2023-08-21

How can patients be in control of their healthcare if they are not in control of their online health information?

Hagglund, M

NordForsk

Fast Track to Vision 2030

A Fast Track towards Vision 2030

In 2019, the Nordic prime ministers adopted a vision that the Nordic Region should be the most sustainable and integrated region in the world by 2030. Accordingly, all co-operation in the Nordic Council of Ministers must serve this purpose.

The Nordic Council of Ministers' action plan for the years 2021 to 2024 outlines how the Nordic Council of Ministers will work to achieve the objectives of the vision through a series of initiatives linked to the vision's three strategic priorities: a green Nordic Region, a competitive Nordic Region, and a socially sustainable Nordic Region. There are 12 objectives linked to the strategic priorities.

The Nordic Council of Ministers is taking the next steps to deliver on Vision 2030 and plan strategic action beyond 2024. The three priorities – a green, competitive, and socially sustainable Nordic Region – are firmly established overarching goals. A new collaboration programme for the period 2025 to 2030 involving the different policy areas of the Nordic Council of Ministers will be set in motion and will be based on:

- an analysis of the challenges and opportunities that the Nordic Council of Ministers has in relation to the three strategic priorities, and
- an assessment of the Nordic added value, impact, and maximisation of synergies in relation to national and European initiatives.

This Fast Track publication is a collection of policy brief articles written by Nordic researchers participating in collaborative projects funded by NordForsk or Nordic Energy Research. NordForsk is aiming for this publication to contribute relevant and up-to-date research-based knowledge that facilitates the analysis of the challenges and opportunities of Nordic co-operation in the coming years. The articles are original and written in April and May 2023 in response to a NordForsk call for policy brief articles to invited researchers and research groups.

The 33 articles in this publication are broadly divided into three chapters. The challenges, opportunities, and consequences of digitalisation in our societies are discussed in the first, followed by the natural environment, climate, green energy, the bioeconomy, and healthy food systems of the Nordic Region in the second. The third and final chapter comprises articles debating the Nordic Region and relations with neighbouring countries, including research on migration, integration and how to preserve and promote safe and healthy Nordic welfare societies.

The papers provide status overviews, descriptions of opportunities and obstacles, and ambitious recommendations for Nordic co-operation and how the vision can be delivered by 2030.

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Director of NordForsk

Contents

A Digitalised Nordic Region

Digitalisation is one of the most powerful tools in delivering Vision 2030. The articles in this section discuss the possibilities and challenges around digitalisation and the use of large-scale data for tackling climate change, and for developing and protecting our Nordic welfare and health systems

Digital Technologies for a Sustainable Nordic Future: Challenges, Opportunities, and Policy Implications

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Key Digital Technologies

Digital technologies (digital tech) are part of our daily lives and play an important role in our economy and interconnected society. Their rise offers a path towards a greener future by enhancing efficiency and cutting emissions. The Internet of Things (IoT), a mix of hardware, software, sensors, and actuators interconnected with each other and the internet, forms the infrastructure of our information society. IoT devices are projected to amount to 30.9 billion units by 2025 worldwide [1], and the global IoT market is expected to grow from USD 662B in 2023 to $3,352B by 2030, at a compound annual growth rate (CAGR) of 26.1% [2]. The Industrial Internet of Things (IIoT) is about interconnected machines, such as using the next generation of high-speed and high-bandwidth cellular networks. IIoT encompasses cloud computing (80% of data is processed in the cloud, but this is unsustainable) and edge computing, which shifts data processing closer to the action, as well as artificial intelligence (AI) that can think for itself, and autonomous systems that act on their own. 'Digital twins' – virtual copies of real-world processes – help to monitor, analyse, and improve systems.

Digital tech can significantly mitigate environmental footprints, optimise energy usage, and enhance resource management through Intelligent Internet of Things (IIoT) applications such as smart energy and waste management, precision agriculture, and personalised healthcare. Notably, digital tech can potentially reduce global CO_2 emissions by 20% by 2030 [3]. Yet, the sustainability of these technologies themselves is critical. The computer technology and telecom industries currently account for about 5% of global CO_2 emissions, set to increase to 14% by 2040, largely due to energy-demanding data centres and cloud computing, especially in AI model training [4]. Moreover, e-waste presents a significant challenge. Each year, about 53.6 million metric tonnes of e-waste is generated, and only 17.4% was recycled [5]. The continual demand for services and the lifecycle of these technologies, from production to disposal, also contribute to environmental impact. Adopting sustainable practices, renewable energy, and creating energy-efficient devices is a requisite for reducing this impact. In addition, it is important to be vigilant against relying on technologies from sources where device safety and security in applications aren't assured, to maintain our own safety and security.

Digital tech faces challenges that stretch beyond the state-of-the-art. In microelectronics, we must design new functions, optimise processes and manufacturing, and promote sustainability and recyclability. The Nordic Region, while not a world-leader in integrated circuits, is adept in system design, leading in applications such as manufacturing systems, healthcare, and transport.

Large cyber-physical systems-of-systems have their own challenges. These range from developing effective architectures and integration platforms, ensuring seamless cooperation, and managing integration, to establishing robust monitoring and control processes. The increasing complexity of these systems presents more challenges, like the need for trustworthy and explainable AI, adaptable models, standardised interfaces, and longer device lifespans.

Edge computing, which processes data closer to the source and not in the Cloud, can be used to tackle the future demands for energy efficiency, protect privacy, ensure application compatibility, and requires the development of distributed AI solutions. Despite a strong tradition in wireless and connectivity technologies, the Nordic countries face increasing competition in communications tech and reliance on a global value chain.

The final challenge lies in trustworthiness, including hardware and software reliability, cybersecurity, safety, resilience, and effective integration of humans and machines. A substantial list of challenges indeed, but one that offers equal opportunities for innovation and progress.

Digital tech in support of Vision 2030

Digitalisation for a green Nordic transition

Industry, forming 20 to 35% of the Nordic GDP (Statista 2019), is currently undergoing a digital revolution. The fourth industrial revolution, termed Industry 4.0 uses IIoT for manufacturing processes. However, emissions from production in the Nordic Region remain above national targets [6]. Industry 5.0 is addressing the next generation of manufacturing, which incorporates environmental and social sustainability—not sufficiently addressed in Industry 4.0—and has the potential to cut emissions through energy efficiency, process optimisation, and waste reduction [7].

The Nordic countries are at the forefront of renewables and are poised to lead a new North Sea renewable energy infrastructure revolution, with the potential to shift Europe's economic epicentre to the north [8]. Smart energy systems, driven by digitalisation, could optimise the entire energy network, resulting in a more efficient and secure power supply. The digital

revolution brings with it a host of tools, such as demand-responsive smart charging for electric vehicles, and optimised integration of renewables into the grid. While digitalisation provides opportunities, it also necessitates robust, interconnected systems to mitigate potential safety and security risks [9].

Digital tech can be used to improve sustainable and smart mobility and transportation. By using real-time data from connected vehicles and infrastructure, digitalisation can help reduce traffic congestion and improve traffic flow. Digitalisation can help to enable greater adoption of electric and hydrogen vehicles by providing real-time information regarding charging/refuelling locations and availability, thus reducing range anxiety often associated with low-carbon vehicles. With hydrogen, there is a lack of infrastructure for refuelling. In addition, digitalisation can help improve accessibility by reducing uncertainties and waiting time with real-time schedules of public transportation and other mobility services such as bike sharing and e-scooters. Autonomous systems (trains, buses) are part of a paradigm shift in transport management and safety and extend to diverse domains like agriculture and mining.

The circular economy – a model prioritising waste elimination and regenerative design – can benefit from a digital transformation. Digital technologies can support activities such as identification, tracing, monitoring, prediction, reuse, recycling, upgrading, down-grading, maintenance, areas where 'product passports' are relevant, and the establishment of service-based business models. Over 100 billion tonnes of resources enter the economy annually, with only 8.6% recycled and reused [10]. The shift could unlock a $4.5 trillion economic opportunity, driving innovation and employment while safeguarding the environment [11]. Digital technologies themselves must also be designed for circularity to improve electronic waste recycling.

Innovation through digital technologies

Digital technologies have revolutionised various industries such as mobility, agriculture, energy, home automation, and manufacturing. By connecting the physical and digital worlds in innovative ways, these technologies generate and process vast amounts of data, leading to new business opportunities and models. This wave of innovation not only drives competitiveness but also creates new markets and transforms existing ones [12]. The Nordic Region is renowned for its innovation. Digital innovations such as the IoT, big data, edge and cloud computing, AI, and various digital technology-based platforms are influencing business ventures and changing the ways that extend beyond entrepreneurship and innovation practices to influence culture, politics, and society. The digital economy has reshaped competitive dynamics in the economy, being a key driver behind national and European initiatives, such as Horizon Europe.

Sustainable Nordic digital life and care

The Nordic countries can greatly benefit from digital technologies. These tools can make cities smarter, improving our everyday life by using data to make informed decisions. This could positively impact areas such as public services and healthcare. Digital technologies can also help cities reach their climate goals faster. Healthcare is one area where digital transformation is already happening fast, and the Nordic countries are at the forefront of this shift. This transformation has made healthcare more personalised and proactive and has been boosted by the use of telemedicine during the COVID-19 pandemic. But there are still hurdles to overcome. We need to create secure health platforms that handle data from our digital devices safely and privately. We also need to focus more on prevention instead of just treatment, which means using technology for early diagnosis and facilitating healthcare right at home. Moreover, digital solutions can help us age healthily by offering innovative home care and patient monitoring options.

Policy implications and recommendations for action

Digital technologies, if harnessed properly, can drive the Nordic Region towards a sustainable future. But this requires targeted policies and innovations that can solve the challenges with digital tech.

The goal of our recommendations is to shape a future where digital technologies play a pivotal role in advancing sustainable systems. Our recommendations, which align with the Nordic Industrial IoT Roadmap [13] developed recently by five Nordic universities, are as follows:

1. **Foster trustworthy digitalisation and multidisciplinary collaboration:** Reinforce Nordic leadership through trustworthy digitalisation by enhancing national competences and cross-disciplinary collaborations, through instruments that incentivise the creation of Nordic competence networks involving industrial, public and research stakeholders. Prioritise research and development to advance solutions that combine digital and green technologies, aligned with the goals of Vision 2030. Leverage digital technologies to catalyse a 'twin' digital and green transitions, enhancing cooperation across sectors, from technology developers to policymakers.

2. **Encourage the use of renewable energy sources, improve energy efficiency, and reduce e-waste of digital systems.** Encourage the use of renewable energy sources to power digital systems, such as solar or wind power. Policies can promote incentives or subsidies for adopting renewable energy solutions. Implement regulations and incentives to encourage the design and production of energy-efficient digital systems. Policies can encourage data centres to adopt energy-efficient infrastructure, cooling systems, and efficient heat recovery technologies to minimise energy waste and optimise overall energy consumption. Create policies and incentives that promote durability, repairability, and recyclability, and enhance the incentives in relation disposal and recycling of digital devices.

3. **Establish 'Sustainability Innovation and Competence Hubs' to drive the digital transformation.** Encourage the exploration of innovative funding models and instruments, including 'small fast grants', to discover new sustainability applications for digital technologies. This can be done under the umbrella of new 'Sustainability Hubs', fostering a culture of sustainable innovation and competence development, including industry, public and research stakeholders. To achieve the objectives of Vision 2030, universities and industry need to collaborate to create new forms that fully embrace lifelong learning to promoting constant upskilling and reskilling in the ever-evolving digital landscape. Furthermore, to bolster the Nordic countries' participation in large international funding schemes related to the 'European Chips Act', we suggest increasing budgets and simplifying rules in instruments like the 'Key Digital Technologies Joint Undertaking'.

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Sharing costs of cross-border computing resources for beautiful climate data

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"Climate change carries no passport and knows no national borders. Countries must work toward the common interest, beyond narrow national interests."

– Ban Ki-moon, Secretary General of the United Nations (4 November 2015)

Summary

Researchers communicate about their achievements at conferences or in journals, and in the spirit of FAIR[A] and Open Science, they are now asked to also share their data, models, software and workflows, along with a plethora of useful additional information to exploit them (so-called metadata). In the near future, they could be rewarded (or at least recognised) for their effort. But whom do they really share it for? What do they share? For what purpose? At what cost? And for how long?

Collecting and/or producing large amounts of climate data and developing models/software comes at a price. Data is a resource, an asset for everyone, and all should be empowered to understand global change-related challenges, assess impacts, and contribute to actions. Beyond FAIR and data sharing, it is paramount to define a cost-sharing model for cross-border computing enabling anybody, regardless of their geographical location and means, to explore, process, visualise and understand climate data, from anywhere, without having to download entire datasets then install, set-up and execute complex tools to do it. This is an opportunity for the Nordic countries to become pioneers in the sharing of cross-border computing costs for a good cause, hence serving as a paragon of selflessness for others and especially for the EOSC[B].

Policy recommendation

A cost-sharing model for cross-border computing to support climate change adaptation actions.

Problem

The amount of weather and climate data continues to grow, and with the Destination Earth digital twins, this is expected to exceed 1 petabyte per day. In this context, the traditional approaches that consist in locally downloading entire datasets for processing become totally unrealistic. As an alternative, a shift towards *moving the compute closer to the data*, is gaining prominence. This involves performing data analysis or processing tasks directly on the storage or computing infrastructure where the data resides, rather than transferring it to a local machine or server. Such a strategy leverages distributed computing frameworks and cloud-

A Findability, Accessibility, Interoperability and Reusability
B European Open Science Cloud

based technologies to process data *in-situ*, thereby reducing data movements. The technical feasibility of this approach was demonstrated during the NeIC-NICEST2[C] project, and a European framework even exists that covers these needs: this is called the European Open Science Cloud or in short, the EOSC. However, moving the computer (software and tools, including an environment requirement, possibly a container) to the data raises other questions, in particular: How secure is it to run codes from *a priori* untrustworthy users? Who should pay for the processing cost? Is it the data depositor or the end-user? How many resources should be made available to ensure an acceptable level of service?

Background and context

Funded by NeIC[D], the NICEST2[E] project (2020-2023) aimed at boosting the position of the Nordic Region in the climate communities. The project focused on enhancing scientists' ability to leverage current and future computing/storage resources (e.g., EOSC, EuroHPC[F]) to perform climate simulations, analyse the results to improve model performance in the Nordic region and adopt Open Science and FAIR practices. Climate models are largely legacy codes that are difficult to master (port, install, use, develop) but encapsulating them into containers can significantly streamline the process. Similar steps can be performed from the data creation (running models on HPC, or collecting observations with edge computing) to its exploitation by different end-users (scientists, local authorities, citizens). In which case, it then becomes straightforward to move all of the compute (software) steps to the data.

Steadily more researchers are learning how to *work openly*, making their data FAIR, to share it along with their models, software and workflows, plus a wealth of metadata. However, climate data are usually large, stored in complex binary formats, and need a lot more context to be fully exploitable. The potential of what one can really do with such data does not lie in the data itself, nor in software, workflows or the metadata, rather, it is the combination of all of these *research artefacts and the links between them* that conditions what can or cannot be done with them. This matter was resolved with the introduction of the concept of FAIR ROs[G] aggregating research artefacts including data, documentation, papers, software/tools/workflows and *machine actionable* metadata. However, *an infrastructure is required to give it life*, and it should be available for all, whether they only need to have a peek, or want to further build on FAIR ROs – this is how otherwise *ordinary* climate data becomes *beautiful climate data*.

Towards a European federated and Open Science Cloud

The EOSC aims to provide a *federated and open* environment for researchers, innovators, companies and more generally European citizens. It enables *seamless access* and reliable reuse of research data and Digital Objects (DOs) following FAIR principles. EOSC's goals are to develop a *Web of FAIR Data and services* and to promote Open Science practices. On the surface EOSC is indeed an attempt to address the issues mentioned hereinabove given that it federates several resource providers and in principle makes it possible to select the *computer closest to the data requested* by end-users. And if computing is available close to the data, and if the data in question comes as an object containing methods (tools) that can be applied to the data, then there is no need to transfer anything anymore but only return the information actually requested by the end-users, typically in the form of a table, graph, map, data summary, *etc*.

C 2nd phase of Nordic e-Infrastructure Collaboration for Earth System Modelling Tools (https://neic.no/nicest2)
D Nordic e-Infrastructure Collaboration
E 2nd phase of Nordic e-Infrastructure Collaboration for Earth System Modelling Tools (https://neic.no/nicest2)
F High Performance Computer
G Research Objects

Budget for the Data Processing

Should the responsibility of cost be on the users requesting data that needed to be processed or on the one who initially produced and deposited it? How should the cost be shared when the data resides in a country but is accessed and processed by a user from a different country? When it comes to cross-border computing a cost-sharing model and clear accounting rules are necessary. The EOSC has not fully addressed this issue yet, focusing instead on delivering services and onboarding new communities. However, users will only come to the EOSC if they can obtain more (or at least similar) computing and storage facilities than they already get from their own institution and/or at the national level. To produce climate data, the modelling community is dependent on being able to access the largest possible HPCs – moving to the EOSC would mean that our national providers agree to join the EOSC. But why would they do that? And what could be the benefit *versus* the cost?

Policies are therefore needed at the national level to support providers (who may lose currently tied-in customers tempted by alternative offers) in joining the EOSC, then a governance at international level to sort out the technical mechanisms (including security and authentication) and split the costs of cross-border computing and storage resources (inspired by that done by GÉANT[H]*, the collaboration of European National Research and Education Networks behind eduroam and eduGAIN).*

Benefits of cross-border cost sharing

An exhaustive list of possible savings and new opportunities would be quite long, and out of the scope of this brief, but we can definitely mention obvious *benefits of having beautiful climate data for the community*. Not transferring large amounts of data and instead having it analysed according to what those who produced it intended (i.e., no risk of variable misinterpretation, or human errors introduced in this process) will significantly:
discharge network bandwidth for other purposes; minimise the time wasted by end-users queuing and downloading;

- reduce the number of unnecessary copies of the data (and associated storage costs);
- preserve the full provenance back to the original producer of the data;
- facilitate recording data usage (for instance assess if the initial investment was worth it);
- grant anybody access to data, regardless of their location, technical means or skills;
- avoid issues by not having to write code to disentangle the data and make sense out of it;
- foster contributions from a wider range of actors who would not otherwise get any support;
- set minds free to explore innovative solutions once released from technical burden (Figure 1).

Figure 1: Symbolic issues when no cross-border cost sharing is implemented with on the left side end-users easily getting useful outputs from climate data processing carried out elsewhere and able to concentrate on mitigation actions, and on the right side another end-user wasting time and resources to procure and process by himself/herself all the data made available by a user from another country instead of thinking about actual solutions to minimise the impacts of climate change.

H Gigabit European Academic Network (https://geant.org)

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Rights and permissions

Sponsor

On the practicalities of sharing pathogen genomics data in the Nordic Region

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Summary

In recent years, microbial pathogen genomics data has come to the forefront as a tool for surveillance and outbreak management for fighting disease. With increased travel and trade, pathogens are crossing borders more frequently, making it essential for the agencies tasked with monitoring these pathogens to share genomics data across borders. This policy brief highlights the need for effective practices for sharing pathogen genomics data in the Nordic Region.

The cross-border spread of disease pathogens

In today's interconnected world, frequent cross-border movement of people and goods is a fact of life. Before the COVID pandemic in 2019, Norwegians made 4.3 million trips abroad, and 50-60% of consumed food was imported, with comparable numbers seen in Denmark and Sweden. However, it is not just people and goods that cross borders – so do disease causing pathogens. Travellers can bring back diseases such as COVID and salmonellosis, while migrating birds and animals can carry diseases such as avian influenza [1] or African swine fever [2]. A considerable amount of trade and travel occurs between the Nordic countries and with other countries. Food products and goods can potentially carry pathogens across borders, causing outbreaks in unsuspecting countries, as exemplified by recent outbreaks of *Listeria* and *Yersinia* [3,4].

Controlling infectious diseases in both humans and animals comes with several benefits. Lower disease incidence can lessen morbidity and mortality, leading to fewer deaths and less treatment being needed. This reduces costs for both humans and animals, with humans for instance requiring fewer hospital stays and food producers not losing animals. This may also decrease antimicrobial use, thus decreasing the risk of developing resistant strains. Furthermore, better pathogen control in animals and food products can increase trade opportunities, as many countries require disease-free certifications for trade approval.

How genomics can help combat disease

In recent years, genomics has become a powerful tool for monitoring and managing infectious diseases, as evidenced by its widespread use during the COVID pandemic [5]. The genome of an organism contains all the genes that the organism needs to live, encoded in DNA consisting of the four nucleotides that we represent with the letters A,T,C, and G. As the DNA changes over time due to random and evolutionary processes, closely related organisms are likely to have more similar genomes than more distantly related ones. Genomic data can be used in several different ways to fight disease. First, the genome can be used to "type" an organism into specific subgroups, and to identify characteristics such as antimicrobial resistance. Second, with typing information it is possible to monitor the prevalence of different types and to establish a baseline, with increases from this baseline potentially indicating outbreaks. Third,

by comparing genomes it is possible to see if some are similar enough to see whether they may be from the same source, and if certain types are adapted to certain hosts or environments, as well as to figure out how pathogens are transmitted.

In recent years, genomics has been extensively used for studying pathogen outbreaks. One of the first well known examples was in 2011, when it helped explain the high lethality of a foodborne outbreak of Shiga toxin-producing *E. coli* [6]. Genomics was also instrumental in combatting the Ebola and Zika epidemics in the early 2010s [7,8]. During the COVID-19 pandemic, real-time genomics provided valuable information on the spread and evolution of SARS-CoV-2 and influenced pandemic management [5]. Genomics has not only been used in medicine and public health but also to study animal agents such as *Actinobacillus pleuropneumoniae* which causes pleuropneumonia in pigs [9]. In the Nordic Region, genomic studies have been used to study disease spread and antimicrobial resistance. For instance, a Swedish study[10] examined the spread of salmonella from passerine birds to cats and humans, highlighting the possibilities of cross-border transmission. Furthermore, a Danish study found that up to 25% of campylobacteriosis cases could be linked to poultry, and described how an effective genomics-based surveillance programme could work [11]. Another study from Norway revealed that quinolone resistant *E. coli* was likely disseminated through poultry production [12]. These examples highlight how genomics can identify reservoirs, outbreaks, and transmission pathways, which can then help inform pathogen management strategies.

The importance of sharing data

Monitoring pathogens is, in the Nordic Region, the responsibility of the public and veterinary health agencies (PVHAs) in collaboration with the respective food authorities. These institutions have established whole genome sequencing and bioinformatics analyses services to generate and analyse data, and the Nordic genomic studies already mentioned are fruits of this labour. However, each institution is limited to analysing its own data, resulting in each institution only seeing a part of the whole puzzle. Outbreaks are typically identified by an increase from the baseline, but if an outbreak spans multiple countries, the increase may not be significant enough to be detected in a single country. Moreover, the data managed by one institution may only capture fragmented parts of an outbreak, hindering a comprehensive analysis. Without having all of the pieces of the puzzle, as illustrated in Figure 1, it becomes difficult for a single PVHA or country to see the whole picture. To fulfil their mandates effectively, PVHAs should be able to share data with each other as needed. The importance of early data sharing has also been emphasised in a recent policy brief by the World Health Organization [13].

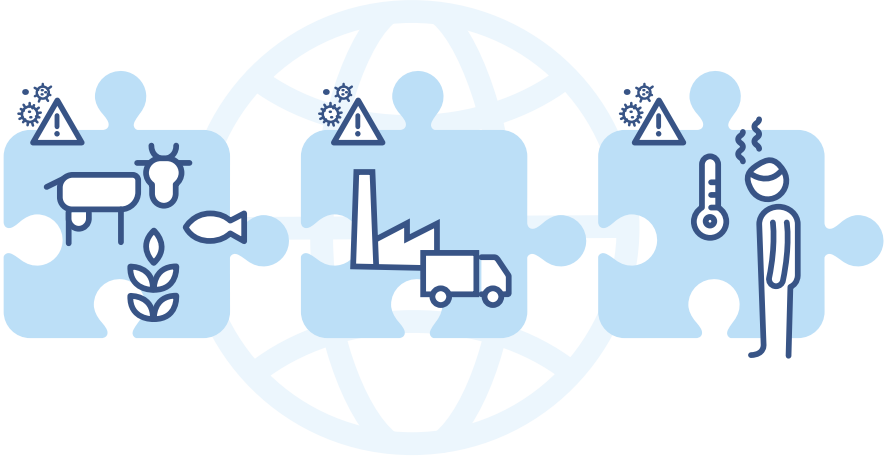

Figure 1. Movement of people or goods across borders can carry pathogens. Without having all the pieces of the puzzle, it may become difficult to trace their movement in a system.

Current options for data sharing

Sharing of sequencing data has a long history in bioinformatics, with the first electronic databases appearing in the late 1970s. Sharing sequencing data in public databases is often a requirement for being able to publish results based on the data. The most well-known sequence databases are the INSDC databases (a collaboration of the databases NCBI, DDBJ, EMBL – https://www.insdc.org/). These databases allow open and free submission of data (sometimes of variable quality) with no restriction on use. During the swine flu pandemic in the late 2000s there were growing concerns about sequences possibly being withheld due to this unrestricted use model. As a response, the GISAID [14] system was created, which now uses servers in Germany and the US. GISAID has been widely used during the COVID pandemic for SARS-CoV-2 sequences. This database requires registration and users must acknowledge and preferably collaborate with the original data producers. However, recent criticisms have been raised regarding issues concerning governance and transparency – these issues are further discussed in this comparison of GISAID and a different COVID database [15]. An additional issue with these public databases could be to what extent it is wise to depend on infrastructure being run by third parties in third party jurisdictions. In Europe, the EFSA and ECDC collect whole genome sequencing data of specific zoonotic pathogens for outbreak investigation and to identify emerging health threats. EFSA has developed a system for exchanging typing profiles and minimum additional information with the ECDC. In addition to collecting data from the PVHAs directly, they might also collect data from INSDC databases.

Current experiences regarding sharing in the Nordic Region

While sharing data openly offers significant benefits, it may not always be compatible with the limitations faced by PVHAs in the Nordic Region, particularly in emergent situations where high quality data should be shared swiftly and efficiently with other institutions. The data managed by PVHAs is often owned by third parties, which might necessitate consulting data owners before data can be shared and used for analysis. Veterinary and food agencies commonly collect data from food producers, animal owners and others, and a lack of knowledge and control over how the sequences will and can be used, combined with the possible market sensitivity of the data may discourage such actors from open sharing. On the public health side, patient privacy laws and GDPR regulations, which may or may not have been updated to cover sequence data, can hinder open sharing.

Additionally, submitting data to public databases can be technically complicated with different databases requiring different formats and different tools for submission. In addition, retrieving data from public databases may be challenging. If two institutions opt to share directly between them, that can be complicated by organisations often having incompatible technological solutions or organisational policies regarding technology use. Due to the absence of accessible technical solutions for sharing between institutions, the practitioners who manage data on a day-to-day basis occasionally resort to sharing via services such as Teams and Dropbox. However, concerns regarding data protection and security may arise as such services are operated by US companies where the data may be kept on servers in the US. In addition, data sharing, whether to an INSDC database or directly to a different institution, requires skills and competence that might be non-existent or in already high demand within the organisation.

Despite these technical, regulatory and organisational challenges surrounding sharing, some of the institutions do submit sequences to an INSDC database even when the data is not part of a publication. However, this usually happens on an ad hoc basis. Some of the public health institutions also share data to restricted databases such as GISAID. Most institutions manage to share data directly with other institutions within their countries, however, not all do so routinely. Sharing directly with institutions outside of their countries, however, such as with PVHAs in other Nordic countries, is typically limited to special circumstances such as outbreaks. This will then of course happen when the institutions have already discovered that an outbreak is ongoing. In many cases the sharing that does take place is done on the basis of informal agreements. While some institutions do have data sharing agreements in place, there is a general lack of awareness of the existence of such agreements among those who manage data on a day-to-day basis. There may also be questions regarding the scope and applicability of these agreements, especially if the conditions that allow for data sharing will only occur in very narrowly defined scenarios, such as outbreaks.

Recommendations

Sharing sequencing data is as demonstrated clearly highly beneficial, but it often poses challenges. The Nordic Region, as a well-coordinated region with similar democratic traditions, should strive to develop systems that allow for easy and timely data sharing among practitioners.

In the authors' opinion, the following are some of the key challenges that would need to be addressed:

- Among practitioners today there is uncertainty and confusion regarding what data can be shared and under which circumstances. An easy to find and easy to use framework for sharing should be developed that enables practitioners to share data when needed. The Nordic countries have similar legislative and regulatory frameworks, and already have forums for intergovernmental collaborations. Leveraging the existing collaborations should ease the process of making such a framework, and ultimately reduce the confusion surrounding sharing.
- Current technical solutions for sharing do not fit with the needs of PVHAs. Encouraging the development of tools that integrate with existing public and veterinary health infrastructures and organisational policies on technology is crucial. The possibility of setting up direct sharing systems between PVHAs should be explored, as this could potentially reduce data owners' concerns regarding sharing since it would only involve two parties.
- Pathogen data management is in a day-to-day setting often handled by bioinformaticians, while the current formal networks between PVHAs commonly connect agent or disease specialists. Establishing a dedicated network for bioinformatics practitioners in the Nordic Region would enable direct connections among those managing pathogen data. Direct contact between those handling the data may help expedite data sharing in situations where it is warranted.

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Humanities-driven Geospatial Data Infrastructure Development for Vision 2030

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Billions of diverse citizens in the Nordic Region use digital spatial data every day: they ask for directions, set up routes, get traffic information, and calculate distances on their gadgets. Citizens generate digital spatial data, too. These and other types of spatial data such as satellite imagery feed geographical information systems (GIS) and geospatial artificial intelligence (geoAI) applications that help researchers, governments and businesses analyse emerging patterns and make millions of decisions as well as monitor and solve global crises. Where will the next Russian bomb fall? Where will the draught hit hardest next year? Where will the next outbreak of the coronavirus take place? What are the best locations for relief efforts in case of calamities be it the 2004 Indian Ocean tsunami or the 2023 Türkiye–Syria earthquake? In short, what is the name of the location, and what are its coordinates?

However, even such an integrated region as the Nordic Region has difficulties in geospatial cooperation in research, government and business, as the findings of the Nordic Spatial pilot project [1] showcase. Regional geospatial data has multiple shortcomings due to ambiguous and/or heterogenous principles behind their collection, metadata and resolution. [2]

In order for the Nordic Region to become the most sustainable and integrated region in the world, one major requirement needed to achieve this is geospatial data that meet the highest quality standards, as well as human knowledge drawn from a range of different practical and intellectual fields. To meet the Nordic Vision 2030 goal of achieving "the green, competitive and socially sustainable Nordic region", [3] decision-makers will need to be able to model Nordic actions and their consequences at national, Nordic, European and global levels, using first-class spatial research infrastructures (SRIs) and spatial data infrastructures (SDIs) designed in accordance with the latest scientific advances. Moreover, spatio-temporal modelling must also reflect the intersectionally diverse Nordic populations with respect to gender, race, ethnicity, socioeconomic status, sexual orientation, ability, and religion/spirituality. A humanities-driven geospatial data infrastructure development plan for Vision 2030 will maximise efforts to utilise spatio-temporal data so that it fits and illuminates human-driven needs in the Nordic Region for the future. The proposed recommendations would thus bring together diverse geospatial, interdisciplinary and multi-sectoral communities, harnessing the expertise and insights of the humanities to increase the impact of technical development.

However, the potential of the humanities to develop inclusive, responsible and sustainable innovation has hitherto been both undervalued and underfunded. Existing models and standards of spatial data as well as applications of those standards in spatial research and data infrastructures (SRIs/SDIs) neither grasp the complexities of present-day spatial data nor meet the ever-expanding repertoire of needs across research, government and private sectors. The available standard definitions and guidelines of digital spatial-temporal data – including linked open geodata recommendations – and, most importantly, ontologies and models, such as the mainstream digital gazetteer model, are incompatible with spatial humanities research, global governmental work on standardisation of names, as well as citizens' and inhabitants' involvement in spatial data policy implementations and

the commercialisation of spatial data. Consequently, there is a lack of existing conceptual infrastructure frameworks and their practical, fit-for-purpose implementations that have the capabilities to accommodate the needs of research communities, governmental authorities, companies, and citizens. Most problematically, the inherent humanistic and democratic perspectives on spatial data and perception of space and place – encapsulated primarily in the concept of a place-name – are marginalised in the existing digital infrastructure landscape. Place-names are much more than standardised labels; they function as – often disputed – cultural heritage, archaeological finds preserving characteristics of place over thousands of years, language items subject to variation and re-interpretation, trademarks, and also personal and group identity markers.

The modelling of spatial-temporal data is a conceptual backbone in the geospatial solutions industry. Indeed, the global geospatial market is expected to grow at a compound annual growth rate (CAGR) of between 13.1% and 15.7 % until the 2030s. [4,5] Innovative technologies such as geoAI and 4D GIS and an increasing demand for geospatial modelling for analysis and decision-making constitute the main development drivers. The Nordic Region and Europe in general have a relatively weak position in the global market and are expected to fall behind during the same period. Moreover, present-day regulations with respect to standardisation, production, and (re-)use of spatial data differ across the Nordic countries. One of the few common denominators is a negative one: although citizens, including indigenous peoples and minority groups, produce data, they have often little say about standardised names and coordinates used on maps produced by government agencies or businesses. In order to make considerable improvements, the Nordic Regions needs a well-developed research and innovation (R&I) strategy and a long-term geospatial development plan for the whole geospatial sector, as well as transparent, future-proof and interoperable legislation.

Nordic collaboration for a green, competitive and socially sustainable Nordic Region

The state-of-the-art EU geospatial policy is summarised in the *Integration of geographic and statistical data for better EU policy making* report from 2021 which states that "no EU level legal mandate exists" [6] for the coordinated collection of spatial data. This, despite the strong EU cooperation on sharing geospatial data on the environment and the existence of specific RI tool for this: INSPIRE. [6] The report points out multiple obstacles on the path towards comparable spatial-temporal datasets such as national approaches to data collection and dataset resolution. The work towards a European geospatial agency proposed in the report is still in its infancy. There is no mention of technical innovations such as geoAI or 4D GIS or any strategies for their use in the EU. The place-name component of geospatial data is not paid any attention either. Global work towards place-name standardisation for effective geospatial data applications has instead been conducted by Member States and Associate States through the UN group, United Nations' Group of Experts on Geographical Names (UNGEGN), since 1959. However, there are still no unified general legal frameworks for the standardisation and representation of minorities' place-name data, and several surveys of differences and similarities of nation-states' approaches to minority place-names have been conducted by researchers active in UNGEGN. [7]

The Nordic Region thus has the opportunity to seize the leadership in solving the EU's geospatial data challenge through timely investments in humanities-driven geospatial data infrastructure development. The high level of integration within the region will lay the foundation for breakthroughs in work towards the collection of comparable spatial-temporal data at a regional level. Access to excellent and comparable geospatial data in the Nordic countries will most effectively facilitate the development of smart specialisation in the region.

Recommendations for visionary geospatial data modelling for Vision 2030

Recommendation 1: Develop a unified intellectual framework for modelling spatial-temporal data in research, the government and the private sector.

It is a vital that this is a unified framework for modelling spatial-temporal data that is firmly grounded in the humanistic mindset for the building of the next generation of geoAI/4D GIS applications that will go beyond reproducing the simplistic Euclidian algorithm so as to incorporate democratic perspectives on spatial data. The Nordic response must pay special attention to the factual needs of citizens and inhabitants, as well as researchers, governmental officials, and businesses. The needs in question are often contradictory; these contradictions have to be managed and reconciled in a transparent sector-dependent fashion instead of being simplified away. Central to the proposal is the adoption of a holistic, inclusive approach to spatial-temporal data that accommodates the perspectives of multiple scientific disciplines, governmental officials, businesses, and diverse citizens and inhabitants – including females, males, gender-diverse people, minorities, and indigenous peoples. Thus, the framework should deepen and consolidate theoretical understandings of complex phenomena concerning name, place, and digital geospatial data.

Recommendation 2: Survey the existing legal frameworks for spatial-temporal data and geoAI/4D GIS and develop a geospatial innovation strategy and roadmap.

The Integration of geographic and statistical data for better EU policy making report (2021) [6] summarises current legislative challenges in the availability, quality and interoperability of European geospatial data. Shortcomings with regard to existing geospatial data management practices become particularly apparent at the regional level, as the results of the Nordic Spatial pilot project [1] show. It is imperative that we have a clear and interoperable legislative base for effective and fruitful development of R&I in the Nordic and European geospatial industry, as well as the implementation of common standards across sectors, and the uptake of geoAI, 4D GIS, and other innovations. The recommendation is to survey the current legal landscapes of production, (re-)use, and standardisation of digital spatial-temporal data – especially place-names – in research, the government, and businesses with respect to licensing, interoperability, compatibility, and citizens' and inhabitants' rights. These investigations will lay the foundations for legal recommendations regarding the solutions for best practice relating to future SRIs/SDIs in the Nordic Region. Besides adequate legislation, the successful expansion of the geospatial sector in the Nordic Region and the export of Nordic geospatial innovation requires a holistic vision for the long-term development of its R&I element, i.e. a geospatial innovation strategy and roadmap. No equivalent to such a roadmap exists. The CoR Geodata Report referenced above does not mention such technical innovations as geoAI or 4D GIS or any strategies for their use in the EU.

Recommendation 3: Develop new cluster-specific tools and infrastructure services to help stakeholders implement the proposed framework, spatial-temporal data models, and workflows.

We recommend investment in the development of tools and services to better enable the implementation of the proposed framework across sectors. These include overviews of legal landscapes of spatial data across the Nordic Region, data and metadata checklists, flowchart overviews of workflows, cluster-specific example datasets, and templates of spatial databases and spatial data services at the national, Nordic and possibly European level. These outputs should be published in accordance with Open Science and FAIR principles. The suggested investments will thus offer new services and opportunities for researchers, governments, and businesses, enabling them to explore geospatial data in novel ways in order to meet both scientific and societal challenges, including environmental change, and citizens' and inhabitants' involvement in the design and implementation of spatial data policies.

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Putting People at the Centre of Digital Welfare Services: Towards a socially sustainable Nordic Region

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The research area's relevance for the vision of a socially sustainable region

The Nordic countries make wide use of digital technologies for communication and the delivery of their respective welfare services. The public sectors are among the world's most digitised. [1,2] The underlying values that have driven this development have included:

1. cost-efficiency by offering services at a lower cost via instalment of digital platforms and self-service with the aim of improving convenience for people living far from public administrative offices, and

2. neutrality in the decision-making with respect to the allocation of welfare benefits to make sure everyone gets a lawful treatment.

However, the widespread use of digital technologies has turned out to come with the price of access and difficulties for some, resulting in inequality as to who benefits from the digitalisation of public services. [3, 4, 5, 6] Inequality is known to erode trust in the state authorities and is a danger to healthy democracies.

This policy brief outlines what we consider to be the best way to achieve a socially sustainable region as per Vision 2030 of the Nordic Council of Ministers. The recommendations are based on the research project *Infrastructures for Partially Digital Citizens: Supporting Informal Welfare Work in the Digitised State* (project ID 100742), which is a NordForsk sponsored collective research project that researches digital inclusion and exclusion in Sweden, Norway and Denmark through a combination of qualitative and quantitative methods.

Current state of the art in the research area

In 2019 the UN's Special Rapporteur on Human Rights called for attention to the widening gap between the rich and poor as a result of digitalisation.[7] In Denmark, between 17% and 25% of the adult population experience problems related to digitalisation of the public sector. [8] At the same time, researchers document ethical and human rights challenges due to the implementation of the digital service state. [9, 10] These warnings are largely based on quantitative surveys. As a result, we know of the problem but still lack a deeper understanding of how citizens experience exclusion across different countries and domains. This constitutes both an empirical and a conceptual challenge that our research seeks to address. Empirically, we lack context-sensitive and situated knowledge about digitised exclusion. Conceptually, we lack better notions of the subtle forms of exclusion that people experience in practice. At present, both citizens and public sector employees of digitalised societies are expected to be self-reliant computer users,[11, 12] but our research shows that despite political ambitions to digitalise hard and fast, 'the digital citizen' is more of an ideal rather than a fact. Society-wide digitalisation has shown that it is the rule rather than the exception that people need help and support to be able to 'self-service'. Throughout citizens' life, there will be periods when they are not able to act as 'digital citizens'. It has been demonstrated that groups that are already

socially and economically vulnerable struggle more than people with social and economic resources, but what they do have in common is that their needs for (digital) support changes depending on the situation and their life conditions. Partially digital or digital (non)citizenship are concepts that better cover how citizenship in digitalised welfare societies is a process.

