured template summarizing your problem definition, NbS measures, expected impacts, farmer adoption model, barriers, and key recommendations.

Final Presentation: An **8-minute pitch (+ 2 minutes Q&A)** presented to the expert jury on Day 2.

6. The Guiding Question

Before submitting, ask your team:

"If this landscape existed 10 years from now, what would be different for farmers, nature, water, and local communities—and why would stakeholders actually implement it?"

3. Toolbox Guide

JACKDAW: YOUR AI ASSISTANT FOR EXPLORING THE LIMFJORD

Videos available: jd-videa

Use data and AI to understand the landscape — then design your own solution

During the trans4num INSPIRE Hackathon, you can use **Jackdaw** to explore the Limfjord region and investigate how agriculture, land use, nature, water and other spatial factors are connected.

So, what is Jackdaw?

Jackdaw is a GeoAI assistant developed within the Horizon Europe PoliRuralPlus project. It

combines artificial intelligence with **geographical and spatial data** so that you can ask questions about a specific place in ordinary language.

Instead of having to search through many datasets or learn how to use a GIS system, you can select an area on a map and ask a question such as:

"What crops and land uses dominate this area?"

Jackdaw uses the geographic context of your question together with relevant spatial data and produces an AI-supported answer. Depending on the question and available data, results can be presented as **text, tables or maps**.

In simple terms:

You choose a place → ask a question → Jackdaw finds and interprets relevant spatial information → you use the evidence to inform your thinking.

What can you use it for in the hackathon?

Your challenge is to design a future agricultural landscape for the **Limfjord region** that reduces nitrogen losses while maintaining productive farming and delivering benefits for biodiversity, climate and local communities.

Jackdaw can help you **understand the starting point** and investigate the spatial context of your ideas.

You could ask questions such as:

Explore the landscape

- *What types of land use and agriculture dominate this area?*
- *What are the main characteristics of this part of the catchment?*
- *How does this area differ from another part of the Limfjord region?*

Investigate spatial patterns

- *Where are the areas that might be particularly relevant for our proposed intervention?*
- *What landscape or environmental characteristics occur around these locations?*
- *Where could wetlands, buffer areas or other nature-based measures potentially make sense?*

Explore agriculture

- *What crops or agricultural land uses are found in this area?*
- *What spatial factors should we consider when thinking about changing crop rotations?*
- *Which areas might be relevant when considering soil, land use or water-management issues?*

Explore policies and evidence

- *What relevant policy or planning information should we consider?*
- *What does the available evidence say about this type of landscape or intervention?*

You can also use Jackdaw to **challenge your assumptions**. If your team thinks a particular measure should be located somewhere, ask Jackdaw what spatial characteristics support or contradict that idea.

A good way to work with Jackdaw

Don't start by asking: *"Design the perfect future landscape for us."* Instead, use Jackdaw as a **research partner**:

1. ASK
Start with a simple question about the Limfjord landscape.

2. EXPLORE
Ask follow-up questions and compare locations. Try to understand *why* a pattern occurs.

3. CHALLENGE
Ask questions that test your team's assumptions.

4. CONNECT
Combine Jackdaw's spatial evidence with what you learn from the experts, the other hackathon tools and your own ideas.

5. DESIGN
Use the evidence to develop **your own Future Landscape Concept**.

Remember: Jackdaw is a tool, not the solution

You are **not expected to become GIS experts or build software**.

Jackdaw should help you answer questions such as:

"What is happening here?"
"Where might this matter?"
"What evidence supports our idea?"
"What should we investigate further?"

But the important decisions remain yours.

A Jackdaw answer is **not automatically a fact or a recommendation**. Check important information, question assumptions and distinguish between evidence, interpretation and your team's own proposal.

Your final solution should bring together **spatial evidence + agricultural knowledge + Nature-**

Based Solutions + farmer perspectives + creativity.

Your challenge

Use Jackdaw to understand the Limfjord — then imagine what it could become.

You don't need to use Jackdaw, and you don't need to use every feature. The strongest idea is more important than the number of tools you use.

SIMPLE USER GUIDE

LOG-IN: https://trans4num.eu/jackdaw/login

1. Start with a place

Begin by choosing the area you are interested in.

2. Ask a simple question

Type your question as you would ask another person.

Try questions such as:

- "What types of agricultural land use are found here?"
- "What are the main characteristics of farming in this area?"
- "What environmental features are important here?"
- "Which areas could be relevant for nature-based solutions?"
- "What factors in this area could contribute to nitrogen losses?"
- "Where might measures to reduce nitrogen losses be relevant?"
- "What types of nature-based measures could potentially be considered here?"
- "How does this area differ from another part of the Limfjord catchment?"
- "Which characteristics are different between these two areas?"

3. Explore the answer

Don't stop at the first answer. Ask follow-up questions. Use the conversation to **explore and investigate**, rather than simply asking for a final solution.

4. Connect Jackdaw to your challenge

Once you understand an area, start connecting what you find to the hackathon challenge. This can help your team move from **understanding the place → identifying opportunities → developing your future landscape concept.**

5. Check before you use

Jackdaw is an **exploration and evidence-support tool — not the final decision-maker.** Use

Jackdaw to **inform your team's thinking**, not to replace it.

A useful way to work with Jackdaw
ASK → EXPLORE → CHECK → CONNECT → DESIGN

ASK a question about your area
↓
EXPLORE the landscape and available information
↓
CHECK the evidence and assumptions
↓
CONNECT findings to nitrogen, farming, nature, climate and people
↓
DESIGN your future agricultural landscape

TRANS4NUM DECISION SUPPORT TOOL (DST) – STUDENT QUICK START GUIDE

Video available:2026-10-16 10-17-37.mp4

What is the trans4num DST?

The trans4num Decision Support Tool (DST) is a spatial, data-driven planning tool designed to evaluate how agricultural management strategies influence nutrient losses, water quality, crop production, and farm economics. Unlike most tools that focus on individual farms, the DST evaluates how decisions interact across an entire regional landscape. It is designed to evaluate a range of Nature-based Solutions (NbS), such as diversified crop rotations, perennial crops, catch crops, and circular nutrient flows.

How it applies to your Limfjord Challenge:

The first DST prototype was developed specifically for the Limfjord region in Denmark. Its primary objective is to identify where strategies like increased perennial grass, catch crops, and green biorefining can be most effective to reduce nitrogen losses to coastal waters while maintaining regional economic performance.

Important mindset:

The outputs of the DST are not prescribed decisions. You should use it to jointly explore alternative scenarios, visualize trade-offs, and identify practical pathways forward.

The 4-Step Workflow

Step 1: Define a goal

Begin by selecting an optimization goal. Examples include:

- *Maximize economic performance while reducing nitrogen losses by a specific target (kg/ha).*
- *Minimize nitrogen losses to coastal waters.*

- *Find the best balance between agricultural productivity and nitrogen loss reduction.*

Step 2: Add constraints

Define practical limits and conditions to make your scenario realistic. You can:

- *Limit the distance to relevant bioindustry (such as biogas plants or composting facilities).*
- *Maintain realistic farm types and respect environmental regulations.*
- *Restrict specific crop changes.*

Step 3: Generate alternative scenarios

Based on your inputs, the DST calculates possible landscape configurations that could achieve your selected goals.

Step 4: Explore and extract the results

The tool visualizes your outcomes in two ways, which you should extract as evidence for your Innovation Canvas:

- **Interactive maps:** View field-plot based changes between the status-quo and your optimized solutions, specifically looking at crop rotations, nitrogen losses, yields, and economic returns. (Perfect for **Slide 3: Future Landscape Concept**).
- **Charts and summaries:** Compare regional indicators before and after optimization, including crop production shares, consistency of the landscape, farm/regional economy, and the overall regional nitrogen balance. (Perfect for **Slide 8 & 9: The Benefits** and **Slide 11: Spatial evidence**).