One implication of this is that Governments in the Nordic countries need to reconsider the citizen as lacking specific competences, but instead try to map the many different ways in which the digital public encounter happens, and what can be done to support it in a way that is respectful toward citizen diversity. Conceptualising the populations in today's Nordic welfare societies as 'partially digital' is one way of acknowledging that one size of digital service solutions does not fit all. More importantly, however, the partially digital citizen can be considered a result of the ways in which the Nordic countries have chosen to digitise. This persona is the result of designs that have a 'narrow' user as a model. This would not have necessarily become a problem if the organisational implementation had supported a more complex or 'socially thick' user, whose needs are varied and who may need assistance throughout various life phases.[13]

A key characteristic of the way public digitalisation has been implemented has been through the decision to reduce the number of channels through which citizens can get help. [14, 15] This strategy has resulted in state authorities that are experienced by partially digital citizens as 'remote' and hard to access.[16] So while self-service works for some people some of the time, it does not work for everybody all of the time. Exercising their citizenship in a digitalised state has become more difficult for people with disabilities. Increased attention to security in public digitalisation strategies also plays a (negative) role for technical designs that favour collective access and diversity. After the war in Ukraine and a heightening of risk awareness due to hackers, electronic identification has come to play a bigger role, and it is likely that this will continue in the future. Access to public services and citizenship will be even further connected and access to basic services will come to hinge on the availability of a personal identification number issued by the state or other forms of state-sanctioned verification, which poses a challenge for migrants, diplomats, and other cross-bordering populations.

An important characteristic in the way in which the Nordic countries have chosen to digitalise is via close collaboration with private companies, who are thought to be able to successfully drive innovation in the public sector. BankID, Smart Travel Cards and cashless societies are examples of public-private partnerships where observers have commented on problems in relation to taking care of the needs of vulnerable groups. Private vendors do not have the same obligation as the public sector to deliver universal services. However, in the context of digital identity required for access to public services, the citizens are not customers who can just find the same services somewhere else. Building public services (which are obligated to be universal) on a non-inclusive and non-universal infrastructure is problematic and is already a point of attention for the public authorities in the Nordic countries.

How to ensure a socially sustainable Nordic Region

In the Nordic countries, there is a strong sense that we must not lose the advantages acquired through society-wide digitalisation. Currently, public debate and concrete initiatives with respect to digitalisation runs in two parallel tracks. One focuses on growth in the IT industry and private sectors' ability to compete on international markets. The other focuses on the population's general ability to navigate the complex passage of access to public digital services. Proponents for focusing on digital growth tend to see the public sector as a market and public services as a product. They consider problems in service delivery as an issue that can and will be solved by the market. Proponents for considering the social aspects of digitalisation tend to focus on digital inclusion as a matter of human rights and ethics. They consider problems in service delivery as an object for state regulation. The two camps display serious difficulties in understanding each other's position. **It must therefore be a government priority to support initiatives that bring these perspectives into closer dialogue.**

Our research focuses on the everyday work that inhabitants of the Nordic countries must perform to access public digital services. The research shows that the relative success of public sector digitalisation depends on an invisible 'people's army' of formal and informal helpers. Design and policy initiatives must become aware of how to support this group of actors who perform invisible work to make self-service solutions work, and in the long run make it superfluous. NGOs, family networks, friends, and volunteers are critical in the digital welfare state, but they often take on substantial risks as they have to deal with other people's private information. **Government support of the informal digital helpers is therefore needed, but to ensure a socially sustainable region, we need digital services that do not rely on invisible digital helpers.**

Currently, there are only a few or even no mechanisms available for citizens or their helpers to communicate their experiences as feedback to the public authorities, the system owners, and vendors.[17] This is both an issue in the design phases where service design is favoured over participatory design or other methods working towards inclusion, and after implementation. Service design originated in the private industry and must be re-considered as the standard design method in the public sector. **To ensure a better fit between users and systems public calls for tender should include requirements to supplement or replace service design methods to avoid designing for a narrow user.**

The research area in relation to Vision 2030

Since the Nordic Region has been first to digitalise across the public sector, it has also had experience with some of digitalisation's teething issues. We propose the building upon of cultural and historical similarities across the region in tackling the challenges of digital exclusion. It would greatly strengthen the region's ability in leading sustainable digitalisation and its position internationally if it finds a way of putting people at the centre of continued digitalisation efforts. We recommend:

1. Mapping and monitoring the benefits and harms of digitalisation across the Nordic Region.
2. Developing and testing methods for capturing the experience of citizens in the digital public encounter.
3. Including vulnerable and affected communities in the writing of national digitalisation strategies.
4. Ensuring in-person easy-to-access support for digital services for people experiencing difficulties.
5. Translating digital content into minority languages.
6. Tenders must specify web accessibility compliance to WCAG (web accessibility guidelines).
7. Tenders should include and budget for feedback and iterations over the lifetime of a digital infrastructure.
8. The government support of universities and higher education in teaching universal design and intersectional approaches as well as disability culture as foundational across degrees.

Putting people at the centre of continued digitalisation means we need a better understanding of the human as a social creature. Often 'the human' is evoked as a guarantor for ethical, accountable, and fair systems, but when it comes to digital services, the human is in practice often a collective. At present, it is unclear how to digitally support the citizen as a social creature. The Nordic Region has an advantage in humanistic approaches to welfare services and should seek to become a leader in the developing of people-centred systems that are complex enough to avoid exclusion.

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Digitalising law enforcement: A critical guide from the Nordic-Baltic countries and the UK

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The aim of the Critical Understanding of Predictive Policing (CUPP) project is to critically engage with the implications of new technologies and advanced data integration and analysis in relation to police work. CUPP conducts research to provide comprehensive evidence-based interdisciplinary knowledge on the various manifestations of digitalisation and prediction in law enforcement across six national contexts: Denmark, Estonia, Latvia, Norway, Sweden, and the UK. The police constitute a key institution that would benefit from digitalisation, so as to make Nordic government bureaucratic operations more efficient [1], reduce fiscal burdens [2], improve accuracy of decision-making, and streamline data management [3]. Predictive analysis of digital data is ascribed with significant potential to prevent crime in the Nordic context [4]. CUPP constitutes a comprehensive technology assessment to critically study and evaluate new police technologies as well as to inform and build public and political opinion about them. By doing so the project addresses several of the societal challenges highlighted at both the EU and Nordic level focusing on major concerns shared by citizens in the Nordic countries regarding: (i) inclusive, innovative, and reflective societies, and (ii) protecting freedom and security of the Nordic Region/Europe and its citizens.

Major challenges: digitalisation under critique

Based on our fieldwork, digitalisation challenges law enforcement in multiple ways:

Firstly, the police must *either* undertake public procurement of digital police tools, thereby outsourcing core issues of police data to private actors *OR* it must develop substantial technological competencies in-house. Our case studies have shown that outsourcing comes with significant security and privacy risks as well as a loss of control over key features of law enforcement and potential vendor lock-in for specific commercial solutions. For example, in the Norwegian context our partners showed that the value of societal trust is high, and predictive policing must not reduce trust. The development of digital policing technologies has been significantly slower in Norway because of the desire for gradual change in policing and for the safeguarding of trust. Prioritising trust led to abandoning a multimillion police digitisation project. On the other hand, in-house competence capacity-building also comes with a heavy price tag and with a risk of each police department "re-inventing the wheel". This first challenge concerns how the police can develop so as to "own" technology as part of its core: traditional professional roles must change, and technology must become part of how law enforcement is formulated, executed, and experienced.

Secondly, the CUPP project argues that when technology becomes part of the limits of law enforcement, such as how it is pre-set, pursued, and perceived, new questions emerge as to how "analogue" questions of policing – meaning physical encounters between the police and citizens – are translated into binary code. This second challenge concerns algorithmic politics [5], but also the streamlining of administration within law enforcement. CUPP investigates the implications of the digitalisation of law enforcement for the contemporary democratic polity in an era saturated with new public analytics [6]. In line with many critical voices around the datafication of police forces [7, 8, 9, 10], CUPP brings an interdisciplinary magnifying glass over emerging data technologies and organisational practices that enable the digital transformation of the police. For example, investigating the implementation of

the *Status System* – a digital platform used by the Swedish police – has uncovered biased policing practices, where individuals from marginalised communities are disproportionately targeted and subjected to police scrutiny. This can lead to increased distrust between these communities and the police, potentially undermining social sustainability, and coherence.

Similarly, in the Norwegian case, concerns about the quality of data related to the life-course of young offenders in general and of youth resilience, or rather the lack of a holistic oversight of the lives of young people, produces one-dimensional portraits of young lives. This methodology/preventive technique leads to youths being viewed as a threat or danger. Our colleagues in Norway note that in this context, treating youths as a security risk implies consequences for net-widening of control. The CUPP case on the implementation of Face Recognition Technologies (FRT) in the UK showed that this new type of surveillance carries and even exacerbates to a significant extent the very same historical discriminations running through the traditionally divided and polarised UK society. In Latvia, our partners note that the development and implementation of traffic surveillance via digital means may be problematic when considered from the perspective of compliance with fundamental rights, data protection law and democratic principles of governance. In other words, CUPP argues that within this widened landscape, pre-existing inequalities are likely to be exacerbated, while transparency in policing practice can be even more challenging than it has been historically. Moreover, in all cases, several police officers expressed scepticism and reluctance to the digitalisation of their organisations. Some even talk about predictive policing as just being hype and a buzzword. All of this signifies the need for not only shedding light on the social and democratic implications of policing in the age of big data but also acknowledging the rigorous transformations of the working world of police officers through the application of data platforms.

Thirdly, the digitalisation of law enforcement affects how different police departments share data, both vertically and horizontally. Data submitted or harvested by one institution may later acquire evidential character elsewhere in the justice system, as it is interoperably shared between institutions (e.g., border police and migration authorities). Although interoperability[A] is seen as 'a technical rather than a political concept' by the European Commission [11], interoperable digital systems challenge existing structures and cooperation dynamics and also redefine the role of the actors involved in the operationalisation, process, and enforcement of the law at the intersections of executive, legislative, and judicial power [12]. In the Norwegian case, lack of effective interoperability in the developing process of the new police digital platform Omnia led to a public procurement fiasco. In the UK, live facial recognition has been predominantly linked to CCTV cameras, with police rolling out opaque trial operations in many city centres. In Denmark, there is no political/policy debate regarding how data is stored, integrated, and used in the data-driven police platform. In Latvia, the implementation of digital traffic control tools has not changed patterns in traffic behaviour. Our partners from Estonia go as far as to claim that the public is ready to accept digital policing technologies once a practice becomes common, without caring if data selection and sharing is efficient, interoperable, and constitutionally sound. Thus, one of the major recommendations that has emerged from our research work in CUPP is that **the digitalisation of the police must be treated holistically as part of an interoperable network rather than focusing on different parts of the police in isolation.**

A Interoperability is a characteristic of a product or system that works with other products or systems. The term was initially defined as information technology or systems engineering services that allow for information exchange. A broader definition considers social, political, and organisational factors that impact system-to-system performance [13].

Data in the dock

Several voices, including highly ranked police officers and politicians across the countries under investigation, claim that digital or predictive policing can be a rationalising force with the potential to reduce prejudices, increase efficiency, and improve prediction accuracy. However, the use of digital technologies may technologically reify bias and deepen existing patterns of inequality [14]. As mentioned above, this has also been manifested in several of the country case studies conducted in the framework of the CUPP project: digital technologies inadvertently and unavoidably carry legacies of (post)colonial, class and gender discrimination that are maintained along in the algorithms/ontologies dictating the use of data and data platforms.

At the same time, a cautious view of technological optimism (cf. 15) is promoted by proponents of the digitalisation of the police, and the challenge is that there are clear gaps in the division of responsibilities and regulation concerning digital technologies. These solutions and perceptions of data driven police platforms are largely speculative and techno-positive. As became evident in the case studies from Estonia, people's perceptions are significantly influenced by social perceptions of data collection and sharing. For example, biometric data collection was often perceived critically, while sharing passports was considered a common normative practice. However, biometric passports are becoming increasingly common, and the Estonian public does not seem to have the same critical reaction. Based on the findings of the Estonian CUPP team, the development and presentation of data technologies play a significant role in shaping public perceptions. There is a need for political scrutiny that monitors how data driven tools are perceived, presented, adopted, and adapted in law enforcement, and critically problematizes data integration and analysis methods that lead to the criminalisation of certain populations.

In line with CUPP's research scope, this policy brief disseminates knowledge on the latest developments within data driven police practices in the region and promotes a community-based research culture that assists civil society in being able to move closer to achieving Goal 16 of the UN Sustainable Development Goals (SDGs), that is, educating people about the challenges brought about by the digital transformation of policing. CUPP's objective is to contribute to a socially sustainable Nordic region by investigating how social and cultural values, politics, and bias, are perceived, and embedded in data-driven police innovations, as well as experienced, and practiced by citizens, law makers, police officers and developers. To support continuous knowledge exchange with policy and practice in the Nordic region we have, together with PROSA, developed a critical engagement model.

Promoting critical engagement: blowing the whistle of digital police technologies

The CUPP project allies itself with social struggles related to inequality, ethical concerns, human rights, and fundamental freedoms as well as to the various data justice, security and privacy issues raised by the digitalisation of law enforcement and their implications for democracy [16]. CUPP's interventionist approach represents an effort through research to foster knowledge and support marginalised views in relation to the deployment of predictive policing software in the countries under investigation. We do this either by:

- Hypothesising that as relations between citizens and the state are increasingly digitalised, and as private companies are now playing a significant role in developing the infrastructures that deliver policing, political action is needed to understand how transparent police institutions and innovations come into being in practice.
- Conducting research that will hold the police accountable for the justice of their actions and credibility of their analyses.
- Engaging in debate with relevant stakeholders.
- Allying with social scientific research on innovation and critical police studies to shed light on the social dimensions of policing in the age of big data.
- Investigating to what extent police data analytics is a rationalising force with the potential to reduce bias, increase efficiency, and improve prediction accuracy or even the opposite, that is reifies biases and deepens existing patterns of inequality.
- Asking how public participation, transparency, and fundamental rights are ensured in the procurement, implementation, and use of digital policing infrastructures when public and private actors collaborate within these digital infrastructures.

To conclude, CUPP encourages political action that approaches digital innovations within law enforcement in a socially consequential context. CUPP's critical engagement acts as a bridge to the larger population without specialist knowledge. We see the value of critical scrutiny on police data-driven innovations not only for policing, but also for law and regulation mechanisms, criminology, social inequality, and research on big data analytics in other public sector institutions. CUPP puts these innovations, and its democratic implications, at centre stage, and invites political action to strengthen grassroots social institutions, by increasing these groups' access to justice.

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How can patients be in control of their healthcare if they are not in control of their online health information?

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Patient online access to health information

The Nordic Region is world-leading in providing its residents with comprehensive digital healthcare. Unlike in most European countries, Nordic patients have online access to their health records through patient portals, organised at a national level and provided free of charge. Through these portals, patients can retrieve their prescriptions and test results in a timely manner, view their diagnoses, and have access to the notes written by healthcare professionals in clinical consultations. **Research has repeatedly found that online access to these health data provides a variety of benefits to the patient**, such as improved health outcomes and increased trust in the care provided. Online health records, however, are far from perfected in the Nordic countries and research on their development continues.

The problem

Despite the many advances in the development of online health records, **Nordic patients still have unequal and fragmented access to and limited control over their online health information**. There is an ongoing shift towards more patient-centred care where the patient health record is viewed not only as a tool for clinicians to document the patient's medical history, but rather as a collaborative tool for shared decision-making. Yet, health information is challenging to access, find, and interpret, and patients have limited possibilities for interaction, contribution, and control of the information. This goes against the principle of the socially sustainable Nordic Region outlined in Vision 2030 and requires a combined effort to resolve.

We exemplify the problem by discussing three cases where increased patient access to and control over their health information is urgently needed. To evidence our arguments, we use data from a recent survey of 29,334 Nordic patients [1] and draw on our collective expertise in the NORDeHEALTH project to offer possible solutions [2].

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The NordForsk-funded project NORDeHEALTH (https://nordehealth.eu/, no. 100477) studies policies, practices and the experiences of patients and healthcare professionals relating to online health records in Sweden, Norway, Finland, and Estonia [1]. The team includes research, patient and clinician experts from the Nordic countries, as well as the UK and the USA.

CASE 1: Unequal access to information across the Nordic Region

While as a whole Nordic patients have a variety of health data available to them through national patient portals and online health records, this is not necessarily true on a regional level. In 2016, Swedish patients cited **the limited availability of information as the main cause of frustration in using their health records**. Six years later, the results from the 2022 NORDeHEALTH Patient Survey indicate that this problem persists, likely due to high variability in how the local healthcare providers manage health records. This is not unique to Sweden. In Finland, **44% of the reported negative experiences were due to unavailable information**, be it delayed due to local processing policies or missing altogether [3]. In addition, although the patient portals generally have fairly high usability, barriers to using the portals still exist, for example for people with cognitive or functional disabilities, new immigrants without an eID, or those who do not speak the official languages.

Equal access to healthcare is a key milestone when it comes to achieving a socially sustainable Nordic Region by 2030, but today, such equality does not apply to patients' online access to their health records. The autonomy of municipalities, regions and countries in the management of health records means that some patients may miss out simply due to their location or background.

Recommended solutions

1. **Clear information on what is provided in the health record**. Some variability in information access will likely remain, and in national patient portals, it is essential to clearly present these differences to patients to reduce frustration and increase trust.

2. **Design for inclusion**. Equal access to health information requires that everyone can access and use the national patient portal, regardless of abilities, language proficiency, and immigration status.

3. **Introduce prescriptive and not suggestive legislation**. Legislation on what health information should be provided online to patients already exists. It is, however, often only a guideline for the local authorities.

CASE 2: Errors in the health record

Recent findings from NORDeHEALTH indicate that around **a third of Nordic patients find errors in their online health records** [4]. For some patient groups, this number is even higher: half of those who have experience interacting with the mental healthcare services report identifying a mistake [5]. When asked to consider its severity, **up to half of all patients judge the error as *'very serious'***. Described errors can range from relatively innocuous ones such as misspellings and false demographic details to more consequential ones: wrong medication dosage, missing allergies or incorrect diagnoses. Despite the high prevalence of reported errors and many of them considered severe, nearly half of the patients admit to not doing anything to rectify it [4,5]. A closer look at current implementation reveals possible causes.

At present, most Nordic patients can find erroneous information thanks to the widespread availability of online health records but they cannot follow up on it online. Rectification requests are instead made through calls to the administrative staff at the health centre or during their next clinical visit. None of these practices are sustainable. They increase the burden both on the patients, who may lack the capacity due to health or socioeconomic barriers, as well as on the healthcare professionals, whose resources have been strained under a heightened workload since the COVID-19 pandemic.

Recommended solutions

1. **Enable patients to interact with errors online.** If a patient suspects an error, they should be able to flag it to their healthcare provider, request its correction and follow its processing in the online health record, without the need to resort to other services.

2. **Enable patients to supplement their health records.** If a patient finds that important information is missing from their record (e.g. allergies), they should be able to contribute to it online using the same health record platform. Supplemented information could take the form of free-text comments or patient-gathered health data.

3. **Introduce legislation ensuring patients' corrections and supplementations.** Patients' right to have their proposed corrections considered should be enabled by law. Legislation should state that healthcare professionals must take the patient's consideration into account to correct errors that have occurred.

CASE 3: Sharing your health record

Appointing a trusted person, such as a parent, guardian or caregiver, to access and manage one's health record is a practice referred to as proxy access. It is a crucial function for vulnerable patients, who may lack the capacity to use their own health records. Not all Nordic countries provide their patients with proxy access. In countries like Sweden, in the absence of this function, **patients are pushed to use insecure methods of sharing their health records**, such as sharing their login credentials.

Underage patients experience additional legislative challenges that may prevent parental proxy access. Recent NORDeHEALTH research has found **great variability between Nordic countries in the age when parental access is retracted and self-access is provided for minors** [3]. For example, parents in Finland have the possibility to access their child's records until adulthood, unlike parents in Sweden and Norway who lose their access when the child turns 13 and 12, respectively.

At present, unequal opportunities for proxy access contrast with the ambition of shared values promoted by the Nordic region. To achieve increased equality of care and improved health and well-being of vulnerable patients with caregiver needs, it is critical to combine efforts in developing secure portal systems, educating stakeholders, and developing shared principles for the allowance of proxy access.

Recommended solutions

1. **Secure adult proxy access in all Nordic countries.** All adult citizens should have the right to grant proxy access to another trusted adult, who should then have the ability to securely manage their health records online.

2. **Educate clinicians, caregivers, and patients on proxy access.** All parties involved in proxy access should be educated on its benefits, as well as how to safely and confidentially manage a health record to achieve the best care.

3. **Introduce legislation enabling patients to share their health records with care partners.** Define a common policy within the Nordic countries for adult and parental proxy access, especially for minors aged between 12 to 18 years.

Summary

Today, Nordic patients experience great challenges in fully utilising the benefits of online access to their health records due to having insufficient control over them. Patients face information inequality between and within the Nordic countries, they find errors embedded in their medical records that are challenging to rectify, and they experience difficulties in sharing their records with trusted caregivers. Together, our region can solve these issues through socio-technical improvements in online health records and changes in legislation (see Figure 1).

Recommendations for patient control over online health records

GAIN EQUAL ACCESS	CORRECT ERRORS	SHARE RECORD
1 Clear information on what is provided in the health record.	**1** Enable patients to interact with errors online.	**1** Secure adult proxy access in all Nordic countries.
2 Design for inclusion.	**2** Enable patients to supplement their health records online.	**2** Educate clinicians, caregivers, and patients on proxy access.
3 Legislative changes to enable these solutions on the local and national level.		

Figure 1. Solutions to increasing patient control over their online health records.

PREPARED BY NORDeHEALTH

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Nordic Research and Digital Research Infrastructure

Planning for Long Term Success

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Summary

Nordic digital research infrastructure enables extensive collaborations on the topics we perceive as having collective Nordic value, i.e. our societal structures and values (such as trust), and our shared history (including languages). Our geography, close proximity, and interconnections provide the basis of the advantages – as well as some of the challenges – of our ability to achieve Vision 2030. Nordic collaboration on digital research infrastructure has proven its value in responding to the needs of Nordic research teams to work together on complex or large-scale problems, such as: biodiversity, climate change, fundamental constituents of matter, health, and sensitive human genomic data, natural language processing. These Nordic collaborations offer a unique level of insight for policy making when it comes to implementing Vision 2030 for sustainable research efforts. The Nordic collaboration on digital research infrastructure has achieved this by developing services and sharing competencies for supercomputing, data management, and training for researchers and the next generation of software engineers.

The level of trust, combined with shared common values, gives the Nordic countries a unique advantage in sharing research and public data across borders, for both research and the common good. This requires digital infrastructure for research built on long-term efforts in coordination, funding, and leadership in working with research communities and a wide range of stakeholders across academia, the government, and industry. National efforts already exist in the Nordic countries to create and update national roadmaps of the current and future requirements and justifications for their research communities within each country as well as the larger European and global context. These efforts need to be built upon and extended through a Nordic effort to foster a regional research digital infrastructure roadmap, as well as the structure to implement it and an appropriate environment to support the regional Nordic digital research infrastructure.

Policy recommendations

Create a roadmap and a plan for developing Nordic-scale infrastructure collaborations in key areas of digital research infrastructure, such as: biodiversity, climate change, health and sensitive data, artificial intelligence, including large language models for Nordic languages and natural language processing, quantum computing and supercomputing and so on.

- This roadmap must look ahead to the common needs of researchers over at least the next decade and be developed in consultation with stakeholders from the NCM digitisation initiatives, the national funding agencies, and the national digital research infrastructure providers in each country.
- It should also take advantage of the potential interactions with longer-term European goals and initiatives.

Develop and implement a set of best practices for organising, recognising, and realising the benefits of the long-term commitments to implement the roadmap.

- The transition of the digital research infrastructure development efforts – specifically in the areas of software, policies, and structures through sustainable support mechanisms – into fully realised services available to academic and industrial researchers across the region will depend on this.

Structure a funding model for the long-term roadmap for digital research infrastructure.

- It is essential to provide a consistent framework for funding the development of digital services that spans across borders and national funding agencies.
- This will necessarily require the administrative willingness and legal ability to support the use of resources and services by Nordic researchers across the full range of nationally funded digital resources.

Nordic Digital Research Infrastructure is integral to all research domains

The Action Plan for Vision 2030 included two major relevant topics relating to digital research infrastructure:

- Objective 6: Help to build up shared knowledge and research.
- Objective 8: Develop Nordic research infrastructure.

As part of NordForsk, the Nordic e-Infrastructure Collaboration (NeIC) has addressed these topics through a set of collaborative digital research infrastructure projects in a broad set of research domains. Digital research infrastructure is truly horizontal across research areas and is both critical and integral to nearly all research, and in particular, for collaborating and the sharing of data as well as knowledge, thus enabling research across many fields and responding to the needs of research teams that cross national boundaries, both within the Nordic Region and also in Europe. NeIC has worked with projects that have proven their value in working on large-scale problems (e.g., particle physics, biodiversity, climate change, sensitive human genomic data, natural language processing, supercomputing, quantum computing, and training for next-generation software engineers) to create new digital infrastructure software and skills and to work towards mechanisms to sustain them.

Digital infrastructure for research requires long-term efforts in coordination, funding and leadership in order to work with research communities, given that bringing this infrastructure into use within the research arena is through an iterative process. This consists of identifying the need, creating and testing possible approaches, implementing the approaches for the different digital research infrastructure environments and communities, and then following up to sustain the results and outcomes. A key aspect of such future work needs to be on the long-term efforts in collecting, maintaining, and sharing data among the researchers in the Nordic Region in ways that meet the international expectations of being *Findable, Accessible, Interoperable,* and *Reusable* (FAIR data). This means collaborating on what is referred to as "data infrastructures" to preserve and "democratise" our combined data in many of the research areas mentioned in this paper. With the level of collaboration present in the Nordic Region, it is possible to work on technical solutions that cross national boundaries, take advantage of the different capabilities and strengths in each country and meet the needs of the researchers to deal with problems that are beyond the capabilities of any individual country.

Currently, there are strong national, Nordic, and EU efforts in many fields working towards developing solutions that address a range of research problems at different scales and with different goals. One important aspect of Nordic collaboration is that it has been working to apply the resultant digital infrastructure to a broad range of research domains through the Nordic e-Infrastructure Collaboration that brings together the five Nordic and one Baltic national e-infrastructure providers, consisting of: Sweden's National Academic Infrastructure for Supercomputing in Sweden (NAISS), Norway's Sigma2 AS, Denmark's Danish e-infrastructure Cooperation (DeiC), Finland's CSC – IT Center for Science Ltd., Iceland's Icelandic University Research Network (RHnet) and Estonia's Estonian Scientific Computing Infrastructure (ETAIS). These national e-infrastructure providers acquire and operate the digital research infrastructure with a focus on sharing computing resources, research data, expertise, and skills within each country, thus enabling such infrastructures for their respective research national communities. The goal of the Nordic e-Infrastructure Collaboration (NeIC) is to expand these broad sharing capabilities across the Nordic Region in multiple fields of research infrastructure.

Thinking and planning for long-term solutions to long-term problems

The process of creating and sustaining digital research infrastructure can span years as the research problems grow more complex and have to take into account better data, computing capabilities, and an understanding of reality. The collaborations that work on both the research problems and their technical solutions need a world-class digital research infrastructure in each country and across the Nordic Region to effectively support the goals of becoming increasingly green, competitive, and socially sustainable.

Because of the long-term nature of research and the necessary digital research infrastructure, it is critical that there are plans for tracking and addressing these needs. National efforts do exist within the Nordic countries to create and update the respective national roadmaps of the current and future requirements and justifications for their research communities within the country. The next step then – working on a roadmap that builds on the national capabilities to the advantage of all researchers in the Nordic Region – remains to be realised. This roadmap effort will extend the national capabilities and deepen and further build on the interaction networks of researchers and digital infrastructure providers across the region, thus increasing their effectiveness and reach. This type of work depends on a long planning horizon for both the work and the funding environments.

The second component is to have a structure in place that is able to plan long-term, at least for a decade, for the creating and maintaining of the collaborations that support the implementation of the roadmap in coordination with the national digital infrastructure providers, research communities, and other stakeholders. This structure, embodied in a Nordic digital infrastructure organisation such as NeIC, would complement the digital research infrastructure institutions in each country by providing a known and predictable path for continuous improvement in the development of Nordic digital research infrastructure. The role of the Nordic digital infrastructure organisation is to provide the framework for collaborations on the development of essential software environments, tools, and training as well as for sustainability models for the resultant infrastructure.

An excellent example of this is in particle physics (CERN) with the combination of national computing, data, networking, and operational support across four countries into a Nordic data processing capability that is used as a single entity by the global high energy physics community and is recognised as being world-class since 2006. A second example is in the area of sensitive human genomic data and the ELIXIR distributed infrastructure for life-science data. The Nordic effort was initiated in 2014 to develop a strong cross-border collaboration around sensitive data involving digital infrastructure, data providers and researchers as a series of three successive development projects. The Nordic sensitive-data infrastructure service has been created at a lower cost than if each country had performed the development by itself and provides a model for secure cross-border data services for health research throughout Europe. In another area of great relevance to Nordic societies, NeIC has also nurtured Nordic collaboration on natural language processing. Joining forces on large language modelling for the Nordic languages may become increasingly important for the public sector in the future in order to manage digital language data in national archives. The NeIC collaborative projects are one key reason for the recognition of the Nordic countries and the trust to lead large European technological efforts that are larger than the countries would have accomplished individually, and clearly shows the added Nordic value of a structured digital research infrastructure organisation such as NeIC that has generated strong support through the national digital infrastructure providers in the Nordic countries.

In order to continue these types of deep Nordic collaborations in the 2025–2030 timeframe, an appropriate funding model needs to be in place for long-term digital research infrastructure. Beginning in 2013, NeIC has – as part of NordForsk – been working under a 10-year Memorandum of Understanding between the national funding agencies and NordForsk that focused on supporting the long-term needs of particle physics researchers and fostering Nordic collaborations. This decade-long window has enabled digital infrastructure teams to develop and deploy in-depth infrastructure approaches that address real-world problems that are scientifically and societally important. A model for the future digital infrastructure with a long-term view is essential for providing a consistent framework for the digital services that stretch across borders and national funding agencies, to enable the creation and continuance of highly beneficial Nordic collaborations.

Harnessing Collective Intelligence to Strengthen Democracy in the Nordic Region

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This policy brief presents recommendations from the COLDIGIT project on how to mainstream the use of democratic innovations such as participatory budgeting and citizens assemblies in the Nordic countries.

Digital technologies have revolutionised the way we live, work, and interact with each other. They pose both a risk and an opportunity for our democracies. On the one hand, digital technology has fuelled misinformation and the misuse of data which risks undermining trust and participation; on the other hand, technology provides innovative approaches to the deepening and scaling up of our ability to collaborate, deliberate and make decisions together as a society.[1] As policymakers in the Nordic Region aim to achieve their vision of a green, competitive, and socially sustainable society by 2030, deepening participation from citizens is more relevant than ever.

Although the Nordic countries are often viewed as strong examples of well-functioning democracies, they still face several democratic challenges.[2] These include increasing voter turnout, especially for younger generations less engaged in traditional political activities, and addressing rising income disparities that undermine social trust and erode the Nordic welfare model. Similarly rises in populism and extremism challenge democratic norms, create divisions within society, and potentially undermine trust in democratic institutions.

Working with the cities of Helsinki, Trondheim and Gothenburg the *Collective Intelligence through Digital Tools project* (COLDIGIT) explores how we can mainstream the methods used to transform how public institutions tackle complex societal issues and use digital tools to involve citizens in decision making, such as citizen assemblies and participatory budgeting (PB), and how to improve the quality and legitimacy of democratic governance in the Nordic Region. We have combined work with cities with analyses of global best practices, from Taiwan to Paris, to develop tools and methods for cities and municipalities to identify barriers to democratic innovation and how to address these.

The need for democratic innovations

Our current political systems are struggling to provide the scale and speed of decision-making required to tackle the crises facing our democracies. A study across 17 advanced global economies found that a median of 56% of people surveyed and 34% in Sweden believe there should be major or complete reform of their political systems.[3] In the Nordics Region, this appetite for change is fuelling a growing demand for increased citizen power in political decision-making. A recent survey found that 700,000 Finns would like to participate in decision-making more than they do now, if only it were easier – while at the same time, less than 20 per cent of elected representatives and public officials thought the public had an adequate capacity to participate in discussions concerning complex decisions.[4]

Governments and municipalities have sought to address these challenges, particularly the increasing need for participation, by introducing democratic innovations that deepen the role of citizens in governance processes by increasing opportunities for participation, deliberation, and influence.[5] Democratic innovations go beyond traditional forms of engagement such as town hall meetings and enables citizens to directly influence final decisions – for instance, through PB, deliberative polls, and citizens' panels.

The use of these innovative approaches has seen rapid growth over the last five years.

Citizen Assemblies – where a representative group of citizens (typically 50–200 people) are asked to learn about, deliberate upon, and make recommendations regarding a particular issue or set of issues, such as legalising same-sex marriage or adapting to climate change – is now used by all levels of government, from the EU and national governments to cities and municipalities. The President of the European Commission, Ursula von der Leyen, has noted that "citizens' panels should become part of the way we make policy."[6] Similarly, PB – where citizens are given the mandate to decide how to allocate part of a municipal or public budget through democratic deliberation and decision-making – was used in over 14,000 places by 2021.[7] The popularity of PB can be explained by the fact that both the World Bank and the United Nations have recommended it as a good practice to use in order to develop better governance practices and enhance the health and well-being of the population.[8] Ten countries have even mandated it by national law.

Lessons from COLDIGIT

To understand the opportunities in the application of collective intelligence methods and tools to better engage citizens in solving public problems and how better to mainstream these, the COLDIGIT (2020–2023) project has focused on four core activities:

- **Creating a platform**[9] for cities and public institutions which contains 150 digital democracy tools and real-life cases illustrating their use in public sector processes ranging from decision-making and planning to examples of co-creation, crowdsourcing, and crowdfunding.
- **Reviewing the evidence** on main barriers and enablers of democratic innovation and digital participation, based on both a review of academic literature and the analysis of global best practice examples, such as the g0v project in Taiwan, the world's largest Participatory PB in Paris and the Decide Madrid platform in Madrid.[10]
- **Learning from citizen participation experiments** designed together with our project partners in three Nordic cities. A city-wide PB process in Helsinki, PB processes run by a housing company in Gothenburg, and a citizens' assembly on a municipal master plan in Trondheim. To evaluate the quality and impacts of democratic innovations more comprehensively, we have applied an innovative *Co-Creation Radar* evaluation framework[11], to which Business Finland awarded major funding to develop it into an international evaluation service.
- **Developing the Deliver–Expand–Embed framework and toolkit** (Figure 1), to advance better adoption of democratic innovations in the Nordic Region. The framework identifies typical barriers to using and mainstreaming democratic innovations in the public sector, such as inequality and access to poorly designed technological solutions, lack of trust and concerns over privacy and entrenched power structures, and the challenge of balancing competing interests in decision-making processes.
- **Leadership** is needed to overcome these barriers and ensure resources and skills needed to overcome them. The framework and accompanying toolkit for public institutions has already been used by municipalities in Sweden, Norway, Finland and the UK to design and develop new approaches to addressing barriers and scaling democratic innovations.

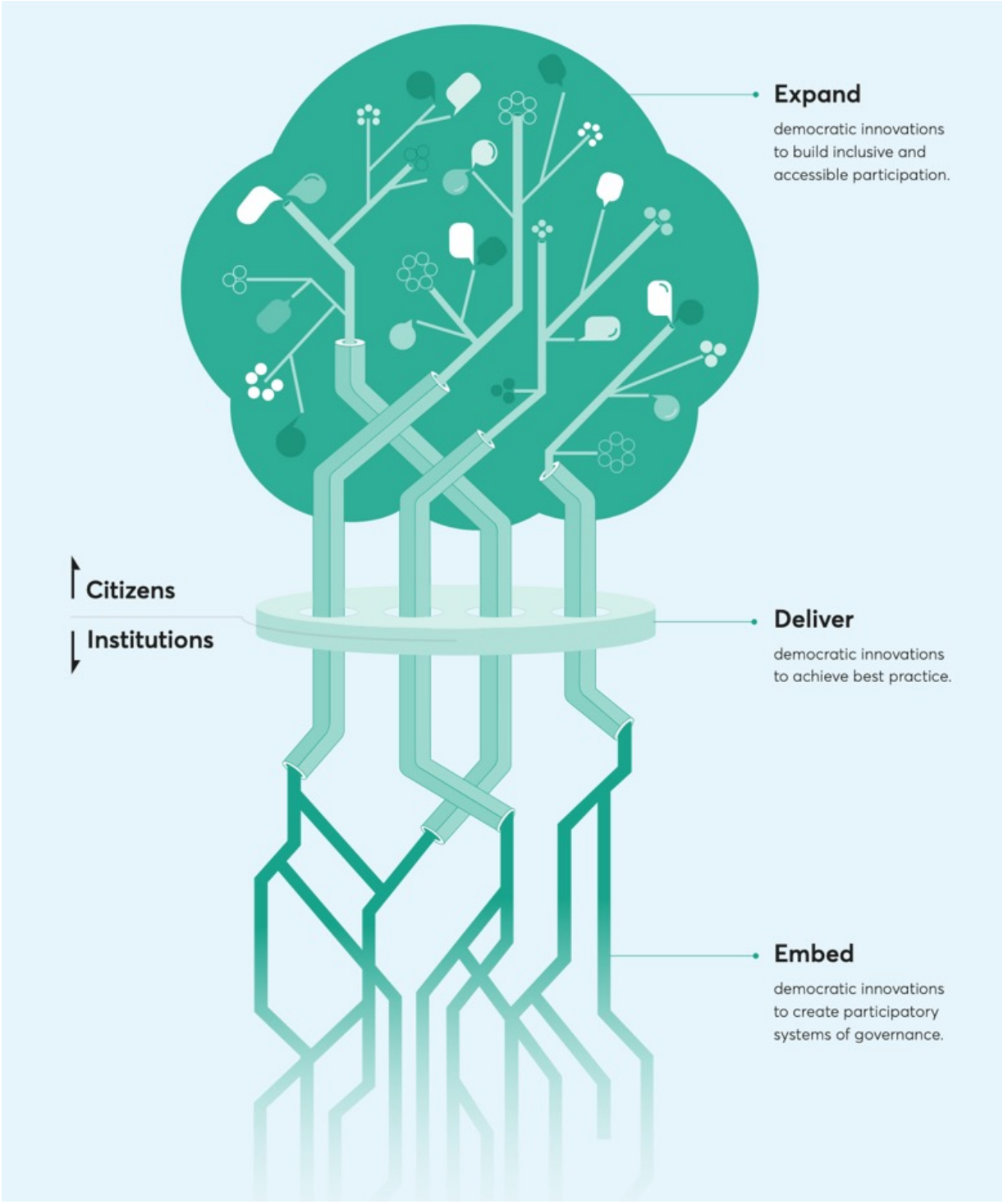

Figure 1. Deliver–Expand–Embed Framework

Recommendations

The Nordic Council of Ministers' Vision 2030 presents an ambitious plan for the Nordic Region to emerge as the most sustainable and integrated area globally. To realise this vision, we must leverage the potential of digital solutions and foster citizen participation in policy-making processes, tapping into the collective intelligence of our communities. This paired with high levels of digital literacy and strong democratic traditions could help make the Nordic countries a test bed for systemic democratic innovation. As we strive to reach these goals, we propose the following recommendations to strengthen the path forward:

1. **Enhance digital infrastructure and develop inclusive participatory tools tailored to local needs:** Invest in research and development to create and improve digital tools for citizen participation, such as online voting platforms, virtual town hall meetings, and interactive maps. Tailor these tools to the specific needs of each municipality, ensuring they are accessible, user-friendly, and integrated with existing city digital innovation and R&D initiatives, such as smart city projects. Enable learning and collaboration on the use of democratic innovations across municipalities in the Nordic Region.

2. **Establish dedicated teams and institutions for digital citizen participation:** Create new teams and institutions responsible for managing and maintaining digital participation initiatives at the municipal level. These teams should work closely with decision-makers to ensure that citizen input is incorporated into policy-making processes and has a measurable impact. Additionally, they should facilitate knowledge sharing and capacity building within and beyond core teams to promote the widespread adoption of democratic innovations.

3. **Foster inclusivity and diversity in citizen participatory processes:** Develop strategies for recruiting diverse, representative panels of citizens to participate in digital democratic processes. Ensure that individuals from various backgrounds, ages, genders, ethnicities, and socio-economic statuses are included, to reflect the full spectrum of perspectives and experiences within the community.

4. **Implement capacity-building and skills-development programmes:** Design and offer capacity-building programmes to equip municipal experts with the necessary skills and knowledge to effectively participate in digital democratic processes. Provide training, education, and resources that cover both general digital literacy and specific participatory methods, such as crowdsourcing, deliberative democracy, PB, and citizen juries.

5. **Secure long-term funding and integrate democratic innovations into existing processes:** Move away from funding short term democracy pilots. Ensure that financing for digital democratic innovations is embedded in core municipal funding and not treated as tokenistic or temporary. Integrate democratic innovations into existing decision-making processes, such as city planning, budgeting, and policy-making. Establish binding commitments to participation and consider shifting power to citizens through increased engagement, transparency, and accountability.

6. **Invest in R&D and AI for democracy and new technologies:** Continue to invest in the development and usability of digital tools for democracy and make the Nordic Region a leader in this field. Align this with investments in Artificial Intelligence to explore how AI could be used to foster larger and higher quality forms of participation and deliberation online.

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How Can Libraries Foster Civic Engagement in Digital Public Service Development?

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Executive summary

Rapid digitalisation in public services in the Nordic countries inevitably excludes citizens who have limited digital skills. At present, public libraries are playing a crucial role in helping such citizens in closing this gap, thus assuming a *buffering* function between public services and disadvantaged citizens. This policy brief recommends supporting this role and further expanding it by creating an institutional model for civic engagement in the public libraries which bridges citizen needs and public service development.

What is the issue?

In the last decade, rapid digitalisation of public services has been a priority on the political agenda across the Nordic countries [1] and they have become leaders within the EU [2]. While the widespread application of digital technologies in government services has several benefits and represents a clear competitive factor for Nordic countries, it also adds a layer of complexity to the relationship between public administrations and certain citizens who have limited skills when it comes to using digital services. This digital inequality is most visible among older people, who are typically slower learners of digital technologies, or migrants, who may not be familiar with the common procedures in public services of their host countries. This creates a gap between public service offerings and the digital capacity of certain citizens, which exists even in the world's most digitalised countries: A recent report by the Danish Agency for Digital Government estimated that approximately 17 to 22% of the Danish population is exposed to the risk of exclusion from digital services [3].

The findings of the NordForsk funded Civic Agency in Public E-service Innovation (CAPE) project clearly demonstrate that this divide exists despite the best efforts of public authorities to reach the largest possible part of the population with the digital services they introduce. Our investigation on public service development suggests that the most viable strategy to reduce the gap is to enable digitally vulnerable citizens to influence how digital services are designed. This approach would allow developers to create more inclusive services and anticipate potential pitfalls up-front. Our mapping of public service development practices shows that user engagement – such as the active involvement of citizens in co-design workshops – is still quite rare in the public sector. The gap between the citizens' capabilities and digital public services, however, will always persist, though in limited forms, as the result of ever-changing technologies, physiological and cognitive limitations, or cultural differences among citizens. Neglecting this gap could pose a threat to the ambitions of a socially sustainable Nordic Region as outlined in Vision 2030.

How do the libraries address the issue?

Libraries are critical physical and social community infrastructures [4]. As seen in our research and previous studies, libraries have, over the past few decades, transitioned from being repositories to becoming centres of digital inclusion [5] and for mitigating a variety of social problems [6]. While trust in public institutions is declining, libraries are seen as credible places for the residents of the three Nordic countries studied in the CAPE project. It is therefore no coincidence that they have become the first touchpoint for those struggling to access and understand new digital services. Libraries currently play a crucial role in facilitating citizen access to new digital services as well as in cultivating digital literacy among the most vulnerable groups. For example, volunteer-driven IT helpdesks in many Nordic libraries offer the extra care and support needed by older citizens that cannot be offered by public citizen offices due to the lack of time and resources (see 7). In this sense, libraries perform a *buffering* function, that bridges the support of the public authorities and the limited digital capabilities of the most vulnerable citizens (see Figure 1). This buffering provides needs-based, flexible help which can range from resetting a password to understanding how to better use one's phone camera. All of this essentially contributes to making those citizens independent.

What is the opportunity

The buffering services offered in many public libraries holds the opportunity to develop an institutional model whereby buffering services are utilised to communicate citizen needs directly to public service developers for service improvements (see Figure 1). Public libraries have an undiscovered potential as hubs for engaging users in design and innovation [8]. The latest IFLA-UNESCO Public Libraries Manifesto [9] also recognises this potential and sets an objective for public libraries "to support the design of services that meet local needs and contribute to improving quality of life". Our proposal follows this recommendation by suggesting the expanding of this buffering function to include citizen engagement in public service improvement. Libraries already promote active citizen engagement to meet local needs through volunteer programmes, interactive displays, workshops, makerspaces, co-creation activities, user-driven innovations, and book clubs [10].

In the CAPE project, we have studied how volunteer-driven IT helpdesks in public libraries can bridge the gap between public services offered and the capacity of digitally vulnerable citizens (see Figure 1). For example, in the release of a new national identification service in Denmark called MitID, an IT helpdesk bridged the gap between the public support service and the needs of the elderly in a local community. We have further explored how the knowledge that is generated and embodied in buffering services can contribute to improving public services. Buffer services like an IT helpdesk service would decrease the digital inequalities existing in a local community. A greater demand for the buffering services indicates a greater number of individuals affected by the inequalities. The demand is dynamic, and more buffering may temporarily be needed, for example, at the release of a new version of a digital public service. Most importantly, the volunteers operating the IT helpdesk accumulate knowledge about the needs of digitally vulnerable citizens which then has potential value for public service developers – this knowledge, however, currently does not reach the developers. As illustrated in Figure 1, our proposal is to build a *civic bridge* between citizens and service developers to communicate citizen needs from the buffering services to the public service developers and by so doing, enabling direct contact between public service providers and citizens (see Figure 1). As proof of concept, the CAPE project has established a bridge between a volunteer-driven IT helpdesk and the public service developer in the MitID-case mentioned above, and successfully exchanged information on citizen needs and the further development of MitID.

Within the proposed model, new buffering services and civic bridges can be developed based on public service issues identified in local communities. This is not limited to IT-related problems and digital services. In a Swedish case, we developed a buffer service in a socially challenged community together with librarians at a local library and residents to support immigrant women in job seeking. To reach full impact the proposed institutional model for a civic bridge requires scaling the operation in a network of public libraries across the Nordic countries as well as infrastructure to support efficient knowledge sharing between citizens and public service providers on citizen needs and digital inequalities. We believe the proposed institutional model could have substantial impact on social sustainability in the Nordic Region as outlined in the ambitions for Vision 2030.

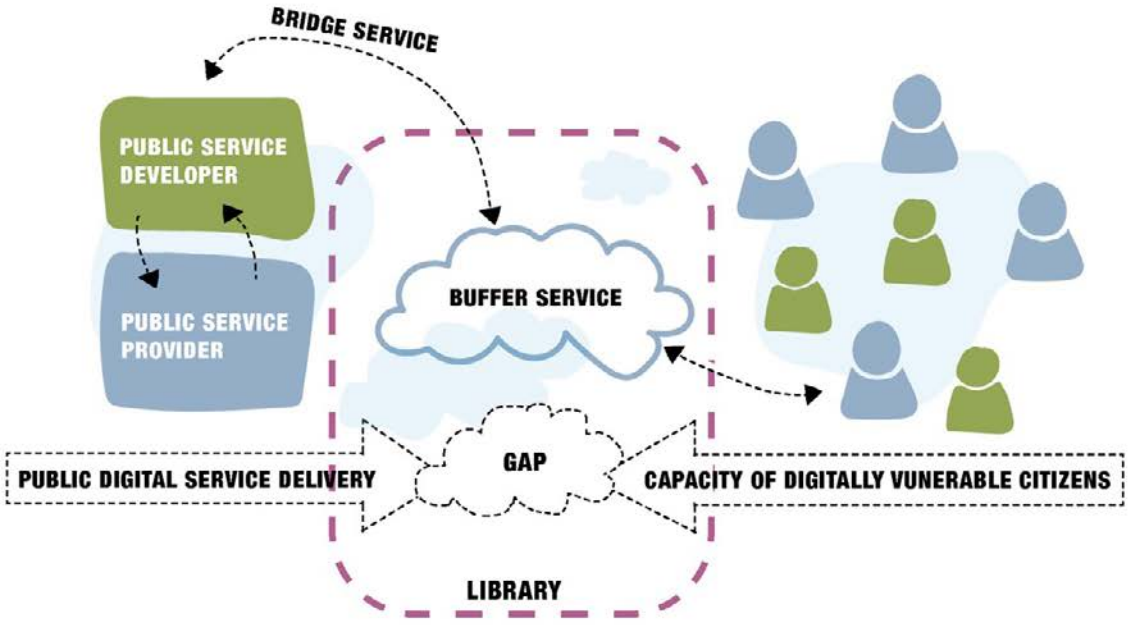

Figure 1: An institutional model with buffer services and civic bridges between citizens and public service delivery (Illustration: Alicia Smedberg)

How could libraries support vision 2030?

We believe that libraries will play an important role in contributing to the realisation of the social sustainability goal of Vision 2030. Successful social sustainability initiatives require local actions which enhance the well-being of communities and promote social justice, inclusion, and equitable access to public services and resources. This local focus and experience in providing services that lift the barriers for citizens from all walks of life in accessing public services are the core strength of the libraries. Building on this strength, supporting libraries to act as civic bridges between citizens and digital service developers will contribute to empowered communities and the development of inclusive public services that reflect the citizens' latent needs and capabilities.

What could policy makers do?

To act as hubs for citizen-driven improvement and development of public services, policy support is needed for the libraries to adapt their own strategies, structures, and capabilities.

- **Involve libraries in the dialogue surrounding digitalisation to ensure that libraries are an integral part of local and national digitalisation strategies and efforts.** Given the unique mission of the library services, governments should ensure that national and local digitalisation plans, policies, and strategies include community-based institutions such as libraries.
- **Develop strategies that acknowledge and support libraries in reducing digital inequality and acting as a bridge between citizens and public service developers.** The diverse roles libraries and librarians assume in bridging the gaps in their communities must be acknowledged and supported by legislators, policymakers, and public-sector strategists. This role must be part of relevant legislations and long-term strategies for digitalisation, culture, literacy, and education.
- **Promote capacity building in libraries to develop as platforms supporting public service innovation by facilitating dialogue between citizens and public sector service developers.** Policies and strategies must ensure that libraries have the right staff, appropriate resources, and training to develop capacity for citizen-driven innovation work. Training should be provided to help library staff develop skills in citizen and community needs identification, innovation, and co-creation with various stakeholders.
- **Provide resources to enable libraries to contribute to removing the inequalities fuelled by the digitalisation of public services and to contribute to inclusive service development.** Governments must ensure that libraries are able to provide free access to digital literacy and other activities that actively target social exclusion in a safe and welcoming environment, aimed at all people. Material and human resources are needed to create commitment, ownership, and space for libraries to assume the role of civic bridges between citizens and public service providers.
- **Create infrastructure that stimulates knowledge exchange and synergies among actors involved in the design and delivery of public services.** To ensure sustained results there is a strong need for establishing formal structures and processes that make civic bridges work as an integral part of the libraries and public service developers' everyday operations. Such processes and structures should ensure ongoing and transparent knowledge flow between the public sector, libraries, and citizens.
- **Ensure support for building partnerships.** Cooperation with diverse partners such as community organisations, volunteer groups, and public organisations is key for libraries to reach a wider public.
- **Promote knowledge exchange across Nordic countries.** Libraries across the Nordic countries should share their experiences to enhance and scale their learnings.

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Natural Environment, climate, and eco- and foodsystems in the Nordic Region

The natural environment is our most valuable resource when it comes to healthy food, healthy lives and sustainable industry in the Nordic Region. These articles outline the challenges and opportunities interlinked through the need for responsible and sustainable use in order to mitigate climate change and ensure healthy ecosystems and food systems in our region.

Climate and marine-ecosystem intelligence for a green and competitive Nordic Region

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Shuting Yang, Danish Meteorological Institute
Torben Koenigk, Swedish Meteorological and Hydrological Institute
Francois Counillon, Nansen Environmental and Remote Sensing Center, Norway

Executive summary

Operational climate and marine ecosystem services are urgently needed at the Nordic level. These services are crucial for combating the climate and marine ecosystem emergencies currently threatening the region. They are also needed to manage climate risks and to increase resilience in transport, construction, and food sectors, as well as to develop a renewable energy sector to achieve carbon neutrality. They are important for managing human activities to ensure a healthy marine ecosystem and sustainable fisheries.

We identify two priorities for developing climate and marine-ecosystem services[A] that capitalise on world-leading Nordic research. First, fully integrated climate and marine ecosystems models need to be developed to predict changes on seasonal-to-decadal timescales. Second, services need to be co-developed with a fundamental understanding of societal needs. This requires trans-disciplinary collaboration among climate and ecosystem researchers, computational scientists, and social scientists, with the active participation of all users.

Cooperation is needed at the Nordic level to address the common challenges that we face. Combining expertise and infrastructure will have major synergistic benefits. The shared cultural and societal values will facilitate the co-development of solutions to achieve a green and more competitive Nordic Region.

Introduction

The Nordic Region is making excellent progress towards *Our Vision 2030* of becoming the most sustainable and integrated region in the world by 2030. However, becoming *a green Nordic Region* requires a greater reduction in greenhouse emissions. In addition, climate change and other anthropogenic factors are negatively affecting marine ecosystems, both in the Baltic Sea and the Barents Sea. At the same time, economic growth must be green to achieve *a competitive Nordic Region*.

Progress on these issues requires climate and marine ecosystem intelligence at a Nordic level. This policy brief outlines the status of the required knowledge institutions and provides recommendations on their development.

A By marine ecosystem services we envisage the provision of information on the status and future changes of the marine ecosystem, in an analogous manner to climate services.

The unique challenges and opportunities facing the Nordic Region

The Nordic Region is experiencing unique and rapid climatic, ecological, and societal change. The Arctic has warmed three to four times as fast as the rest of the globe causing rapid and disproportionate changes in the climate and marine ecosystems. At the same time, globalisation has brought about dramatic consequences for small communities in the Nordic Region. Achieving carbon neutrality and the sustainable use of marine resources is a significant challenge under these circumstances.

Adding to this complex situation, the adverse consequences of long-term changes are most acutely felt by society through extreme, short-term events. An iconic example is the so-called North Atlantic "mackerel fishing war" of 2010 to 2014 between the Nordic Countries and the European Union. It was caused by mackerel moving north beyond country fishing zones, due to the sudden warming of the North Atlantic Ocean. Another example is the ten-fold increase in energy prices in southern Norway in the summer of 2022. The installation of two large cables allowing the sale of power to Europe and the conflict in Ukraine were already causing rising prices. However, extreme dry conditions strongly limited hydropower production and caused the large price spike.

Predicting these types of climate-driven events provides a major opportunity to better manage and develop renewable energy and marine-ecosystem resources. These timescales are very relevant to decision making on immediate and pressing issues. However, providing the information in a useful form is a challenge that requires full engagement with the users.

Nordic research lays the foundations for climate and marine ecosystem services

A green and competitive Nordic Region requires climate-optimised renewable energy systems, resilient farming and aquaculture, and sustainably managed marine resources. For this we need the answers to questions such as: when and where it will rain; how long and strong will winds blow; will it be a harsh winter with high energy demands; and how will climate influence marine ecosystems over the coming years and decades? Climate and marine ecosystem services are central in being able to answer such questions.

A range of research projects have made progress on these issues. These include the NordForsk funded GREENICE and ARCPATH projects[B] [1,2]: Climate predictions have been developed. First applications of marine ecosystems were demonstrated. Climate services are being developed in different centres. The following cases highlight breakthrough achievements from Nordic researchers.

B GREENICE: Impacts of sea ice and snow cover changes on climate, green growth and society, NordForsk, Top-Level Research Initiative (Project no. 61841); ARCPATH: Arctic Climate Predictions - Pathways to Resilient, Sustainable Societies, NordForsk Centre of Excellence (Project no. 76654).

CASE 1: Predicting climate-driven shifts in marine ecosystems

The North Atlantic Ocean underwent rapid warming in the mid-1990s that extended all the way to the Arctic. In addition to affecting mackerel, these changes were felt across the marine-ecosystem, from bluefin tuna in the North Atlantic, to cod in the Barents Sea. The warming was driven by a strengthening of the major ocean currents that occurs every few decades.

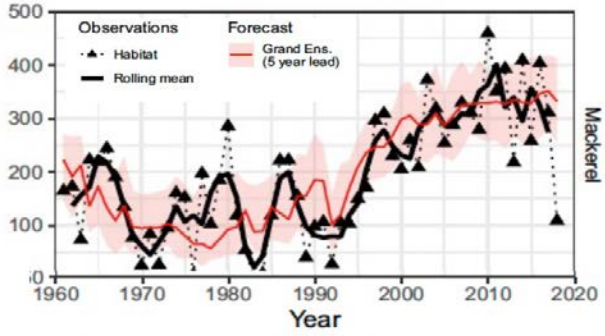
Numerical climate prediction systems can predict these oceanic changes [3]. When combined with empirical models, the recent shifts in mackerel and bluefin tuna can be predicted ten years in advance [4] (Fig. 1A). These approaches can be extended to predictions of Barents Sea cod and other major fish stocks [5]. **These systems are now predicting declines in bluefin tuna and cod.**

CASE 2: Predictions to support renewable energy and agriculture

Weather patterns in the North Atlantic also underwent a major shift in the mid-1990s. During this period the Nordic winters were warmer, wetter, and stormier, while southern Europe was drier and less stormy. Since then, storminess and rainfall have decreased in the Nordic Region and increased in southern Europe. These changes in weather patterns have been linked to changes in ocean currents mentioned above [6].

For the first time, exciting new research has shown that these changes in weather patterns can also be predicted [7] (Fig. 1B). This offers unexplored opportunities for climate services in the Nordic Region. For example, predicting long-term changes in winds is important for the planning of new wind-energy parks [8], while seasonal predictions could optimise the use of renewables across Europe, thus avoiding prices spikes as mentioned above. In addition, they can facilitate agriculture in becoming more climate resilient.

(A) Predictions of Mackerel habit areas (10^3 km^2) for the next 5 years.



(B) Predictions of rainfall for Nordic region for the next 2-9 years.

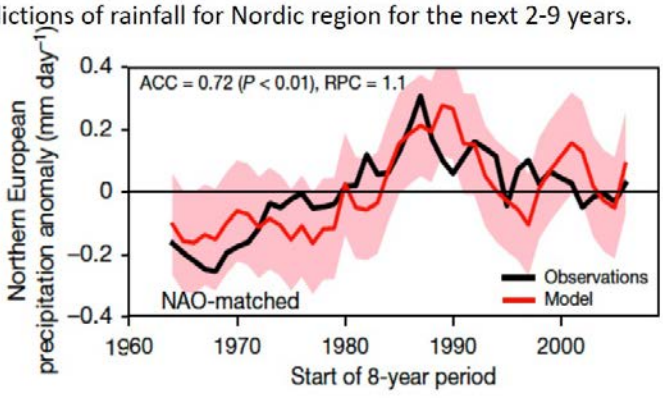


Figure 1: Illustration of emerging capability to predict marine ecosystem and climate in the Nordic Region on multi-annual timescales. The ability to predict changes is assessed by performing retrospective predictions. Model predictions are shown in red and historical observations are shown in black. The predictions are based on climate models, including those developed in the Nordic Region. The figures are adapted from Payne et al. 2022 [4] and Smith et al. 2020 [7]. More details can be found in those articles.

Trans-disciplinary cooperation is needed at the Nordic level

Climate and marine ecosystem services are needed to ensure a green and competitive Nordic Region by 2030. Nordic research has prepared a solid basis for developing such services. To complete the development and operationalisation of these services, further research and innovation is now needed in two priority areas.

Priority 1: Integrated climate and marine ecosystems modelling

Two climate prediction systems have been developed at the Bjerknes Centre for Climate Research, and jointly at the Danish Meteorological Institute and the Swedish Meteorological and Hydrological Institute. These have been used for quasi-operational multi-annual climate predictions [9]. At the same time, marine ecosystem models are being developed for long-term climate change projections [10]. Research is now needed to combine these two efforts and develop integrated climate and marine-ecosystem predictions. This also demands the better understanding of biophysical interactions and techniques to provide information, including uncertainties, on scales and in forms relevant to users.

Priority 2: Co-development of services

Services need to be co-developed with users, and with good understanding of societal needs [11]. This requires trans-disciplinary collaboration among natural and social scientists and with interaction with private and public sectors. Promising case studies have been developed for climate services based on multi-annual predictions, and these include applications to renewable energy [11] and marine ecosystems [12]. Climate services are now being developed at a few institutes in the Nordic Region[C], but efforts are required to consolidate and integrate these at the Nordic level.

Achieving carbon neutrality and the sustainable use of marine resources requires cooperation at the Nordic level, given the common challenges that extend beyond our national borders. Furthermore, shared cultural and societal values facilitate the co-development of common solutions. The sharing of expertise and data from climate, marine, and social sciences, and of computing and modelling infrastructure will have major synergistic benefits. This will lead to improved mitigation strategies, the development of common policies and management practices, and stakeholder engagement, and increase the profile and competitiveness of research in the Nordic Region.

Nordic research can play an internationally leading role in addressing these important research areas. Compared to other regions of the world, there is a relatively good level of availability of both physical and biological data. There is also good access to significant amounts of computing resources, including Europe's first exascale supercomputer, LUMI, in Finland. At the same time, we can also benefit from large international initiatives such as the EU Destination Earth programme to provide high-resolution climate data, which can be tailored to the Nordic situation. International cooperation on integrated modelling and climate and marine ecosystem services will accelerate the development of these urgently needed tools and approaches.

C Climate Futures, a centre for innovation based research funded by the Research Council of Norway (# 309562)

Recommendations

Climate and marine ecosystem services are needed to achieve a green and competitive Nordic Region. Developing such services requires research and innovation in two key areas:

1. Combining competence in climate prediction and marine ecosystem modelling to develop integrated prediction systems

2. Building on initial climate services being developed nationally to co-develop services directed for the renewable energy, agriculture, and marine ecosystem/fisheries sectors.

These will require innovative and enhanced transdisciplinary cooperation at the Nordic level.

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Citizen Science for Environmental Governance in the Nordic Region

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Executive Summary

Environmental citizen science can be a great tool for a green, competitive, and socially sustainable Nordic Region. It fosters collaboration between citizens, researchers, communities, and authorities to collectively tackle environmental challenges, and encourages participation in decision-making processes related to environmental policies and conservation efforts. To advocate its importance and significance, this policy brief proposes four recommendations for the Nordic Council of Ministers and describes how best to connect and integrate environmental citizen science in the Nordic Region so as to achieve three relevant objectives of the Action Plan.

What is citizen science?

Citizen science (CS) can be defined as the non-professional involvement of volunteers in the scientific process, commonly in data collection, but also in other phases, such as quality assurance, data analysis and interpretation, problem definition and the dissemination of results [1]. CS projects can cover a wide range of domains and topics, including ecology, climate change, biodiversity monitoring, and air and water quality assessments. Volunteers often use mobile apps, online platforms, or low-cost sensors to gather and share data with researchers.

Collaboration with volunteers allows scientists and authorities to collect data at a larger scale and at relatively lower costs compared to traditional science [2]. Alternative datasets can complement government data, allowing citizens to participate in democratic processes at the local level [3]. Acting as volunteers means citizens can serve the public good (e.g. collecting data on air and water quality) and provide local authorities with evidence about issues affecting their quality of life [4].

In Europe, examples of good practice have demonstrated the added value of environmental CS in monitoring and policymaking in the areas of air pollution[A] and waste/litter[B], among the others.

One such project promoting collaboration in citizen science across the Nordic Region is that of NordicPATH, which focuses on air quality and the interlinked challenge of climate change. NordicPATH has developed a new model for citizen participation and collaborative planning in the Nordic countries. The model has been demonstrated in Urban Living Labs, which are hubs where citizens, policymakers, experts, and industries get involved in activities aiming to co-create urban solutions that respond to the needs of four pilot cities (Kristiansand in Norway,

A https://curieuzeneuzen.be/
B https://www.eea.europa.eu/themes/water/europes-seas-and-coasts/assessments/marine-litterwatch

Lappeenranta in Finland, Aalborg in Denmark, and Gothenburg in Sweden). NordicPATH promotes the uptake of sustainable urban development. The project was presented at the Nordic Council of Ministers in Copenhangen as an example of praxis towards sustainable cities.

What is the value of environmental CS in the Nordic Region?

Here we specifically align environmental CS to three objectives – 1, 6, and 10 – linked respectively to the three strategic priority areas in the Action Plan [5].

Green Nordic Region: Objective 1

Environmental policy to support carbon neutrality and climate adaptation can be enhanced by data collected by citizens. CS data can provide valuable insights into local conditions, behaviours, and preferences. CS data can complement other existing data sources on support of environmental policies.

CS data in environmental governance can help overcome political deadlocks. Citizens can demonstrate greater awareness and proactiveness than politicians when given the opportunity to participate. As a result, political leaders can be inspired to take decisive action with more confidence and willingness.

CS data contributes to the legitimacy and public acceptance of solutions in support of carbon neutrality and climate adaptation. As the transition towards a low-carbon future unfolds, the consequences will have a more direct impact on people's daily lives. Engagement of citizens in decision-making processes increases public confidence and consent for unpopular decisions, knowing that fellow citizens have had a role in shaping them.

Involving citizens fosters environmental awareness and political empowerment. Citizens become more knowledgeable about their environment and develop the skills and confidence required to participate more actively in both individual and collective actions.

Competitive Nordic Region: Objective 6

All the governments face the challenge of a global environment where they need to maximise green economic growth and mitigate the effects of climate change by promoting innovation for more climate-efficient solutions and opportunities for inclusive growth.

Environmental CS and the green economy are interlinked concepts. The intersection of citizen science and the green economy lies in their shared focus on environmental sustainability and public participation. CS can contribute to the green economy by providing valuable data and insights that can inform sustainable economic practices and support the transition to a green economy. In return, a green economy can contribute by creating platforms and funding opportunities that support CS growth and sustainability.

Socially sustainable Nordic Region: Objective 10

Environmental CS can be a great tool for a socially sustainable Nordic Region as it helps move from a reactive approach of citizens to a more proactive and holistic perspective on environmental issues. Environmental CS is aligned with the Nordic Council's goals of "involving everyone living in the Nordic Region in the green transition and digital developments" (p. 19) [5]. The Nordic Region has long promoted social dialogue and citizen participation of all and at all levels. To this end, environmental CS is relevant as it can be designed to be accessible

and inclusive, considering the needs of different communities and individuals. Through the involvement of citizens in research, social innovation, and environmental governance, environmental CS can lead to increased community ownership, trust in science, and empowerment.

Integrating environmental CS into environmental governance in the Nordic Region

Environmental CS can be a powerful tool for public engagement and empowerment in decision-making and for raising awareness of environmental issues and policies. Environmental CS is a vehicle for facilitating transformative change through public participation and insightful data. Environmental CS can contribute to the solution of the complex challenges faced by policy and decision makers, while also making policies more open and transparent. In this respect, in 2020, the Swedish government mentioned – and defined – citizen science as a very important initiative for our future social challenges, such as for climate change [6]. The Swedish government acknowledged that when various societal actors are actively involved in the research process, researchers can contribute knowledge useful for science while the public can contribute knowledge and support socially relevant research.

Recommendations for supporting the integration of CS in the Nordic Region to build capacity

The potential value of environmental CS is high, but this potential, particularly for policy and decision makers, seems to remain largely untapped in the Nordic countries. If CS initiatives are sporadic and implemented inconsistently, they do not live up to their promise. The result is little impact on decisions and frustration among the involved citizens. Capacity building and collaboration among Nordic countries in environmental CS can enhance scientific knowledge, promote environmental awareness, empower citizens to actively contribute to research and conservation efforts and foster the uptake of CS data in policy. By sharing best practices, data, and resources, the Nordic Region can create a supportive ecosystem for citizen science, allowing for more impactful and widespread engagement of the public in scientific research and innovation.

Based on our work in NordicPATH and in the community of CS at the European level, we encourage policy makers to consider the following actions needed to support the integration of CS in the Nordic Region and to build capacity:

Recommendation 1: Assembling information on national CS initiatives, tools and resources to enhance visibility and exchange at the Nordic level.

Create a platform for federating national citizen science portals (e.g., medborgarforskning.se, citizenscience.dk) that serves as a common point of entrance for all of the Nordic CS portals. As the Nordic countries experience similar societal challenges and threats, the pooling of resources aims to promote synergies, identify gaps, and avoid overlaps and duplications between initiatives. Resource/funding needs can then be planned at the Nordic level, and alternative funding sources considered.

Recommendation 2: Support the development, enhancement, geographical extension and/or scaling up of environmental CS initiatives across the Nordic Region

Environmental CS can complement official environmental monitoring and/or reporting in a cost-effective manner, but it requires investment as well. Policy impact could be enhanced by ensuring that relevant initiatives are launched, validated, scaled up, and sustained over time across the Nordic Region. In addition, the potential of environmental CS could be explored in other contexts relevant to the Action Plan, such as the circular economy [5].

Recommendation 3: Local and regional authorities should work with environmental CS experts from the Nordic Region to develop mechanisms for the validation and uptake of CS data.

Environmental CS has the potential to become a strong additional source of environmental information, providing greater temporal and spatial availability of observations that contribute with relevant data for management at local and regional level in the Nordic Region. Experts can help improve the use of CS data by recommending requirements and methodologies necessary to ensure transparency and data quality to promote trust in the data.

Recommendation 4: Increase visibility and recognition of environmental CS in public institutions

Formalise and valorise the role and value of CS in environmental monitoring. Strengthen the recognition of CS as a powerful tool for research and policymaking. Provide sufficient visibility and credit to the contributors.

The way forward

Environmental CS can prove its potential to make the Nordic Region the world's most sustainable and integrated region by 2030. Helped by increasingly available tools and technologies, environmental CS projects are now generating valuable data and knowledge in a whole range of environmental domains. However, the uptake of CS data for official monitoring and reporting is still limited. To advocate the importance and significance of environmental CS, this policy brief proposes four recommendations for the Nordic Council of Ministers and describes how best to connect and integrate environmental citizen science in the Nordic Region to achieve three relevant objectives of the Action Plan.

Notably, environmental CS is not just about collecting data. Aside from raising awareness of environmental issues and policies, it also engages and empowers the public. As a result, it aligns with the spirit of the Aarhus Convention, aiming to promote transparency, public participation, and access to justice in environmental decision-making processes.

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Achieving National Energy and Climate Plans (NECPs) via Nordic Cooperation on Energy System Modelling

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Introduction

The Nordic Council of Ministers has a vision to make the Nordic Region the most sustainable and integrated region in the world by 2030. It has therefore carved out three strategic priorities to achieve this vision: a green, competitive and sustainable Nordic Region, respectively [1,2]. One essential pillar of this is the green transition of the energy system towards sustainability and carbon neutrality: Production, distribution and consumption of energy must be sustainable and carbon neutral. Energy system optimisation models allow us to identify how these goals can be achieved at the lowest costs for society and with the least environmental impact on our planet. For the Nordic Region, there exist several energy system modelling communities developing their own models. They differ in a number of ways, for instance their: input data, mathematical representation of the energy system, geographical scope, temporal resolution and sector categorisation. The different models often give correspondingly varying solutions to the same problem. For more detailed results for parts of the energy system, domain-specific models can be used, such as for the power system, buildings or the transport sectors. Institutes researching the green transition of the Nordic energy system typically use and develop methods for both general and domain-specific energy system models.

In 2022, the Nordic Energy Outlooks (NEO) [3] was launched: A programme organised by Nordic Energy Research (NER), and financed jointly by NER, the Swedish Energy Agency, the Research Council of Norway, and the Danish Energy Agency (DEA). The main aim of the programme is to *strengthen Nordic research competence and cooperation in the field of energy systems analysis, by building on existing national research programmes*. By creating a forum for collaboration between different research groups and institutions, NEO helps to synthesise the results of current national research and put these into a Nordic context while also helping to clarify how the choice of analytical methods can create different results. An additional aim of the programme is to discuss if and how the results from the programme can be used for the following up on the integrated national energy and climate plans (NECP), and if the results can provide a regional perspective. Finally, the programme points out where there is a need for more joint research and investigation. NEO has focused on what actions we should take as a society to reach a green transition for the Nordic Region by way of working towards sustainability and carbon neutrality. The programme is divided into four work packages

(WPs) with different foci: Bioenergy, agriculture and LULUCF; increased electrification – new generators and consumers; energy efficiency and conservation and; fossil free and resource efficient transport. All participating institutions listed in the author list used their models that were relevant to the current WP topic, in collaboration with SINTEF as the lead institution for the programme. The outcomes from WP1, WP2, and WP3 are documented in [4–6], whereas the outcomes of WP4 will be available on the programme's website once they are ready. Each WP addresses the main sectors and in part, the main measures required to decarbonise the Nordic Region.

Insights for updating National Energy and Climate Plans in the Nordic context

As aforementioned, one objective of the research programme was to analyse the results with regard to how the NECPs could be updated in the upcoming process. In this section, specific insights are described for clear recommendations, based on the results described in the Final Reports [4–6] related to assessments of the Swedish NECP and the Norwegian Climate Plan [7]. It should be noted that modelling approaches and frameworks applied in this NEO could be relevant for achieving NECPs in the EU within the core areas of: energy efficiency, renewables, greenhouse gas (GHG) emissions reductions, interconnections, and research and innovation. This concept is shown in Figure 1.

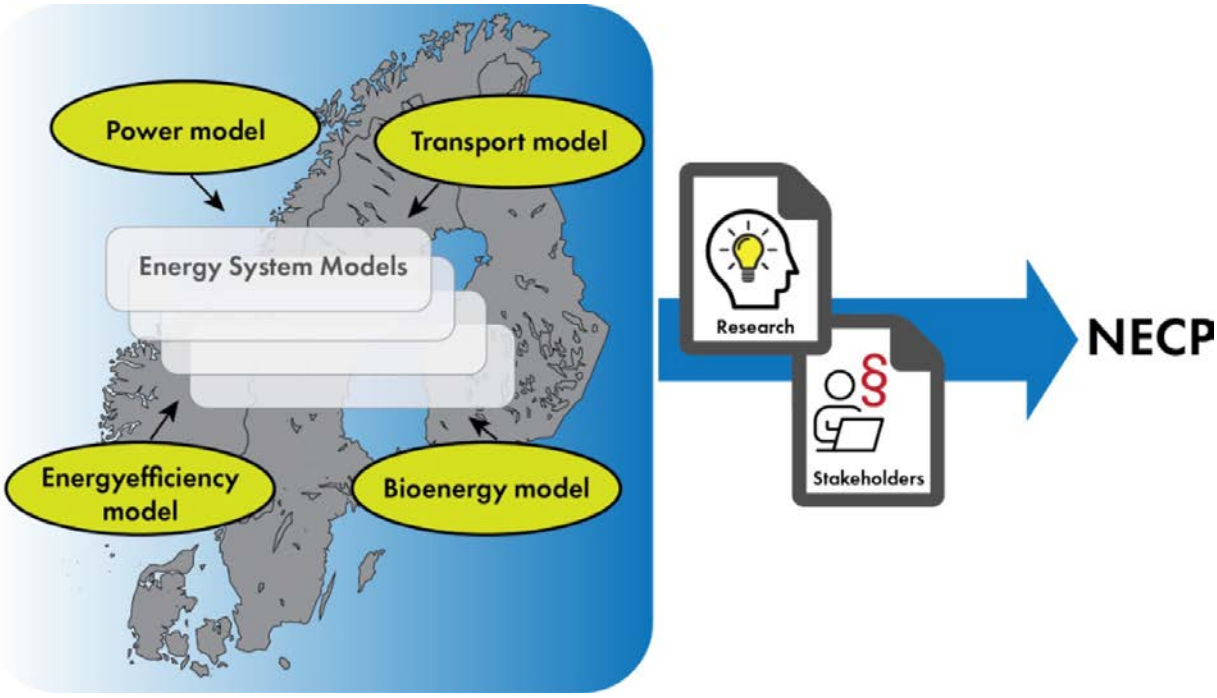

Figure 1: Several energy system models linked with sector specific models provide output that can be interpreted by researchers and used by stakeholders to inform policies such as the NECP.

Electrification and new electricity generators

Electrification is described in the NECPs as one key pathway for reaching net-zero carbon in energy services. Our modelling results comprehensively show that the decarbonising opportunities are great in this regard. However, possible challenges around increasing generation capacities to meet future electricity demand are not elaborated on in the NECPs,

especially beyond 2030. With the long planning phase for large infrastructure projects, ***we recommend that updates to NECPs specifically address electricity capacity expansion, and preferably in the Nordic context as well***. The Nordic countries combined show a large potential for increasing power generation, with capacity to trade electricity within the Nordic Region and export electricity to the rest of Europe, via primarily on and off-shore wind. The results from this project highlight, for example, a 6 GW potential for off-shore wind at the Sørlige Nordsjø II wind farm by 2030 – a doubled capacity as compared to Norway's current plans. However, this potential depends to a large extent on the permissions given to the large and complex infrastructure projects needed. Hence, one important recommendation is that ***clear support for accelerated wind power permits should be defined, with clear inclusion of local democracy in the process*** to avoid moratoriums.

Bioenergy and LULUCF sector in the Nordic Sustainable Energy System

For the overall Nordic Energy System, sustainable use of biomass resources – such as via forest and agricultural residue, and even organic waste fraction – is shown as important renewable energy resources, for instance for combined heat and power generation, district heating, and transportation. Nevertheless, differences between the countries in availability and applications still exist, and thus one recommendation is that ***a Nordic collaboration*** should focus on understanding, and quantifying the differences, deducing a framework for a Nordic ***bioenergy market***, and highlighting how bioenergy can ***service security-of-supply in a Nordic context***. This should include technological development, new policies at the national or regional level, new products or markets, improvements in modelling techniques, or available inputs. There is also a need for harmonisation, and to understand how GHG estimates and other environmental impacts (e.g. biodiversity and ecosystems services) from the bioenergy and LUCUCF sector can be consistently applied in energy system models.

Efficiency improvement in the building sector and in industry

Existing plans target the energy efficiency in the building sector by pointing out opportunities via improved standards, with subsidies in some cases, the labelling of buildings, and smart metering to aid. Additionally, refurbishment of existing buildings is brought forward. Results from this work indicate that there are indeed several techno-economically feasible efficiency measures to implement, however the timing and rate of refurbishment of existing buildings can significantly influence the ability to realise the full potential. Thus, ***policies and planning that accelerate the rate of refurbishment are recommended, along with clear targets and mechanisms for follow-up***. When it comes to energy efficiency, there are no specific targets in plans other than the energy intensity per GDP – the national level – with carbon tax, support for energy audits, and some incentives for investment as steering mechanisms. Electrification in industry is often high-lighted as a key for decarbonisation, however this is not automatically the same as steering towards efficiency, and efficient use of resources. Key findings from this work show how the re-use of surplus heat from industrial activities (and, for the future, the inclusion of large-scale hydrogen production, and potential expansion of nuclear power) risk becoming a "lost opportunity". The present sector-siloed policies do not fully address the system's interaction between electricity generation, industrial activities, and the heating and demands of the building sector. Only with interaction between such systems can we have an optimal service and robust function via sound integration of energy storage and heat pumping technologies. For these reasons, ***a common standard in the Nordic countries for reporting heat demand, excess heat and possible material streams is recommended***, for helping future predictions to be more accurate and comparable between countries.