Accessing the Tool: The tool is available at: **https://trans4num.cordulus.com/.**

4. Direction Document

DIRECTION DOCUMENT: Guiding Your Future Landscape Design

This guide provides a structured thinking framework to help your team develop a holistic, realistic solution for the Limfjord region. Rather than focusing on isolated interventions, approach the landscape as an interconnected system.

1. Think in Systems, Not in Isolation

A management change on a single field cascades across the catchment, influencing water quality, farm profitability, and regional society:

Farm → Landscape → Water → Biodiversity → Climate → Economy → Society

Consider key connections and trade-offs:

- Can an intervention reducing nitrogen run-off also generate a new revenue stream for farmers?
- Where can landscape elements retain nutrients while actively creating ecological corridors for biodiversity?
- How can emerging value chains (e.g., green biorefineries, biogas facilities) provide market off-take for new cropping systems?

2. Ground Your Thinking in the Catchment

Before designing your future vision, understand the current landscape baseline:

- **Agriculture:** Which crops currently dominate (e.g., annual cereals, feed silage), and where can rotations realistically be altered?
- **Water & Nutrients:** Where are the primary nitrogen leakage points, and which sub-catchments or soil types are most vulnerable?
- **Landscape Elements:** Where are natural buffering and filtration zones missing, and where could wetlands or buffer strips be restored?
- **Climate & Soil:** Which drained lowlands are causing high emissions, and how can soil organic carbon sequestration be enhanced?

3. Deploy Multifunctional Nature-Based Solutions (NbS)

Treat Nature-based Solutions not as passive land abandonment, but as active, productive landscape infrastructure delivering specific ecosystem services:

- **Perennial Grasses & Grass-Clover Rotations:** Ensure continuous ground cover, build deep root architectures to cut nitrate leaching, and supply protein biomass for biorefineries.
- **Constructed & Restored Wetlands:** Drive anaerobic denitrification in depressions and drain tile collection points to convert nitrates into harmless nitrogen gas (N_2).
- **Lowland Peat Rewetting:** Terminate carbon mineralization and heavy greenhouse gas emissions from drained organic valley soils.
- **Targeted Buffer Strips & Agroforestry:** Trap surface run-off along stream corridors, provide windbreaks, and support natural pest predators and pollinators.

4. Put Yourself in the Farmer's Shoes

An environmentally optimal design will never scale if it is financially ruinous or unworkable in daily operations. Ask: **"Why would a farmer actually adopt this?"**

- **Motivation:** Does the solution reduce input costs, provide new biomass sales, lower regulatory risks, or improve soil resilience?
- **Barriers:** What are the capital requirements, machinery constraints, knowledge gaps, or temporary yield penalties?
- **Support Mechanisms:** What role do farm advisory services, CAP eco-schemes, co-op investments, or long-term supply contracts play in de-risking adoption?

5. Chart the Transition Pathway

Do not only depict an idealized end-state. Show how the landscape moves from current reality to your proposed future:

TODAY (High N leaching, cereal monocultures) → TRANSITION (Pilots, supply chains, CAP incentives → FUTURE (Resilient, low-loss landscape)

6. Value Chain Collaboration & Digital Decision Support

- **Multi-Actor Engagement:** Transformation requires cooperation between farmers, agricultural advisors, municipalities, biorefinery operators, and regulators.
- **Digital Toolbox (Jackdaw & DST):** Use these tools to explore spatial datasets, query policy rules, and test agronomic assumptions. Let them support and validate your thinking without constraining your creative vision.

7. Define Your Key Innovation

Every successful proposal must clearly answer:
"Our key innovation is..."

Innovation does not require inventing unproven technology. It often lies in novel combinations of land use, circular nutrient recycling, and practical business models tailored to the Limfjord landscape.

5. Innovation Canvas Template

TRANS4NUM INNOVATION CANVAS

Designing the Future Landscape of the Limfjord Region

This single canvas summarizes and defends your proposed landscape solution. Keep answers focused, specific, and grounded in realistic implementation mechanisms.

Download your own trans4num_innovation_canvas.pptx

Basic Information

- **Team Name:** .....
- **Team Members:** .....
- **Our Solution in One Sentence:**
  "We propose
  .....
  ....."

A. Main Challenge

What specific primary problem in the Limfjord catchment does your solution target? *(e.g., severe nitrate leaching on sandy soils, dependency on imported feed proteins, continuous emissions from drained peat soils)*

Answer:

Why is this important?

Answer:

Who is most directly affected by this challenge?

- [ ] Farmers
- [ ] Limfjord Water Ecosystem
- [ ] Municipalities
- [ ] Downstream Bio-industries

B. NATURE-BASED SOLUTIONS

Select and describe 2 to 4 concrete measures integrated into your landscape:

Measure / Element	Landscape Placement	Core Function (N-retention, biodiversity, carbon, feed)
1.		
2.		
3.		
4.		

How do these measures function together as an interconnected system?

Answer:

C. EXPECTED IMPACTS & Trade-Offs

Anticipated Multi-Benefits:

- Nitrogen Reduction: .....
- Biodiversity Enhancement: .....
- Climate & Soil Health (C-Sequestration / GHG cuts): .....

- Farm Economics & Income:
  .....

Identified Trade-Off or Bottleneck: *(e.g., reduction in cereal acreage, upfront processing facility costs, temporary yield adjustments)*
Answer:
How does your design mitigate or manage this trade-off?
Answer:

D. FARMER ADOPTION & Business Case

Why would a local farmer actively adopt this solution?

[ ] New commercial income streams *(e.g., green biorefinery protein, biogas feedstock)*
[ ] Reduced expenditure on synthetic fertilizers and imported protein feed
[ ] Compliance with tight national nitrogen quotas and EU Water Framework Directive mandates
[ ] CAP subsidy eligibility *(e.g., eco-schemes, agri-environment-climate commitments, wetland support)*

What is the single biggest barrier to farmer adoption, and how do you overcome it?
Barrier:
Mitigation (e.g., farm advisory programs, machinery-sharing cooperatives, long-term off-take contracts):

E. ROLE OF DIGITAL TOOLS & Spatial Evidence
How did the available tools and data inform your design choices?

- *Jackdaw GeoAI Platform:*
  .....
- *Decision Support Tool (DST) / Regional Spatial Data:*
  .....

F. KEY INNOVATION & STRATEGIC RECOMMENDATIONS
Our Key Innovation:
"Our core innovation is that
.....
....."

Top 3 Action Steps to Enable Implementation:

1. *Farm / Advisory Level:*
   .....
2. *Regional / Market Level (Biorefineries, Processing Hubs, Farmer Cooperatives):*
   .....
3. *Policy / Regulatory Level (Targeted Subsidies, Permitting, Land Consolidation):*
   .....

OUR INNOVATION IN ONE VIEW
Complete the following five statements:
1. THE PROBLEM
We want to solve...
.....
2. THE SOLUTION
We propose...
.....
3. THE BENEFIT
This will help because...
.....
4. THE FARMER
Farmers will adopt it because...
.....
5. THE TRANSITION
To make it happen, we need...
.....

---

6. Future Landscape Concept

FUTURE LANDSCAPE CONCEPT

Your task
*Create a visual representation of the **future landscape you propose for the Limfjord region**. Your concept should show how agriculture, nature, water, climate, economy and society could work together in a more sustainable landscape.*

Choose your format
You can present your concept as:

- a map;
- a landscape diagram;
- a system map;
- a transition roadmap;
- an infographic;
- a storyboard;
- or another visual format of your choice.