Fossil free and resource efficient transport

The existing plans identify decarbonisation of the transport sector as an important step to reach the GHG emissions reduction as committed by the Paris Agreement. As air pollution and climate change are closely interconnected, the decarbonisation of the transport sector will help reduce other air pollutants. ***The coordination of policies is recommended to benefit both a reduction in air pollution and increased decarbonisation for the transport sector***. Battery technology is seen as a key technology for decarbonising transport. ***The climate plans could benefit from including the use of critical materials for the suggested technologies and develop a plan to ensure sustainable and secure supply of critical raw materials***. For road transport, a ***Nordic cooperation for zero emission technologies*** beyond hydrogen is recommended to ensure a seamless and consistent supply of energy to border crossing transport. For aviation, ***ensuring a levelled playing field for sustainable aviation fuels*** could be further developed.

Nordic Cooperation for Sustainable Energy Systems

Despite geographical proximity and a common aim of a climate neutral future, the Nordic countries have structural and cultural differences. Working together improves our understanding of how other Nordic countries think, and inspires us to broaden our perspective on ways forward and synergies that can be obtained by extended collaboration.

For the NECPs and their upcoming updates, collaboration will offer benefits. A few examples of this include:

- Nordic electrification would be benefit through cooperation via a holistic approach to expanding the needed capacity and integrate it into ***a functional Nordic power market.***
- Cooperation ***enables stronger resilience and adaptability***, in lieu of climate change and geopolitical developments that could otherwise bring about challenges to security of supply.
- Energy conservation and resource efficiency consist of local measures. However, via commonly adopted strategies for demand-side-management, energy efficiency and the conserving of resources will facilitate electrification via better control of supply and demand matching. Thus, to have ***a common, Nordic strategy for efficiency and conservation*** would generate various benefits and enable better planning across the full energy value chain.
- Nordic cooperation related to ***biomass and surplus heat sources*** can give insights into how these resources ***can support the overall resilience of the energy system in a Nordic context***.

In conclusion, the analysis of energy systems using a multi-model approach via the collaboration between institutes, such as in the Nordic Energy Outlook, is important for providing quantified insights on transition pathways for decarbonisation of energy services into the future. In fact, our analysis of ***present NECPs has revealed that specific, quantified targets are often lacking, as well as relevant indicators for monitoring progress***. In addition, this project has revealed the need for open, accessible, and well documented datasets of which the different existing modelling frameworks can build on. In this regard, the established community of expertise and modelling tools enabled by the project is now equipped to demonstrate the development of energy and climate plans in the Nordic context, to aid timely decision-making needed for sustainable development.

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How to improve climate change adaptation in rural areas of the Nordic Region

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Key recommendations

- Climate change adaptation should be addressed in a similar manner as mitigation, as a **cross-sectoral societal challenge** across all levels of governance. This requires involvement of all societal actors from both public and private sectors, civil society organisations and citizens, and **improved collaboration between local, regional, and national governance** levels.
- Solutions for climate adaptation need to be adapted to the local context and **integrate local knowledge and practices**. This requires that local authorities improve their communication with citizens and engage citizens in decision-making. For this to be possible more dialogue about the connection between climate change and the increase of local risks is needed.
- Climate adaptation strategies need to consider **societal groups that are particularly vulnerable** to the effects of climate change, such as indigenous and rural communities and socio-economically disadvantaged groups. This requires increased efforts to identify not only physical climate vulnerabilities, but also social and economic vulnerabilities.
- Laws and regulations must be developed further in order to **enable collective adaptation action** in local communities.

Introduction

At the time of writing, global warming already amounts to 1.1 degrees Celsius, displaying tangible effects around the world, of which the scenarios indicate that this will get much worse [1]. The Nordic Region is also affected by climate change with the Arctic being one of the fastest warming regions globally [2]. Climate change-related hazards – such as floods, droughts, wildfires, landslides and avalanches – have become more common in recent years and the risk of such hazards will significantly increase in the future. In addition to these more acute events, there are also gradual changes, such as the disappearance of permafrost and a changing flora and fauna, that need to be managed. However, the current speed of climate adaptation in the Nordic Region is too slow. There is therefore a great need for the Nordic countries to intensify their efforts to adapt to a changing climate [3, 4].

To achieve the vision that the Nordic Region will be the most sustainable and integrated region in the world by 2030, climate change adaptation should be at the centre of attention. While the main focus of current adaptation efforts is on urban areas, we argue that rural areas deserve more attention in the context of climate change adaptation. How successful rural areas manage to adapt will have large consequences for rural livelihood and economies. Central parts of rural economies, such as agriculture, forestry and tourism, rely on the weather and biodiversity and must improve their resilience to climate change-induced hazards.

Important infrastructure, such as roads, railways, and electricity lines pass through rural areas and should be adapted to withstand extreme weather events. Furthermore, rural areas are home to some of the most vulnerable groups to climate change, such as Sami reindeer herding communities and rural communities with nature-dependent livelihoods. Lastly, all citizens in the Nordic Region, including those living in rural areas, should be able to live with a minimum of risk from climate change-induced hazards. Increased climate adaptation efforts will thus reduce inequality between rural and urban areas and contribute to environmental, economic, and social sustainability of rural areas across the Nordic Region.

This policy brief is a result of a collaboration through the NordForsk-funded project CliCNord (Climate Change Resilience in Small Communities in the Nordic Countries). The recommendations presented here build on CliCNord project results and more generally on the state of research on climate adaptation in rural areas.

Climate change adaptation efforts are limited to specific societal sectors

While climate change mitigation and the reduction of greenhouse gas emissions is increasingly understood and dealt with as a cross-sectoral challenge, of which all societal actors (including citizens) engage with, climate adaptation is still a topic only dealt with by the few – mostly in the technical department of municipalities and in the scientific community. However, independent of our global success of reducing CO_2 emissions, climate change is already happening, and the Nordic countries must adapt. The climate adaptation challenges that the Nordic countries face demand the involvement of all sectors, in the same manner as our societies today engage with climate mitigation and the reduction of emissions.

Municipalities in the Nordic countries experience an increase of tasks related to the preparing for and handling of extreme weather events [5, 6]. For most climate change-related hazards, local governments have the responsibility for both assessing the risk and managing climate adaptation projects. The process of applying for planning and construction permission in rural municipalities in Norway, for example, has become more complex due to the increased focus on risks related to climate-induced hazards. The officials in charge who were previously able to process these applications alone, now often have to involve additional expertise to implement the risk assessments. These additional tasks stretch the human and economical resources, especially those of smaller municipalities in rural areas, which have fewer people to take care of the broad variation of tasks and who often lack the specialised competences needed to deal with climate change adaptation. Thus, climate adaptation needs more attention from regional and especially national authorities to support the adaptation efforts of municipalities. There is then also potential for increased learning and collaboration across municipalities, for example through sharing resources in intermunicipal cooperation. Additionally, there is a need for more actors to be involved on the local level too – such as citizens, businesses, and civil society organisations – as they have specialised knowledge that can support the management and decision making of the municipalities.

Policy recommendation 1: Address climate change adaptation as a cross-sectoral societal challenge on all levels of governance

Climate change adaptation must be treated as an important issue across all public and private sectors, as well as in civil society. Actors on both local, regional, and national levels must take responsibility for local climate change adaptation. For this to happen, climate adaptation must be treated with the same political attention as climate change mitigation.

Rural communities hold important knowledge about adapting to extreme weather

Adaptation to a changing climate occurs at the local level. Given that risks, needs, capacities, and possibilities vary between different physical places and different social communities, local knowledge about hazards and the specific places should form the basis for developing suitable adaptation strategies. Many rural communities have experienced events like storms and floods for generations and have thus developed strategies for handling them. These adaptation strategies are based on local knowledge and local practices which have often developed over generations and which enable said communities to deal independently with climate change-related hazards. For example, it is common that people in such communities are more aware of observing signs in the environment that indicate that a landslide or avalanche is about to happen, and will clean gullies or fill water streams with gravel in order to prevent an event such as a landslide [7, 8]. On top of this, the first response to such events in rural communities is often organised by citizens while they wait for professional emergency response to arrive from further afield. Without this local knowledge and such practices, many communities would experience more damage from extreme weather events. Thus, such knowledge and practices should be included in climate adaptation efforts in the future.

Policy recommendation 2: Integrate local knowledge and practices into climate adaptation

Future climate adaptation efforts would benefit from taking their starting point in local knowledge and practices. There is therefore a need to find ways to include this knowledge in all phases of climate adaptation, planning, implementation, operation, and maintenance, and in disaster management on local, regional, national, and Nordic levels.

Rural areas are among the most vulnerable to climate change and extreme events

To increase the Nordic countries' ability to implement climate adaptation, the social, political and geographical contexts need to be taken into consideration. Climate adaptation is never neutral – there will always be different goals, values and ambitions. The distribution of disadvantages and benefits may favour some groups and individuals more than others. Groups that are hardest hit by disasters are often synonymous with groups that are already economically, socially, and politically marginalised [9, 10].

People in rural areas are among the most vulnerable to climate change and extreme weather events. Rural areas are exposed to the changing climate in different ways than those in urban settlements due, for example, to nature-dependent livelihoods, large areas with small populations, high physical and social vulnerability, and lack of financial and human resources and expertise. Though rural communities are experienced in handling challenges locally, climate change also stretches their resources and consistently provides both greater and new challenges. Rural communities therefore need help from outside if they are going to be able to prepare for and respond to increased climate related risks on the same level as people in urban areas. Hence, rural areas are dependent on support from the wider society, both for the prevention of hazards and by way of support during acute events. This support could be in the form of training, funding for preventive measures or in some cases, help for relocation.

Policy recommendation 3: Consider societal groups that are particularly vulnerable in climate change adaptation efforts

There is a need to increase our understanding of how marginalised and vulnerable groups are affected by a changing climate, as well as how a fair distribution of responsibility for climate adaptation can be developed. Climate adaptation needs to be just and inclusive.

Laws and regulations create barriers for collective climate adaptation action

Today the regulations in force across the different Nordic countries constrain the opportunities for local communities to adapt to a changing climate. Even if the responsibility for adaptation varies between countries and hazards, the CliCNord project shows that there are similar problems throughout the Nordic Region. Adaptation to several of the climate related hazards is today the responsibility of individual home or landowners. For example, in Sweden, a large responsibility lies with the owner of the property or forest, and in Denmark protection against flooding from the sea is a private responsibility [11]. In recent years, research has argued that this division of responsibility, and especially the responsibility that lies with the property owners, is unreasonable given that individual property owners may be hit particularly hard and in most cases do not have the resources or ability to reduce the risk by themselves [3, 12, 13]. Furthermore, it might be difficult for property owners to act effectively, as measures often require coordination. Today, legislation is often designed to support individual actions and even creates barriers to more collective climate adaptation projects.

Policy recommendation 4: Enable collective adaptation action through the adjustment of existing laws and regulations.

There is a need to update the laws and regulations to ensure they support collective action in the best way possible, and that they do not create unnecessary barriers for people in rural areas to take action themselves to reduce their risk from climate related hazards.

Research needs

As input for the abovementioned policy recommendations, more inter- and transdisciplinary research on climate change adaptation is needed. Based on the current state of knowledge, we suggest the following, though not exclusive, list of research priorities, of which point to specific, much needed contributions of the social sciences:

- **Citizen engagement in climate adaptation** has mainly been argued for and studied from a top-down perspective. How citizens themselves understand their responsibility for and how they engage with adaptation needs to be investigated further.
- **Identification of vulnerability:** Research is needed to investigate who is vulnerable to climate change and which sectors, communities, and individuals will suffer the most and should thus be the focus of policies and measures.
- **Just climate adaptation:** Justice is a fast-growing field of research in the context of sustainability transitions and climate change mitigation. However, it has not been addressed widely in relation to climate change adaptation. Studies of distributional, recognition and procedural justice especially related to vulnerable groups in rural areas are needed.
- **Governance:** Small municipalities do not have enough resources for the climate adaptation tasks required. Research is needed to develop new governance models that focus on collaboration between local, regional, and national governance levels, but also on innovative ways of collaborating between local authorities, which can then aid in increasing capacity in rural areas.

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Recommendations for Future CO_2 Management in the Nordic Countries

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Summary

The development of alternative carbon capture and utilisation technologies is essential if we are to meet the goals of the IPCC for negative CO_2 emissions. To create a sustainable chemical industry, we must find solutions for replacing crude oil and gas with CO_2 as the carbon source. Among possible strategies, we propose the increase of locations for direct air and point source capture by developing new materials based on waste and biomass, as well as expanding the number of products formed directly from CO_2 using efficient and low energy-intensive chemical processes. The knowledge transfer required between disciplines and sectors to develop these processes and accelerate their implementation will require significant investments in Nordic cooperation.

Policy recommendations

We must invest heavily in research to identify new carbon capture and utilisation technologies. Existing technologies are not sufficient.

We need to invest more in creating multiple mission-driven Centres of Excellence that aim to reduce carbon emission, decentralise carbon capture and exploit chemistry and biology for the conversion of CO_2 into valuable chemicals and fuels.

We need to inform society about the challenges of carbon capture storage and utilisation (CCSU), the investments planned for CCSU facilities and the need for highly educated people to solve these challenges.

The causes of the problem

Over the last four decades, global climate change – primarily due to increased atmospheric temperatures – have resulted in catastrophic environmental damage, as witnessed by intensified precipitation leading to flooding, a rise in sea level and the withdrawal and disappearance of glaciers and sea ice. The culprit for this global warming has been uncontrolled greenhouse gas emissions, with CO_2 dominating from the burning of fossil fuels, mainly for energy production. Almost three-quarters of the human-caused CO_2 emissions are evenly distributed between energy used in buildings, transport, and industrial production. [1] Most of this energy is produced by burning fossil fuels, such as natural gas, gasoline, diesel and coal. In addition, industrial processes with CO_2 as waste from the production of chemicals and materials, such as cement production, account for 5% of the emissions. The second largest share, that of 18%, concerns food production and land use.

The need for carbon capture

Meeting the goals set by the Intergovernmental Panel on Climate Change (IPCC) for staying below a 2 °C global surface temperature rise over the next decades requires an intensive and dedicated effort internationally. This challenge involves the undertaking of two central endeavours. Firstly, it is imperative to decarbonise existing CO_2-producing processes, such as switching energy production from fossil fuel burning to alternative energy sources and implementing effective CO_2 capture technologies at point sources. Secondly, we need to develop breakthrough technologies for direct air capture by 2030, which are functional at scales of a minimum of 1,000 million tonnes of atmospheric CO_2 but which can eventually be increased to carbon capture of 20,000 million tonnes of CO_2 by 2100. This goal is daunting due to the lack of current methods that can even remove 1 million tonnes of CO_2 annually. To realistically address direct air capture and point source capture at gigaton scales within this short period of time, the carbon capture processes must be coupled with large industrial sectors to provide enormous amounts of materials and energy required. These sectors would include those currently providing more than a million tonnes of products, such as agriculture (food), electricity and heat, cement, steel, aluminium, chemicals, and water.

The need for storage and utilisation

The CO_2 captured can be utilised (CCU) or stored (CCS). To achieve the net zero scenario with the current utilisation technology, over 95% of the CO_2 captured in 2030 must be geologically stored and less than 5% used. [2] This accounts for several CCS projects in the Nordic countries, where 11 are already operational and 24 are planned by 2030 [3]. However, only the utilisation of CO_2 for synthesising fuels, chemicals and materials represents a potential source of revenue for industrial emitters. In Iceland, Carbon Recycle International (CRI) was the first company to produce renewable methanol from CO_2 and electrolytic H_2 at an industrial scale (110,000 tonnes of methanol in 2022), and it is now extending this technology with projects in other countries across Europe as well as in China. Similarly, Project Air from the Swedish Perstorp plans to replace the fossil methanol they use as raw material with sustainable methanol by 2025. Furthermore, Norsk e-fuel has plans to produce 250 million litres of aviation fuel by 2030, combining air-captured CO_2, water and renewable electricity to produce a mixture of carbon monoxide and hydrogen, called syngas, which is then converted into hydrocarbons of different chain lengths by a Fischer-Tropsch reaction.

All these initiatives are based on directly converting purified CO_2 into products containing one carbon atom – methanol (CH_3OH) and carbon monoxide (CO). There is substantial interest in such processes as they provide a solution for generating green fuels by applying existing technology. Furthermore, CH_3OH and CO are versatile chemical feedstock for the further transformation of a large body of chemicals currently generated from the oil-based feedstock. The challenge of implementing these processes in bulk scales is their substantial energy requirements for the electrochemical formation of H_2, and for reaching the conditions of temperature and pressure required for an efficient CO_2 reduction. Furthermore, this energy must originate from renewable sources. Unfortunately, access to large amounts of pure CO_2 and sustainable energy is challenging.

Actions to reach a green Nordic Region by 2030

To fulfil the IPCC demands for removing one gigaton of CO_2 by 2030, investments must be directed in two directions, by: 1) increasing the locations for direct air and point source capture and 2) diversifying the materials used as capturing agents. In addition, the investigation should focus on transforming the most common and abundant waste materials through simple and efficient chemical modifications into valuable substances for expediting the capture and sequestration of CO_2 directly from air or point sources. Considering the tremendous quantities of waste materials at our disposal, developing appropriate technologies could contribute substantially to large-scale carbon removal and utilisation.

The number of products directly formed from captured CO_2 should be expanded, as they can serve as reagents in already existing processes for the formation of fuels and chemicals. In addition to CH_3OH, direct CO_2 conversion to methane (CH_4), CO and products containing two carbons (C2 compounds) – such as ethylene, acetate or ethanol – should be further developed to become efficient and low energy-intensive chemical processes that could be implemented at an industrial scale. Methane formation is interesting because, like ethanol, it can be used directly as fuel or oxidised to methanol. Methane could be formed in CO_2-saturated water via an integrated bio/electrochemical technology. Previous experiments have primarily used pure CO_2, but future investigations should also explore the possibility of performing this transformation with CO_2 bound to new capture materials.

Carbon monoxide represents an important C_1-building block in the manufacturing of a variety of basic chemicals and fuels, including methanol and phosgene, as well as for the synthesis of alkanes, aliphatic alcohols, aldehydes, and carboxylic acids via key processes. These include the Fischer-Tropsch reaction, hydroformylation, and alkoxycarbonylation. A major safety issue in exploiting CO as a chemical reagent has been its toxicity and flammability. Thus, a current and future task is to identify efficient and low-energy technologies for generating CO directly from CO_2, and its immediate use in follow-up chemical transformations to high-value chemicals and fuels, thereby circumventing the storage and handling of this toxic gas.

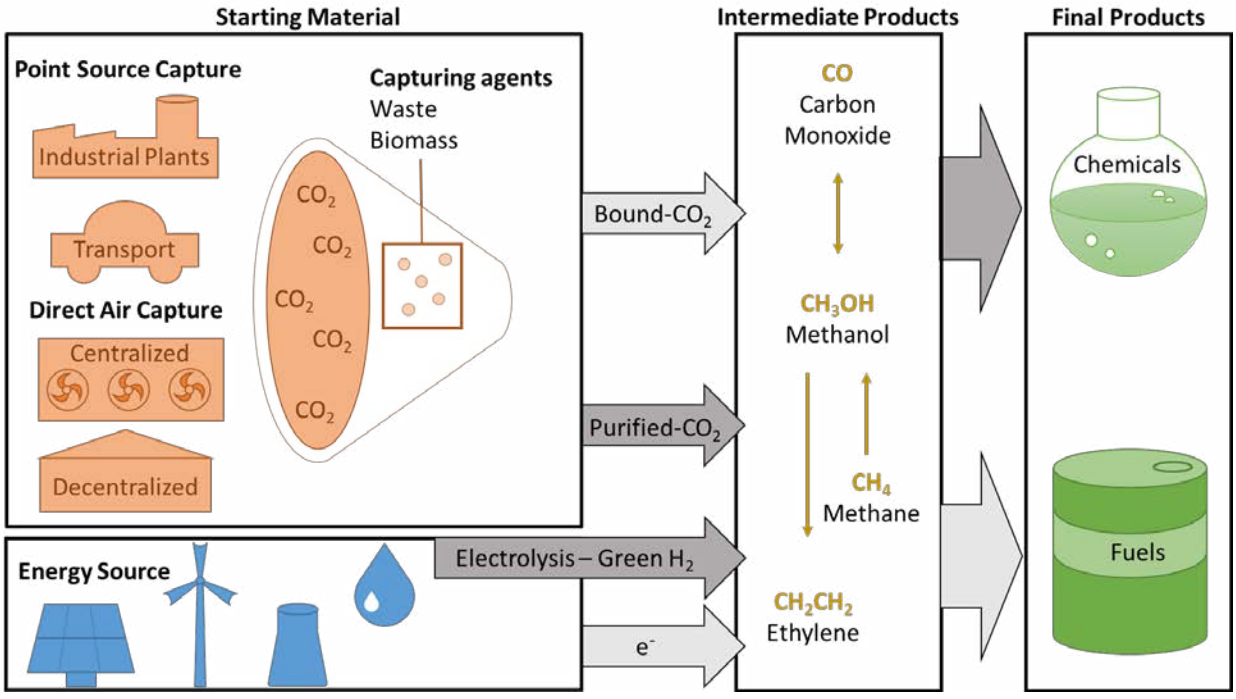
More focus should be given to research in low-energy methodologies for converting CO_2 to C2 compounds, which represent key constituents for the chemical industry concerning the synthesis of chemicals and fuels. Ethylene is one of the most important manufactured organic compounds with a global production of approx. 200 million tonnes. This small molecule, a major feedstock to plastics, synthetic rubbers and other chemicals, originates from the high-temperature cracking of ethane. Homogeneous catalysis and electrocatalysis for the dimerisation of CO_2 could be alternative methods for accessing the C2 compounds. Additionally, significant efforts should be undertaken to investigate the potential of biology for converting CO_2 into acetate and ethanol followed by chemical conversion to ethylene.

Need for Nordic cooperation

CCSU technologies require massive investments worldwide to improve the existing methodologies, identify new ones, and accelerate the transferability from development to application. To carry out such tasks efficiently, both the scientific community and industries must communicate to agree on and develop the most promising technologies from a scientific and industrial perspective. In the Nordic countries, this transferability of knowledge should be promoted by investing in shared projects and personal exchange between academia and industries, two sectors in which cooperation has been traditionally difficult because of their different interests. It is time to combine both worlds into more mission-driven research to provide solutions to the urgent problem of climate change.

The science behind CCSU with CO_2 is multidisciplinary, involving the fields of chemistry, applied physics, catalysis, engineering, computer science, artificial intelligence and biology, and again highly connected to the need for cooperation and education. Individually, the Nordic countries do not possess the intellectual mass, investment or size to solve these issues. Only through cooperation across the Nordic Region, involving both academic and industrial institutions, can we be competitive in identifying innovative solutions/knowledge to these grand challenges.

Nordic cooperation to access sustainable energy, captured CO_2 and placements for CO_2 storage would also be beneficial. The lack of these components should not limit our efforts at CCSU. So far, accessibility to renewable energies is one of the advantages for our countries, with wind energy in Denmark, hydroelectric power in Norway, Sweden and Iceland, geothermal energy in Iceland, and nuclear energy in Finland. Considerable investments are being undertaken for increased wind power in Denmark by building offshore wind farms generating 9 GW or more electricity. Now the goal is to store this energy where there are surpluses. Integrating the energy facilities with CO_2 placements and utilisation will be crucial to make the new CO_2 technologies economically feasible.



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Hydrogen HOPE for the Nordic Region: Shipping as a frontrunner

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Background

Maritime transportation is one of the key remaining sectors to be decarbonised in the Nordic Region, as other industries having largely moved out of the fossil fuel-era or designed concrete strategies for this, with cars, buses and lorries switching to renewable fuels and electricity at a high pace – Norway, Iceland and Sweden all being world-leaders in this regard. The Nordic Region is to become the most sustainable and integrated region in the world by 2030 [1]. The aim is also for the Nordic Region to become carbon-neutral [2]. Being open, export-oriented economies with a large share of the trade carried out through maritime transport, a low-carbon and competitive shipping sector is highly relevant for the Nordic Region. Furthermore, key connections between the people of the Nordic countries are conducted through waterways, including Finland-Sweden, Denmark-Norway, and Denmark-Sweden.

In this context, the introduction of alternative low-carbon fuels is a necessary complement to energy efficiency improvements for reducing greenhouse gas (GHG) emissions (as well as other harmful emissions) as other measures are not sufficient. There are several maritime fuel options, with varying levels of technological readiness, but some with large potential as they can represent zero carbon fuels. Thus, it is important to learn more about the possibilities and impacts of hydrogen-based solutions for shipping in the Nordic Region as they are not yet introduced on a large-scale.

With this, as well as the Clydebank Declaration for Green Shipping Corridors [3], as a backdrop, the Ministers of Climate and the Environment from Denmark, Finland, Iceland, Norway, Sweden, the Faroe Islands, Greenland, and Åland in May 2022 signed a joint declaration for the creation of zero-emission ferry routes between the Nordic countries [4]. The overall aim of the declaration is to help the Nordic shipping industry accelerate its transition towards new fuels and propulsion technologies that have low emissions throughout their value chain – from production to end use. The ministers agreed to focus on the ferry sector and to promote the creation of zero-emission ferry routes between Nordic countries. This would allow key stakeholders to gain experience and test new fuels and technologies in pilot projects involving short ferry routes.

The HOPE project

The research project HOPE (Hydrogen fuel cells solutions in shipping in relation to other low carbon options – a Nordic perspective) has addressed how regional shipping in the Nordic Region can transition to become fossil-free (https://www.nordicenergy.org/project/hope/). The project partners consist of IVL Swedish Environmental Research Institute, SINTEF Ocean AS, University of Iceland, Stena Rederi AB, PowerCell Sweden AB and – for communication – the Swedish 2030-secretariat.

The project aimed at clarifying the potential role of hydrogen based marine solutions in reducing the Nordic GHG emissions. It has been centred around a typical ROPAX-vessel (a ferry transporting passengers and goods) with an operating distance of around 100 nautical miles, for which a conceptual design for operation with hydrogen as fuel and fuel cells for propulsion has been outlined (Figure 1). The conditions include technical design and costs of fuel systems, handling, and powertrains in relation to other fuel options such as ammonia, methanol, and batteries [5, 6] as well as an analysis of barriers and drivers for the realisation of such ships [7, 8]. Strategies and the potential of producing these fuels in the Nordic Region were reviewed from a shipping perspective [5]. A potential uptake of these technologies/fuels by Nordic shipping was assessed and the emissions of climate gases and air pollutants calculated.

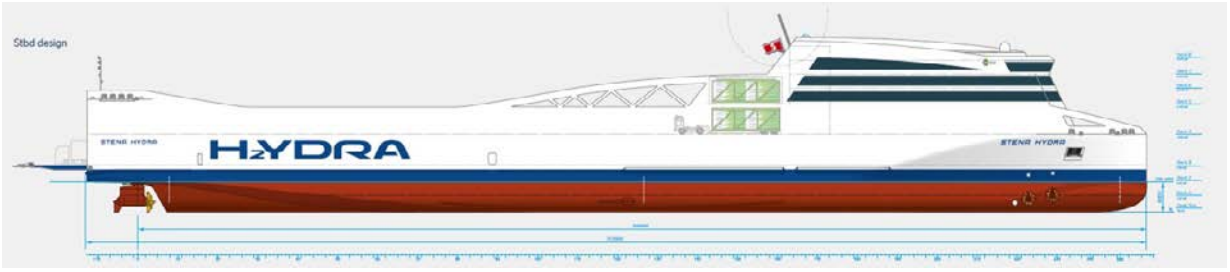

Figure 1. Illustration of the concept design for the studied vessel (Stena Teknik).

Insights

The HOPE project has gained several insights, including:

- Hydrogen in some form (liquefied, compressed, ammonia, or electro-fuels), may be an interesting solution for long-term reduction of GHG emissions from shipping. However, we expect a limited introduction of hydrogen and associated fuels in the next ten years, even though there are some initiatives to introduce hydrogen use in shipping, mainly in Norway.
- For regional shipping in the form of ROPAX vessels between the Nordic countries, hydrogen could be an interesting future solution, but electrification has advantages on certain routes, though often with electrical power challenges. Case-route-specific assessments are needed.
- Using hydrogen for a regional ROPAX vessel between the Nordic countries is found to be technically feasible. A concept design has been developed focusing on fuel cells for propulsion, and storage of hydrogen in compressed or liquefied form. Fuel cell systems in the megawatt range are needed.
- Hydrogen-based solutions for regional shipping may not be the lowest cost option at present and will require an increase in electricity production; however, considerable cost reductions are expected in the future. There are also uncertainties linked to the cost of other options such as renewable methanol or electricity.

- Barriers for the introduction of hydrogen in shipping include economic, technological, organisational, and behavioural aspects. Economic barriers are currently regarded as the most challenging but issues regarding a lack of infrastructure, green hydrogen supply, and regulations/standards have also been raised. Furthermore, uncertainties about costs and high risks are hindering the development in the Nordic Region.
- There is a general global lack of knowledge of hydrogen as an energy carrier, shipowners and ship operators are unaccustomed in operating the technology, and there are questions to solve about its safety for maritime applications. However, hydrogen solutions for shipping must be tested in parallel with the development of rules and regulations and cannot wait for them to be finally adopted first.
- Even with significant plans for hydrogen production in the Nordic Region, it is uncertain what amount of hydrogen will be available for shipping. Relatively few of the Nordic projects for hydrogen production clearly address the possible use in shipping, and the expansion of bunkering infrastructure for hydrogen in different forms is an extensive task.
- It is possible to substantially reduce the GHG emission from Nordic shipping by introducing hydrogen-based marine fuel options by 2030–2050. Furthermore, other emissions such as nitrogen oxides (NOx) and particles would decrease significantly.
- Drivers for hydrogen in Nordic shipping include EU and national policy proposals for the transition of the shipping sector, the hydrogen economy in general and a willingness from shipping companies to decarbonise their operations. Thus, there is a growing interest in sustainable marine fuels in the Nordic Region, including green hydrogen.
- Policies are crucial for the transition of the shipping sector. Details in the policy design can be crucial for the prerequisites of various options not the least for hydrogen-fuel cell solutions.

Policy recommendations

The project delivers several policy conclusions on how to fast track the developments of Vision 2030 and specifically how to deliver on the declaration on zero-emission ferry routes between the Nordic countries:

- Zero-emission ferry routes between the Nordic countries should be prioritised due to the potential to replace fossil-fuel powered ferries, and the climate benefits this would lead to.
- Sufficient public economic support is needed to bridge the cost difference between fossil solutions and renewable ones for Nordic shipping actors. There is a need for pilot projects to promote technical maturity and reduce costs. The high costs and risks for first mover shipping actors need to be shared by the society.
- Regional and clearly coordinated policies are needed for a wider adoption of hydrogen and fuel cells in the Nordic Region. Coordination of polices for the energy and shipping sector is also important.
- Green hydrogen and green hydrogen-based fuels should be a prioritised energy carrier, as it would help position the Nordic countries as a centre of excellence within the nascent hydrogen economy, and because it is well-suited to the increased fluctuations of the Nordic electricity production, due to an increased share of wind and solar. Policy interventions would be needed to facilitate the adoption of hydrogen and to address the barriers associated with their use, including the high costs, lack of supply, lack of infrastructure and the uncertainty and high risks for early adopters.

- The price of fossil fuels in shipping needs to increase – the current price of heavy fuel oil, marine gas and diesel oil, and liquified natural gas does not incorporate all the external costs society must bear from their production and consumption. Whilst the scope in HOPE has been that of the Nordic Region, addressing this issue through the EU Emissions Trading System (ETS) is seen as a key policy instrument to help achieve this. Part of the incomes in the ETS system should be used to help fund investments by early adopters in alternative fuel and propulsion systems for regional shipping.
- The Nordic countries will gain from jointly pushing the development of policies for decarbonising shipping in the EU and in the International Maritime Organization (IMO).

Further research

Bearing in mind how immature the subject of hydrogen for shipping is, it comes as no surprise that several areas are not yet at the level of providing policy recommendations, but rather, need more insights gained from additional research and early field trials. Such research questions include:

- **What economic incentives are the most efficient for sustainable shipping based on hydrogen in the Nordic Region and at the EU level?** How can these best be introduced at a national level in the Nordic countries, and be the next steps of the already decided policies in the EU?
- **How can sustainable energy best be used in shipping?** A what-goes-where is urgently asked for by shipowners and policy makers alike, including what ships should use which fuel and to what extent the drop-in of fuel and hybrid solutions are needed.
- **What is the point of entry for hydrogen in shipping?** Would it, for instance, be relevant to support hydrogen solutions for small scale vessels (not covered by proposed policy initiatives in the EU) or auxiliary systems to gain insights which can be used when hydrogen is later introduced in more large-scale vessels? The development of rules and regulations to meet safety challenges linked to hydrogen as fuel for ships is also needed.
- **How can the cost of hydrogen in shipping be brought down?** Topics appropriate for further research include the mixing of hydrogen with methane (natural gas or biogas), to reduce the need for specific adaptations, use the already existing fleet of gas driven ships and reduce the need for space on the ships.
- **How can the production of hydrogen be increased, and how can the distribution and infrastructure for hydrogen be expanded?** What is the potential role of ports as hydrogen hubs?
- **To what extent can hydrogen for shipping and land transport be combined?** With the new alternative fuels infrastructure regulation (AFIR) directive from the EU, a green hydrogen infrastructure for land transport must be established at pre-determined intervals. If this can be shared with the shipping, using the ports that are relevant for both transport modes, costs will be shared, and initial demand might increase.
- **Definition of green hydrogen (and ammonia).** The EU has hitherto failed to reach a consensus on what constitutes green hydrogen. Potentially, the well-to-wheel GHG emissions (also including methane and nitrous oxides) could be the deciding criteria. The actual climate and environmental performance of hydrogen based marine fuels is, however, still uncertain due to the lack of knowledge on real emissions. Other environmental impacts linked to various alternative fuels also need to be further assessed.

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Plant phenotyping and remote sensing for a sustainable and competitive Nordic agriculture

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The Nordic countries comprise the most northern area of crop cultivation in the world. This presents certain limitations for agriculture, with the region's short and intense growing seasons, and late frosts – something Nordic farmers and agribusiness have adapted to, for example, by developing early maturing crops.

Today's challenges are obvious: climate change, diminishing biodiversity, harmful effects of pesticides, and over-exploitation of non-renewable natural resources. Increasingly, these challenges are met with new, innovative technologies, such as the handling and analysing of big data, AI applications and the robotisation of agriculture. These solutions are not without problems, but adequately applied new technology may strongly contribute to a green, competitive, and socially sustainable Nordic agribusiness industry. One especially pertinent factor, in our opinion, is the full use and integration of plant phenotyping and remote sensing. The use of these technologies is summarised in Figure 1.

Crop phenotyping refers to the observation and recording of various characteristics, or traits, of plants in order to understand their growth, development, and response to different environmental conditions. It involves the analysing and quantifying of traits such as plant height, leaf area, flowering time, disease resistance, and yield potential. In *remote sensing,* specialised instruments gather information from a distance, without direct contact with the plants. Sensors can be mounted on satellites, drones, or ground-based platforms such as robots.

The combination of crop phenotyping and remote sensing are pivotal when it comes to understanding crop performance with the goal of optimising agricultural practices. Ultimately, these methods enhance food production and can secure plentiful and nutritious food as well as plant-based materials and energy. However, they need to be highly integrated. This, in turn, requires a stronger cross-disciplinary effort around plant physiology, big data handling, sensors and vehicles for sensors – meaning the use of technology from satellites to robotics. Screening and analysis steps must be streamlined throughout the entire process, from pre-breeding of future crops to finding new and efficient biostimulants suitable for Nordic conditions. The communication of challenges and solutions requires a strong outreach effort. The target audience for such outreach consists of the countries' decision-makers, public opinion creators, and farmers, as well as teachers and school pupils.

This policy brief from the NordPlant and UPSCALE consortia is based on the review "Functional phenomics for improved climate resilience in Nordic agriculture" [1] and the references therein.

Characteristics of Nordic agriculture

The Nordic crop cultivation area spans a large, almost 2,000 kilometre, latitudinal range from 54° to 69° north. Farming is often conducted in relatively small units, and there is a high degree of organic farming. The Nordic food market is heavily dependent on imports. The recent pandemic and current disruptions to the food chain show the general need to increase food sovereignty by increased local food production. At the same time, the Nordic labour market is characterised by high levels of employment, education, and pay. Despite the high labour costs and unfavourable climate, southern agricultural areas of the Nordic Region have high labour productivity. A unique feature of the Nordic Region is the wild crops and berries that make up the most important non-timber forest products.

Facing a new climate – no Nordic bananas, but...

The global temperature increase is driven by human carbon emissions, elevating the concentration of CO_2 in the atmosphere. Worldwide, food systems themselves equate to 30% of greenhouse gas emissions. Within the next 50 years, the vegetation period is predicted to take up to 100 days longer in the Nordic Region, depending on latitude. This will extend the growth seasons and have a great effect on crop yields, in addition to the selection of the crops that can be produced. According to the IPCC 6th Assessment Report, the average projected increase in temperature is 1–3 °C, with the greatest increase, possibly as much as 6–8 °C, predicted in the northernmost areas. Rainfall is estimated to increase by up to 30%.

While crop productivity in northern latitudes may increase, heat waves, micro-droughts and waterlogging, together with increased risks of invasive species expanding north and thus disrupting the agriculture, are all likely consequences of climate change. Extreme weather events causing drought, frost, and floods will be more frequent and can cause substantial yield losses. Future Nordic crops and forest resources need to be adapted to future climate scenarios.

It is predicted that the areas in the Arctic will warm up twice as fast as in other places. This means that farming will be more profitable in the most northern parts, while many other agricultural areas in the world will be negatively affected. Consequently, the relative importance of crop production in the Nordic countries is likely to increase. So, even if we still won't be able to produce bananas in the future, we can expect to grow more crops associated with southern Europe, such as sorghum. This can complement and help diversify Nordic agriculture if efficiently adapted to northern cultivation systems. Such an addition calls for increased breeding efforts as well as locally tailored measures in precision agriculture. Here, sensor-based phenotyping is a powerful tool.

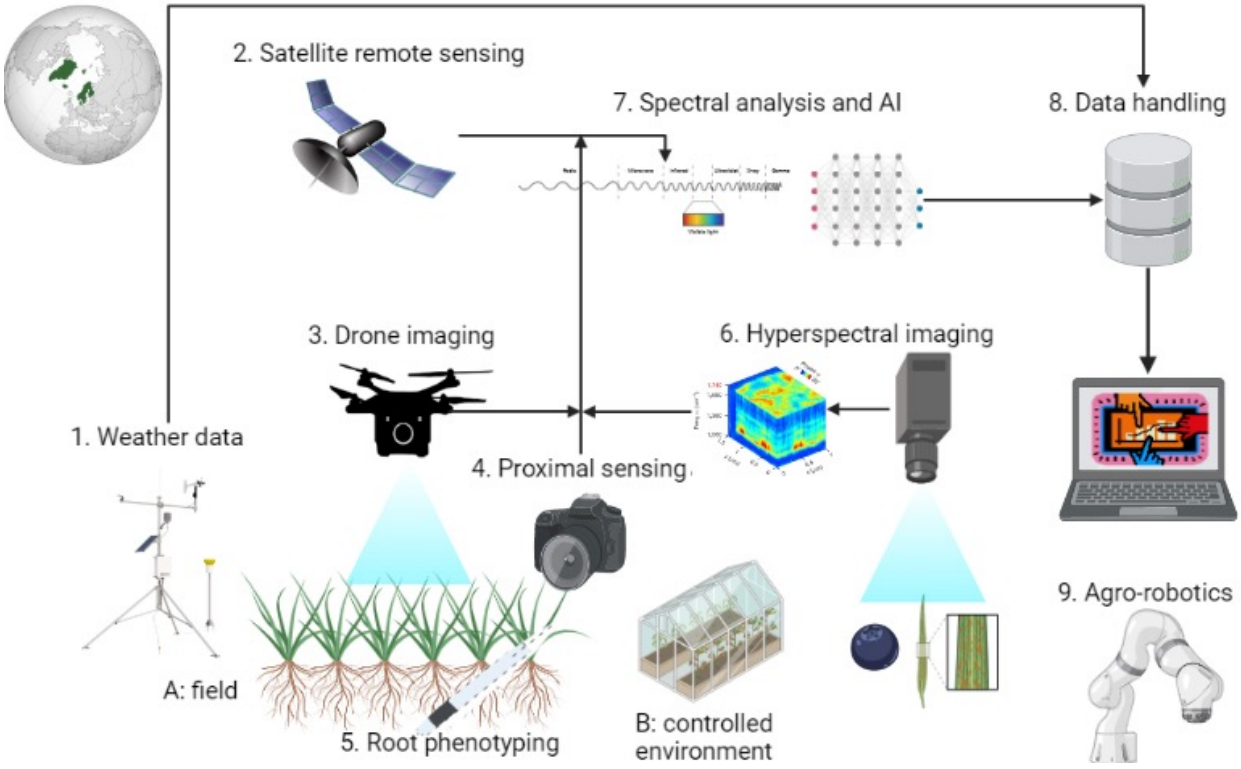

Figure 1: Meta-data such as weather data (1) is important to link to plant phenotyping and remote sensing, which can be obtained and integrated at different scales: satellite (2), drones (3), proximal sensing (4), root phenotyping (5) and by hyperspectral imaging (6) either in the field (A) or a controlled environment (B). Hyperspectral imaging can also be used for analysing food and material. Analysis is a major effort (7). The data need to be provided according to the FAIR principles (8) and can, for example, be used to develop agro-robotics (9). Image created in BioRender.

Breeding faster, and for better food and quality

To mitigate the impacts of climate change and meet market demands, there is a drive to increase the adaptive capacity of crops. This should lead to resilient crops, which can withstand various harsh and fluctuating growth conditions, and are suited to northern latitudes. It will require functional phenomics approaches that integrate sensor-based high-throughput phenotyping (HTP), plant physiology, and bioinformatics [2].

In Roitsch et al.1, we present a number of important breeding traits for the Nordic countries, not only with a focus on climate change but also regarding increased quality and eco-friendliness, for example through decreased dependence of pesticides. To add Nordic value, focus will likely be aimed at nutrient content rather than limited to crop yield. Nordic agriculture could play a role in the important shift towards producing more plant-based proteins and nutritious crops to balance the current global overproduction of starch and sugars that do not comply with nutritional recommendations for human food intake. Remote sensing to scan food properties can help in increasing the quality and value of Nordic food and contribute to a Nordic diet.

New diseases and increased demands to reduce chemical pesticides

Traditionally, there has been a low degree of crop disease because of the unfavourable winter conditions for pathogens and pests in the Nordic countries. However, climate change will also affect disease distribution, and the Nordic countries are predicted to be especially badly affected by an increased plant disease pressure. To this end, site-specific plant disease phenotyping will be important to evaluate available genetic resources including traditional, cultivated varieties for pre-breeding and to find appropriate management systems. Both disease surveillance by remote sensing and disease resistance phenotyping will be important tasks to incorporate in current breeding strategies, in addition to decision support systems for disease and integrated pest management.

The European Green Deal proposes to reduce the use and risk of chemical pesticides by 50% by 2030. It is therefore urgent that new control methods are identified. Unfortunately, there are only few studies on the effect of Nordic climates on the effectiveness and durability of biologicals including biostimulants, which could reduce the dependency on chemical inputs. We think that there is a need to test pathogenicity and host resistance at more northern latitudes and by comparative studies taking advantage of a latitudinal gradient across the Nordic countries.

The current state of plant phenotyping and remote sensing in the Nordic countries

Automated sensor-based phenotyping, foremost via drones, had already had a large impact on breeding companies. Likewise, remote sensing via satellites and tractors now play an important role in fertilisation too. Satellites have the ability to increase the capacity of monitoring compared to drones, as they cover very large areas. For more advanced decisions support systems the level of impact depends on the development of effective processing methodologies.

There is only a handful of high-throughput phenotyping facilities in controlled environments in the Nordic countries [3]. Climate facilities that allow the testing of future environmental conditions can, together with sensor-based phenotyping, greatly facilitate screening for improved climate resilience in crops. Here, it will be important to phenotypically screen GenBank collections. It is also necessary to simulate temperature gradients in combination with the specific light intensities and qualities of the Nordic Region; however, there are a lack of facilities that combine high through-put phenotyping with highly precise climate simulations. One example of a new affordable phenotyping system combined with a precise climate is the recently established Phenocave [4]. There are also ongoing developments of high precision field phenotyping approaches such as the PhenoField developed at the University of Copenhagen [5]. Still, further development is needed, and field phenotyping and remote sensing data need to be comparable along the latitudinal gradient across the Nordic countries to better understand the climate impact on agricultural production.

The way ahead: bigger data, better models, AI and robotisation

The Nordic countries are strong when it comes to agricultural innovation, with research institutions and agricultural organisations working together on developing new technologies and practices to enhance productivity and sustainability. We believe that a stronger focus on plant phenotyping and remote sensing is an important component in Nordic Agripreneurship. There are already several good examples of this. This will be a steppingstone for these techniques to reach the industry at large and come into full use, leading to a more sustainable society and the strengthening of rural development.

The handling, analysis and sharing of data will be key to making the most of the phenotyping and remote sensing techniques. An improved data management strategy will be necessary to capture the comprehensive picture of the plant performance and responses. We foresee future increased efforts to more systematically record and integrate other types of data as well such as genotypic and molecular data, and also comparisons to climatic data. Here, we see a need to also collect and organise different data types and resources into a Nordic field trial database. Large efforts regarding data structure have already been implemented in the NordPlant project.

Several studies have demonstrated how remote sensing can be integrated with crop growth models via data assimilation techniques, thereby combining knowledge of crop growth with observations from space platforms. This will improve the quality of model predictions and bring them closer to real-time applications. AI and robotisation will trigger further changes in Nordic agriculture. We foresee that robotics will play a role both in plant phenotyping for plant breeding and in precision agriculture to detect disease, in terms of both management and harvesting. Development and integration of real-time phenotyping via deep learning for computer vision are crucial for advanced agro-robotics.

How does plant phenotyping and remote sensing create a green, competitive and socially sustainable Nordic Region by 2030?

We need plant phenotyping and remote sensing in the Nordic countries to:

- Accelerate plant breeding in order to diversify and adapt Nordic agriculture to future climate scenarios, increase demand on self-sustainability, and improve nutrition. This can also help in meeting demands around the increased importance of Arctic agriculture.
- Monitor and better understand factors affecting the crop yield and quality, including crop diseases, also caused by new invasive species expanding North due to climate change.
- Supply phenotypic and remote sensing data to improve crop growth models, which can lead to a more resource-efficient agriculture and better decision support systems for farmers.
- Assist in robotisation and adaption of AI in Nordic agriculture.
- Create a closer link to ecosystems research where remote sensing by satellite together with root phenotyping can help the understanding of carbon fixation and flux in large-area estimations of crop-dynamics, and help develop mitigation actions against climate change.

In order to meet these needs, we have to strengthen:

Networks and education

- By maintaining current networks and creating new meeting arenas that foster solution-oriented, interdisciplinary improvements and innovations.
- Through continued private–public breeding partnerships, which have historically held a strong position in the Nordic plant breeding community. Furthermore, the relatively small but cross-disciplinary Nordic phenotyping and remote sensing community can be an efficient ground for an increased interaction around AgTech and AI.
- By strengthening the teaching and communication regarding plants and their importance in mitigating climate change, and in providing sufficient and nutritious food and clean energy. We believe that technology around phenotyping and remote sensing can attract new student groups as young as those at high school level, who may not have been previously interested in agriculture.

Establish comparative latitudinal studies to:

- Contrast the yield performance and nutrient status of crops along the Nordic latitudinal gradient.
- Better understand root establishment in Nordic climates by root phenotyping; a larger root system can increase the carbon fixation potential and facilitate more climate resilient crops.
- Determine the climatic influence on the efficiency of biologicals that can lead to a lower reliance on chemical agricultural inputs.

Improve data storage, handling, integration and analysis

- Improve methodologies to process and integrate remotely sensed data from optical and radar platforms with crop models.
- Create user-friendly and rewarding systems for researchers, companies and farmers to report phenotyping and remote sensing data adhering to the FAIR principles.

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Biocircularity to create a sustainable Nordic oasis: Transitioning toward novel feed ingredients (SUSTOASIS)

Focusing on a high-value seafood commodity to reach Vision 2030 of the Nordic Region

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Policy brief

- Microbe-derived ingredients (oil, pigments, meals) and insect meal produced in waste streams can be used in aquafeeds for a sustainable, circular and bio-based economy.
- Reliable sources of novel ingredients are necessary to contribute to the nutritional quality of aquafeeds, the health and welfare of animals, and the quality of seafood.
- Members of the Nordic Region should earmark novel feed ingredients as targets for green and competitive growth, to attach sustainability to one of the high-valued food products of the region.

Increasing need of novel feed ingredients that comply with biocircularity in order to take the path of sustainability to achieve a green and competitive Nordic Region

Support to enhance the sustainability of the fastest-growing food production system cannot be disregarded in the aim of achieving a green, competitive, and sustainable Nordic Region. Norway, Sweden, Finland, Denmark, and Iceland produce salmonid fishes to cater to the demands of the burgeoning population. Sweden and Norway have impressive gross domestic product (GDP) of USD 635.66 billion and 482.17 billion, respectively [1, 2]. A percentage of the GDPs of the Nordic Region that goes into research and development [3, 4] can be utilised to generate relevant information about novel sustainable feed ingredients that can be used to produce a healthy alternative to other meat products, which have greater footprint and poor feed to food conversion rate. The emphasis should be on biocircularity where low-trophic feed ingredient sources grown on waste streams can be the feedstock for aquafeeds. A close collaboration between researchers from the Nordic countries will enable knowledge and skill transfer generated through targeted research activities in these areas of study. It is critical to obtain new knowledge, strengthen expertise and produce excellent results for the aquaculture industry in the Nordic Region and elsewhere to encourage the sector to provide carbon neutral food for the global community as well as to increase job opportunities to support the local societies and spur economic growth. The foreseen integrative research among partners in the Nordic Region that is directed towards finding the best locally produced alternative to the currently imported, high-priced feed components with a substantially higher carbon footprint will aid in developing conducive conditions for a socially and environmentally sustainable zone. The net result will be attaining the Nordic Region Vision 2030 and adding value through the collaborative build-up of academic excellence, as well as enhancing the learning experience of the future generations by equipping them with the apt knowledge and skills. Upon providing evidence on the efficacy of the waste stream-grown low-trophic organisms, the Nordic Region could establish next-generation aquaculture protocols.

Charting a path to aquaculture sustainability

Considering the aquaculture industry's role in providing food to the world population and the Nordic region's importance to the seafood trade, sustainability should be ingrained in the food production system. A competitive advantage of the Nordic countries is that they have a well-established industry and infrastructure to produce food fish rather than harvesting wild stock. The availability of clean water, excellent control of diseases, great care for fish welfare and growing aquatic animals without significantly impacting the environmental balance are other merits of the Nordic Region. Carnivorous salmonid species produced in the Nordics require high-quality feed ingredients. This key input in the production process must be linked to sustainability. Currently, aquafeeds are manufactured using finite resources and imported feed ingredients such as soybeans, which increase the industry's carbon footprint. The industry should take a turn from their current path through a phased shift to the use of novel low-trophic feed ingredients. This move is pertinent for a greener transition as such resources will comply with the need for biocircularity. The ideal way of achieving this is to utilise the side streams from food production sectors, including aquaculture, to produce, for example, microalgae and insect larvae that can be incorporated into aquafeeds. The advantages of these ingredients are that they do not compete with the production of other food, and they can be produced in the Nordic Regions with limitations associated with climate and outdoor cultivation in large areas. *Nevertheless, these ingredients should be appropriately processed to increase their bioaccessibility and bioavailability to ensure translatability to the growth and health of salmonids and the quality of consumer products.*

Research performed in the last decade has shed light on the suitability of both microalgae biomass and insect meal for feeds of carnivorous fish such as Atlantic salmon. As of the time of writing, no studies have identified an ideal alternative to fishmeal/soybean meal or fish oil. Hence, there is a need to perform in-depth studies to: i) find suitable alternatives to current feed ingredients, with the replacements complying with biocircularity ii) increase the bioaccessibility and bioavailability of untraditional ingredients iii) understand the safety of both the novel feed ingredients and marketable products and iv) understand the feasibility of them being produced economically and available in large quantities to meet the industry demands.

This policy brief, which aims to inform the Nordic Council of Ministers about the need to perform advanced research to find suitable low-trophic aquafeed ingredients, considers the objectives listed under *'A green Nordic Region'* and *'A competitive Nordic Region'* [5]. However, the objectives under *'A socially sustainable Nordic Region'* will have to be strictly followed during the conduct of all the funded projects [5]. Research-based evidence is necessary to nudge the aquaculture industry towards a more sustainable path, which will help Nordic consumers to choose 'healthy and environmentally and climate-friendly' food [5]. The generated information will stimulate the industry to responsibly produce high-quality proteinaceous food for the burgeoning population.

State-of-the-art innovation within our research area in relation to the three strategic priorities

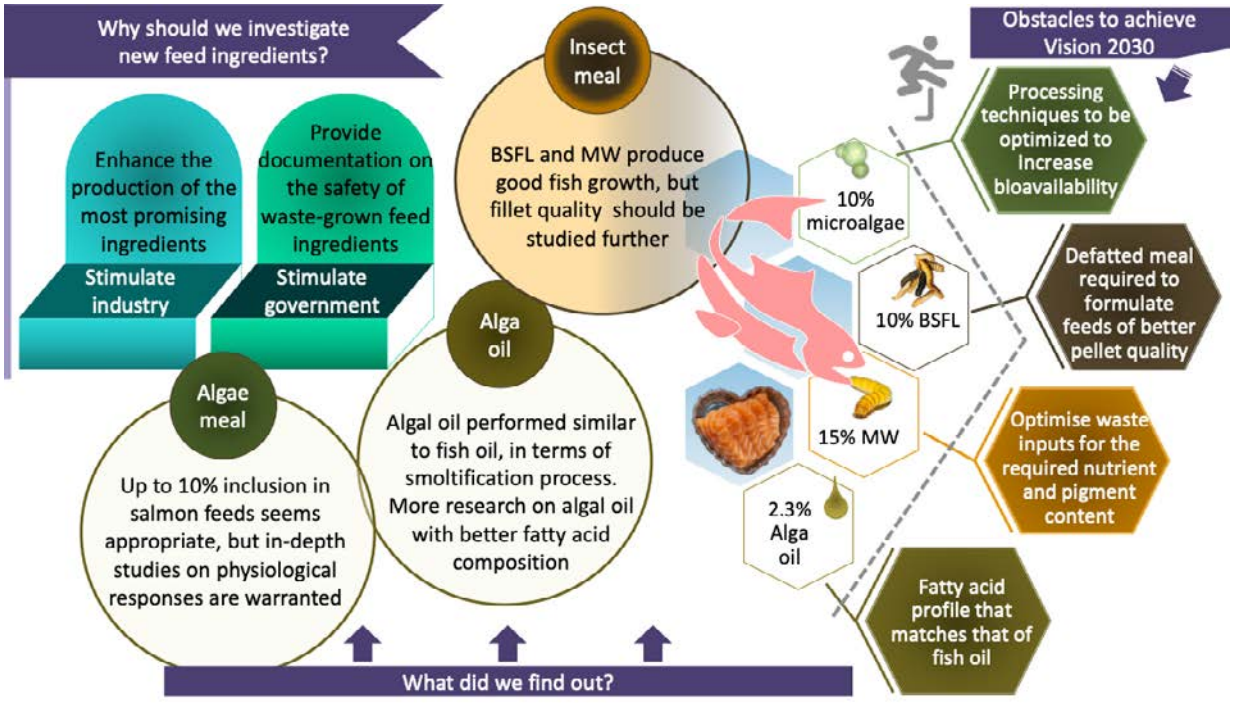
Our research focuses on novel feed ingredients to provide evidence on sustainable ingredients, to stimulate the aquaculture industry to use such ingredients to elevate the level of their sustainability status. By doing so we are also finding evidence that we should rely on ingredients that promote a circular and bio-based economy (*'A green Nordic Region'*). For example, we performed feeding experiments to evaluate the suitability of a microbial oil (replacement of which reduces the marine footprint) and insect meals (that uphold circular and bio-based economy with resources that are presently considered as waste). The knowledge

that we created was achieved through innovative ideas and Nordic collaboration with an emphasis on interconnectedness (*'A competitive Nordic Region'*; NordForsk Project#: 104310).

Methods

We performed feeding studies with Atlantic salmon both at Nord University and at LetSea AS in Norway to generate reliable results for the aquaculture sector. Experiments were performed by experienced scientific personnel with inputs from the partners. The strong collaboration with our partners in the industry and research institutions in the Nordic Region was instrumental in producing the excellent results. The life cycle analysis performed by the collaborators in the Baltic Region helped in understanding the environmental sustainability of the feed ingredients. Thus, the Nordic-Baltic alliance was crucial in generating the required knowledge for the industry.

Results



Figur 1: Microbial meal, oil and insect meal replacement studies indicate their suitability in salmon feeds

In addition to the experiments that we performed as part of the NordForsk project (104310), microalgae meal-based studies were conducted as part of another project. Research on microalgae and insect meal conducted over the past decade has indicated the suitability of the ingredients in Atlantic salmon feeds [6-15]. However, to exploit the full potential of these ingredients more research on their processing is crucial, as our studies have indicated that black soldier fly larvae (BSFL) must be defatted to adopt a higher inclusion level and mealworm (MW) pigments should be tweaked in order to have the appropriate impact on the fillet colour preferred by the consumers. Hence, defatted BSFL and desirable pigment containing MW must be studied by conducting experiments with Atlantic salmon. Like fish oil, algal oil provided the hormonal, morphological and osmoregulatory capabilities to salmon during its parr-smolt transition [14]. Future studies must investigate algal oil inclusion levels of 15% and algal meal/insect meal inclusion of up to 30% in Atlantic salmon feeds if we are to considerably reduce the dependence on our finite resources and imported products. As for the microalgal meal that we studied in another project, the impact of different species varied

widely [6-13]. Some were able to impart pigmentation, others were capable of depositing polyunsaturated fatty acids in the fillet of salmon, a characteristic regarded as healthy. Nevertheless, there is still a long path ahead until considerable amounts of microalgal/insect meal can be included in salmon diets as the digestibility of these ingredients is still a limiting factor that reduces the bioavailability of nutrients/pigments.

Policy insights

Salmonids being one of the main commodities of the Nordic countries, it is important to find the best sustainable alternatives to the current feed ingredients. The production of these novel components should be based on biocircularity, preferably by utilising the waste stream from different sectors. This move will help the Nordic Region realise its Vision 2030 and contribute to different aspects of Nordic added value. Currently only a tiny fraction (0.4%) of Norwegian salmon feeds are composed of novel ingredients and only 8% of the ingredients are from Norway. Current salmon feeds contain locally produced marine ingredients, but more information about possible ingredients such as mussel meal must be gathered to follow a self-sufficiency path. The generated information of the available, low-trophic a marine ingredients will not only encourage the emergence of new businesses that comply with biocircularity but will also allow the Nordic Region to follow a sustainable path by supporting research on aquafeeds which is key to the growth of the rapidly growing food producing sector.

Obstacles to be surmounted to achieve the Nordic Region's Vision 2030:

- Lack of appropriate policies to encourage the use of novel feed ingredients
- Prioritisation of funds for research that targets next-generation feed ingredients
- Efficient use of waste streams for the production of novel feed ingredients
- Advanced fermentation and photobioreactor technology to produce microbial ingredients
- Effective processing techniques to increase the bioavailability of nutrients and pigments
- Indepth testing of novel products in salmonids including Atlantic salmon and rainbow trout
- Research-based evidence to encourage the industry to produce large volumes of sustainable feed ingredients to allow the region to follow a green, competitive and sustainable path

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Collaborate, innovate, and share: Towards a smarter aquaculture in a smart region

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Summary

The use of recirculating aquaculture systems (RAS) for land-based fish farming is a growing global industry. The Nordic Region has long traditions within aquaculture and is currently a main driver for aquaculture development. Yet, the RAS industry is facing numerous challenges related to water quality management, energy efficiency, fish health, and pollution. New technological advancements and developments in the fields of Artificial Intelligence (AI) and the Internet of Things (IoT) have the potential to transform RAS management by turning RAS into smart and highly automated systems, potentially resolving many of the problems that the industry is facing today. The Nordic Region should not lag behind in this development, but rather actively take a leading role in developing the next generation of RAS systems, which will contribute significantly to making the Nordic Region the most green and competitive region in the world over the coming years. The Nordic Region is well suited for this transition, given the general high educational level in the region and its overall current expertise in RAS farming. We believe that a good way for the Nordic Region to move forward in developing the RAS industry is to bring together individuals from different countries and sectors to actively collaborate on teaching, research, and knowledge transfer activities. A co-operation between the Nordic countries in developing a smarter RAS industry will create Nordic added value in several ways, such as enhancing: cost-effectiveness, regional mobility, and scientific excellence.

RAS – A globally growing industry

Over the last few decades, there has been a rapid global increase in the number of land-based RAS facilities. There are several reasons for this development, such as an increased global demand for seafood due to population growth and an increased awareness of the nutritional benefits of eating fish, as well as a global decline in fish populations due to over-fishing and pollution. Moreover, there is an increasing awareness of the advantages of a land-based production of fish compared to traditional farming in on-shore net-pins. Growing fish in a closed, controlled environment removes the problem of sea-lice, fish escape incidences, and if biosecurity measures are successful, it also reduces the risk of disease outbreaks. By being able to control the waterflow, RAS farmers can exercise the fish, thereby producing an overall healthier fish, with a more natural fat and tissue composition. RAS farms can be built close to market, thereby limiting transportation costs and CO_2 footprint. In terms of efficiency and productivity, RAS also enables highly reliable production and harvest cycles throughout the year.

The RAS industry in the Nordic area.

Aquaculture in the Nordic countries has a long history, beginning in the 1850s when hatcheries for the restocking of salmon and trout were established in Norway [1].

The Nordic countries have accumulate considerable hands-on experience over the last 3 to 4 decades in designing, building, and operating intensive land-based RAS for different species. Today, Atlantic salmon is the dominant cultured species in Norway and the Faroe Islands, with rainbow trout dominating in Denmark, Finland, and Sweden, and Arctic char and cod dominating in Iceland. Taken together, the production of fish in RAS significantly contributes to the production of food in the Nordic countries. High capital costs are one of the biggest challenges for the further development of an economically sustainable RAS industry in the Nordic Region. This drives RAS development towards large scale intensive productions in order to reduce investment and operational costs per kilo of produced fish. However, large scale intensive farming increases the technical complexity of RAS systems, which puts large demands on system management. This – combined with strict environmental regulations and the focus on both waste water management and animal welfare – slows down growth of the industry in the Nordic Region [2]. There is thus a need for the development of cost-effective, economically viable aquaculture production methods that minimise the environmental impact while at the same time ensure optimal rearing conditions and quality of the produced fish. Developing methods to meet this need is a common challenge for all Nordic countries.

Next generation RAS

As in other industrial fields, the next generation of RAS can be expected to make use of new technology and further developed operational procedures for improved system performance. Advances in sensor technology make it possible for RAS farmers to collect an ever-increasing amount of real-time data about biofilter performance, water quality, and fish health. This development paves the way towards more automation and better system control through extensive use of computer systems and AI for process optimisation. The transition towards smarter operation procedures in the aquaculture sector has already begun, with the use of AI and the IoT to improve water quality monitoring, optimisation of feeding procedures, recognition of abnormal fish behaviour, and the management of the whole aquaculture process through smart phones [3]. The Nordic Region should not lag behind in this development, but rather actively take a leading role in developing the next generation of RAS systems, thereby contributing to making the Nordic region the most green and competitive region in the world over the coming years.

Collaboration challenges

Developing the RAS industry in the Nordic Region requires close collaboration across borders, and within and between the academic and the industrial sectors. Building good collaboration environments requires the development of trust, tolerance, self-awareness, empathy, and transparency. This is challenging, given that different companies compete for customers and different academic groups compete for funding and prestige. In addition, the industrial sector and the academic sector approach the development of RAS in fundamentally different ways. The industry, for instance, wants to develop immediate practical procedures towards making a marketable product. Academics, on the other hand, seek to discover the fundamental principles of nature. The corresponding gap in terms of differing goals, motivations, and measures of success makes collaboration difficult. At the same time, the industrial and academic sector depend on one another. The creativity and expertise of academics provide a problem-solving resource for the industry. Academics need help from RAS operators to gain insight into what problems the RAS industry needs to solve.

In order to unify the academic sector and industrial sector across all Nordic countries, it is essential to establish collaboration activities where individuals work together with common goals.

Joining forces for a more sustainable Nordic RAS industry in the Nordic Region.

We believe that actively working together is the best way to build trust, tolerance, self-awareness, empathy, and transparency. When we do things together, we can build long lasting personal relationships, facilitating the opportunity to identify and engage with common goals. Thus, we think that actions should be taken to stimulate the establishment of long-term collaborations where individuals from the RAS industry and academia in the Nordic countries can actively work together on multiple levels to identify and reach specific common goals regarding: the teaching of students, research, technology development, and knowledge transfer. We therefore propose the following recommendations:

Recommendation 1: Establish one or several online courses for bachelor's and MSc students. Such a course could, for example, focus on the integration of new technologies, such as the use of AI and the IoT, as well as on biofilter monitoring by means of high-throughput OMICS technologies, water quality sensors, and new water treatment procedures towards the establishment of a smarter RAS industry. Establishing such a programme will bring instructors from different fields together to discuss, identify, and raise awareness of critical steps towards the development of smart RAS. A course should include instructors and students from several or all Nordic countries, and it should include industry practitioners providing lectures on topics and application perspectives that are particularly relevant to the industry. Such collaborations could have many benefits. Instructors from academic institutions gain a better understanding of the challenges facing the RAS practitioners, while the owners and workers in RAS will gain insight into how increased knowledge and new technologies can lead to higher quality and lower environmental impact of RAS. Respectful relations are formed in order to create possible future problem-solving collaborations among instructors. Contact with students gives the instructors a recruiting advantage. Students benefit from building networks with other students and instructors across national borders, and they get exposed to real data and real-world insights.

Recommendation 2: Provide funding to establish small thematic RAS research consortia. A consortium could consist of up to 30 persons from 4–6 academic and industrial institutions. The funding should cover expenses over 3–5 years for arranging annual physical meetings for members of the consortium. A focus should be on offering a safe environment for PhD students and MSc students to present their research and to build long-lasting relationships between individuals from different sectors and different Nordic countries. Moreover, a central aim of establishing the networks should be to provide long-term connections leading to the development of research proposals aimed at reaching common goals among representatives from the industrial and the academic sector.

Recommendation 3: Develop courses for RAS employees continuing education and skills development. Such activities will bring the academic and industrial sector closer together in the aim of reaching a common understanding of the challenges and solutions involved in developing the RAS industry.

Recommendation 4: Establish a 'Nordic Centre for RAS Research and Development' that could work towards enabling researchers to access and analyse RAS data with the aim to improve the value and impact of RAS research on the environment and the economy. Activities in the Centre could be that of developing guidelines and best practices to generate and manage RAS data, develop software for data analyses, develop and update databases on published RAS data for research purposes, organise events that bring the private and public sectors together, and run training courses.

Coordination of the activities suggested above could be done through NordForsk or the already existing Nordic Network on Recirculating Aquaculture Systems, which, as its main objectives, works towards co-ordinating and strengthening the research and development of RAS in the Nordic countries [4].

Nordic added value

A co-operation between the Nordic countries in developing a superb RAS industry through teaching and knowledge exchange will create Nordic added value in several ways. It will contribute to: i) bridging the gaps between different nations and sectors so as to build RAS expertise on a Nordic level; ii) the development of a smarter RAS industry that can make the industry greener and enhance the cost-effectiveness of RAS in the Nordic Region; iii) increased regional mobility and networking among industrial and academic partners in the Nordic countries; and iv) positioning the Nordic Region in a leading position for RAS development, which will enhance scientific excellence and increase the chances of success for Nordic researchers in international research co-operation, and stimulate the creation of innovations and patents.

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Towards a Nordic wastewater-based antimicrobial resistance surveillance network and an integrated digital platform

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Summary

The need for efficient pandemic preparedness has been highlighted as an important lesson for us from the COVID-19 pandemic. The threat of antimicrobial resistance (AMR), also known as 'a silent pandemic', continues to demonstrate an upward trend in attributable deaths regardless of a country's economic status. One of the well-known strategies for curbing this threat is the establishment of an effective surveillance system at regional, national and global levels. Some Nordic countries have established such surveillance systems based on healthcare records at national levels, which may also be part of the European Antimicrobial Resistance Surveillance Network (EARS-Net). However, not all Nordic countries have this system in place. Moreover, in addition to the unified healthcare-based Nordic surveillance on AMR, there is a need to develop a compiled Nordic surveillance infrastructure on AMR at population level using municipal wastewater, which is an **especially valuable and trustworthy source of information for timely policy decisions.** The value of information from wastewater treatment plants (WWTPs) on epidemiological status was clearly demonstrated during the COVID-19 pandemic. However, for WWTPs to provide accurate information on the epidemiological threat and AMR, it is necessary to establish: routine protocols, a list of monitoring targets, and threshold values. There is a clear lack of comparable methodology in this respect – not only in the Nordic Region, but also globally.

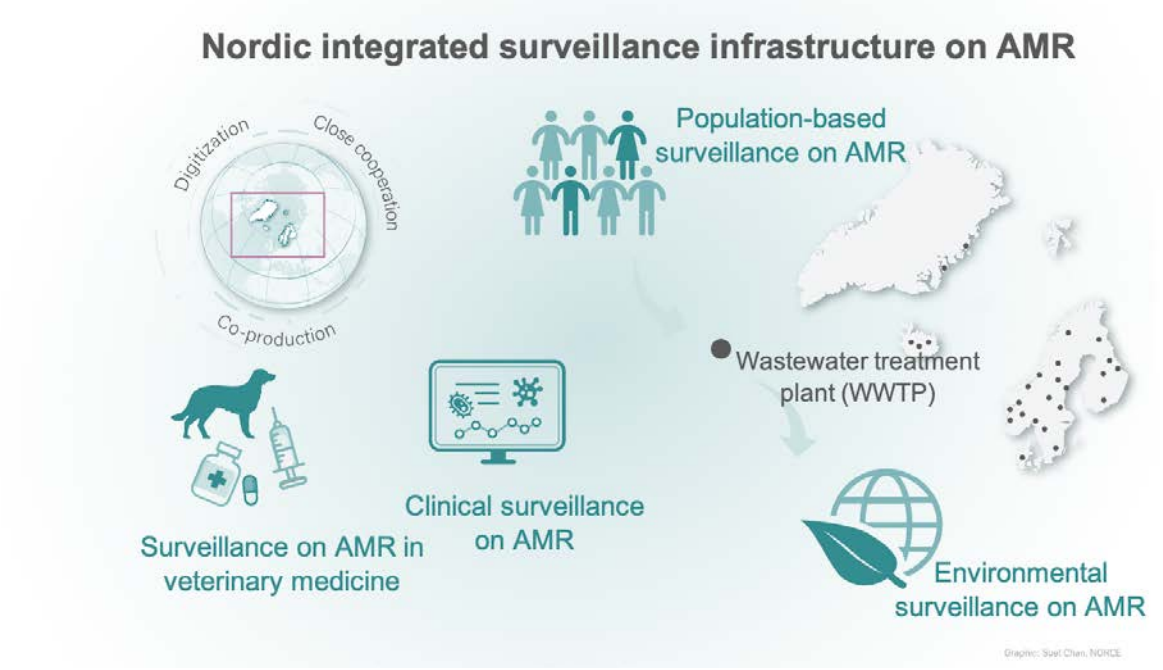
For this reason, we recommend initiating a Nordic transformation in the handling of AMR by the introduction of **unified and digitised surveillance at wastewater treatment plants** (WWTPs) not only as a unique source of information at the population level but also because WWTPs constitute **the only possible barrier** that can be used to prevent the spread of AMR into the environment as well as further AMR escalation. Establishing such a Nordic surveillance infrastructure at WWTPs will provide a real benefit by facilitating a robust interpretation of temporal trends of AMR in the Nordic Region, as well as providing early warning for **better preparedness to upcoming and unavoidable epidemiological crises.** We believe that establishing this highly digitalised Nordic surveillance infrastructure will bring long-term societal benefits and reduce healthcare costs.

Policy recommendations

Vision 2030 has proposed three strategic priorities: a green Nordic Region, a competitive Nordic Region, and a socially sustainable Nordic Region. Achieving these goals will not only benefit, but largely rely on the Nordics having a healthy and prosperous society where early signs of infectious disease can be detected, and preventative measures can be proposed in a timely manner. As such, we suggest initiating **a joint creation process of a Nordic infrastructure in hotspots for AMR at WWTPs**. We propose the use of existing knowledge and technological solutions to design robust operational routines and implement regulations at WWTPs in the Nordic countries. This will require funding for the development of routine activities in order to: build infrastructure at WWTPs, provide practical guidance for WWTP operators, and set threshold values for discharges in terms of pathogens and AMR. The infrastructure at WWTPs will result in:

1. **Pandemic preparedness** Nordic countries should agree on standardised guidelines. These should include sampling routines and methods, a list of monitoring targets (such as multidrug resistant pathogens and population level AMR determinants), testing protocols and data collection. Consistent and compatible data across the Nordic Region for comparison and analysis will facilitate *robust interpretation of temporal trends of AMR and will constitute a powerful tool for timely policy decisions* (see illustration).

2. **Inclusion of the One Health approach by enabling control of the quality of WWTP discharges and limitation of AMR spreading.** There is a need to provide practical guidance for WWTP operators to set threshold values for discharges in terms of pathogens and relevant genes (see illustration).



To ensure an effective exchange of information between individual locations **we recommend building a robust IT infrastructure with enhanced security.** There is a need to establish an IT platform that can be shared among Nordic countries. This will serve as a communication platform for timely intervention in response to any early indications of super bug outbreaks, in addition to that of unacceptable epidemiological quality of WWTPs discharges. Such a platform could also build on existing Nordic databases for AMR surveillance in clinical and veterinary settings.

Problems

- There is a lack of preparedness or coordination in counteracting the AMR crisis in the Nordic Region.
- The wastewater epidemiology approach is not adequately applied or coordinated in the region.
- There is a lack of standard monitoring targets and agreed threshold values, and a lack of unified monitoring protocols at WWTPs in the Nordic Region.
- There is a lack of comprehensive infrastructure and digital solutions for information sharing at WWTPs for use in public health actions.
- There are a lack of standards governing the quality and quantity of factors describing AMR in WWTP discharges.

Background

The experiences from our last global pandemic with COVID-19 has shown the fragility of our society in the face of communicable diseases that we cannot treat with currently existing drugs. It also raised global awareness of the need for enhanced public health monitoring and preventative strategies. With the increased spread of AMR, we are seeing, at a global level, more and more multidrug-resistant and even pandrug-resistant bacteria that can no longer be treated with antimicrobials [1]. AMR is seen as one of humankind's largest unmet medical challenges, and a problem that is rapidly expanding both geographically as well as in quantity [2]. It has been estimated that by 2050, the spread of AMR would cost ten million lives every year [3]. This figure exceeds those from the leading cause of death, cancer (estimated at 8 million), and even the average excess deaths associated with COVID-19 in the 2-year period of 2020 to 2021 [3] [4]. More recent data still show an increasing death toll associated with AMR of about 4.95 million in 2019 [5] [3]. AMR surveillance in Europe is based on both the decision of the European parliament of preparedness and the response to serious cross-border health threats (EU 2022/2371), including AMR, and of the Commission Implementing Decision of 22 June 2018 (EU 2018/945) on communicable diseases and related special health issues to be covered by epidemiological surveillance. AMR surveillance data from Europe is of good quality [6], but the WHO stated in its report in 2014 that the global surveillance of AMR is not coordinated or harmonised and there are many gaps in the information [7]. Currently AMR surveillance is predominantly conducted at clinics or healthcare institutes and therefore reflects the clinical AMR situation. With the advent of the One Health philosophy (that human health is connected to that of animals and the environment), **it is becoming increasingly clear that such an approach (based solely on clinical data) will fail to correctly demonstrate the fluxes of resistance spread and development** in society at the national and global level. It has been widely underscored that only a multidisciplinary effort can provide an adequate response.

WWTPs receive wastewater from various sources (households, industries, and hospitals) and therefore constitute a unique source of information on AMR and epidemiological status at a population level (at the inlet) and play a significant role in the spread of antimicrobial agents and AMR (at the outlet). Information on the epidemiological situation can be provided through this, and the content of WWTP discharges can be monitored in each region due to our possession of DNA-based tools capable of providing rapid, key comprehensive information. The feasibility of this task is made possible by technological and IT advancements, eliminating the need for access to fully equipped laboratories. **Such monitoring can be conducted at individual WWTPs** for inlet and outlet samples.

Surveillance on AMR at the inlet of WWTPS (Pandemic preparedness, societal security and trust building) – The observation that wastewater in Europe reflects the pattern of clinical AMR prevalence [8] and the demonstration of the utility of wastewater for monitoring the evolution of the COVID-19 pandemic strongly contributed to the accelerated development of Wastewater-Based Epidemiology (WBE). WBE is a new tool that complements infectious disease surveillance by rapidly monitoring the spread of disease, and offers benefits such as revealing trends, real-time data collection, and also provides population-wide information on AMR. Individualised medicine focuses on personalised treatment but may not effectively address global or regional patterns. To effectively address AMR, a strong knowledge base and policy framework is required. While global actions are necessary, Nordic countries can lead by example through standardised responses to AMR challenges and a well-established anti-AMR strategy. Norway, much like Sweden and Finland, has a public administration characterised by local self-government [9]. Thus, it seems that a more appropriate approach is to undertake systematic actions at the local level rather than massive transformations in AMR management. Furthermore, understanding regional and local variations in trust-building and citizen assessments of healthcare services is crucial for collective learning and improvement.

Surveillance on AMR at the outlet of WWTPs to prevent transmission – Even though WWTPs are regarded as hotspots of micropollutants, there is a lack of EU standards for WWTP effluent in this respect. In principle, the EU policy suggests developing precautionary end-of-pipe measurements in environmental protection strategies. In the EU Water Framework Directive (WFD), several Pharmaceutically Active Compounds (PhACs), including three antibiotics, are listed in the first surface-water watch list established in 2015 (Environmental Quality Standards Directive, EQSD), but there are currently no EU-level environmental quality standards. Most likely due to the lack of regulations at international and national levels, there are large differences in wastewater treatment management approaches and practices not only on the international scale, but also within individual Nordic countries. For instance, in the Tromsø municipality (Norway) biological contaminants are not removed at all, unlike the urban WWTPs in Bergen and Stavanger that utilise multistep and advanced treatments. In Iceland, treatment consists of screening at best, but in many places the wastewater enters coastal waters untreated. In Reykjavík, home to more than half of the country's population, only a single-step wastewater treatment process is in place.

The utilisation of WWTPs for an integrated epidemiological monitoring, coupled with the implementation of rigorous, systematic, and coordinated measures, constitutes the recommended actions that can be undertaken by the Nordic governments. In addition to conducting public information campaigns on the role of human behaviours in AMR emergence, these efforts will play a pivotal role in preparing for potential outbreaks of (multi) resistant pathogens. This approach encompasses two interconnected facets: (A) raising awareness within society regarding the risks associated with AMR and dangerous pathogens, and (B) leveraging WWTPs as a protective barrier to mitigate the release of anthropogenic AMR into the environment.

In light of the Nordic Vision 2030

The proposed actions herein align with Vision 2030 for the Nordic countries. This is an innovative approach, requiring tight collaboration, knowledge exchange among different stakeholders, and the digitisation of the overall process. In the long run, it **will improve human health and welfare and safeguard natural environments.** We consider welfare to be intricately interlinked between societal trust, good health, a safe environment, and preparedness for upcoming and unavoidable epidemiological threats.