Your concept should show

Landscape

- What does the future landscape look like?
- Which landscape elements are important?

Agriculture

- What is produced?
- How do farming practices or production systems change?

Nature-based solutions

- Which NBS are included?
- What functions do they provide?

Nitrogen

- How does your proposal reduce nitrogen losses or improve nutrient management?

Environment

- What are the benefits for water, biodiversity, soil and climate?

Farmers

- What are the benefits for farmers?
- Why would they adopt the proposed changes?

Transition

- What needs to happen to move from today's situation to your proposed future?

Optional

You may also show:

- key stakeholders;
- digital tools and data;
- infrastructure;
- economic flows;
- policy or incentives;
- potential risks and trade-offs.

7. Presentation

PRESENTATION

*Your team will pitch your results to the other participants and the international jury. Use the official **trans4num Innovation Canvas slide template** for your presentation:*
trans4num_innovation_canvas.pptx

Recommended Presentation Timing & Structure (Total: 8 min pitch + 2 min Q&A)

1. Introduction & The Challenge — 1 min *(Slides 1–2 & 5)*

- **Who you are & Core Idea:** Introduce your team and state your solution in one sentence.
- **1. The Problem:** What specific challenge in the Limfjord catchment are you addressing (e.g., nitrogen leaching, peat soil emissions, feed protein reliance), why does it matter, and who is most affected?

2. Product 1: Your Future Landscape Concept — 3 min *(Slide 3)*

- **The Spatial Vision:** Present your map, diagram, or spatial infographic.
- Show *where* and *how* key Nature-Based Solutions (NBS) and agricultural interventions fit across the Limfjord landscape.

3. Product 2 (Part A): The Solution & Multi-Benefits — 2 min *(Slides 6–9)*

- **2. The Solution:** Detail your core measures and how they function together as an interconnected, circular agroecological system.
- **3. The Benefits & Trade-Offs:** Highlight anticipated impacts (N-reduction, biodiversity, carbon/soil, farm income) and explain how you manage critical bottlenecks or trade-offs.

4. Product 2 (Part B): The Farmer & The Transition — 1.5 min *(Slides 10–12)*

- **4. The Farmer:** Why will local farmers buy in? (New income streams, savings, CAP subsidies/compliance) and how do you overcome their single biggest adoption barrier?
- **5. The Transition:**
  - How did digital tools and spatial evidence (JackDaw GeoAI agent, trans4num DST, Copernicus/catchment data) guide your choices?
  - Your top 3 concrete action steps across Farm, Market/Cooperative, and Policy/Regulatory levels.

5. Synthesis: Our Innovation in One View — 0.5 min *(Slide 13)*

- Wrap up with your completed **1|2|3|4|5 summary canvas** to leave the jury with a clear, memorable takeaway before Q&A.

Total Time: Strictly max. 8 minutes presentation + 2 minutes Q&A / Jury Discussion *(Slide 14)*.

SUBMISSION CHECKLIST

Before submitting your final slides, make sure your team has:

- [ ] Completed **Slide 1** (Team name, members, and one-sentence solution tagline).
- [ ] Delivered **Product 1 (Slide 3):** Clear visual Future Landscape Concept (uploaded map, diagram, or spatial design).
- [ ] Addressed all deep-dive worksheets (**Slides 5–12**) covering the 5 thematic pillars (Problem, Solution, Benefits, Farmer, Transition).
- [ ] Delivered **Product 2 (Slide 13):** Fully synthesized **"Our Innovation in One View"** summary canvas.
- [ ] Rehearsed your pitch to stay strictly within the **8-minute limit** (ensuring all team members presenting are ready).
- [ ] Submitted your completed .pptx or .pdf file according to the instructions provided by the organizers.

Remember:

You are not expected to deliver a fully engineered or final commercial implementation. The jury is looking for a **systemic, innovative, and realistic vision** of how the Limfjord landscape can transition toward resilient agriculture, verified with spatial evidence and circular nutrient logic

Where to send / upload your final presentations?

Teams final presentations or marketa.kollerova@plan4all.eu

8. Evaluation Criteria

Evaluation Criteria

The jury will assess each team's proposal using the following criteria. The aim is not to identify one "perfect" solution, but to recognise ideas that combine **environmental impact, feasibility, innovation and potential for real-world implementation**.

Criterion	Weight	What will be assessed?
1. Nitrogen Reduction Potential	**25%**	How effectively does the proposed solution address nitrogen losses and improve nutrient management? Does the team clearly explain how the proposed changes could contribute to reducing nitrogen losses while maintaining agricultural production?
2. Nature-Based Solutions	**20%**	How meaningfully are nature-based solutions integrated into the proposed future landscape? Are they appropriate to the local context and do they provide clear environmental or ecosystem benefits?
3. Feasibility & Farmer Adoption	**20%**	How realistic is the proposal from a farming and implementation perspective? Does it provide convincing reasons for farmers to adopt the proposed changes? Does the team consider costs, benefits, practical barriers, knowledge, infrastructure and incentives?
4. Climate & Biodiversity Co-benefits	**15%**	Does the proposal create benefits beyond nitrogen reduction? The jury will consider contributions to biodiversity, climate mitigation, climate adaptation, water quality, soil health and wider ecosystem resilience.
5. Innovative Thinking	**10%**	How original and creative is the proposed approach? Does the team introduce a new idea, combination of solutions, cooperation model, business model, land-use approach or other innovative way of addressing the challenge?
6. Use of Tools & Evidence	**10%**	Has the team made effective use of available data, evidence and digital tools where relevant? Does the proposal demonstrate informed decision-making and distinguish evidence from assumptions? The use of tools itself is not rewarded unless it contributes meaningfully to the quality of the solution.

What the jury will look for

1. Nitrogen Reduction Potential – 25%

The proposal should clearly address the central nitrogen challenge.

The jury will consider:

- whether nitrogen losses are explicitly addressed;
- whether the proposed measures are relevant to nutrient management;
- whether the team explains the expected contribution to nitrogen reduction;
- whether nitrogen reduction is considered at both farm and landscape level;
- whether the proposal balances nitrogen reduction with continued agricultural production.

2. Nature-Based Solutions – 20%

Nature-based solutions should be an **integrated part of the proposed landscape**, rather than an isolated addition.

The jury will consider:

- relevance and appropriateness of the proposed NBS;
- their contribution to nitrogen retention or nutrient management;
- biodiversity and ecosystem benefits;
- integration with agricultural production;
- how different landscape elements work together.

3. Feasibility & Farmer Adoption – 20%

The proposal should be ambitious but also **realistic enough to imagine being implemented**.

The jury will consider:

- practical feasibility for farmers;
- economic viability;
- farmer motivation and benefits;
- investment and operational requirements;
- identified barriers to adoption;
- proposed incentives or support mechanisms;
- involvement of advisors and other relevant stakeholders.

4. Climate & Biodiversity Co-benefits – 15%

The strongest solutions should deliver **multiple benefits at the same time**.

The jury will consider whether the proposal contributes to:

- biodiversity;
- climate mitigation;
- climate adaptation;
- water quality;
- soil health;
- ecosystem resilience;
- other environmental or societal benefits.

Teams should also recognise potential **trade-offs** rather than assuming that every measure has only positive effects.

5. Innovative Thinking – 10%

Innovation does not necessarily mean inventing a completely new technology.

The jury will consider whether the team:

- proposes a genuinely new approach;
- combines existing solutions in an innovative way;
- connects different sectors or stakeholders;
- introduces new business or cooperation models;
- uses land or resources differently;
- identifies creative ways to support the transition.