Disclaimer - The article contains solely the opinions of the authors and does not represent the official position of the research organisations

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Where to find more information - https://www.norceresearch.no/en/projects/wastewater-treatment-plants-as-a-trusted-source-of-timely-information-on-antimicrobial-resistance-threat-trustme

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Responsible health management across the Nordic Region in a OneHealth climate-change perspective

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Introduction

Climate change is a global phenomenon that occurs at twice the speed in Northern regions as compared with other parts of the world [1]. In fact, a recent study indicates that Northern climate change accelerates as much as four times faster than in the rest of the world [2]. Thus, the impact of climate change will be faster and quantitatively more noticeable in the North, especially given that the region is also a forceful climate driver on the planetary scale [3]. It is therefore of local, regional, and global interest that actions taken in the North are adequate, far-reaching, policy-fulfilling, and closely surveyed with respect to dynamic management effects and cost-benefit results. As a consequence of global warming, the globe faces increasing climate hazards that introduce multiple risks to ecosystems and humans. Health problems such as heat-related human mortality and morbidity, as well as food-borne, water-borne and vector-borne diseases, have already been reported as on the rise [4], as have their associated mental health challenges [5]. Other projected large-scale climate-change effects are the flooding of coastal regions and low-lying cities, loss of biodiversity in terrestrial, freshwater, and marine ecosystems, loss of fundamental glacial fresh-water resources, and decreasing food production.

A Nordic sustainability initiative through the era of climate change, broken down into short and long-term objectives, is required. The acceptance of this vision is likely to depend on the strategy for implementation decided on by the policymakers and the civil society they represent, conducted in bilateral partnership with scientists and science diplomats, and the essential bilateral communication with society as a whole. Being initiators and benefactors of the CLINF Nordic Centre of Excellence [6], under the NordForsk joint Nordic initiative "Responsible Development of the Arctic: Opportunities and Challenges – Pathways to Action" [7], we hereby summarise some of the CLINF results produced during its eight year 6.5 MEUR effort for the benefit of joint Nordic climate-change management. CLINF has engaged more than 50 senior scientists, who have produced more than 65 peer-reviewed publications.

International harmonisation of national health-survey programmes

CLINF has applied the OneHealth perspective as its general method of assessment – meaning the integrating of environmental data with human and animal disease data for the identification of emerging climate-sensitive infections (CSIs) of the North, including CSI prediction in accordance with the standard IPCC climate scenarios. The past 30-year CSI climate scenarios have been mapped together with predictive maps that consider the principal dynamic processes that regulate CSIs as they migrate across societal infrastructures of the North. Accordingly, the dynamically interacting social, economic, and cultural CSI effects constitute the OneHealth scenario assessed by CLINF. It has thereby been demonstrated that it is possible to project outbreak scenarios even on a regional level with a manageable level of uncertainty. The rapid harmonisation of national programmes that conduct health

surveys, as well as of the associated databases for public dissemination of health data, need to be prioritised, given that these are key elements required for the further improving of predictive CSI projections, and to further decrease the associated model uncertainty. For societal OneHealth assessments, simple information such as the gender and age of patients are examples of factors that urgently need to be included in a harmonised scheme of disseminating health data across the North – and internationally.

Emerging climate-sensitive infections

With respect to recent and historic epidemics and pandemics, climate changes may lead to shifting geographic boundaries of pathogen, host, and vector populations, and amplify the transmission of endemic climate-sensitive pathogens [8, 9]. The projected "winners" of the animal realm will be the species having a rapid reproduction-rate and a short life span. Rodents, small vertebrates, and insects are huge transmitters of pathogens. The North, with its relatively low diversity of animal, plant, and microbial species, and with its surface temperatures increasing significantly faster than the global average, is likely to experience more severe changes in infectious disease patterns than other regions [3].

The basic reason why CSIs may spread towards the North alongside climate change lies in the transformation of warming landscapes where principally frozen biomes are greening and becoming wetter, and thus transforming into pathogen habitats that hold the potential of attracting relatively warm organisms that migrate along Northern climate gradients. The CSIs may respond to the invitation by either translating or expanding at the populations scale, or simply by terms of changing population density while staying geographically stationary. Among these potential CSI effects, the geographic expansion of disease populations has a special bearing on Siberia. With its 13.1 million sq km, as compared with the approximately 0.8 million sq km that applies to the Nordic region above 55 degrees North, Siberia holds a potential of CSI habitat that dwarfs other parts of the Eurasian North. There is well-known remotely sensed evidence [10] that vast areas of Siberia are greening and growing wetter at alarming rates which, by law of nature, invites CSI vector and reservoir organisms. Since this threatens to multiply the sheer mass of threatening pathogens, it is vitally important to keep track not only of the landscape transitions visible from space, but with Siberian CSI dynamics observed in situ. Furthermore, with the probability of globally eradicating infectious diseases being principally proportional to pathogen mass [11], the current ban of scientific exchange with Russia constitutes a global OneHealth threat. As pointed out by authors such as Evengård and Thierfelder, [9] and Evengård et al. [12], the method of overcoming the current block of vitally important OneHealth information may be achieved by way of "science diplomacy" where scientists and diplomats act as forerunners in contact with colleagues in the parts of the world where sanctions have been introduced for political reasons. The very existence of Homo sapiens is under threat – something that should be of concern to everyone.

While in situ observations across most of the North are blocked, the statistical corroboration of hypotheses regarding CSI responses to climate change will remain constrained. Instead, remotely sensed data may be used to model and forecast future CSI scenarios. Such modelling efforts require mechanistic or statistical disease models [13] that have been validated in regions still available for in situ CSI sampling and may be further linked with relevant landscape and hydro-climatic models, data, and projections into the future [14, 15]. Such disease models may be combined with climate model projections – such as of future temperature, precipitation, thawing of permafrost that in turn changes the vegetation of the landscape, soil moisture, snow cover, atmospheric pollution, and other disease-relevant factors – in order to assess potential impacts of landscape and hydro-climatic change on future disease spreading. Multiple alternative models should be tested for both diseases (often not

available) and environmental conditions including various landscape and hydro-climatic data (often available and should be used) as far as is possible, so as to quantify and understand multi-model uncertainty and robustness of inferred implications of future disease evolution [16, 15].

Reappearance of ancient microorganisms

There is a significant probability that ancient, buried microorganisms, including severe pathogens such as anthrax, will re-appear in Northern ecosystems due to the thawing of permafrost and glaciers. Several ancient families of viruses have recently been discovered in Russia [17] and the concept of viral spill-over, meaning that pathogens may switch host, has been pointed out by Canadian researchers [18]. The reappearance of permafrost pathogens is in many cases triggered by extreme temperature and precipitation events that seem to escalate by amplitude and frequency as a result of climate change.

The climate-change thawing of landscapes have socio-economic effects such as changing land-use. As an example, the increasing accessibility of precious metals across the far North is likely to initiate mining projects that have the potential to reveal millennial-old buried microbes that may become revived. It is therefore highly recommended that an in situ inventory is carried out of ancient burial-sites where human and animal victims of diseases such as anthrax and the Spanish flu have been buried in permafrost localities across the North. The data captured with such an inventory, of which does not reflect the risk for "CSIs on the move" but for long-time existing diseases that may reappear, should be added to the Nordic OneHealth database, which will be further discussed below.

There can be no human health without healthy ecosystems

With many northern cultures being holistically dependent on the welfare of their animal husbandry, climate-change effects with the potential of changing the exposure of such livestock to more infectious diseases may strike at the heart of northern cultures. With such developments adding to the effects of direct human exposure [19], as well as climate-change effects such as having reindeer winter-pastures blocked by the icy snow-pack strata introduced with an increasing frequency of mid-winter thawing episodes [20], the cumulative effects of all this constitute the holistic approach to health called OneHealth [21]. In the OneHealth perspective, human welfare depends on a multitude of factors whereby direct human illness may be a subsidiary to changing cultural conditions, where the identity of individuals in certain communities diminished alongside the increasingly challenging effort to uphold husbandry and hunting traditions. It is recommended that the modern health model is expanded into the holistic One-Health paradigm that has been developed and managed to fit original Northern cultures as an inherent part of their cultural evolution. The majority of emerging CSIs are likely to depend on host and vector organisms that may develop infections and transmit them further onto humans as part of pathogen lifecycle, as most CSIs are zoonotic by nature. To effectively monitor emerging CSIs, it is therefore recommended to introduce pathogen sampling of typical host and vector organisms as a standard source of information, in addition to the survey of human health. Such sampling, performed on the rodents, ticks, roe deer and so on, that are known to carry infectious diseases onto humans and their livestock, should be carried out as a standard part of national environmental monitoring and designed for international compatibility. There is a multitude of organised environmental sampling facilities covering the North, with one such example being the approximately one hundred terrestrial research stations organised under the auspices of the INTERACT (www.eu-interact.org) and SITES (www.fieldsites.se/en-GB) organisations. Such long-term environmental information facilities could easily catch and store the required materials for consecutive pathogen analysis, at a significant cost-benefit ratio. Citizen science is a currently expanding field and should be used.

When the veterinary inspection of husbandry animals and game, as well as the traditional human health survey, is added to the above in situ approach to the pathogen survey, a supportive OneHealth infrastructure must then be established across monitoring facilities, OneHealth authorities, and stakeholder communities [22]. The resulting holistic database would hold the requirements to aid in the decision-making of the design of a true OneHealth strategy across the North while fulfilling the requirements of the stakeholder community to a much greater extent than the incompatibly scattered health data presently available. As a result, internationally harmonised databases, and forecasts for environmental CSI parameters, as well as for infectious diseases and microbes, may be pursued and made openly and routinely available to support decisions aimed at keeping humans and animals healthy, and societies sustainable across the North. This requires diplomatic efforts to establish a solid network for international collaboration, including indigenous knowledge and community-based participatory research as an approach. With a strong enough mandate, such an organisation/ network would be able to rapidly share results, strengthen the input of Nordic resources, and reinforce swift exchange of information for the benefit of a globally sustainable environment. The above inclusion of OneHealth within the Nordic Vision 2030 relies on the building of a bilateral relationship with stakeholder communities, with its objective being the co-production of scientific knowledge.

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How do we ensure clean water under a green transition?

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"The Nordic Region will become the most sustainable and integrated region in the world in 2030". As is the vision presented by the Nordic Council of Ministers, and we will here elaborate on one aspect of this vision – that of the sustainability of our water resources under a green transition. The green transition implies that we will move to an economy based on renewable biomass resources for the provision of food, fodder, fibre, and fuel – a bio-economy. But will this so-called green transition provide clean and healthy water resources in the Nordic countries?

The green transition and the biomass gap

As stated by the Nordic Council of Ministers [1], a bioeconomy *"comprises those parts of the economy that make responsible use of renewable biological resources from the land and water for the mutual benefit of business, society and nature"*. Indeed, this green shift sounds like an enticing future: By using renewables, we will stop exploiting fossil resources, emission of climate gasses will be reduced, and the climate will be saved. But what will this shift actually *mean*? The last time we survived on renewable resources, there were considerably fewer people on this planet. How much forest do we need to cut down to replace the fossil resources we use for multiple purposes today? And when we have cut it down, what about tomorrow's generations? In Nordic boreal forests, trees take 60 to 100 years to mature. Will we, in the future, have enough replenishment of biomass for all our needs, so that we can continue our present way of living? In a recent report on the progress of the bio-economy policy of the EC [2], it is stated that we need more knowledge to manage the balance between environmental and economic requirements, in addition to promoting a more sustainable consumption pattern. In 2022, John Bell, the director at the European Commission's Research and Innovation Department, expressed in an interview that[3]: *"Studies suggest that the gap between the potential demand for biomass and its sustainable supply can be as big as 40-70%"* by 2050 depending on the scenarios.

Thus, biomass will clearly become an increasingly important economic asset, but how will this affect the land use pattern in the rural Nordic Region? Will we see an intensified exploitation of forested and agricultural areas in the coming years? We know that there is a close connection between land use and the quality of our water resources. Will the combined effects of a changing land use and climate result in an increase in soil erosion and nutrient losses, followed by water quality deterioration and more frequent toxic algae blooms in Nordic lakes and coastal waters? None of us have the answers to these questions, but we should ask them nonetheless, because we need to be prepared. Which is the exact purpose of the NordForsk-funded Nordic Centre of Excellence, BIOWATER (www.biowater.info), consisting of researchers and PhD students from eight institutes in four Nordic countries: Norway (lead), Denmark, Finland and Sweden. Over a period of five years, we have studied the effects on the water resources of a bio-economy.

Developing Nordic Bio-economy Pathways

Given that the future is unknown, BIOWATER used specific scenarios that were plausible but also resulted in contrasting directions for a Nordic future. By combining expert judgement and stakeholder involvement[4,5], we translated the existing, well-established Shared Socio-economic Pathways[6] into future Nordic Bioeconomy Pathways (NBPs) that outline land use and land management directions under a bio-economy. Our five NBPs can briefly be described as follows: [1] A sustainable future, modelled as the maximum implementation of environmental mitigation measures and maximising conservation methods in land management. [2] Business as usual, where we continue to develop along the same patterns as today, continuing current trends in land use and land management. [3] A future with reduced co-operation between countries, with trade borders and an increasing need for self-sufficiency and food security. We translated this to a future where we use as much as possible of the land to feed and provide for our own population. [4] A pathway caused by a widening gap between a small affluent urban elite and larger groups of lower income; a "cities first" scenario. Land use under this pathway could be interpreted in different ways but was often suggested as land conservation management close to the cities, and a more "forgotten" hinterland with less environmental practices. [5] A "maximum growth scenario", where we rely on technology to solve our problems with finding sufficient food, energy and materials, and where we continue to exploit fossil resources.

Our modelling results: Achieving Water Framework Directive goals under a green transition

We then fed these land use scenarios – together with the climate scenarios – into models in order to estimate to what degree water quality, and thereby society, may be affected. The outcome of the models was compared with the common principles for water management in the four Nordic countries, i.e., the environmental goals of the EU Water Framework Directive (WFD). By implementing this directive, all four countries have agreed to the obligation of reaching the goal of at least *good ecological and chemical status* in all rivers, lakes, groundwaters and coastal areas. This is not an easy target to achieve, and especially not in agricultural areas where nutrient losses give subsequent risk of algae blooms. Which of our NBPs could fulfil the WFD goals? To make a long story short, we found that the best way to obtain good ecological status in our freshwaters would be to follow NBP No. 1, focusing on sustainability [7]. This means to ensure conservation practices in both agriculture and forestry, with maximum implementation of environmental mitigation measures.

Economic consequences

Does this sound expensive and hard to achieve? Well, we also modelled consequences for economic value generation under the different pathways using an ecosystem services framework, and the good news is: Both total income for society and the income of rural landowners were quite similar for NBP 1 (sustainability) and NBP 5 (maximum growth) [8]. Choosing a sustainable pathway for the future, therefore, does not need to come at a higher cost than pathways geared towards continuing today's practices and dependency on fossil fuel. This also reveals how valuable clean water is for us: in a landscape with freshwaters of good quality, both nature and people thrive.

What about food supply?

In terms of the outcome of the NBPs for food production, BIOWATER did not look specifically into this, but others have pointed out that the bio-economy's demand for land can represent a conflict with the incentives for the sustainable intensification of agriculture to feed a growing human population [9]. In a discussion of food security, however, it should not be forgotten that what runs in our streams will eventually reach the sea, which is another important food source. Hence, by polluting our freshwaters, we also jeopardise our food supply from the ocean.

Land use poses a more severe pressure than climate change – until 2050

Our modelling work also resulted in another piece of important information: the water quality of our freshwaters is more dependent on how we use and manage the land, than the effects of climate change, at least until 2050[7]. This means, for example, that local managers are not helpless against the larger global patterns of climate change, but they can take action to reduce nutrient losses through targeted mitigation measures. By doing so, the Nordic Region will be more prepared for the assumedly more severe effects of climate change on soil erosion and nutrient losses after 2050.

The added value of Nordic co-operation

Nordic countries can without a doubt benefit from co-operation on several topics related to the blue environment under a green transition. In general, our agricultural practices follow similar annual patterns with a need to protect the soil during autumn rainstorms and spring snowmelt. Natural purification processes utilised in constructed wetlands, for example, are dependent on temperature and will, in our climate, not be the same in winter and summer. Furthermore, we noticed that the most commonly used mitigation measures in agriculture differed somewhat from country to country, and that we can therefore learn from each other, for example on how to treat nutrients in water from sub-soil ditches. Whereas ditch water often goes untreated to a river or a lake, Danish researchers [10] have, over the years, developed mitigation methods for this particular problem. These methods could also be tested out in other Nordic countries. A simpler, but highly effective measure is to establish and maintain buffer zones with trees and bushes along water bodies. Indeed, Finnish scientists found that this measure can improve the water ecology so much that it can almost move the water body up one status class in the WFD [11]. This is highly interesting from an economic point of view too: If a water body moves from a moderate to good status in the WFD, this means that the environmental goal is achieved, and resources spent on further mitigation measures can be saved. The definition of these status classes is also of economic interest, and in BIOWATER we compared how Nordic countries have defined the reference or background state of nutrients in water bodies [12]. Especially in lowland areas, this can be tricky since people have cultivated the land for centuries, and there are few, if any, pristine catchments. We noticed that the Nordic countries had used different methods that gave contrasting background values for phosphorus and nitrogen, and we therefore decided to continue this work in an EU-funded project, Nordbalt-Ecosafe (https://projects.au.dk/nordbalt-ecosafe), where we aim to assess and possibly improve the WFD's target of good ecological status in Nordic waters.

Another topic where Nordic co-operation is of value, is the exchange of monitoring data. BIOWATER assembled a database of water quality and quantity data from 69 small headwater streams in the four Nordic countries, in catchments covered by either forestry, agriculture, or natural vegetation [13]. These data showed that areas under forestry had nutrient concentrations in between agricultural (higher levels) and natural (lower levels) catchments, which can mean that a future intensification of forestry can give more nutrients to our freshwaters. Furthermore, the analysis indicated that the level of mitigation measures implemented today has not improved the water quality significantly. In addition, we found that data on the effects of forestry on water quantity and quality are sparse on the ground, with the exception of Finland. While hugely benefitting from the Finnish data, the other Nordic countries need to improve their monitoring of forestry effects on waters, as the processes in Finnish forested peatlands will not readily reflect processes in shallow mineral soils in Norwegian or Swedish forests.

Think both green and blue!

The future is not known to us. But here is what we do know: There is a close connection between how we manage our land resources and the water quality of the receiving streams and lakes. Toxic algae blooms are a result of excessive nutrient losses to water. Nutrient enrichment of water will introduce problems when drinking water becomes expensive to produce, the fish die, rivers, lakes, groundwaters and coastal waters deteriorate, and tourists no longer visit our countries.

BIOWATER has shown that Nordic water resources could potentially be strongly threatened by the emerging bio-economy. While we acknowledge that a change from an economy based on fossil fuel is important for the climate and life on this planet, we must stress the importance of ensuring that a green transition is done in a way that will ensure environmental sustainability both for us and future generations.

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Fat making microbes for greener and sustainable industry

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Can microbes make the world greener? Microbes are ubiquitous and know no borders. They possess the ability to adapt, survive and thrive in extreme and constantly changing environments. While some microbes are pathogenic, the majority are beneficial and essential for sustaining life. For decades microbes have been used in industry for the production of food ingredients and chemicals. Presently, microbes have the potential to become a central player when it comes to addressing the global challenge relating to fat production, which serves as a central factor in the establishing of a stable and sustainable green economy.

Used for centuries and are now in high demand.

From ancient civilisations to our modern and contemporary society, fats (lipids) have always had a primary role in the history of humankind, having gone from food and non-food domestic and cosmetic uses to medical applications and later to large-scale industrial uses for food, feed, pharmaceutical, cosmetics, paints and biofuel production [1].

Today, fats are in high demand in food and feed production, nutritional supplements, detergents, lubricants, and biofuels [2]. For centuries, plants, fish, and animal fats have represented the primary source of fats. However, with the growing population and limited cultivable land, traditional fat production methods alone cannot meet the rising demand. Furthermore, there has been a shift in the use of fat sources. Industries are now mainly interested in polyunsaturated fatty acids (PUFAs), which have beneficial properties for human and animal health. There is also a need for high-value fatty acids to facilitate innovative and environmentally-friendly production of biofuels and feedstocks [1,2].

Due to the constant increase in the demand of fats and the fact that marine and vegetable sources are inadequate when it comes to meeting the high level of fat required worldwide, on top of issues posed by climate change, it is now imperative that we search for renewable and sustainable fat sources [1,2].

Fat-producing microbes to solve the global fat dilemma

Various microbes belonging to algae, yeast and filamentous fungi, or marine-derived microorganisms such as thraustochytrids possess the ability to accumulate lipids in their cells [2,3,4,5]. It is amazing how much fat content they offer – up to 80% of their mass can be in the form of fat (Fig. 1). Microbial fats, often called *single cell oils*, are very similar or even identical to plant oils and in some cases fish oil and contain unsaturated fatty acids. The production of microbial fats occurs independent of season, climate, and location, and can be realised anywhere and by using residual materials, side streams and by-products as a feedstock – in the case of algae this can even be from CO_2 – and such production does not require the use of arable land, while still resulting in high production volumes.

Considering the foreseeable depletion of crude oil, the highly controversial "food-or-fuel" discussion about using plant oils for biodiesel production, the overfishing of the oceans and the urgent need for the reduction of greenhouse gas emissions, microbial fats seem to be intriguing substitutes for crude, plant, and fish oil [6]. Thus, during the last decade microbial biomass has been positioned as a new emerging source of fats for food, feed, cosmetics, chemicals and the biofuel industry.

More than just a fat

Fat making microbes are not just a fat, rather, they can contain many other valuable components with a broad range of applications. Thus, fat-producing yeast and filamentous fungi contain proteins, carotenoids, chitosan, chitin and beta-glucans in addition to high amounts of unsaturated fat. Each of these components can be separated and used for its suitable applications. For example, chitin and chitosan are emerging biopolymers for developing new sustainable and safe-by-design biomaterials for medicine and textile industry. Glucans and carotenoids are essential components in food and feed.

Such a multicomponent nature and multifunctionality of fat-producing microbes makes them unique players in developing green production. Utilising fatty microbes as cell factories may allow us to build radically new bio-based production where more than one bio-product is produced simultaneously.

A solution to locally produced food and feed ingredient

The production of local food and feed ingredients is on many countries' agendas, especially in the Nordic Region. The aquaculture and animal feed industry is desperate to find ways to replace imported soya, fish meal and rape seed oil. Norway alone needs about 4 million tonnes of proteins to accomplish a strategy of locally produced feed. Recently, fatty microbial biomass has been tested as a component of fish feed and chicken feed and it showed as being compatible in replacing traditional proteins and fat sources. Moreover, due to being a multicomponent biomass it can provide additional nutritional and health benefits. The production of fatty multicomponent microbial biomass is highly flexible and can be based on various wastes, by-products and side-streams from forestry and agriculture [7]. It can therefore be established in any country based on locally available feedstock and resources.

Production potential for the Nordic Region

Nordic countries have the largest forest industry and well-developed agriculture and are considered as one of the largest lignocellulose producers in the world (both of wood and wood wastes and of straw from agriculture) and developing lignocellulose-based technologies will largely boost Nordic economy. Lignocellulose materials, such as woody feedstock from forestry are available in large quantities across Norway, Sweden, Estonia and Finland. In a recent study, it was estimated that the annual lignocellulose production potential in Sweden to be 680,000 tonnes of straw and 910,000 tonnes of wood waste. For the latter, a production potential of more than 3 million tonnes of wood per year was determined [8]. Per capita, Estonia has one of the highest sustainable feedstock potentials in the EU [9], including significant forestry resources. Currently, the use of sustainable feedstock is under-exploited in Estonia as the majority of manufactured wood (51%) is used in combined heat and energy production, which has a very low value addition. Regarding an average sugar content of this biomass of 66% there would be about 1 million tonnes of lignocellulose available in Sweden alone, and regarding a lipid yield of 0.2 from this biomass, there would be a potential of about 200,000 tonnes of lipids when utilising the currently harvested amount of biomass, and this amount can be doubled when utilising the full wood potential.

In addition to forestry resources, the Nordic countries have various under-utilised agriculture and aquaculture side-streams which can be directed into microbial fats production. In Norway alone, around 600 000 tonnes of the agriculture and food supply chain by-products are generated annually (EUROSTAT, 2020). Today, the lions' share of these by-products are used for low-value applications, combustion or disposed as waste (EUROSTAT, 2020).

Sustainability challenge of microbial fat in Nordic Region

Microbial oil production is established in US and some EU countries, where the main feedstock utilised for this is conventional sugars. The Nordic Region is certainly in need of more sustainable feedstock resources needed for establishing industrial microbial oil production. But why do we not yet have it? There are several reasons for this:

- Production technology which is based on fermentation is only optimised on a small laboratory scale. We have too minimal upscaling opportunities to obtain enough data and experience to move on to industrial production.
- Due to the fact that the available feedstock is of different origin, mixed fermentation technology needs to be developed to uncover the full potential of Nordic resources.
- Implementation of precision fermentation and engineering of microbes with improved fat production abilities are still questionable for Nordic Region application due to authority regulations.
- Fractionation of fatty microbial biomass is expensive and often involves toxic chemicals. The optimisation of this process needs to be developed
- There is a lack of long-term cooperation between relevant industries and industry-academia that could stimulate establishment of new production processes.

All of these issues present obstacles for the production of microbial fat in the Nordic Region.

The way forward:

Nordic collaboration is crucial for solving the current fat dilemma in a sustainable way. Cooperation on different levels including industry and academia is the only way to move the technology from lab to industrial production. Society at large will be the eventual end-user and consumer of the new alternative fat sources, and thus, education about the importance of a bio-based economy and sustainable alternatives is key for the successful transition from traditional resources to a new more sustainable one.

The transition to a greener and more sustainable society associated with the establishment of a new industrial sector poses quite the challenge. During the last few years, a large number of start-ups within the area of bio-based production have been established in Europe. This has not happened to the same extent in the Nordic Region. There is thus an obvious need for the support and setting up of kick-start programmes in the Nordic Region to trigger the establishment of a new green industrial sector.

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Towards a bio-economy – An integrated approach for biogas utilisation and policy analysis in the Nordic Region

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Introduction

There is enormous biomass potential in the Nordic Region [1]. While Sweden, Norway, and Finland have well-developed forestry industries, Denmark has large amount of agricultural land [1][2]. Out of the total biomass supply in the Nordic countries, forest biomass accounts for 70%, agriculture residues 20%, and the remaining is waste biomass [1]. The key reason behind the upwards trend of biomass utilisation is the increased use of biofuels used in transport and bioenergy for heating. It is estimated that bioenergy will be the single largest energy carrier in the Nordic Region by 2050 [3], which raises the importance of sustainable biomass, especially in terms of its impact on land use change. Deployment of modern bioenergy is considered as one of the region's decarbonisation strategies [4].

In the Nordic Energy Outlooks - Nordic Energy System Research Programme (NEOs) – WP1 project (Bioenergy and links to agriculture & LULUCF in a Nordic context) the role of bioenergy in the Nordic energy system is explored. Crop and livestock production plays a vital role in the agriculture sector in the Nordic Region. This project aims to address: (a) What is the production potential of biogas from agriculture residues and livestock manure in the Nordic countries? (b) What are the sustainability aspects in the production of biogas? (c) How can biogas systems be integrated into existing energy systems and its role in decarbonising the energy sector and (d) How can biogas from the agriculture sector be promoted in an integrated climate-land-energy-water nexus approach?

In this policy brief, the role of biogas as a vector for low-carbon transformation in energy systems in the Nordic countries is summarised in the consideration of a bio-economy and integrated approaches. Biogas has received increased attention due to its potent greenhouse potential and its enormous benefits from capture and utilisation in the replacing of fossil fuels [5]. Nutrient/bio-fertiliser is also one of the co-products of making waste (residues and manure)-to-biogas. This use of biogas is expected to generate new knowledge on its multiple benefits, such as energy and climate gains, agricultural productivity, and the strengthening of a bio-based economy in the Nordic countries. Biogas production in a nexus approach has not yet been explored. Biogas plays a key role in balancing grid electricity, decarbonising the natural gas systems, and providing storage options. Biogases serve as versatile energy carriers [6] for the production of electricity and its use as both a transport fuel, and cooking gas. This research provides a sound basis for integrating climate-land-energy-water strategies (CLEWs) into techno-economic optimisation models when it comes to biogas systems.

Biogas production from crop and livestock production – Mapping the potential

There is a vast potential for bio-resources (i.e., crop residues and manure), which can be converted into biogas and other energy carriers in the region. The examining of the spatial distribution of biomass feedstock to pinpoint the optimal size and location of biogas production facilities, among other things, is essential. The spatial data to estimate biomass potential (from agricultural crops and livestock) is obtained from the Food and Agriculture Organization of the United Nations (FAO). The FAO data is projected to a grid of 30x30 km^2. The major types of livestock (e.g., chicken, cattle, sheep, goat and pig) and crops (e.g., wheat, barley, cereals, maize, potato, rapeseed and sugar beet) found in the Nordic countries are considered in the analysis. Crop production is estimated based on the crop harvested area and the crop yield. Agriculture residues are quantified by multiplying the crop production and the residue to crop ratio (RPR) [7] and livestock manure is quantified by multiplying the livestock population and the amount of manure produced by livestock per day. For the spatial assessment, the practical biogas potential in each grid is calculated.

The majority of the livestock concentrates can be found in southern Sweden and Denmark, while Iceland and northern Norway, northern Finland, and northern Sweden have the lowest numbers. Major crops are also produced in southern Sweden, southern Finland and Denmark. It should be noted that certain amount of crop residues should be left in the farmland for maintaining soil quality [8]thereby advancing climate goals, food security, better land use, and sustainable energy for all. In this study, we assess the surplus agricultural residues availability for bioelectricity in six least developed countries (LDCs. In this study, we consider the sustainable removal rate as 40%. The total manure and crop residues available for biogas production are 60 and 10.5 million tonnes, respectively. Biogas potential in the Nordic countries is estimated at 129 PJ/year (manure: 54 PJ/year and residues: 75 PJ/year). Figure 1 shows the spatial distribution of the total biogas potential in the region. The biogas production was 25.2 PJ in 2017. The estimates show that we have only harnessed around 19% of the total biogas potential.

Realising biogas-based circular solutions in an integrated approach in the Nordic Region

Building an integrated framework for assessing biogas deployment and policy support

In this research, a modelling framework for integrated assessment of biogas production from the agriculture sector (see Figure 1), such as for crop and livestock production, is proposed. A spatial assessment of crop and livestock population is done at the grid level, which provides the basics of biomass feedstock supply. We have compiled techno-economic parameters (investment and operational costs) of three technologies, namely: anaerobic digestion (AD) plant, CHP, and biogas upgrading technologies. The costs of feedstock, transport and the production of biogas are prepared in the modelling dataset. We also prepare the emissions from the agricultural field while producing livestock and crop. The final demand of different fuels such as natural gas, electricity, and transport fuels are estimated. It is also important to obtain the price and emissions factors of avoided energy products. The model would determine the optimal location, size, and type of the technologies based on the feedstock supply, energy demand, costs, prices, and policy instruments such as subsides and carbon tax. All revenue streams and emissions need to be accounted and considered as input data for the model.

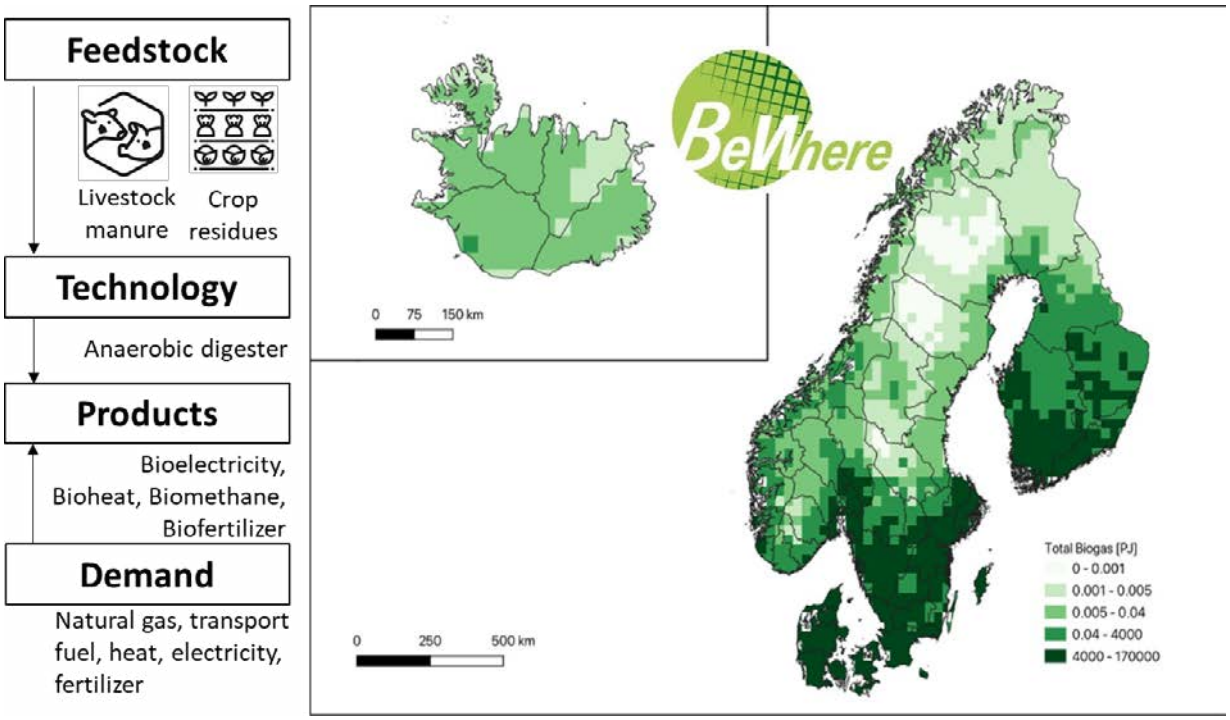

Figure 1. Integrated approach for assessing biogas potential in 2020

The water-food-energy (WEF) nexus is central to sustainable development. In this resource constrained world, demands of all three are increased due to economic growth, population rise, urbanisation, and changing dietary patterns. The agriculture sector requires freshwater for crop production, energy for cultivation, and transport for food commodities. Additionally, the use of nitrogen fertiliser and methane emissions from the sector contributes to the greenhouse gas (GHG) emissions, thus posing a threat to climate systems. This work proposes to conduct further research into developing the inextricable links between these critical domains, which requires an integrated approach to ensuring water and food security, sustainable agriculture, and energy production in the region. The impact of climate change in crop production, the use of fertiliser, energy and water, and agricultural practices need to be considered in the integrated model.

Nutrient recovery and utilisation as fertilisers for circularity and climate change mitigation

The management of the bio-digestate is a particularly important aspect that determines biogas sustainability. The nutrient quality in the digestate is calculated and compared with the current fertiliser demand in the region (see Table 1). While comparing the total bio-digestate potential in the Nordic countries to the synthetic fertiliser consumption in 2019, it is observed that around 29% of the synthetic nitrogen fertiliser and 46% of synthetic phosphorous fertiliser can be replaced using bio-digestate. In addition to that, the bio-digestate potential in Nordic Region could replace the entire synthetic potassium fertiliser demand in 2019. This would also contribute in reducing emissions from the production and application of the fossil-based synthetic fertilisers.

Table 1. Current fertiliser consumption in crop production in the Nordic countries in 2019 and bio-digestate potential

Particulars	**Bio-digestate in tonnes** (kilo-tonnes)	**Fertiliser consumption,** (kilo-tonnes) (FAO-STAT)	**Comparison** (bio-digestate/fertiliser)
N	194.5	671.6	0.3
P	50.9	111.2	0.5
K	194.5	187.9	1.03

The contribution to national energy and climate plans

The impact of climate change on agricultural and livestock production has to be incorporated in the national energy and climate plans (NECPs). The study reveals that by utilising the full potential of biogas, around 4 % of the total power can be provided by bioelectricity and 3% of the district heating and cooling demand by bio-heat. Around 60% of natural gas can be replaced by biomethane, which results in an 18% reduction in emissions. The total bioelectricity potential is around 51.6 PJ, which can substitute 13.5% of the non-renewable energy in the region. In the Nordic countries, emissions from the transport sector are high due to fossil-oil based transport systems. Around 12% of fossil oil can be replaced by biomethane.

NECPs need to incorporate a biogas support scheme (e.g. subsidies, tax rebate) in order to ensure an increased share of biogas in the types of energy used. Measures specifically intended to reduce greenhouse gas emissions include: the production and use of renewable energy (including the production of biogas); improved manure management; more efficient nitrogen use and; measures to prevent nitrogen leaks. Table 2 summarises the total biogas potential in the region. It has been shown that 129 PJ of raw biogas can be produced from crop residues and manure in the Nordic countries. That amount can then be upgraded to 77 PJ of biomethane or converted to 52 PJ of electricity and 58 PJ of heat, if the total amount of biogas is to be used as fuel in CHP plants. In 2019, 382 PJ of non-renewables were used for electricity consumption in the Nordic countries. This project has shown that the potential biogas production from crops residues and manure in the Nordic countries can cover 13.5% of its electricity consumption, if the total biogas production was used for electricity consumption. It has also been shown that 12% of the fossil oil used for refining vehicle fuels can be replaced by biomethane, i.e. the upgraded biogas being produced in the Nordic countries. Thus, an increased production of biogas in the Nordic countries can also contribute to the long-term emissions targets for GHG emissions.

It should be noted that many environmental benefits can be obtained by the increased use of manure. It reduces GHG emissions and eutrophication of fresh and marine water, and produces biogas which can then be used as energy. As mentioned, the biogas obtained in this process can then be used to generate electricity or heat and as a fuel for vehicles. The majority of Swedish biogas is distributed via lorries, with its gas pipeline infrastructure limited to the south-western part of Sweden. Thus, a pipe infrastructure could also be further explored. Concerning the national objectives on energy security, the domestic production of biogas can play an important role for the national energy security, which also increases the flexibility of the national energy system while improving the resilience of regional energy systems.

Table 2. Total energy potential from crops residue and manure in 2020 in all Nordic countries

Technologies and energy production		PJ	TWh
AD plant	Biogas	128.9	35.8
Upgrading plant	Biomethane	77.4	21.5
CHP plant	Bioelectricity	51.6	14.3
	Bioheat	58.0	16.1

Finally, the bio-economy concept primarily includes: (a) sustainable production of bio-resources with the aim to reduce both anthropogenic climate impacts and the dependency on fossil-based products, and (b) increased added value of biomass materials considering a reduced consumption of natural resources. Thus, it is important to evaluate the potential of bio-resources, their conversion into multiple products (biofuels, food, bio-materials, etc.), nutrient recycling, and synergies for climate mitigation and adaptation strategies. This aligns with the Nordic action plan for Vision 2030 on sustainable production. An integrated assessment facilitates the understanding of bioenergy and bio-economy developments in the region and enhances the involvement of stakeholders and local communities in a transparent decision-making process. The bio-economy offers a unique opportunity to address inter-connected societal challenges, while simultaneously achieving sustainable economic development. Last but not least, the interconnectivity within the region but also beyond – such as with the rest of Europe – must be considered in the decision making and planning.

Acknowledgements

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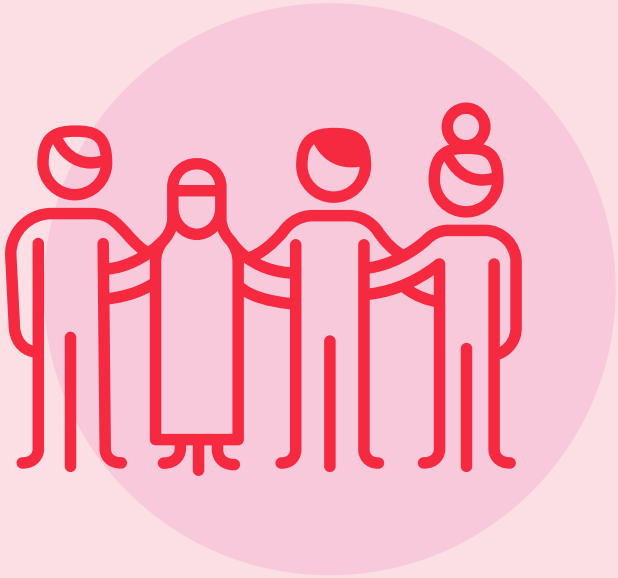

The Nordic region – a good neighbour and a good home

Articles outlining how the Nordic Region should uphold good neighbourly relations, including with regard to migrants, and how to preserve and promote good, safe and healthy lives for everyone who lives there.