The key question is:

What makes this proposal different from simply continuing with today's approach?

6. Use of Tools & Evidence – 10%

Teams may use the trans4num toolbox, including **Jackdaw and the Decision Support Tool**, as well as other data and tools.
The jury will consider:

- whether tools or data were used appropriately;
- whether they helped the team understand the problem or develop the solution;
- whether the proposal is supported by relevant evidence;
- whether assumptions are clearly identified;
- whether digital tools could realistically support implementation.

Important: Teams are not expected to use every available tool. The quality of the solution is more important than the number of tools used.

Overall principle
The jury will look for proposals that combine:
Environmental impact + **Farmer value and feasibility** + **Innovation** + **Realistic pathways to implementation**
A strong proposal should demonstrate not only **what the future landscape could look like**, but also **why farmers and other stakeholders would be willing and able to make it happen**.

4.2 Annex 3: Student Background Package

Background Package & Policy Context

Limfjord Context

1. Limfjord Regional Challenge Description

The Limfjord catchment in Northern Jutland exemplifies a complex, shallow sound and fjord system under severe environmental pressure from intensive agricultural land use. It serves as a benchmark case for testing how to balance high-yield agricultural production with critical environmental protection.

- **Severe Aquatic Ecosystem Crisis:** According to the latest River Basin Management Plans, only 1 out of 109 Danish coastal waters currently achieves "good ecological status" under the EU Water Framework Directive. The Limfjord experiences chronic ecological degradation caused primarily by nutrient loading.
- **Magnitude of Nitrogen Losses:** Agricultural nitrogen (N) leaching across Denmark is estimated at approximately 50,000–60,000 tonnes of N annually, making agriculture the dominant contributor to nutrient pollution. In the shallow, enclosed waters of the Limfjord, excess N run-off drives severe eutrophication, toxic algal blooms, seasonal bottom-water hypoxia (oxygen depletion), and widespread loss of benthic habitats and fish populations.

- **The Core Dilemma:** How can the region maintain food, feed, energy, and biomass production alongside a viable agricultural economy while achieving dramatic reductions in nitrogen losses to the aquatic environment?
- **Key Strategic Trade-Offs for Student Solutions:**
    - Fertilizer input limits and soil management vs. farm yield stability and farm income.
    - Taking productive arable land out of production for retention/nature elements vs. land availability and food security.
    - Introducing alternative crops (e.g., perennial grasses) vs. the immediate availability of regional processing facilities and commercial market off-take.

2. Landscape and Agricultural Background

The Limfjord catchment represents a heavily cultivated, highly productive agro-industrial landscape.

- **Land Use and Spatial Footprint:** Approximately 63% of the 260,000-hectare Limfjord catchment is dedicated to agricultural production, underlining the dominant role farming plays across the landscape.
- **Crop Systems and Livestock Density:** The agricultural area is dominated by conventional crop rotations featuring annual cereal crops (primarily winter and spring barley, winter wheat), silage maize, and oilseed rape. The region is characterized by high livestock densities (dairy and swine production), resulting in substantial volumes of animal manure (slurry) and a high reliance on imported feed protein, notably South American soybean meal.
- **Heterogeneous Soil Properties and Retention:** Soils range from coarse, highly permeable sandy soils in western areas (vulnerable to severe nitrate leaching into shallow aquifers) to richer clayey loams in the east. Natural underground nitrogen retention (the capacity of soils and subsoils to eliminate nitrates via denitrification before reaching surface waters) varies widely across the catchment, meaning the environmental impact of identical on-field measures depends heavily on their spatial placement.
- **Artificial Drainage and Landscape Alteration:** Widespread historic drainage, ditching, and stream canalization turned alluvial wetlands and lowland meadows into arable fields, stripping the catchment of its natural buffering and nutrient-filtering capacity.

3. Inspiration Examples of Nature-Based Solutions (NbS)

Nature-based Solutions (NbS) in the Limfjord context should not be viewed simply as passive land abandonment, but as multifunctional measures delivering agronomic, environmental, and climate benefits.

Nature-Based Solution	Optimal Landscape Placement	Primary Environmental & Ecological Mechanisms	Farmer & Bioeconomic Benefits

Perennial Grasses & Grass-Clover Rotations	Vulnerable arable fields, sandy recharge soils, sloped land	Year-round ground cover, deep root architectures, drastic reduction in nitrate leaching, and enhanced soil organic carbon sequestration.	Biomass feedstock for **green biorefineries** to produce local protein concentrates for monogastrics (replacing imported soy) and fiber for ruminants.
Constructed & Restored Wetlands	Lowland depressions, valley floors, tile drain collection points	Creates anaerobic, carbon-rich conditions that accelerate natural **denitrifcation** (converting nitrate to harmless N_2 gas) while capturing sediment and phosphorus.	Regional flood buffering, drought adaptation, biodiversity revival, funded via CAP Pillar II investment schemes and national wetland funds.
Rewetting Lowland Organic Peat Soils	Low-lying peatlands and drained organic valley soils	Restoring high groundwater tables halts peat oxidation, immediately terminating heavy CO_2 and N_2O emissions.	Eligibility for land-consolidation buyouts, peatland stewardship payments, or alternative wet-agriculture (paludiculture).
Integrated Buffer Zones & Agroforestry	Stream corridors, fjord coastlines, field boundaries	Surface runoff filtration, erosion prevention, pollinator refuges, predator habitat for natural pest control, and wind protection.	Microclimate regulation, enhanced landscape aesthetics, and fulfillment of GAEC buffer/fallow requirements.
Circular Organic Waste & Digestate Valorization	Connected farm clusters linked to biogas and biorefinery plants	Returning biorefinery side-streams and anaerobic digestate to fields stabilizes nutrients, builds soil carbon, and closes circular nutrient loops.	Replaces expensive synthetic mineral fertilizers, creates renewable energy, and improves soil structure.

4. Guidance for Student Teams: Translating Context into Solutions

When completing your **Future Landscape Concept** and **trans4num Innovation Canvas**, keep these guiding principles in mind:

1. **Adopt a Connected Systems Perspective:** Avoid designing single, isolated measures. Demonstrate how elements interact across the catchment hierarchy (e.g., arable fields

under catch crops → perennial grass filter strips → constructed wetlands along streams → the open fjord).

2. **Prioritize Practical Farmer Adoption:** Environmental measures fail if they are economically unviable or excessively burdensome for growers. If replacing annual cereals with perennial grasses, demonstrate who buys the biomass, how the farmer gets paid, and how biorefineries or biogas plants fit into the business model.
3. **Leverage the Digital Toolbox:**
    - Use **Jackdaw** to analyze spatial layers, soil leaching vulnerabilities, and policy constraints to target where NbS measures achieve maximum efficiency.
    - Reference the **Decision Support Tool (DST)** to explore field-level nutrient budgeting, cropping trade-offs, and practical advisory decision pathways.
4. **Clarify Your Distinct Innovation (*Our key innovation is...*):** Groundbreaking hackathon entries do not require unproven technologies; they create novel combinations of land management, circular business models, and collaborative governance tailored to the Limfjord landscape.

Policy Context

How to Use This Document

As part of your hackathon challenge, your team is asked to design a future agricultural landscape for the Limfjord catchment that substantially reduces nitrogen losses, supports biodiversity, mitigates climate impact, and maintains farm economic viability.

Real-world landscape design does not happen in a vacuum—it is shaped by strict environmental regulations, financial subsidy schemes (EU Common Agricultural Policy), and regional/global biodiversity mandates.

This guide outlines the core policy landscape in Denmark:

1. **Danish Nitrogen Regulations & Environmental Mandates** (The regulatory boundaries and goals)
2. **The Common Agricultural Policy (CAP) & Subsidy Context** (The financial enablers and economic mechanisms)
3. **Biodiversity Objectives & Landscape Integration** (Ecological restoration targets and nature mandates)
4. **Strategic Synthesis for Hackathon Teams** (How to leverage policy inside your Innovation Canvas)

1. Danish Nitrogen Regulations & Aquatic Protection

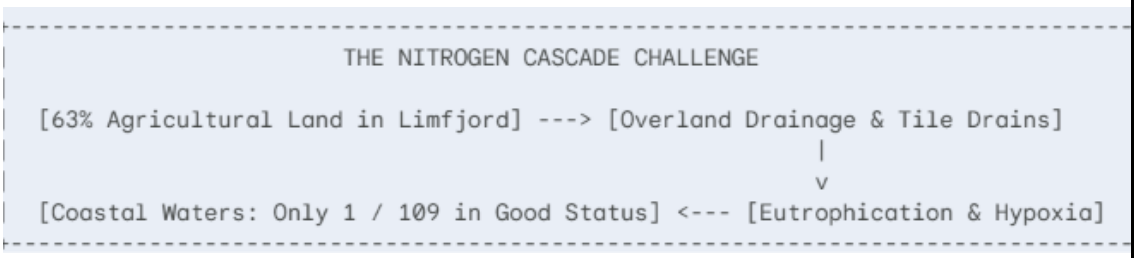
1.1 The Baseline: Decades of Nitrogen Regulation

Denmark possesses one of the most comprehensive and strictly enforced agricultural nutrient

governance frameworks in the world. Agricultural nitrogen (N) leaching is estimated at 50 000-60 000 tonnes N per year, representing the primary contributor to coastal eutrophication.

Under the **EU Water Framework Directive (WFD)** and Danish River Basin Management Plans (RBMPs):

- **The Target:** All coastal and inland surface waters must achieve **"Good Ecological Status"**.
- **The Reality:** Today, **only 1 out of 109 Danish coastal waters meets good ecological status**. The Limfjord basin is particularly vulnerable due to shallow waters, semi-enclosed circulation, and intensive agricultural land use (~63% of the basin).
- **The Reduction Mandate:** Scientific assessments indicate that reaching WFD targets requires reducing national agricultural N discharges to coastal waters by approximately 13 000-20 000 tonnes N annually, with significant reduction quotas assigned directly to the Limfjord catchment.



1.2 Mandatory Baseline Measures for Farmers

Danish farmers operate under baseline rules established through national legislation and the implementation of the **EU Nitrates Directive**:

- **Field Fertilizer Norms:** Farmers are subject to strict quotas on the maximum allowable nitrogen application per crop type and soil class. Applications are legally capped and monitored via the mandatory annual Fertilizer Accounts.
- **Mandatory Catch Crops:** Farms must plant autumn cover/catch crops on a set percentage of their arable area to take up residual nitrogen before winter drainage begins.
- **Targeted Catch Crops:** Additional autumn catch crops are mandated in specific sub-catchments with vulnerable coastal water bodies (such as sub-basins feeding into the Limfjord).
- **Livestock & Manure Application Limits:** Maximum application rates of organic nitrogen (the standard Nitrates Directive cap of170 kg/N/ha/year from animal manure), strict rules for storage capacity (minimum 9 months), and application techniques (low-emission trailing hoses or acidification to minimize ammonia volatilization).
- **Riparian Buffer Strips:** Mandatory uncultivated and unfertilized buffer zones along registered streams, lakes, and coastal shores to curb immediate runoff.

1.3 The Targeted Regulation Shift

Uniform national blanket rules are no longer sufficient to reach WFD goals without drastically hurting farm yields. Consequently, Denmark has transitioned towards **spatially targeted regulation**:

- **Catchment-Based Retention Mapping:** Retention varies dramatically across the landscape. In some areas, natural reduction in subsoil, groundwater, and riparian zones breaks down over 70-80% of leached nitrate via natural denitrification before it reaches the fjord. In other areas (e.g., fractured limestone or drained clays), retention is lower than 20%, meaning almost every kilogram leached enters the aquatic system.
- **Spatially Targeted Interventions:** Policy increasingly directs intensive measures (wetland restoration, catch crops, perennial crops, land retirement) directly into low-retention or high-vulnerability micro-catchments.

1.4 The Tripartite Agreement

In 2024, Denmark established a landmark agreement between the government, agricultural organizations, environmental NGOs, and industry—the Green Tripartite:

- **Carbon Tax on Agricultural Emissions:** Phased introduction of an effective GHG levy on agricultural biological emissions starting from 2027–2030, paired with transition subsidies and tax relief.
- **Large-scale Land Conversion:** A national fund dedicated to taking over 250 000 ha of carbon-rich peat soils and vulnerable agricultural lands out of production, converting them to restored wetlands, permanent nature, and afforestation.
- **Focus on Structural Shift:** Pushing farming systems toward circular nutrient flows, bio-based feedstocks, and perennial forage crops.

2. EU CAP & Subsidy Context

The **Common Agricultural Policy (CAP) 2023–2027** provides the financial framework for farming in Denmark. Rather than functioning simply as production support, modern CAP subsidies incentivize transition, climate action, and environmental management.

```
+-------------------------------------------------------------------------------+
|                          EU CAP ARCHITECTURE                                  |
+-------------------------------------------------------------------------------+
|  CONDITIONALITY (Cross-compliance / Baseline rules required for all subsidies)  |
+-------------------------------------------------------------------------------+
|  PILLAR I (Direct Payments - EAGF)                                            |
|    - Basic Income Support for Sustainability (BISS - per hectare)             |
|    - Eco-schemes (Voluntary 1-year annual environmental incentives)           |
+-------------------------------------------------------------------------------+
|  PILLAR II (Rural Development - EAFRD)                                        |
|    - Multi-year agri-environment-climate commitments (AECM)                   |
|    - Capital investments (Biorefineries, precision machinery, slurry technology)|
|    - Collective land consolidation & wetland establishment grants             |
+-------------------------------------------------------------------------------+
```

2.1 Conditionality (GAEC Standards)

To receive any EU direct payments, farmers must comply with statutory management requirements and **Good Agricultural and Environmental Conditions (GAEC)**:

- **GAEC 4:** Establishment of buffer strips along watercourses (no tillage, pesticides, or fertilizers).

- **GAEC 6:** Minimum soil cover during sensitive periods (preventing bare soil over winter).
- **GAEC 7:** Mandatory crop rotation or crop diversification requirements on arable land.
- **GAEC 8:** Minimum share of agricultural area devoted to non-productive features or areas (hedgerows, ponds, fallow land) to support biodiversity.

2.2 Pillar I: Eco-schemes

Eco-schemes are annual voluntary programs paid per hectare on top of basic income support. In the Danish CAP Strategic Plan, key eco-schemes include:

- **Extensive Grassland / Fallow schemes:** Compensating farmers for converting arable cropland to non-fertilized, non-sprayed permanent or semi-permanent grass.
- **Targeted Nitrogen-Catch Crop Subsidies:** Funding catch crops exceeding statutory baselines.
- **Precision Farming Subsidies:** Incentivizing the use of GPS-guided precision application tools, sensor-based fertilizer calibration, and variable-rate slurry application.
- **Organic Farming Support:** Per-hectare conversion and maintenance payments for certified organic farming systems that exclude synthetic mineral fertilizers.