Post-war reconstruction of Ukraine and the role of the Nordic Countries

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The Vision 2030 strategy aims to make the Nordic Region the most sustainable region in the world. However, environmental pollution knows no borders. The realisation of a green Nordic Region hinges upon sustainable development in other parts of the world, and especially in nearby and neighbouring countries. At the time of writing, we are witnessing massive environmental damages in Ukraine, caused by the ongoing war with Russia.

This policy brief assesses the direct and indirect environmental damage resulting from Russia's full-scale invasion of Ukraine. The aim is to provide the Nordic Council of Ministers with an understanding of the scale of the problem, the implications, and recommendations of potential support measures. The analysis reveals that due to the immediate survival priorities, the advancement of environmental protection legislation has been put on hold. The environmental consequences caused by the aggression will have long-lasting effects not only within Ukraine but also beyond its borders. Consequently, the Nordic Council of Ministers should help to address these challenges, which necessitates both the providing of immediate assistance to Ukraine as well as establishing long-term reconstruction plans aimed at the country's infrastructure, conservation and future sustainable development. Achieving lasting peace and justice is a prerequisite for any such efforts, as it is essential to prevent the continuation or renewal of the war.

Russia's aggression has resulted in significant damage to human lives, economic development, critical infrastructure, and the environment in Ukraine. This has placed immense pressure on individuals, communities, the economy, and the environment. The damage to key infrastructure, including energy facilities, water supply systems, transportation networks, and communication lines, has had a profound impact on essential services and the daily lives of millions of Ukrainians. This has garnered substantial attention and support from national and international organisations involved in humanitarian aid and reconstruction efforts.

While the focus has primarily been on the immediate humanitarian and infrastructure needs, the environmental damage caused by the conflict has received less attention. However, its consequences are likely to extend beyond Ukraine's borders and have long-term, negative, transboundary effects. It is therefore crucial that the Nordic Council of Ministers supports a thorough assessment of the short, medium, and long-term environmental impacts of the war. This assessment should consider the potential transboundary effects and the interconnectedness of ecosystems, which requires a comprehensive understanding of the environmental consequences of effective mitigation and future planning.

The environmental impact of the war encompasses damage to ecosystems, biodiversity, and both soil and water resources [1, 2], which are crucial for Ukrainian agriculture and, consequently, global food security. The magnitude of the damage and the subsequent need for reconstruction is substantial; however, it also presents an opportunity to rebuild in a more sustainable manner, ultimately working towards a carbon-neutral and sustainable future for Ukraine [3]. The Nordic countries are committed to helping Ukraine in this process.

For instance, in July 2022, the Nordic Green Bank Nefco – which is owned by the Nordic countries – initiated the Green Recovery Programme for Ukraine. This programme aims to assist municipalities in the environmentally sustainable reconstruction of critical infrastructure. Such efforts align with the Nordic Council's aspiration to contribute to positive developments in international cooperation relating to the environment and climate, including the promotion of Nordic green solutions worldwide [4]. As the Nordic countries are committed to supporting Ukraine in its reconstruction efforts, it is crucial that we evaluate the impact of the war and plan future actions accordingly, considering the environmental consequences and the need for sustainable solutions.

Domestic context

Since the Revolution of Dignity and the signing of the EU-Ukraine Association Agreement, Ukraine has made significant progress in addressing environmental and broader climate challenges, despite the ongoing war in the Donbas region and the occupation of Crimea. The country has adopted important strategic documents on climate policy, including an updated Nationally Determined Contribution (NDC) in July 2021. The updated NDC outlines Ukraine's commitment to integrating climate goals into all sectors of the economy: industry, agriculture, transport, buildings, energy, waste, and land use, land-use change and forestry (LULUCF).

Furthermore, in October 2022, the Ministry of Environmental Protection and Natural Resources of Ukraine adopted the Environmental Security and Climate Change Adaptation Strategy until 2030 [5]. This strategy represents the first comprehensive policy addressing climate change adaptation in Ukraine. Alongside the strategy, an action plan was also adopted to guide its implementation. The main objective of the strategy is to fulfil Ukraine's obligations under the Paris Climate Agreement.

The full-scale invasion has obstructed the implementation and further development of many environmental regulations in Ukraine. Hence, reports on the Monitoring, Reporting, and Verification (MRV) of emissions, which became mandatory in 2021 and were originally scheduled for submission in 2022, have now been made voluntary due to the war. This might impact the future implementation of the Emissions Trading System policy, which is an important tool for reducing greenhouse gas emissions. Similarly, the adoption of the NDC Implementation Action Plan has been postponed.

Since the start of the full-scale war, various reforms and plans have been placed on hold, with the focus shifting to the prioritisation of survival and national defence. Despite the adoption of several strategically significant documents before the war, the war has significantly impeded progress in the environmental protection agenda. This setback poses a threat to the country's sustainable development and requires attention in the rebuilding of Ukraine. The Nordic Council of Ministers should continue its efforts in supporting Ukraine's reforms on environmental protection and climate change.

Describing the damage

Russia has caused enormous damage to many aspects of life in Ukraine, including the environment. Some damage is direct and the result of deliberate attacks on civilian infrastructure, while other damage is indirect, caused, for example, by power-supply cut-offs [6]. The full extent of environmental damage caused by the war is still being assessed, and the long-term effects may only become apparent over time. It is crucial that the Nordic Council of Ministers supports the prompt efforts of evaluating and addressing the damage as part of the assistance provided to Ukraine. The environmental damage caused by the war includes the following.

Chemicals and other pollutants

- Bombs and rockets contain toxic substances such as lead, cadmium, mercury, and TNT, which pose a significant long-term threat to both human health and the environment. The toxic elements can enter surface waters and contaminate streams, rivers, lakes, and the Black Sea and the Sea of Azov – shared by Ukraine, Bulgaria, Romania, Turkey, Georgia, and Russia.
- The detonation of bombs and rockets can release asbestos into the environment, further contributing to environmental pollution and posing health risks to both humans and wildlife.

Soil contamination

- At least 10.5 million hectares of agricultural land in Ukraine have been contaminated with chemicals which has significant implications for the health and safety of Ukrainians and citizens of neighbouring countries, as well as global food security.
- More than 5 million hectares of agricultural land has become unusable due to mining and contamination of explosive remnants [7], mainly in the eastern and southern regions, which are areas of intense agricultural production. This is consequential for the livelihoods of local civilians and the global food supply.
- Russian attacks have targeted refineries resulting in the leakage of oil and other chemicals into the ground.

Water contamination

- Water infrastructures, including dams and water supply systems, have been targeted and are at risk of being targeted [8]. A few cases of deliberate damage to dams have been reported [9]. This poses a significant threat to the availability of clean water for communities and further exacerbates the ecological damage caused by the war.
- Rivers and networks of irrigation channels that are natural barriers for movement of troops have also become burial sites for military objects [9]. The underwater decomposition of ammunition leads to the release of heavy metals and toxic explosive compounds, and also pose a potential risk to the environment and water quality [10].
- Electrical blackouts resulting from deliberate attacks on electricity infrastructure have increased the threat of water source pollution with mine waters due to failures in the operation of pumping equipment [9].
- The damage to water infrastructure in the eastern and southern parts of the country, which are areas of intense agricultural production, impacts both the livelihoods of local civilians and the global food supply [11].

Natural habitats

- The war has inflicted damage upon natural habitats, including forests, rivers, and wetlands. Military actions have resulted in the destruction and, at times, complete loss of forests, leading to deforestation, loss of biodiversity, and harm to wildlife populations.

Radioactive risks

- Russian troops occupied the Chernobyl Nuclear Power Plant and the Zaporizhzhia Nuclear Power Plant, increasing risks of an accident. There were additional reports of Russian forces shelling Zaporizhzhia Nuclear Power Plant, causing damage to a transformer and a fire in a training building [12].

Flooded coal mines

- Since February 2022, mines such as Zolote and Toshkovskaya have reached critical levels of flooding [13]. Mines like Carbonite and Gornaya are gradually being flooded due to damage to the power supply networks caused by shelling. Flooding of mines can lead to the inundation or complete flooding of large areas above the mine, including settlements and agricultural land. This flooding causes salinisation and soil degradation.
- Untreated mine water can potentially mix with groundwater, which is often used as a source of drinking water. When mine water rises to the surface, it can enter reservoirs and rivers within the Siverskyi Donets basin, which directly contribute to the main waterway of the region. The polluted water from the Siverskyi Donets can then be carried to the Sea of Azov.

Recommendations

1. The Nordic Council of Ministers should ensure an environmental assessment of the damage and corresponding risks related to water quality, soil, and air quality is conducted in both the short-term and long-term for Ukraine and beyond. This assessment could be integrated into Nordic-Ukrainian cooperation projects involving local communities, allowing for the streamlined monitoring and evaluation of the environmental impact.
2. Assessing the extent of the damage requires building local capacity to conduct such assessments. This can be achieved through training conducted in collaboration with Nordic experts and laboratories and research institutions in Ukraine. By providing training on assessment methodologies and techniques, local professionals can enhance their capabilities to effectively evaluate and monitor the environmental damage caused by the war.
3. The Nordic Council of Ministers should mainstream environmental protection in the design of their plans for the post-war reconstruction of Ukraine.
4. The Nordic Council of Ministers should work towards an agreement that environmental harm caused by the war should be considered in the future international trial faced by Russia. According to the Geneva Convention, it is forbidden to use methods or means of warfare that are intended to cause or may be expected to cause widespread, lasting and severe damage to the natural environment [14].
5. It is important that economic compensation for the damage of the war includes compensation for the harm inflicted on the environment. The related costs should be borne by the Russian Federation, as they are responsible for the environmental damage caused by the war. These costs should cover various aspects, including clean-up and restoration efforts, conservation initiatives, reforestation projects, activities aimed at rehabilitating damaged ecosystems, and the restoration of water bodies. The Nordic Council of Ministers should help to design a system of resource allocation to address environmental justice and ensure the sustainable recovery and restoration of the affected areas.
6. Post-war rebuilding should be carried out through a coordinated international effort, in close cooperation with Ukrainian environmental NGOs and relevant national bodies. The Nordic Council of Ministers should prioritise local ownership and adopt a demand-driven approach, ensuring that the needs and perspectives of local communities are considered. By fostering collaboration and involving key stakeholders, sustainable and effective environmental governance can be established in the aftermath of the war.

7. Rebuilding should occur hand-in-hand with the improvement and further development of environmental legislation in Ukraine, with the help of the extensive experience of the Nordic countries.

   In any plans for Ukraine's post-war recovery, the Nordic Council of Ministers should emphasise green economy and low-emission development principles. Post-war green reconstruction should not be viewed as a desirable and optional "good to have" strategy, but rather as an economic necessity for facilitating a fundamental transformation of Ukraine towards a green and net-zero economy.

8. In the short term, Nordic support to Ukraine should focus on the elimination and reduction of immediate risks that the war poses to human health and the environment.

With their decades-long experience as forerunners in the domain of environmental protection, the Nordic countries can make a specific and unique contribution to the sustainable recovery of Ukraine, while at the same time moving closer to realising their ambitious vision of a sustainable Nordic Region.

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Harnessing the Nordic-Baltic cooperation experience for Ukraine's post-war recovery

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Executive summary

Ukraine's fast and sustainable post-war recovery is a prerequisite for the realisation of the Vision 2030 strategy of the Nordic Council of Ministers. This policy brief provides recommendations on how to utilise the long-time Nordic-Baltic cooperation experience in assisting Ukraine's recovery. Based on the analysis of the Nordic-Baltic relationship since the early 1990s, we recommend to the Nordic Council of Ministers the implementation of the following policy steps:

1. Harness the opportunities granted by the historical momentum to deepen the Nordic (-Baltic) links with Ukraine.
2. Build on the strong existing cooperation with the Baltic countries and prioritise joint action.
3. Open an office of the Nordic Council of Ministers (or a joint office with the Baltic Assembly) in Kyiv as a hub for local knowledge, exchange and the development of multi-level networks with Ukrainian stakeholders.
4. Based on the Nordic welfare model, develop short-term support programmes for Ukrainians who continue residing in Ukraine and address deeply-rooted weaknesses of the Ukrainian social security system.
5. Use Nordplus and other available programmes to train qualified Ukrainian refugees, students and professionals in the Nordic Region (and Baltic Region) as liaison persons between Ukraine and the Nordic countries (and the Baltic countries) in various spheres of their specialisation. This recommendation applies to both Ukrainians who intend to stay in the Nordic or Baltic Region and may work for Ukraine-related projects and potential reintegrated experts, i.e., those who intend to return to Ukraine and contribute to recovery-related programmes.
6. Develop 'sandwich' support programmes for Ukrainian governmental organisations, civil society and the aforementioned reintegrated experts.
7. Introduce institutional structures, flexible grant schemes and short-term exchange opportunities to ensure the viability of links between such reintegrated experts, Ukrainian NGOs and their Nordic and Baltic counterparts.
8. Design monitoring and integrity mechanisms to avoid the misuse of support provided.

Ukraine's sustainable recovery as a prerequisite for realising Vision 2030

According to the Vision 2030 of the Nordic Council of Ministers: "The Nordic Region will become the most sustainable and integrated region in the world by 2030". [1] Yet, as the COVID-19 pandemic and Russia's invasion of Ukraine demonstrate, the contemporary world is so tightly integrated that a crisis in one region has implications for others. Therefore, to realise the Vision for the future of the Nordic countries, the Nordic Council of Ministers must support the sustainable recovery of Ukraine.

Peace, political stability and resilience in Ukraine is critical for the Nordic Region for various reasons. First, Ukraine is an outpost for protecting Europe from an aggressive and assertive Russia. Any Russian military or political success in Ukraine jeopardises the stability and sustainability of the Nordic Region. Russia's direct Northern neighbours – Finland and Norway – are facing an increased Russian threat [2-4]. The Baltic states, which share borders with both Russia and its ally Belarus and – together with Denmark, Sweden and Finland – are bordering states to the strategically important Baltic Sea, which may be the next target of a resurgent Russia. [5] Furthermore, in the Arctic, Russia's hybrid offensive strategy has intensified. [6] Second, Ukraine has 15 operable reactors at four nuclear power plants, the safety of which is critical for energy and environmental security Europe-wide. Third, Russia's war against Ukraine highlights how important grain exports from Ukraine are for food security and food prices, especially in the Middle East and Africa. Political instability and conflicts in these regions, provoked by hunger, would contribute to new migration movements that will also impact the Nordic Region.

On the bright side, the experiences of Nordic-Baltic cooperation offer many valuable lessons for Nordic and Nordic-Baltic joint support [7] to Ukraine's sustainable post-war recovery. The experiences with the Nordic-Baltic cooperation since the early 1990s should be harnessed by the Nordic Council of Ministers when it comes to rebuilding Ukraine. Ukraine's post-war recovery is envisaged to be tightly connected to the process of its EU accession. [8] The close cooperation between the Nordic countries and the Baltic states since 1991 had been conducive to the latter's European integration. The most recent cooperation agreement between the Nordic Council and the Baltic Assembly puts the spotlight on Ukraine. [9] The Nordic Council of Ministers should follow in their footsteps.

Recollecting the Nordic-Baltic cooperation experience from the early 1990s

In order to "support Estonia, Latvia, and Lithuania in the struggle to reassert their independence" [10] the Nordic Council of Ministers launched a multifaceted cooperation with the three countries in 1991. This early phase of the cooperation, including the opening of offices in all three capitals of the Baltic states, enabled the Nordic Council of Ministers to make the best possible use of the historical momentum offered by the collapse of the Soviet Union. The cooperation established between the Nordic Council and the Baltic Assembly in Tallinn in 1991 laid the foundation for the Nordic Baltic Eight (NB8) cooperation format that has since brought together prime ministers, parliamentarians, executives, and experts from five Nordic and three Baltic countries. Importantly, the Nordic Region actively supported the Baltic countries in their preparation for integration into the EU and NATO through multilevel cooperation structures, as well as through diplomatic efforts within the EU and transatlantic integration structures. [11] The Nordic Council of Ministers should recollect this success story and support Ukraine in its struggle for independence and EU accession.

After the Baltic countries' accession to the EU and NATO, their cooperation with the Nordic countries changed. [11] It became a partnership of equals, and freed up the Nordic Region's resources to cooperate with the Baltic Region beyond its integration issues. The NB8 format, however, continues to be used by the participating countries as a forum for political cooperation. Beyond the political and foreign policy domains, the Nordic-Baltic cooperation revolves around five key themes, involving: 1) education, research and innovation, *inter alia*, exercised through the Nordplus programme [12]; 2) business, clusters and creative industries; 3) the environment, climate and energy with the focus on the Baltic Sea; 4) a variety of international challenges, faced by welfare states, ranging from the fight against human trafficking and spread of HIV/AIDS to improving hospital services and; 5) cross-border regional cooperation aimed at promoting shared values both in the Nordic-Baltic Region and with respect to neighbouring countries. [10]

Lessons from the Nordic-Baltic cooperation for the support of Ukraine's recovery

The experiences from both phases of Nordic-Baltic cooperation offer several lessons for the Nordic and/or Nordic-Baltic support of Ukraine. First, it is important to harness the opportunities that the current historical momentum provides. International attention and support to Ukraine amidst the war are unprecedented. Cooperation between Ukraine and the Nordic countries has increased at all levels, and perceptions of the country have changed dramatically. This offers valuable opportunities for the deepening of the ties between Ukraine and its Nordic and Baltic counterparts and to exercise political and technical support for their integration into European and Euro-Atlantic structures. Nonetheless, in contrast to the Baltic countries back in the 1990s, Ukraine is a large and a war-torn country, and as of now, a considerable part of its southeastern territories continues to be occupied by Russia. It is therefore important for Nordic and Baltic leaders to develop a deep understanding of the challenges Ukraine's recovery and European integration represents and thus distinguish areas where the Nordic and/or Nordic-Baltic joint contribution can have strongest added value.

Second, Nordic-Baltic cooperation is strong and covers many fields that are directly relevant for the recovery of Ukraine. It is therefore advisable to build the support of Ukraine on these existing structures, to closely coordinate activities, and to prioritise joint action.

Third, local knowledge and multilevel networks, facilitated by the offices of the Nordic Council of Ministers, proved to be crucial for the Nordic-Baltic cooperation and the Nordic support for the Baltic Region's independence, transformation and European integration. Opening an office of the Nordic Council of Ministers (or a joint office with the Baltic Assembly) in Kyiv is required for the establishing of close contact with the Ukrainian government and civil society. This is a prerequisite for tailor-made Nordic support. Such support could, as a first priority, deal with countering the social consequences of Russia's invasion, which pushed Ukraine 15 years back in its fight against poverty. [13] Using the experience of the Nordic welfare model, immediate support should address the most vulnerable groups (e.g. those living with HIV/AIDS, those in state-funded nursing homes) and provide technical assistance for analysing and improving Ukraine's legislation on pensions and social support, for instance, to strengthen the contributory pension system in Ukraine.

Fourth, in this context, a visible role should be played by Ukrainian refugees, students and professionals. This includes both those who intend to stay in the Nordic countries (or the Baltic countries) and engage in Ukraine-related projects and those who seek to reintegrate into the professional environment in Ukraine. Qualified individuals should be trained to act as liaisons between Nordic (or Baltic) countries, on the one hand, and Ukraine on the other, including in various project domains, ranging from social security to transport, education and infrastructure. This requires creating viable and well-funded structures and sectoral educational opportunities, e.g., via the Nordplus programme, ideally coupled with network-building opportunities with colleagues from the Nordic and/or the Baltic countries. In addition, it is key to design attractive reintegration schemes for Ukrainian graduates and young professionals that should be coupled with support for Ukrainian civil society. This could be done by creating 'sandwich' schemes for funding Ukrainian civil society's post-war recovery initiatives with the involvement of reintegrated experts, acquainted with relevant Nordic and Baltic experiences. Attention should also be dedicated to the design of monitoring and integrity mechanisms to avoid the misuse of the support provided.

The Sandwich Scheme

Brain drain is one of the central problems Ukraine will face in the post-war period. As the war continues, the number of Ukrainian refugees seeking to settle abroad increases. [14] At the same time, almost 50 percent of refugees declare an intent to come back, with the end of the war (51.2 %) and the absence of fighting or air attacks (34.1 %) reported as essential prerequisites for return. [15] Importantly, many Ukrainians report being ready to return even to regions, different from their home regions, provided that there are job opportunities and support schemes there (e.g. subsidised flats, relocation packages). [15]

Support for the reintegration of Ukrainian refugees should thus be seen as a crucial form of post-war recovery assistance agreed by international donors. For qualified staff, an opportunity to directly contribute to post-war recovery projects – exercised by government and non-governmental organisations – can serve as a strong incentive to return. 'Sandwich' schemes envisage that a donor provides institutional and project-based support to an organisation active in recovery projects, and finances the reintegration of experts to work on such programmes. To make 'sandwich' schemes effective, it is important to ensure that reintegrated experts and other employees get equal remuneration (a donor may have to consider salary top-ups for other employees, if necessary), and that there are pathways to support an organisation's institutional development. Moreover, sandwich schemes function best when all employees are engaged in active knowledge exchange processes with peers from the donor country and beyond.

Repeating a success story with a Nordic signature

In the 1990s, the added value of Nordic-Baltic cooperation from a Nordic perspective consisted in the "economic prosperity and political stability in the region" [11 (p.1)]. Today, the Nordic countries face a similar situation. The goals of the Vision 2030 strategy can only be achieved in a prosperous and stable Europe including, first and foremost, a safe and recovered Ukraine. The Nordic Council of Ministers should harness the experiences of the Nordic-Baltic cooperation to support Ukraine as it once supported the Baltic countries and thus repeat a success story with a Nordic signature.

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Unlocking Potentials, Building Bridges, Empowering Futures: Recommendations for Nordic Integration Policies for Young Refugees' Education, Employment, and Health

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As the Nordic Region sets out to become the most sustainable and integrated region in the world by 2030, it is imperative that we ensure that our welfare systems remain inclusive and effective when it comes to integrating young refugees into society. The Nordic countries have a long-standing international reputation for their generous social welfare systems and progressive policies. The social welfare system rests on the values of universalism, equity, solidarity, and trust, where everybody participates according to their capabilities and receives according to their needs. In recent decades, the increase in immigration and refugee arrivals has put pressure on the welfare system and has raised concerns about integration and social cohesion. This has led to debates on how to balance the need for an inclusive society, avoiding exacerbating social inequities, and ensuring the continuation of the welfare state in a sustainable manner. In this policy brief, we draw upon the fast growing international and Nordic evidence on migrant and refugee health, which encompasses recent findings from a multidisciplinary Nordic research project titled "Coming of Age in Exile" (CAGE) funded by NordForsk [1]. Based on this evidence, we provide recommendations for Nordic authorities and policymakers on how to effectively integrate young refugees into the Nordic societies with a special focus on education, labour market participation, and health, recognising the immense potential these areas hold for the successful integration and well-being of young refugees.

A potential source for a socially sustainable Nordic Region

Refugee children and youth are of higher risk of poor mental health, poorer educational achievements and weak ties to the labour market compared to their native-born peers [1]. This is owing to their exposure to traumatising events in their countries of origin, such as violence and war, exposure to hazardous experiences during their flee to safety such as separation from family members and other negative factors in the resettlement context such as temporary residence permit, poor psychosocial and parental support, and language barriers [2, 3]. These adversities interact, leading to a higher risk of becoming marginalised in society. While refugee children and youth constitute a heterogenous group in terms of age of arrival, migration experiences, cultural roots and family resources, all with various strengths and needs for psychosocial and educational interventions, they are often also resourceful with a high degree of resilience that can be promoted within the socio-ecological context [3].

The future prospects and integration of refugee children and youths are highly dependent on how well the resettlement country receives them and safeguards them, so that they can become equal members of society [1]. On this account, we bring forward three recommendations for Nordic authorities and policymakers with concrete suggestions for the successful integration of young refugees that can inspire the Nordic strategy of Vision 2030 within the area of social sustainability. We argue that to: 1) *unlock the potential of refugee children and youths*, national policies in terms of reception, educational and psychosocial support along with frontline workers' competences need to be in place; 2) *build bridges*, the educational system is a suitable and potentially powerful setting for majority peer interaction and support combined with community engagement, and civil society's support and mentor roles; 3) *empower the futures* of young refugees and support their contribution to the Nordic societies, continuous access to inclusive and diversity sensitive services of our welfare services are central. By adopting these recommendations, the Nordic countries can continue to be a safe place for refugee children and youths, while ensuring that our societies remain inclusive, cohesive, and sustainable for all.

Unlocking Potentials

Reception matters: care, social relationships, and learning

The way in which young refugees are welcomed upon their arrival in a Nordic country can significantly impact their future prospects in terms of education, employment, and health outcomes. National policies and resources need to be in place regarding a good reception that creates a stable environment with safe frameworks characterised by care, social relationships, and learning. This includes i) a supportive environment with easy access to psychosocial care, including for the parents when needed; ii) mental health screening upon arrival and subsequent and if needed, suitable mental health offers with systematic transfer of information across care levels; and iii) security and stability regarding residence permits and a minimum of transitions within the resettlement country [1, 2, 4].

Reception classes are of great importance as they form a culture of care and safety [5, 6]. Here, refugee children meet other children who have recently arrived in the country, with whom they can reflect and receive support. The reception class teachers can provide emotional and practical support, besides helping the children with the linguistic and academic transition. Furthermore, the teachers collaborate with other actors and the municipality, thereby providing a gradual inclusion into general education and a smoother integration into society [5, 6]. Language acquisition is central in the successful resettlement of refugee children. Mastering the resettlement language promotes long-term educational achievements, employment prospects, well-being, and integration [1]. Effective acquisition of a Nordic language is most likely to occur through a combination of intense instruction and regular interaction with majority peers in everyday settings [1, 7].

Flexibility in education provision and prioritising completion of upper secondary school

The schooling of refugee children and youths have often been disrupted before and during migration. Those who arrive in the Nordic countries at an older age face significant challenges in learning the resettlement language and catching up academically with their peers. This increases their risk of dropping out of upper secondary school. Completion of upper secondary school is associated with increased opportunities for higher education and more stable employment, ultimately resulting in stronger social and economic ties to society [1]. Thus, it is important to prioritise flexible educational provisions that facilitate secondary education attainment.

Improving professional competencies

Special knowledge and competences among frontline workers are warranted to effectively support refugee children and youth, who often have complex educational and psychosocial needs. Teachers, school health nurses, doctors, social workers, and other professionals may find themselves addressing issues that go beyond their typical role and training, and support structures are often not in place. Many lack sufficient diversity competency. Thus, it is crucial to allocate resources to schools and other welfare institutions to enhance the competences of their staff in supporting this diverse group. While experience and co-worker support can be helpful, systematic training is needed to ensure that professionals are equipped to meet the unique needs of young refugees.

Building Bridges

Schools as a health promoting arena and fostering interaction with peers from majority populations

Schools can play a crucial role in promoting the mental well-being of young refugees [8] as well as being a platform of integration. Schools provide essential contact points between young refugees and the host society. Likewise, schools can facilitate social support networks and positive intercultural relationships, while also combatting stigma and discrimination [7, 9]. To support the integration of refugee children and youth, policy initiatives should prioritise early interaction with peers from the majority population. While reception classes can provide a sense of safety and promote language acquisition, additional initiatives like peer mentorships and physical activities should be implemented to encourage early interaction with majority peers [10]. Refugee young people themselves often seek peer interactions, which can improve their understanding of social norms and life in the host country and build social networks promoting well-being and further social achievements.

Civil society

The civil society can meet the individual newcomers where they are – both physically in the community and in the psychosocial and integration process. They provide important assistance and practical help regarding their understanding of the new society, cultural codes, homework, everyday language training as well as acting as an important social tie to society. Ongoing psychosocial support from members of the civil society is also important for the successful resettlement of young refugees. Meaningful social activities that enable the formation of close relationships appear to be the preferred form of support for many young refugees [4, 10]. Promoting a sense of belonging is similarly central. Encouraging children and young refugees to participate in community events, activities, and organisations – such as sports teams, youth groups, and cultural events – can help them to feel a sense of belonging and support. Pairing children and young refugees with mentors or peers from the local community provides additional support and guidance and can also help to foster relationships and a sense of social connectedness [7, 10]. This can also promote a greater understanding and appreciation of different cultures among the wider community.

Empowering Futures

Easy and equal access to coordinated welfare services and resources

Continuous access to services and resources, such as education, employment support, and healthcare can help to promote social inclusion and independence. Removal of formal and informal barriers to access and ensuring inclusive services is essential. Education, employment and health outcomes are closely related and interdependent [1]. Resettlement language acquisition and upper secondary education achievement is key for successful life prospects in the Nordic countries. Tailored job training and placement programmes can facilitate access

to stable and secure employment, which is also important for the long-term empowerment and independence of young refugees. However, services for supporting these processes are embedded in different sectors and are not always well coordinated, leading to lack of coherence. This is a general challenge, but not least when dealing with the complexity of health and social factors often present among refugees. Thus, the co-ordination of services including data sharing and collaboration is necessary from day one of the arrival of the refugees [1].

Involvement and participation

The COVID-19 pandemic has clearly demonstrated the importance of tailored and interactive communication with migrant and refugee communities for ensuring resilience, empowerment and engagement in preventive actions [11]. This has confirmed the general evidence from research on migrants and refugees that active involvement and participation of the target groups in the planning and execution of health and social programmes is crucial in order to ensure successful interventions.

The importance of Nordic collaboration to ensure the integration of young refugees

The integration and inclusion of refugee children and youth is a common challenge that the Nordic countries face. Unlocking the newcomers' potential and safeguarding their life chances in the resettlement context by providing the right support and resources and building bridges to society can empower the futures of these young people. While many welfare trends and equity principles are quite similar across the Nordic countries, the migration and refugee policies and the approaches to integration have differed considerably. Combined with the unique Nordic research opportunities, this has created an excellent basis for learning. The Nordic data systems are quite unique, not least regarding registers, but Nordic research collaborations on migrants and refugees have clearly demonstrated the need for easier data transferral across countries and better standardisation of the data to allow smooth comparative research producing mutual learning on factors promoting integration [1]. By continuing the long tradition of Nordic collaboration, best practices, resources, policies and innovative solutions,expertise can be shared to ensure that refugee children and youth are given the support they need to integrate. By doing so, we fulfil our commitment to equity and human rights, while at the same time make use of an unused resource that increase the chances of our welfare systems to remain sustainable and effective as well as enhance our Global competitiveness. Likewise, by working together, the Nordic countries can amplify our voices on the global stage and influence international policies by leading by example, based on our shared values of democracy, equality, and human rights.

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A Nordic model for supporting language learning in everyday contexts

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Summary

We argue that the present challenges in the linguistic integration of adult immigrants in the Nordic societies require radically new thinking about language and learning. The remedy to the current poor linguistic integration of adult immigrants is not found in organising more integration courses or in tweaking the classroom practices. Rather, we propose that the Nordic countries should join forces in developing a Nordic model for adult immigrants' linguistic support based on ideas of language companionship and language mentoring on the job. Such a model would be one important step towards making the Nordic Region more socially sustainable.

The challenges in adult immigrants' linguistic integration into the Nordic societies

As researchers working in linguistics and language education, we have been studying the processes of second language learning for decades. In particular, we have been interested in how newcomers to the Nordic societies use and learn the languages of their new home country outside of formal education, for example as part of their everyday life and while working [1]. Understanding the linguistic realities of newcomers is important in creating support systems that help learners to start using and learning the language of their new home country quickly and without too much effort. In this policy brief, we provide a summary of the action points that we consider most important in developing support for the linguistic integration of adult newcomers in the Nordic societies. The need to support newcomers in becoming active members of our societies is recognised in the goals of Vision 2030, as well as the aim to strengthen the integration of different vulnerable groups into the labour market, including adult immigrants and refugees.

The Nordic countries are currently experiencing a number of demographic changes: Our population is not only aging but is also diversifying due to increased immigration. We need more working-age people to tackle the challenges brought about by the labour shortage. Consequently, work migration is vital for ensuring the competitiveness of the Nordic Region now and in the future. As democratic societies, we also need to be able to provide asylum for people who are forced to leave their home countries, and to support their integration into society and the labour market. For all adult newcomers, learning the local language is key for participating in the democratic society and decisive for both the labour market and local, social integration.

The challenges in adult immigrants' linguistic integration into the Nordic societies are well recognised. For example, in Finland the results of the language courses of integration training for adult immigrants are poor and the employment ratio of adult immigrants is the lowest in the OECD countries [2]. In Sweden, a large proportion of immigrants have arrived because of various humanitarian reasons. Migrants who arrive because of humanitarian reasons often have low educational levels and face severe challenges entering the labour market. A central reason for this is the insufficient support in learning the local language [3]. A similar problem has been reported in Denmark [4], resulting in a schism of linguistic acceptance: On the one hand, for the well-educated and highly skilled people, society accepts or even promotes a world where English is used alongside Danish. On the other hand, a world of poor labour market integration and language learning support is offered for the less educated [5]. In Norway, as in Finland and Sweden, the right to language courses is contingent upon residency status. This puts different groups of immigrants in unequal positions in relation to linguistic support. The poor linguistic support for adult immigrants leads to a vicious cycle: It delays labour market integration, hinders the creation of social networks with the local population, prevents building trust in democratic institutions and – in the worst scenario – leads to intergenerational accumulation of social and economic disadvantages.

Factors contributing to challenges in linguistic integration

The notion of a "second language" refers to any language that a person learns after their first language in an environment in which that language is used. This means that newcomers in Sweden are learning Swedish as their second language, and newcomers to Finland will learn either Finnish or Swedish depending on the area in which they live. In current thinking and theorising about second language learning, the central role of social interaction is widely accepted [6]. Languages cannot be learned without using them. However, it is far too common in the Nordic countries that even after years of attending integration courses and studying the local language in the classroom, adult learners are still unable to use the language in the life-worlds outside of the classrooms. There are several factors contributing to this. One is the widespread use of English: If a newcomer knows English and works in an international environment, English may suffice, and it requires a lot of motivation and investment from the newcomers to start using and learning the local language.

Another reason for the poor success in reaching communicative competence in the Nordic languages lies in the tradition of language teaching that favours the written language, textbook materials, and theoretical approaches. Such tradition is still widely observable in language education. If everyday spoken language and interaction are not emphasised in the classroom, it is more difficult for the adult learner to start using the language outside of the classroom. The challenges of classroom teaching have been widely recognised. Still the education political changes that have been introduced as a reaction to this have been merely cosmetic. For example, the idea that language learning should be combined with on-the-job training is now emphasised in all Nordic countries, and part of language training in integration courses is organised not in classrooms but as internships in the workplace. While such new models have the potential to accelerate labour market integration, research observations show that learners in the workplace are often left alone [7]. In addition, in some jobs, a common language is not needed [8]. There is a need for developing these models and for creating a more sophisticate infrastructure for supporting language use and learning while working.

Yet another – and perhaps the most important – factor is the reported scarcity of contacts that refugee-background immigrants in particular have with first-language speakers of their new home countries [9]. It has also been recognised that some macro-societal issues, such as regional segregation [10], or sociopolitical decisions – such as Child Home Care Allowance policies [11] – may impact the integration processes of adult immigrants negatively as they contribute either to keeping different language groups in different areas of cities or mothers at home with their children, thus making it more difficult to create contacts with the locals in the new language. These observations also indicate that the issues of linguistic integration cannot be solved by linguists alone. Instead, we need broad understanding of how such issues materialise in the everyday life of adult immigrants and how the issues are, in very practical terms, connected to where people live, whom they meet, which languages they need and use in their everyday life and what possibilities for language learning they face.

Recommendations: A Nordic model for supporting language learning in everyday contexts

We argue that the present challenges in the linguistic integration of adult immigrants require radically new thinking about language and learning and solutions that function not as add-ons to existing teaching practices but as replacements for the old solutions.

1. A Nordic model for language companionship

The remedy to the current poor linguistic integration of adult immigrants is not found in allocating more money for organising more integration courses or in tweaking the classroom practices. Rather, the solution is found in turning the gaze to the world outside the classroom and supporting newcomers' language use as part of their everyday life in interactions both in working life and their spare time. Infrastructures for language companionship should be developed and supported. In other words, because languages are best learned as part of everyday life with the help of supportive friends and colleagues, society needs to sustain infrastructures that enable and promote such learning. Language companionship gives co-ownership of language learning to the migrants themselves, and language schools can be part of such an infrastructure for learning the language of recurrent everyday encounters.

2. A Nordic model for language learning at work

The initiatives that seek to develop ways of supporting language learning at workplaces should be supported. Based on the research, we know that there are people doing important everyday language work at different workplaces as language brokers and mentors [12]. This invisible language work at workplaces should be recognised. We also need policies, practices, and procedures for assigning language mentors as 'everyday language teachers' to the newcomers. The mentors could be thought of as 'language representatives', in a way akin to union representatives. Such language representatives should also be compensated for the work they do in coordinating the language support work as part of their everyday work. This would pave the way for a Nordic model for language teaching and learning on-the-job. Nordic cooperation would be valuable in this since there have been many initiatives that have been launched recently in Nordic countries in this area [13,14].

3. Broader understanding of language, learning and competence

The field of applied linguistics has rapidly widened and deepened without language education following suit. The current challenges in language education are connected to old conceptions of language as a formal system, of language competence as an individual capacity and language learning as an individual achievement. These conceptions still underlie language-related educational solutions, language testing and many other current integration measures even if they become more and more outdated.

According to our current understanding, language learning is a profoundly social activity and human cognition is fundamentally embodied, situated, socially shared, and enacted through our actions in the environment [15]. This means that interactional competencies are not only individual but largely shared and distributed capacities that may take on many local forms drawing on knowledge of the world, including other languages [16]. These competencies can be distributed between people or between people and different technological or material support systems. In the era of artificial intelligence (AI), a plethora of technological devices are readily available. At its best, AI as well as technology more generally are an aid to our cognitive processing and support for learning – not a threat. Everyday technologies, such as smart phones, are valuable in supporting language use. The distributed nature of language learning across people and technologies should be acknowledged and supported, and we believe that the building of a Nordic model for language learning with language companions, brokers and mentors emerging as integral parts of a new work culture, can be a first step in this direction.

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Nordic Region to push for knowledge-based migration governance

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Summary

Current research reveals substantial gaps in our understandings of the practical implications of migration policy mechanisms, with limited knowledge being incorporated into new policy frameworks. However, new research offers valuable insights into migration and border control policy. This research must inform policy design and implementation strategies, influence funding decisions, and shape priorities for migration research. This brief presents two policy recommendations relevant for the Nordic Council of Ministers and NordForsk:

- **Bridge policy and research on the effects of external migration governance:** Research findings on the effects of European external migration policies should be integrated into the current migration policy-making processes in the Nordic Region and the European Union.
- **Broadening NordForsk's scope beyond integration for comprehensive migration governance:** The Nordic research vision must be expanded to include a more comprehensive understanding of migration dynamics, enabling more effective navigation of the complexities of migration governance.

Nordic position and responsibility in migration governance

Irregular migration from the Global South towards Europe has caused significant political and social upheaval. The prevention of irregular immigration has risen to the forefront of European and Nordic policy concerns. Following the EU's externalisation policies,[A] [1] the Nordic states have also embraced stricter migration governance policies.[B] The Nordic countries are marked by robust economic growth, profound trust in institutions, vibrant democracies, and a strong sense of equity and freedom, and they also hold a unique position: they are small, independent states but are ingrained as partners and members of the European community and the EU. This gives them the potential to steer global political agendas and values. However, the actual impact of current European and Nordic policies on migration in neighbouring regions remains uncertain with irregular migration still exacting a heavy human toll.