2.3 Pillar II: Rural Development & Collective Structural Schemes

Pillar II funds multi-year, long-term transformational measures:

- **Constructed Wetlands & Drainage Catchment Filters:** 100% public funding for installation of small-scale constructed filters and surface wetlands at tile-drain outlets to remove nitrate before reaching local rivers.
- **Lowland / Peatland Rewetting:** Capital subsidies and permanent easement compensations for raising the water table on organic soils, which ceases CO_2 emission and creates natural denitrification zones.
- **Green Biorefineries and Perennial Cropping Support:** National and EU innovation grants supporting the processing of perennial grass-clover biomass into concentrated protein feed (replacing imported soy) and fiber-rich residues for biogas.
- **Land Consolidation:** Voluntary land re-allocation tools where regional authorities trade agricultural plots to create contiguous, connected corridors of wetland and nature reserves while leaving farmers with consolidated, productive arable land.

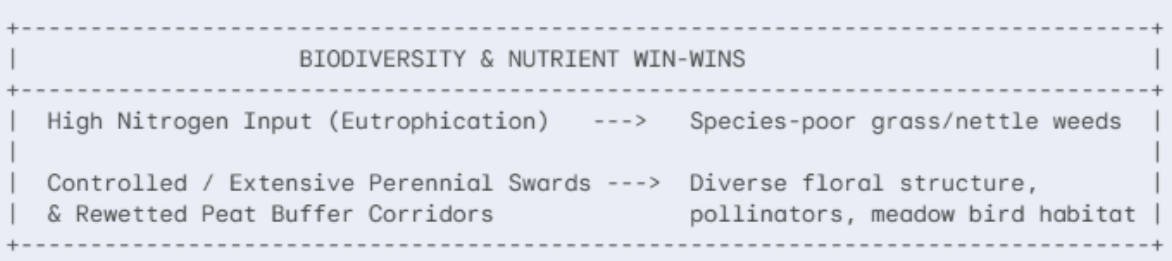
3. Biodiversity Objectives & Landscape Restoration

Biodiversity policy is closely linked with nutrient regulation: excess nitrogen deposition is one of the single greatest drivers of terrestrial and aquatic species loss in Denmark.

3.1 EU & Global Mandates

- **EU Biodiversity Strategy for 2030:**
  - Protect at least 30% **of EU land and sea areas**, with 10% under strict ecological protection.
  - Reduce nutrient losses by at least 50%, leading to a reduction in chemical fertilizer use of at least 20%.
  - Bring back at least 10% **of agricultural area under high-diversity landscape features**

(hedges, flower strips, buffer strips, wetlands).
    - Reduce the overall risk and volume of chemical pesticides by 50%.
- **EU Nature Restoration Law (NRL):**
    - Legally binding restoration targets across ecosystems: restore at least 20% of land and sea areas by 2030, and all degraded ecosystems in need of restoration by 2050.
    - Explicit indicators for agricultural ecosystems: increasing grassland butterflies, cropland bird indices, high-diversity landscape features, and soil organic carbon in mineral soils.
    - Binding goals for rewetting drained peatlands used for agriculture.



3.2 Landscape-Scale Connectivity & Natura 2000

In Denmark, terrestrial nature is fragmented into small patches surrounded by high-intensity monoculture.

- **Natura 2000 Habitats:** Coastal inlets, brackish lagoons, dunes, and salt marshes around the Limfjord are protected under the EU Habitats and Birds Directives. Nitrogen leaching from upstream farms reaches these shallow coastal areas, triggering algae blooms, smothering eelgrass (*Zostera marina*) meadows, and stripping fish populations of nursery grounds.
- **Blue-Green Corridors:** Isolated conservation patches cannot maintain viable populations. Biodiversity policy prioritizes reconnecting protected patches across the landscape via riparian strips, agroforestry belts, hedgerows, and extensive grasslands.

3.3 The Trade-Offs: Intensive Nature vs. Intensive Production

When designing your landscape, consider the fundamental trade-off:

- **Land Sharing:** Farming more extensively across all fields (lower inputs, lower yield, more space for birds/insects across the whole farm).
- **Land Sparing:** Concentrating high-yield biomass production on resilient mineral soils (e.g., intensive perennial grass-clover with green biorefineries) while completely sparing low-yield, flood-prone, or low-retention lowland soils for unmanaged, wild wetlands and natural succession.

4. Policy Cheat-Sheet for Hackathon Teams

Use this matrix to understand how policies directly affect the feasibility, scoring, and farmer adoption of your proposed solutions:

Policy / Mechanism	What It Requires / Promotes	How Your Hackathon Concept Can Leverage It	Impact on Farmer Economics

Water Framework Directive & RBMPs	Zero-deterioration; strict catchment N-reduction quotas to coastal waters.	Direct measures to **low-retention areas**; prioritize wetland and buffer placement where N loads to the Limfjord are highest.	Avoids harsher future production cutbacks; aligns with regional regulatory compliance.
Danish Catch Crop & Fertilizer Rules	Mandatory quotas; limits on mineral/organic N applications.	Propose deep-rooting catch crops or multi-species perennial grass that naturally curb leached N below regulatory caps.	Cuts regulatory penalty risks; reduces spend on synthetic mineral fertilizers.
EU CAP Eco-schemes (Pillar I)	Annual direct payments for eco-friendly practices (buffer zones, precision farming).	Show how farmers receive annual compensation for setting aside field edges, sowing clover, or adopting digital rate tools.	Direct annual income supplement; stabilizes annual cash flow.
EU CAP Rural Development (Pillar II)	Multi-year funding for capital works, constructed wetlands, and rewetted lowlands.	Design collective constructed wetlands (*minivådområder*) or landscape-scale rewetting funded by regional schemes.	Low or zero investment capital cost for the farmer; compensation for loss of productive ground.
Danish Green Tripartite (Carbon Levy & Land Fund)	Upcoming agricultural GHG tax + national funds for peatland and farmland retirement.	Transition drained peatlands to wetlands; replace imported soy protein with local biorefinery grass-protein.	Avoids future agricultural carbon taxes; creates high-value bio-economy revenue streams.
EU Nature Restoration Law & Natura 2000	Binding restoration of habitats, pollinator corridors, and wet meadows.	Connect fragmented forest and stream ecosystems through blue-green corridors along Limfjord tributaries.	Positions the farm to access corporate biodiversity credits, ESG supply chain premiums, and public restoration grants.

5. Practical Application: Answering Canvas Questions

When filling out your **trans4num Innovation Canvas**, reference these policy points to make your solution realistic and robust:

- **Section C (Expected Impacts):** Do not merely state *"reduces nitrogen"*. Specify how your solution helps the sub-basin meet Danish RBMP standards, halts eelgrass die-off in the Limfjord, and restores GAEC/NRL biodiversity indicators.
- **Section D (Farmer Adoption):** Explain what funds your transition. Will the farmer tap into CAP Eco-schemes for annual maintenance? Will national Tripartite funds pay for land retirement on drained peat soils? Will avoided GHG penalties improve farm resilience?
- **Section F (Key Innovations and Recommendations):** Provide concrete policy asks (e.g., *"Regional authorities should streamline wetland permitting for multi-farm cooperatives"* or *"CAP Eco-schemes must offer multi-year premiums for green biorefinery feedstocks"*).

4.3 Agent-based Model Handout

Who delivers the grass? An agent-based model of grass-clover for green biorefining in the Limfjord catchment

Background material for the trans4num INSPIRE Hackathon, Aarhus, 22–23 October 2026

Anke Möhring[1], Christian Grovermann[1], Mette Vestergaard Odgaard[2], Tommy Dalgaard[2]

[1]Research Institute of Organic Agriculture FiBL, Switzerland. [2]Aarhus University

The challenge

The Limfjord receives more nitrogen from its catchment area than good water quality allows. One option being discussed in the region is replacing part of the arable crop rotation with a grass-clover mix. A perennial ley leaches much less nitrogen than cereals, maize or potatoes. However, the grass needs an outlet: a green biorefinery could process it into a protein concentrate for animal feed. The residues, such as the fibre fraction and the brown juice, could then be used to produce biogas. Whether this works across the landscape depends on farmers' decisions and processing capacity, which influence each other. This is what our model simulates.