A Here, the term 'externalisation' is used to refer to European attempts – including those of the EU and individual states such as the Nordic countries – to regulate mobility outside their jurisdictional borders by collaborating with state and non-state actors beyond Europe's confines.
B See, for example, EU driven programmes such as Mobility Partnerships, the EU Emergency Trust Fund for Africa (https://trust-fund-for-africa.europa.eu/index_en); and the newly formed "Global Europe" programme (https://international-partnerships.ec.europa.eu/funding-and-technical-assistance/funding-instruments/global-europe-neighbourhood-development-and-international-cooperation-instrument_en)

Bridging policy and research on the effects of external migration governance

Migration policy in a North-South context often entails extending border control and migration management far beyond the receiving region's external borders, reaching into neighbouring, transit, and sending states. [2] Coinciding with the growth in externalisation policies over the past two decades, there has been a proportional increase in the analysis and evaluation of their effectiveness – essentially measuring how well these policies meet their intended objectives as set by states and unions in the Global North. [3] This can prove to be challenging, especially in contexts in which the national policies do not align with international priorities – as in Lebanon where there is no national migration policy or official framework and refugee crises are addressed via a series of ad-hoc policies. [4]

Research on migration governance more generally, has found that discrepancies frequently arise between policy discourses, the actual implementation of policy mechanisms, and their tangible outcomes on the ground. Ineffectual policy design or flawed execution can lead to unexpected results or, indeed, policy failure. These findings are consistent with more recent research on European externalisation policies, focusing on not only the effectiveness, but also the wider effects. For example, in Senegal, the EU's soft migration governance in the form of migration information and risk awareness campaigns has recently gained momentum. [5] However, these policy interventions are often unsuccessful because while local people are often aware of the attached risks and dangers of migration, they are unable to access local opportunities promoted in the campaigns. [6] A different example can be drawn from Ghana, where European funding on migration control has led to a shift from human rights-oriented towards security-oriented narrative frames on migration. While the early 2000s saw more work to support the aims of free mobility within the region, recent external funding has primarily focused on limiting irregular migration. [7]

A substantial cross-disciplinary literature has emerged examining European efforts to externalise migration and border control into Africa, particularly since 2015. [8,9] Recent findings scrutinise different interests, unequal power dynamics and conditionality, and highlight unintended, rippling, or even harmful, consequences in partnership countries. [10,11,12] Research has also shed light on the complexities of this process, highlighting the agency and resistance manifested by local state actors and civil society groups. [13,14] These explorations of external migration governance, including policy partnerships, not only enhances our understanding of their wide-reaching effects but also illuminates the need for greater integration of research findings into policy development to ensure success. One approach to the externalisation of migration policy has been to invest in development to address the 'root causes' of (irregular) migration. In Ethiopia, for example, the EU trust Fund for Africa invested in technical and vocational education and training to help young people gain skills and improve their employment prospects to reduce irregular migration. While this has delivered some strong programmes, its impact on migration is uncertain. [15]

Research findings in the field of migration governance underscore several key points of relevance for European and Nordic policymaking, such as the need for more equal partnerships, and context-based migration governance mechanisms informed by partner countries' priorities. This signals a dual necessity: the need for more knowledge on the implications of externalisation policies, and the need for more effective application of existing knowledge. [16] Indeed, as suggested by research on externalisation since the so called "refugee crisis" of 2015, there's an exigent need for more of this knowledge to be incorporated as a foundation for knowledge-driven policy. These requirements are of direct relevance to Nordic countries collaborating directly with partners in the Global South, for example, on return

and readmission. Moreover, the need for knowledge-sharing becomes critical for the Nordic states when engaging with EU programs on externalisation. Indications of existing expertise in this field suggest that the Nordic countries could benefit from establishing stronger ties for knowledge-exchange with countries that possess more extensive experience in this field, and in externalisation policies, such as other EU nations and the UK.

Policy recommendations:

By embracing a comprehensive, inclusive, and knowledge-driven approach to migration policy, the Nordic countries can contribute to more sustainable and equitable regional and global migration governance through:

- Encouraging Nordic states to collaborate with and include Global South partner countries in all stages of crafting externalisation policies – such as readmission agreements and development aid projects that target migration governance
- Using the Nordic Region's leverage to push for increased Global South inclusion in policy making at the European and EU levels
- Incorporating research findings on the effects of externalisation policies into current and future migration policy-making

Broadening research scope to incorporate broader migration dynamics

In its Vision 2030, the Nordic Council of Ministers outlines a future that cultivates a socially sustainable Nordic Region that is inclusive, interconnected, and champions shared values. [17] A cornerstone of this vision is the bolstering of national integration policies through experience-sharing and the leveraging of research-based knowledge. Based on the above insights, it is clear that integration policy and research should not be siloed but instead interlinked with migration policies. It is crucial to acknowledge that Nordic integration policies are intrinsically dependent on both national and European migration governance. Matters of asylum processing, readmission, border governance, EU mobility management, welfare coordination, and collaboration with origin and partner-countries in the Global South are just as critical and interconnected as integration policies. Additionally, awarding funding to migration research – beyond that on integration – also has potential to inform broader global foreign policy agendas related to climate change and development.

Prioritising research beyond the Nordic Region

NordForsk's recent allocation of funding to projects related to migration issues beyond the Nordic countries indicates a recognition of the importance of comprehensive migration-related knowledge in the region.[C] While primarily targeting research and knowledge-exchange on integration issues in the Nordic Region, calls for funding have also emphasised exchange and collaboration with other regions. For instance, the UK-Nordic thematic call on migration facilitated collaboration with the UK, and the recent funding call on the integration of Ukrainian, Russian and Belarusian refugees which emphasised collaboration with the Baltic Region. Such opportunities for international collaboration are crucial for the Nordic research community to further expand its expertise on migration dynamics. Understanding integration in the Nordic countries remains a priority, but achieving this goal requires building on expertise that extends beyond the region. Equally relevant to integration are research areas related to, for example, mixed migration, transnationalism, and migration partnerships in the Global South.

C See, recent funding on two projects: Effects of Externalisation: EU Migration Management in Africa and the Middle East (EFFEXT), project number: 95288, www.effext.org; and Influx of Ukrainian, Russian and Belarusian Migrants: Integration and governance dynamics in Nordic and Baltic states (INFLUX), project number: 161678, https://www.cmi.no/projects/2953-influx

Policy recommendations:

NordForsk should broaden the vision of migration research from a focus on integration in the Nordic countries and foster research collaborations within and beyond the Nordic Region. This can be done by:

- Increasing or prioritising calls that include *both* integration and broader migration dynamics
- Encouraging applications that include research foci within and beyond the Nordic Region, enabling financial and practical support to partners outside of the Nordic countries and the EU/UK

Conclusions: Ways ahead for Nordic collaboration on migration

Across Europe, migration governance is a source of contention with stricter measures implemented to deter migrants. Not only are there calls for more stringent conditions for integration, including welfare service access and other requirements, but migration control measures are being tightened. Alongside stricter entry stipulations across Europe, in the UK, outsourcing asylum processing to third countries, such as Rwanda, is underway despite these plans breaching the refugee convention. Additionally, migrants and asylum seekers are now returned by force or without due process along the borders of Europe and further afield, including at the US-Mexican border. The escalating political tension, coupled with the need for preparedness in the face of unexpected migration crises, underscores the pressing need for an enhanced knowledge base and underlines the importance of strengthening migration research. Moreover, there is a need for more equitable partnerships and international collaboration to provide legal migration channels that can safeguard individuals, benefit sending countries and improve integration in receiving countries. Research findings indicate significant knowledge gaps in understanding the real-world consequences of migration policy mechanisms. Despite a growing body of research providing valuable insights for policymaking, there's a notable shortfall in feeding these insights back to policymakers. These research outcomes should influence the funding opportunities and priorities for migration research, particularly within the Nordic Region.

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Radical (re)localisation to bring the cities and countryside together for sustainable Nordic societies in 2030

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Nordic populations have become concentrated in a few urban regions. This trend is expected to hold in the foreseeable future [1]. For food, raw materials and energy as well as various public benefits – such as clean air and water, places for recreation and relaxation – people in these cities depend on landscapes beyond the city limits [2]. Commodities and energy from all over the world reach urban homes via intricate and long transportation routes held together by pipelines, lorries, trains, and planes, financed and organised with capital from a few globally operating multinationals [3].

The climate emergency together with the COVID pandemic, as well as the energy crises resulting from the Russian invasion of the Ukraine, have demonstrated once more how unsustainable but also morally questionable this global network of commodity trade is [4], in a variety of aspects. The overt reliance on foreign goods and services results in long trade connections, and the intricate trade network complicates effective disease control and a secure provision basic needs, leaving cities vulnerable [5]. Moreover, the global urban-rural flows of goods and services contribute to high emissions and excessive use of fossil energies [6]. And finally, making use of the goods and services from a handful of big companies and industries keeps intact the excessive inequalities in power that hurt people and nature, but that remain out of sight and out of our moral ambit [7].

Proposals to make cities more resilient tend to duly focus on urban innovation and creativity [8; 9], often forgetting that greater self-reliance of Nordic cities hinges on greater extraction from their immediate hinterlands [10; 11; 12; 13]. Any proposal for sustainable Nordic cities needs to come to terms with ecologies and communities in these hinterlands. To be more precise, urban societies need to recognise the exhaustibility of nature's goods and services, as well as their dependence on people working in agriculture, fishery, forestry, and mining to make these goods and services available. In this policy brief, both aspects will be outlined with the aim of formulating a recommendation for making Nordic societies more sustainable and more resilient towards 2030.

That there are limits to what Earth can cope with in terms of human demands for basic and public needs has been a recurring finding since the report "Limits to growth" was published in 1972 [14]. More recently, Nordic research has been leading the search, and finding the evidence, for the precise identification of these limits on a global scale [15]. Yet, despite the discovery of these so-called "planetary boundaries", production and consumption in Nordic societies has continued to grow exponentially [16].

The argument put forward in this policy brief is that through the (re)localisation of urban consumption, Nordic cities can remain within planetary boundaries. By shortening supply chains, Nordic societies can regain control over basic necessities, but also bring negative effects of consumption back within public awareness and subject to moral consideration. As we will see next, the transformation of urban lifestyles through (re)localisation also supposes an agrarian and rural transformation. But what is the potential and prospect for such a transformation?

The recent history of modernisation in the Nordic countryside is a paradigm case of what the belief in untrammelled growth can result in. With the availability of fossil fuels, fertilisers, chemicals, subsidies, science, and a "get big or get out" ideology, farm production in the Nordic region scaled up tremendously after the Second World War [see e.g. 17; 18]. Land was then consigned to continuously produce large monotonous acreages of crops or forests. The cultural and ecological damage of this development started becoming apparent in the 1970s.

Today numerous studies demonstrate the detrimental effect that large-scale monocultures, heavy machines, fertilisers and chemicals have on the quality of water and soil, and consequently on biodiversity [19; 20]. The negative consequences of biodiversity loss for human wellbeing are hard to overstate [21]. Many plants that we eat depend on pollination by insects for their survival. Insects also decompose manure and dead organic material, and in so doing replenish nutrients in the soil. Without biodiversity life is not possible.

Nowadays most people in Nordic countrysides no longer live of the land. The environments that Sámi communities depend upon have long been colonised, resulting in a marginalisation of their livelihoods that continues to this day [22]. People working in agrarian occupations (farmers, herders, fishers, foresters, and small rural entrepreneurs, e.g. sawmillers) are nowadays also struggling or quitting [23]. Their properties are bought up, leaving an oligopoly of (often absentee) owners and corporations in charge. However, people wanting to establish themselves in the countryside are also having difficulties when there is little properly paid work, property is expensive, and banks or credit lenders dictate the scale and pace of work [24]. Rural work has become less able to contribute to lives of which rural people aspire [25]. A telling illustration is that many farmers, herders, and fishers nowadays often find that their children are better off without a farming or fishing livelihood [26].

Starting in the 1970s, to make sure that alongside their provision of a cheap supply of food, fuel, and fibre, countrysides also safeguarded nature, the Nordic governments created a bureaucracy of rules and restrictions. These aimed to keep production of agriculture, forestry, and fishing growing while at the same time restricting negative effects on biodiversity and animal welfare. Five decades of proof demonstrates that this strategy does not work. A logic of growth beyond limits cannot be made commensurable with ecological resilience through regulation – rather, a much more radical rural transformation is needed. But, many rural people nowadays do not want to be told to change.

The scaling up of primary production during the previous five decades not only damaged ecologies and rural cultures, it also unravelled the moral and social ties between the countryside and cities. As Nordic societies urbanise, the social network that connects the urban with the rural is dissolving. Nowadays most urban citizens no longer have family, colleagues or friends working and living in rural areas. They don't know where the goods and services that they obtain from the countryside come from, or who produced them.

Without direct connections to the countryside, city people lose an understanding of and affinity with rural people and their livelihoods. The social distance between urban and rural also grows as rural people find that the breakdown of identities, lifestyles and communities is, in urban and meritocratic times, not treated as a matter of common concern [27; 28; 29; 30; 31].

The widening urban-rural divide is illustrated poignantly with the US election of 2016 and 2020 [32], as well as a number of elections, referendums, polls, and farmers' protests in Europe of recent years [31; 33; 34; 35]. Nordic countries have also seen so-called landbygdsupprör or distriktsopprør (countryside/regional/farming uprising) [36] aimed against issues such as the placement of wind energy [37] and the conservation of large carnivore conservation [38], as well as the attraction of populist politics among rural voters [39].

How to address the urban-rural divide to create a common ground for a just and sustainable transformation of Nordic societies? To begin with, the recommendation that follows is radical in the sense that it addresses the root cause of urban vulnerability and rural discontent – after all, "radical" comes from the Latin word "radix" meaning "root". Scholars explaining rural discontent [27; 28; 29; 30; 31] point out that grievances produce feelings of injustice related to: (a) the financial and social recognition that rural people receive for their goods and services; (b) the lack of freedom they experience in deciding on their everyday lives and future; and (c) being forced to transform their lifestyles to make up for the lack of sustainability in others' lives, i.e. urban lifestyles. Rural discontent thus manifests as feelings about [inspired by 40] procedural justice (who is leading; who is following); distributional justice (who gets what?); contributive justice (who gets recognition?); and environmental justice (who is suffering from overuse, pollution, and degradation of nature?). Interventions to (re)localise Nordic societies and to preempt rural discontent therefore need to address all four dimensions of justice, which translate to the following final recommendations:

1. Distributional justice. Equalise the distribution of rural property and limit the scale of primary production [41].

2. Procedural justice: Localise political decision-making according to the principle of subsidiarity so that rural people get the opportunity to experience a degree of autonomy over processes that concern their life world [42].

3. Contributive justice. Improve the financial rewards for the production of material (e.g. food) as well as immaterial products and services (e.g. biodiversity). Lower rewards (such as rent, interest and profit) for income earned through ownership of assets and capital [43].

4. Environmental justice. Recognise the (historical) harm done to nature and culture, as well as the environmental benefits that are embodied in local and indigenous styles of primary production and livelihoods [44].

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Emergency management in small remote communities – an urgent issue in the Nordic countries

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Context

Nordic countries face increased risk as a result of climate change [1–3], and both sparsely and densely populated areas will be affected. Most climate change adaptation research focuses on densely populated areas [4,5], but globally and in the Nordic countries, a significant proportion of people still live far outside the bigger cities, and many of those small remote communities face climate-related hazards that cannot be solved with the same approaches as employed in the densely populated areas, which have robust infrastructure and ready access to emergency services [6-11].

Overall, there are two ways a risk can be reduced. One is to reduce the likelihood of a hazard occurring. Here, building structures is often the preferred solution, but this is costly. The second is to reduce the consequences if the hazard occurs [12], which, for instance, can be achieved by improving emergency management [13,14]. There is a large focus on how to adapt cities to climate change. Solutions frequently referred to are, for instance: the construction of infrastructure such as dykes or avalanche barriers to remove potential hazards, or the relocation of the most important infrastructure or buildings. In small remote communities, this will not be an option, or, if it is an option, this would only be possible in a scaled-down version because of the cost of those measures. Governmental funds will be prioritised to more densely populated areas, and there are too few people in the small communities to fund these structures themselves. Thus, climate adaptation in small remote communities must be thought of differently.

Across the Nordic countries, climate change-related incidents will add further strain to the contemporary emergency management system. Climate-related hazards occur more frequently and on a large scale [15,16] and will thereby stretch existing resources [17-19]. Hence, it is not realistic that the formal emergency management system will be able to prioritise all operations in small remote communities. Instead, there is a need to rethink the present organisation of emergency management in the Nordic countries to support the inclusion of novel resources and the implement of new principles for organisation. In practice, this can be done by involving citizens living in small remote communities but also local civil society organisations and private entities not traditionally part of emergency management set-up. Most importantly, this is not to be organised in the midst of a disaster. There is an urgency for the integration of new actors and entities through planning and training before disasters occur. Consequently, in-depth explorations are needed to find solutions to this impending need.

Key findings in recent Nordic projects

- There is an inherent tradition of independence in relation to handling local emergencies and disasters in small remote Nordic communities, since they cannot expect emergency management assistance from external sources. However, they lack formal context-specific scenario training concerning climate change-related incidents, since these hazards pose new challenges that most communities have limited experience with. However, the frequency and scale of these disasters will increase.
- Exercises and training within established, traditional emergency management systems are designed to facilitate learning and secure preparedness among professionals, but when new actors such as citizens, civil society organisations, and private entities are included in those exercises, their learning is limited.
- There is a need then to develop new ways of organising emergency management systems in small remote communities and also to create new methods to train and learn within emergency management that has been designed for a situation where a diverse and heterogenous group of actors are involved.

Ways Forward

Novel ways of organising Nordic emergency management

Remoteness forces community members to deal with hazards themselves when they initially occur, since the isolation often complicates the presence of the rescue service. However, the remoteness not only creates challenges but can also create a strength concerning building adaptive capacity to climate change. Such communities often have a long tradition of responding independently to challenges and developing local solutions [9,14]. Many small remote communities already have their own first responders and fire brigades, and they have a well-established tradition that local services are operated based on voluntary work [10].

Contemporary emergency management in the Nordic countries identifies and addresses the need for including new actors in the existing system [20]. A growing attention towards new ways of including volunteers and other organisations can be identified [21]. The prognoses for more extreme weather events are to a large extent expected to overwhelm the capacity of the emergency management system. Larger events such as avalanches, landslides, flash floods, temperature extremes, wildfires, storms, and floods will most likely create a situation in the future where the civil society needs to be included in ways that there has not previously been a tradition for in the Nordic countries [21]. It will create situations where other actors, not only people and organisations in remote areas, need to play an active part in the relief work in case of an emergency or disaster.

An intensified focus on both the establishment and improvement of emergency management in small remote communities will not only strengthen the resilience of those communities but also provide an important testing ground for developing a Nordic emergency management system better prepared for a future affected by climate change.

Novel approaches to training and learning within emergency management

Despite the tradition in remote communities of independent problem-solving and the development of solutions tailored to local needs, most communities still lack the formal training and experience to do so [22]. Thus there is not only a need for new ways of organising emergency management in a Nordic context but also for developing new ways to train and develop the competencies among the new actors involved.

The use of emergency management exercises is a traditional and often applied format to practice skills and competencies within professional emergency management organisations. Exercises are used to train, for example, coordination, communication, and decision-making [23]. The aim is to enhance the organisations' and stakeholders' capacity to react, their ability to prioritise critical societal functions, and to respond in a sound way to rare incidents through simulation. The central aims of such exercises are to practice the organisations' plans for responding to a certain scenario and to test weaknesses and address the need for improvements. Representatives meet across sectors, organisations, and spheres to train their capacity to cooperate and coordinate their response and need for resources [11].

Despite the fact that actors and entities outside the emergency management sector, such as citizens, private companies, and civil society organisations, are nowadays also included in emergency management plans, they are rarely included in the training and exercises of professional emergency management. The engagement of remote communities in training and exercising emergency management requires the development of new formats. Firstly, there is a need to include all the participants' know-how and insights, including those who are not professionally engaged in emergency management organisations but who have a knowledge of local conditions and routines [24]. Secondly, it is important to overcome the often-faced problem that initiatives are required to construct exercise formats which ensure that individuals, organisations, and communities actually become better prepared for a real incident through exercises [25]. Thirdly, the formats are often directed either towards decision makers on a strategic national level [26] or towards firefighting, healthcare and medical care, and law enforcement on an operational level. Finally, there is a need to include the context of climate change-caused extreme weather events in the formats [26].

Added value in a Nordic context

Research has shown that despite their differences, the challenges that small remote communities face across the Nordic countries are very similar [9,10,13,14]. In some communities, robust solutions have been developed, such as the development of local extreme weather emergency plans [9,10], but there is a lack of sharing such insights across communities facing similar situations.

Hence, there is a comprehensive potential for facilitating learning and developing solutions in cooperation across the Nordic countries. It is very plausible that good examples, experiences, or solutions to learn from can be found in the other Nordic countries. At the same time, parallel welfare state systems, governance standards, and principles of emergency response provide transferability of solutions.

Policy recommendations

- Small remote communities have to adapt to climate change through other solutions and tools compared to cities and more densely populated areas. Consequently, it is paramount to include the communities when developing solutions and plans for how to face climate change in the Nordic countries.
- To respond to and manage the increasing number of climate-related hazards in the future, also in the smaller communities, emergency management organisations need to transform and reorganise resources. The inclusion of citizens, civil society organisations, and the private sector in the emergency management structure is imperative.
- Special attention is needed to develop new formats of training and learning for managing emergencies. New actors, such as local communities, need to strengthen their own capacity and to learn to cooperate with professional emergency management systems both locally and nationally, but also across the Nordic countries.

Recent research projects in a Nordic context

This paper builds on international, European, and Nordic research, and the latter includes results from two NordForsk-funded research projects:

"The Climate Change Resilience in Small Communities in the Nordic Countries project" (CliCNord, 2021–2023) focuses on how to increase capacity building in small communities to meet the effects of climate change. The project investigates how small communities understand their situation in relation to climate change, how they handle climate-related challenges, how competencies and resources among the local citizens can help build capacity, and the circumstances regarding the citizens' need for help from the established system and civil society organisations. CliCNord has received funding from the NordForsk Nordic Societal Security Programme under Grant Agreement No. 97229.

"Building resilient communities in the High North" (2020–2022) aimed to map out an understanding of community resilience to catastrophic incidents in Greenland and the Faroe Islands through scenario exercises and workshops to enhance situational awareness. The project sought to improve the understanding of the currently available learning tools on organisational resilience when applied to a context that significantly differs from our knowledge of communities that are logistically well connected to national emergency response infrastructure. The project was financed through Nordplus under the Nordic Council.

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The Arts as Healthcare

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Executive summary

There is growing evidence that the arts can effectively be used to promote health and well-being, which is a topic of my anthropological research. [1,2,3] The arts provide not only an **effective** approach to healthcare, but also serve as relatively inexpensive ways of ensuring targeted forms of such care. They do not, for example, have the negative side effects we tend to associate with pharmaceuticals.

However, the arts are not currently used extensively to support Nordic health in ways institutionalised across arts organisations, medical infrastructures, national governments, and inter-Nordic collaborations. Although **Arts on Prescription** (AoP) and **Social Prescribing** (SP) **of arts** and culture are discussed and debated, they have not yet been broadly implemented in the Nordic Region. The umbrella term of social prescribing refers to diverse types of social engagement and activity—for instance, artistic—that may be "prescribed" to assist with health and social issues. [4] Arts on Prescription on the other hand, tends to specifically refer to the use of arts towards bettering mental health and wellbeing. AoP is also called Culture on Prescription in some Nordic and EU contexts.

This policy brief recommends the scaling up and, through research and dialogue, the optimisation of AoP and SP for arts in the Nordic Region. Promoting health and well-being is one way of enhancing the **social sustainability** of the Nordic countries as outlined in Our Vision 2030 – the action plan of the Nordic Council of Ministers.

Contributions of the arts in healthcare

There is always a need to support healthcare in national policy. Arts as healthcare is one way of supporting preemptive and remedial healthcare. It has the further potential to also offer **cost-saving benefits**. [5]

Arts engagement, for example, provides **preventative effects** for mental health. It can decrease biological stress levels, salve nascent anxiety, and reduce the risk of developing depression. Going to concerts, theatres or museums, and making music, dancing, performing, and creating visual art additionally contributes to cognitive reserve (the brain's resilience as we age).

Ample research evidence shows that engaging with the arts such as music, dance, theatre, live arts events, literature, and museums can **decrease symptoms** if or when a disease develops. Arts engagement helps with the management and treatment of mental illnesses in particular, be that perinatal mental illness or other mental distress such as loneliness. The World Health Organization Regional Office for Europe published a quantified summary of over 1,600 academic studies (titled *What is the evidence on the role of the arts in improving health and wellbeing? A scoping review*) that suggests that music has the greatest number of health benefits overall, and also contributes to pain management and insomnia. Music therapy—music practices for therapeutic uses—and listening to music even helps in severe mental illness with psychotic, paranoiac and catatonic symptoms. Other mental illnesses assisted by music are obsessive-compulsive disorder and social anxiety disorder. Post-traumatic stress disorder can be addressed through the arts. [6]

There is also solid research evidence that the arts support the care of people with acute and chronic conditions. Hearing music and being read to can benefit the health of premature infants. The ability of musical engagement to reduce pain and anxiety also finds applications in surgery and intensive care. Music and sound can help with chronic pain.

The arts also positively contribute in a wide range of neurological and neurodevelopmental disorders, such as autism, cerebral palsy, stroke, acquired brain injuries, and Parkinson's. Artistic activities additionally help prevent the worsening of cognitive decline in dementia.

Furthermore, research shows that the arts assist with the treatment of noncommunicable diseases. The health-enhancing aspects of the arts support cancer patients in their recovery, based on complex biological, psychosocial, and cultural factors. For people with respiratory illness, singing builds healthier airways and improved mental well-being. Listening to music reduces some symptoms in people with diabetes and cardiovascular disease.

Arts engagement has a variety of other health-related applications. Among them are beneficial uses of the arts in end-of-life care, health communication, and shaping social determinants of health. [7]

What matters most to policy is that AoP and the SP of the arts *work*. According to research findings, the arts hold great complementary potential to existing medical treatments, and especially where pharmaceutical treatment is not feasible in the long-term, as is the case with trauma. In some cases, the mechanisms by which the arts can protect or enhance health and well-being are well understood, while in other contexts, this is not yet the case.

The arts in Nordic health policy?

As may be expected, Nordic policies address the health needs of their respective countries in their national policies. [8] There have also been recommendations for the increased integration of Nordic health policies. [9] However, using the arts as a form of healthcare is missing from these.

This is not to say that the Nordic Region is unsupportive of the arts as healthcare. Certain municipalities, arts institutions, and universities have joined forces in the trialling of AoP as an initiative, especially in Sweden and Denmark. [10] With the impetus largely coming from municipal governments and via the help of EU co-funding, Arts on Prescription in the Baltic Sea Region (2021–2027), seeks to develop a scalable AoP model. Aarhus University Hospital in Denmark participated in a pilot study in an EU-wide project called Culture for Health (2022–2023). Globally, a variety of institutional partnerships, policies [11] and funding models have been launched to initiate Social Prescribing. [12] These, in addition to innovative Nordic projects, can serve as points of inspiration for arts as healthcare in the Nordic Region.

Policy recommendations

1. **Integrate the use of arts as healthcare into national health policies**
   Integrate the use of arts as healthcare into health policies of Nordic national governments, thereby facilitating governmental support.

2. **Develop the infrastructure for Arts on Prescription and Social Prescribing of arts**
   Within the Nordic nations, develop the infrastructure for AoP and SP of arts as an extension of primary or other medical care. Medical professionals could thereby make referrals to partner arts professionals and initiatives. The key question of the type of healthcare training, knowledge, skills, and competencies that the arts practitioners require in order to deliver AoP and SP must be productively addressed.

3. **Scale up the use of arts as healthcare**
   Grow the few existing and successful programmes that twin medical and arts-healthcare experts and/or institutions. In collaboration with arts health scholars and medical professionals, design new initiatives based on research findings. Do not scale up "Arts on Prescription" or other Social Prescribing of arts offered by organisations or people that have no knowledge of either arts as healthcare or medicine.

4. **Prioritise arts as healthcare for people in need**
   In newly developed initiatives, work towards making arts as healthcare available for all, but prioritise first initiatives for people experiencing healthcare access limitations and who have special needs. This could mean:

   - offering AoP or SP of arts to people living in geographically remote and in socio-economically marginal circumstances. This would promote health equity in the Nordic Region, and thereby achieve maximum social sustainability.
   - prioritising appropriate arts initiatives for demographics disproportionately affected by mental health issues, such as
     - youths, focusing on preventative early measures;
     - Indigenous peoples of the Nordic countries, the *Sámi (Norway/Sweden/Finland)* and the Inuit of Greenland (Denmark), many of whom live in remote areas;
     - asylum seekers and refugees, such as those impacted by the trauma of war; and
     - senior citizens.

Inclusion of potentially vulnerable groups must be approached with the highest respect for human dignity and ethical considerations (e.g., non-discrimination).

5. **Fund networking and research on arts as healthcare**
   Cross-Nordic knowledge exchange and development should initiate work towards scaling up arts as healthcare, and its effectiveness. This can be accomplished through:

   - research-based dialogue, between medical and arts scholars and practitioners aimed at building optimally effective programmes and infrastructures across the Nordic area. We often learn about the outcomes of using the arts in healthcare through reading systematic reviews, which too frequently reproduce research errors. [13] Dialogue among experts is necessary.

- supporting research toward better understanding why and how arts and culture boost health. This innovation would optimise the health and cost effectivity of arts as healthcare. It would enhance the global competitiveness of AoP and SP in the Nordic Region. The research would pertain not only to current AoP projects, but artistic projects that could be developed into, or already model, health benefits of the arts. Careful socio-cultural and qualitative studies are essential and fundamental to developing a solid research base, in addition to qualitative studies such as randomised control trials. There should be studies based on when social prescribing does work well and when there are failings. Understanding the nuances of which aspects of arts initiatives for health actually boost health, and which even have negative implications for health, [14] is part of optimising the efficiency of any programme that includes arts as healthcare.
- cost-benefit analyses of current Nordic arts-related healthcare practices. Cost savings of implementing AoP and SP of arts broadly across the Nordic nation states must be calculated for the opportunity to scale-up.

Challenges and proposed solutions

Arts as healthcare for social sustainability in the Nordic Region offers both challenges and potential solutions.

- The scaling up of arts as healthcare initiatives, infrastructure development, and research requires **money**. More government funding is needed.
- Barriers also exist when it comes to scaling up, implementing, and researching AoP and SP of arts due to societal **stigmatisation** of the arts as purely "entertainment." This may hinder some decision-makers, or the general public, from taking the potential of the arts for health promotion seriously. On the other hand, some artists and arts researchers resist the instrumentalisation of the arts. Campaigns may be necessary to achieve widespread support for arts as healthcare. The responsibility of implementing these can be assigned to the infrastructures and administrators.
- Arts as healthcare, although highly promising, is **an emergent field** of practice and research. Like with any new field, there needs to be constant critical evaluation of, encouragement of, and engagement with the newest and most dependable research-based findings. This can be facilitated by cross-Nordic knowledge exchange among arts-related healthcare and medical experts.

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Toward a gender equal and diverse research and innovation area in the Nordic Region

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Over the years, academic institutions in the Nordic Region have witnessed a sharp rise in the proportion of women and ethnic minorities among the student population, but a much slower influx of these groups in top academic positions. The share of women among professors has slowly risen to around 30 percent in Finland, Sweden and Norway. Denmark, however, lags behind, with a share of women professors well below the EU average (see She figures 2021, Figure 6.3).

The distribution of women and men varies significantly across disciplines in all Nordic countries, particularly in the fields of Natural Science, Engineering, Technology and Math (STEM), where women continue to be underrepresented at all levels. Although Finland used to have a higher share of women in top positions in these disciplines compared to other Nordic countries, it has experienced slower progress, currently trailing behind its neighbouring Nordic countries.

Gender equality and diversity play a crucial role in shaping research and the questions prioritised within the scientific community. This is essential for democratic progress and ensuring the scientific community's contribution to complex future challenges. Understanding the factors that hinder or promote gender equality and diversity in Nordic research has been the central question guiding NORDICORE—a Nordic Centre of Excellence with researchers from Iceland, Finland, Sweden, and Norway.

No bias against women in academic CV evaluations

A study involving faculty members from Iceland, Norway, and Sweden assessed CVs of hypothetical candidates for an Associate Professor position [1]. The candidates were randomly assigned either male or female names, while their CVs varied in terms of publication records and parental status. Interestingly, female CVs received higher ratings for competence and hireability compared to male CVs, despite the underrepresentation of women in professor positions across all evaluated fields. These findings therefore suggest that biased evaluations of equally qualified candidates may not be the primary cause of the persistent gender gap in Nordic academia. Still, the problem may be that career paths and academic production are typically gendered, such that male and female candidates often do not have "equal" CVs in practice.

The study concludes that biased evaluations of equally qualified candidates for Associate Professor positions do not seem to be the key explanation behind the persistent gender gap in academia in the Nordic Region. Given these findings, one potential explanation for the persistent gender gap is that the underrepresentation of women in professor positions is the result of sorting mechanisms occurring at earlier stages in their academic career, which — constrained or not —could lead fewer women to ascend to professor positions.

Work-family balance in Swedish, Icelandic and Norwegian academic careers

Qualitative studies of experiences and career prospects among PhD holders conducted in Sweden, Iceland, and Norway revealed that both men and women consider leaving academia due to family-related concerns. Family considerations, job insecurity, and caregiving responsibilities were identified as common factors leading to their exit from the sector. Female academics in particular employed various strategies to minimise the impact of family obligations on their careers [2]. The Icelandic study highlighted gendered societal time norms and the associated stress faced by women in balancing career and family obligations [3].

PhD holders in Norway outlined various trade-offs and strategies they used to balance family and career demands. Slowing down career progression after securing a permanent job in academia, pursuing portfolio careers outside academia with higher wages earlier on in the career, or seeking permanent positions outside academia were common strategies employed to achieve a better work-life balance [4].

Narrow criteria for evaluating quality in hiring processes

To explore the scope available for considering diversity in academic hiring, actual recruitment processes were analysed, focusing on how evaluations and quality assessments are embedded in the organisational process of recruitment. In an in-depth study of 48 recruitment cases for permanent academic positions in Norway and 52 qualitative interviews with the recruiters involved, it was found that neutral routines and 'objective' criteria in recruitment seemed to result in an institutional preference for certain types of candidates [5].

Despite initial considerations of diversity during the early stages of the recruitment process, the evaluators ultimately resorted to narrow evaluation instruments, such as the number of articles published in prestigious journals, favouring certain types of candidates. A key insight here is that, due to their characteristics and the circumstances in which they are used, these instruments have unintended consequences: they transform the definition of quality and define it in particularly narrow terms. It is rare that there are institutional procedures in place to ensure that factors of significance for lower production are taken into account, such as childbirth, parental leave, and the number of children. The practical implication of this is that as long as gender equality and diversity considerations are not taken into account in the crucial stages of recruitment processes, then the potential for change will be minimal.

Some equality policies seem to work

A comprehensive survey of all the universities in Sweden, Finland, and Norway evaluated the equality measures implemented in the period between 1995 and 2018. Data was collected from 37 institutions and matched with registered data on the share of women professors, to assess the impact of each type of policy measure three years after it was implemented [6]. Figure 1 shows how the Nordic institutions have developed their use of equality policies over time. In particular, we see increasing use of awareness-raising measures and organisational responsibility measures.

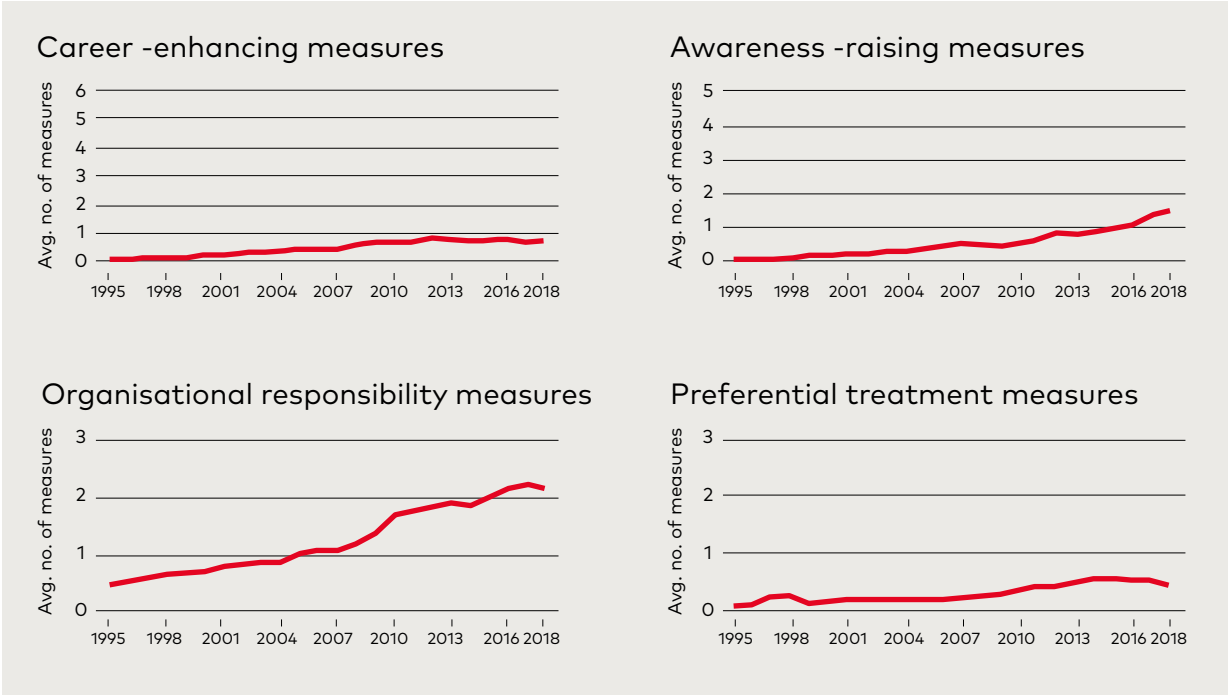

Figure 1. Average number of measures implemented across institutions

Policies categorised as *preferential treatment* and *organisational responsibility* were significantly associated with increased female representation. Institutions offering hiring support, such as earmarked funds and faculty lines for female candidates, witnessed a substantial rise in the proportion of women professors. Additionally, institutions with dedicated equality officers or such an office in place also had a significantly larger increase in women professors than those that did not.

Recommendations for more inclusive research careers

To address the challenges and promote gender equality and diversity in Nordic academic institutions, the following four recommendations are proposed:

I) Equality officers: The establishing of institutional equality officers or offices with responsibility for continuous monitoring, involvement, and organisational development to improve equality and diversity within the organisation is crucial. These are positions that hold a dedicated responsibility for organisational processes meant to stimulate and realise active, targeted, and systematic equality efforts. This is important in ensuring that equality considerations are included in the institutions' various processes. The (head) equality officer should be represented in the institution's management team, to ensure that work with equality and intersectionality has priority in ongoing strategies and processes.

II) Making gender mainstreaming work: Gender mainstreaming should be integrated into the daily work of top management, with accountability for institutional outcomes of equality policies. Identifying and specifying the necessary measures within the relevant unit (typically the department) is essential. What is needed for gender mainstreaming to work must be identified and specified within the relevant unit (often the department). Only by doing this, can mainstreaming then become the instrument it has the potential to be. It should be ensured that a) **career paths are fair, open, and inclusive**, b) **all decision-making bodies should be gender balanced and diverse**, and c) gender mainstreaming should be **integrated in a cross-cutting manner**. Successful examples of measures implemented to stimulate gender mainstreaming, such as the Norwegian BALANSE programme, should be continued and shared across Nordic countries.

III) Gender and diversity in research content: The integration of gender and diversity perspectives into research content is important for recruitment to research fields, and not least for the development of good, relevant, high-quality research. Processes to secure the integration of gender and diversity perspectives beyond the most obvious research areas are largely in their infancy, but nonetheless contribute to a promising field that promotes change. One of the major issues at stake with a mono-cultural and homogenous faculty is that it may impede necessary diversity in perspectives, methods, qualities, and insights. This may also discourage talented individuals from diverse backgrounds from pursuing academic careers.

IV) Policy coordinating mechanism: It is necessary to establish a policy coordinating mechanism that can support the institutions' equality work, development of equality plans, work for gender mainstreaming, and so on. Such policy coordinating mechanisms should be established at the national level, alongside the furthering of Nordic cooperation, which is linked to a dedicated EU network or institution. Lessons can likely be learned from the Norwegian Committee for Gender Balance and Diversity in Research (KIF). Policy coordinating mechanisms can be developed within established structures and through the dedication of sufficient resources and should be anchored in decision-making structures that ensure attention and action. It is important that these bodies do not exclusively focus on the underrepresentation of women, but rather introduce mandates that address mono-cultural and gendered institutional structures as well as gender and diversity aspects in research content.

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