What is an agent-based model?

An agent-based model (ABM) is a computer simulation in which individual decision makers, the agents, are represented explicitly. Each agent has its own attributes, follows simple rules and reacts to its environment and to other agents. Patterns such as the speed of adoption or the location of processing plants are not prescribed; they emerge from the decisions of farmers and processors and their interactions. ABMs are therefore well suited to answering "what-if" questions, such as what would happen if a payment were introduced or if processing plants could source grass from further away.

Our model does not forecast the future in absolute terms; it assesses scenarios ex ante, and the information lies in the comparison between them.

ADAPtES: our model of the Limfjord catchment

ADAPtES covers the sub-catchments 157 and 158 in Northern Jutland (2,621 km², 416 parishes). It is built on the Danish field and farm registers: 57,422 fields belonging to 2,426 farms, of which 23,111 fields are suitable for grass-clover. The agents are farmers and processors. Decisions are taken field by field, because two fields of the same farm can differ in their distance to a plant. Every four years, each farm agent goes through four questions for each field (Figure 13). A farm agent becomes willing to convert a field only if three conditions hold together: the field is suitable and within reach of a processor, grass-clover is more profitable than the current rotation, and enough neighbours have already converted to meet the farmer's adoption threshold. Innovators start first; the late majority waits. These adopter types are estimated from farm characteristics. A biorefinery opens at one of the 55 existing biogas sites once enough fields of willing farms lie within its trading radius to supply at least 20,000 t of fresh grass per year. The model runs for 28 simulated years. Each scenario is repeated 100 times, because prices and yields are drawn at random in each period. The scenarios vary the processing route (biorefinery with biogas, or biogas only), the trading radius of the plants (5, 10 or 20 km) and an area payment for grass-clover (0, 100 or 200 EUR per hectare and year) (Möhring et al., 2026).

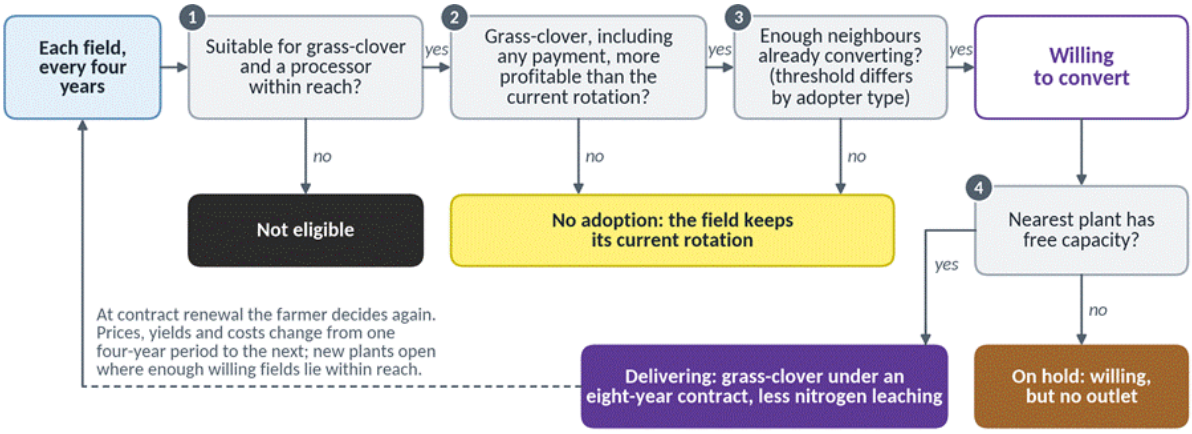


Figure 13: Decision steps for each field in each four-year period (simplified). The colours of the outcomes are those of the maps in Figure 14.

What the model shows

Figure 14 shows the status of every field at the end of one simulation run; Figure 15 summarises 100 runs at a payment of 200 EUR per hectare. Five results stand out.

1. **Willing is not the same as delivering.** In every scenario, more farmers are willing to convert than can deliver. At a trading radius of 20 km, farm agents are willing to convert 6,729 fields, but only 3,801 deliver, because the nearest biorefinery plant has no free capacity or none is within reach (Figure 15). Doubling the capacity of each plant raises the number of delivering fields by 53 %.

2. **Many medium plants do better than a few large ones.** At 10 km, 16 plants convert 35,719 ha; at 20 km, 11 plants with larger sourcing areas convert 28,050 ha (Figure 15). This difference appears only with a payment of 200 EUR per hectare.
3. **Grass-clover pays only narrowly.** Without a payment, it earns 55 to 74 EUR per hectare and year more than the arable rotation, and few farmers are willing to convert. At 200 EUR per hectare, about a third of the delivering fields depend on the payment.
4. **Contract renewal is a critical moment.** The converted area reaches its final level after about twelve simulated years, when the first eight-year contracts expire. From then on, supply rises and falls, because farmers decide again at each renewal.
5. **A contribution, not the whole solution.** In the best scenario, grass-clover reduces the nitrogen load by about 246 t per year, about 15 % of the 1,615 t per year required in the two sub-catchments. The biogas route converts far less land, because Danish law caps energy crops at 4 % of the input of a biogas plant.

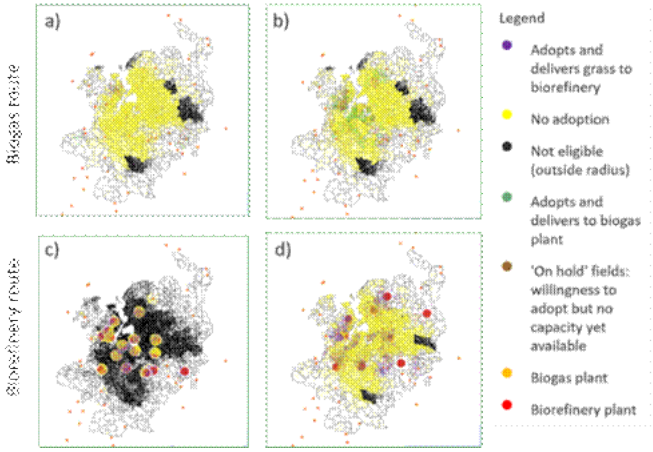


Figure 14: Status of every field at the end of one simulation run (simulation years 25 to 28), at 200 EUR per hectare.

Top: biogas route, a) with and b) without the energy crop cap. Bottom: biorefinery route with a trading radius of c) 5 km and d) 20 km. A small radius leaves most fields out of reach (black); a wide radius reaches most fields, but many do not convert or find no free capacity. One run only: the maps show the spatial pattern, not the quantities.

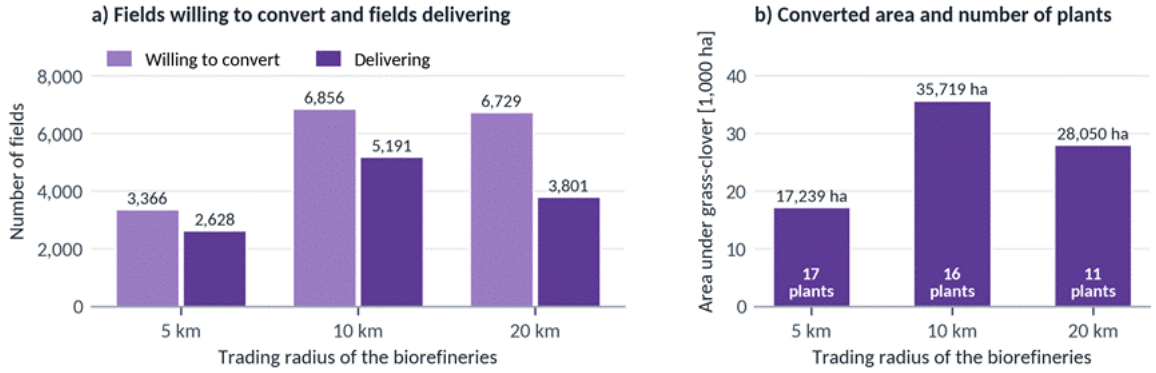


Figure 15: Trading radius of the biorefineries a and b.
a) Fields that farm agents are willing to convert and fields that deliver, and b) converted area and number of biorefineries, by trading radius, at 200 EUR per hectare. Medians of 100 runs at the end of the simulation; medians of different quantities do not add up.

Save the Limfjord: where could farmers work together?

The model contains no cooperatives: every farmer decides alone, and supply groups only form around plants. Its results nevertheless show where collaboration could make a difference.

- **Pooling supply.** A plant opens only when enough grass is available within reach. Neighbours who commit together could make a plant viable earlier.
- **Learning from neighbours.** Most farm agents convert only after some neighbours have done so. Visible early adopters make it easier for others to follow.
- **Organising transport jointly.** Lower haulage costs, as with contracted lorries instead of tractors, raised the converted area by 54 %, without public money.
- **Planning contracts together.** When many contracts end in the same year, supply drops at once. Permanent contracts raised the converted area by 44 %; staggered start dates (not simulated) would spread the risk.

Questions for your team

? Which constraint would your landscape design tackle first: profitability, processing capacity or reach?

? How would a farmer cooperative change the decision steps in Figure 1?

? Where in the catchment would you place a plant, and how large should it be?

? Which benefits of grass-clover, such as biodiversity, soil carbon or climate resilience, do you think should be a priority when considering further development of the ABM?

4.4 Presentations by Hackathon Mentors

Topic	File	Presenter(s)
Welcome and Introduction	Welcome_IntroductionWP3HackatonAIAS_Dalgaard2026_1022.pdf	Tommy Dalgaard (Aarhus University)
Inspiration from Nature-Based Solutions: Background & Vision	Limfjorden_Challenge_mgra_hackathon.pdf	Morten Graversgaard (AU) & Morten Winther Vestenaa (ICOEL)
The Limfjord Challenge	3_Hackaton_From_field_to_fjord_EN.pptx.pdf	Morten Winther Vestenaa (ICOEL) & Morten Graversgaard (AU)
The Innovation Canvas & Future Landscape Concept	4_trans4num Hackathon FLOW.pptx.pdf	Markéta Kollerová (Plan4all)

Introduction to the Digital Toolbox: trans4num DST	trans4num - PA - DST.pdf	Morten Birk (Cordulus)
Introduction to the Digital Toolbox: JackDaw	5 Jackdaw T4N.pdf	Filip Leitner (Plan4all)
ALMaSS : Animal Landscape and Man Simulation System	Trans4Num Hackathon 26j 22.pdf	Tommy Dalgaard (Aarhus University)

Table 2: Overview of mentors' presentations

4.5 Participant List

Name	**Surname**	**Country**
Marie	Nishino	Japan
Sofia	Vila Verde	Portugal
Leila	Jahanbazi	Iran
Katharina	Jentzsch	Germany
Jeppe	Tværmose Munk	Denmark
David	Peacock	Great Britain
Monssef	Ettalbi	Marocco
JAOUAD	ZEROUALI	Marocco
Komal	Kumari	India
Adenna	Nurrahman	Great Britain
Alessandro	Berardi	Italy
Monika Wiktoria	Bienkowska	Poland
Andreas Peter	Buhl	Denmark
Erik Sahlholdt	Hansen	Denmark
Katrine Schmidt	Jensen	Denmark
Fran	Jonckheere	Belgium
Kirstine	Kronborg	Denmark
Patrick Fyhn	Madsen	Denmark
Julia	Rode	Austria
Emma-Sophie	Tossmann	Austria
Marketa	Kollerova	Czechia
Filip	Leitner	Czechia

František	Zadražil	Czechia
Morten	Birk	Denmark
Tommy	Dalgaard	Denmark
Morten	Graversgaard	Denmark
Nele	Lohrum	Denmark
Morten	Birk	Denmark
Maria	Strandgård Vesterdal	Denmark
Karel	Charvát	Czechia
Morten Winther	Vestenaa	Denmark
Runar	Bergheim	Norway
Li	Quiriui	Germany
Geoff	Groom	Denmark
Tomas	Mildorf	Czechia

Table 3: List of participants and countries

4.6 Evaluation Matrix & Scoring Sheets

Team Name	Jury Member Name	1. Nitrogen Reduction Potential (25%)	2. Nature-Based Solutions (20%)	3. Feasibility & Farmer Adoption (20%)	4. Climate & Biodiversity Co-benefits (15%)	5. Innovative Thinking (10%)	6. Use of Tools & Evidence (10%)	Weighted Total Score	Comments	Jury members: enter a raw score 1-5 points in column C-H; 5 the best, 1 the weakest
Atlas Geoforg	Karel Charvat									
Atlas Geoforg	Runar Bergheim									
Atlas Geoforg	Tommy Dalgaard									
Atlas Geoforg	Morten Winther Vestenaa									
Nitrogen Busters	Karel Charvat									
Nitrogen Busters	Runar Bergheim									
Nitrogen Busters	Tommy Dalgaard									
Nitrogen Busters	Morten Winther Vestenaa									
MEGURI	Karel Charvat									
MEGURI	Runar Bergheim									
MEGURI	Tommy Dalgaard									
MEGURI	Morten Winther Vestenaa									
Low-hanging fruit	Karel Charvat									
Low-hanging fruit	Runar Bergheim									
Low-hanging fruit	Tommy Dalgaard									
Low-hanging fruit	Morten Winther Vestenaa									
Regenerative agriculture	Karel Charvat									
Regenerative agriculture	Runar Bergheim									
Regenerative agriculture	Tommy Dalgaard									
Regenerative agriculture	Morten Winther Vestenaa									

Table 4: Scoring sheet

4.7 Award certificates created by HCC



Figure 16: Gold award certificate

trans4num INSPIRE HACKATHON 2026

Design the Future Landscape of the Limfjord

CERTIFICATE OF COMPLETION

presented to

Name name

in recognition of their successful participation in the ***Design the Future Landscape of the Limfjord trans4num Hackathon***, a two-day collaborative event dedicated to exploring innovative ideas and shaping visions for the future of the Limfjord landscape.

Throughout these two days, participants engaged in an intensive process of collaboration, creative thinking, and knowledge exchange, working together to address landscape-related challenges and develop forward-looking solutions.

Through their active involvement, diverse perspectives, and commitment, they contributed to exploring new possibilities for sustainable landscape development and strengthening the collective vision for the Limfjord region.

This certificate acknowledges their dedication, creativity, and valuable contribution to the hackathon, celebrating their role in demonstrating how collaboration and innovation can help shape a more sustainable and resilient future.

Thank you for your participation and for contributing your ideas, energy, and vision to the future of the Limfjord landscape.

October 2026 **Aarhus, Denmark**

Funded by the European Union AARHUS UNIVERSITY Plan4all Cordulus Rethinking weather trans4num

Figure 17: Certificate of completion