BSR Policy Briefing series 8/2023

The wicked problem of eutrophication

- next steps in the process towards sustainable agriculture in Finland

By Anna Törnroos-Remes

CENTRUM BALTICUM

ISSN: 2342-3153

The wicked problem of eutrophication

- next steps in the process towards sustainable agriculture in Finland

By Anna Törnroos-Remes

Anna Törnroos-Remes is an Associate Professor (tenure track) at Environmental and Marine Biology and the interdisciplinary research profile The Sea at Åbo Akademi University. Her research focus is two-fold. On the one hand she studies the functioning of coastal areas, marine environments and particularly the seafloor. She is especially interested in what organisms do in the system, that is, what roles or functions they perform and how that translates to services for us humans, such as food resources, stabilisation of coastal landscapes and carbon sequestration. On the other hand, her work also brings her across disciplines such as social science, business, technology and humanities to investigate our human relationship with the sea and marine socio-ecological challenges, or wicked problems. She has been involved in various EU projects, and are currently leading the newly established Centre for Ocean Sustainability Science at Åbo Akademi University.

Abstract

Sustaining food production in a future climate is vital, but at the same time doing so in a way that is sustainable and particularly not contributing to nutrient pollution, that is eutrophication, is equally important. This is key, as the agriculture is still the major source of nutrient enrichment in the Baltic Sea region. The report aims to highlight next steps and measures needed in tackling eutrophication in coastal waters, by focusing on the case study of Finnish waters and particularly the agriculture sector. First, a brief introduction is given to the wickedness of the eutrophication problem in the Baltic Sea and the current situation in Finnish waters, as well the sustainability concept. Then, an assessment of current knowledge basis and gaps based on recent national ministerial reports and programs, national and international project reports and some scientific literature is presented. Last, some key measures and next steps are outlined. The report identified two key knowledge gaps for transitioning towards more sustainable agri-environmental practices and an improved marine governance; 1) need for improved data, especially agricultural-related data such as soil nutrient values and agricultural methods applied, this also includes coordination of data availability, and 2) need for more effective collaboration and integration across sectors for improving a common knowledge base for a broader set of relevant actors than today. Both of these would facilitate rephrasing of the narrative of agriculture for the wicked problem of eutrophication and allow for inter- and transdisciplinary approaches to seek sustainable solutions to this wicked problem.

Key words: eutrophication, water management, sustainable food production, agriculture data, inter- and transdisciplinary collaborations, agriculture narrative.

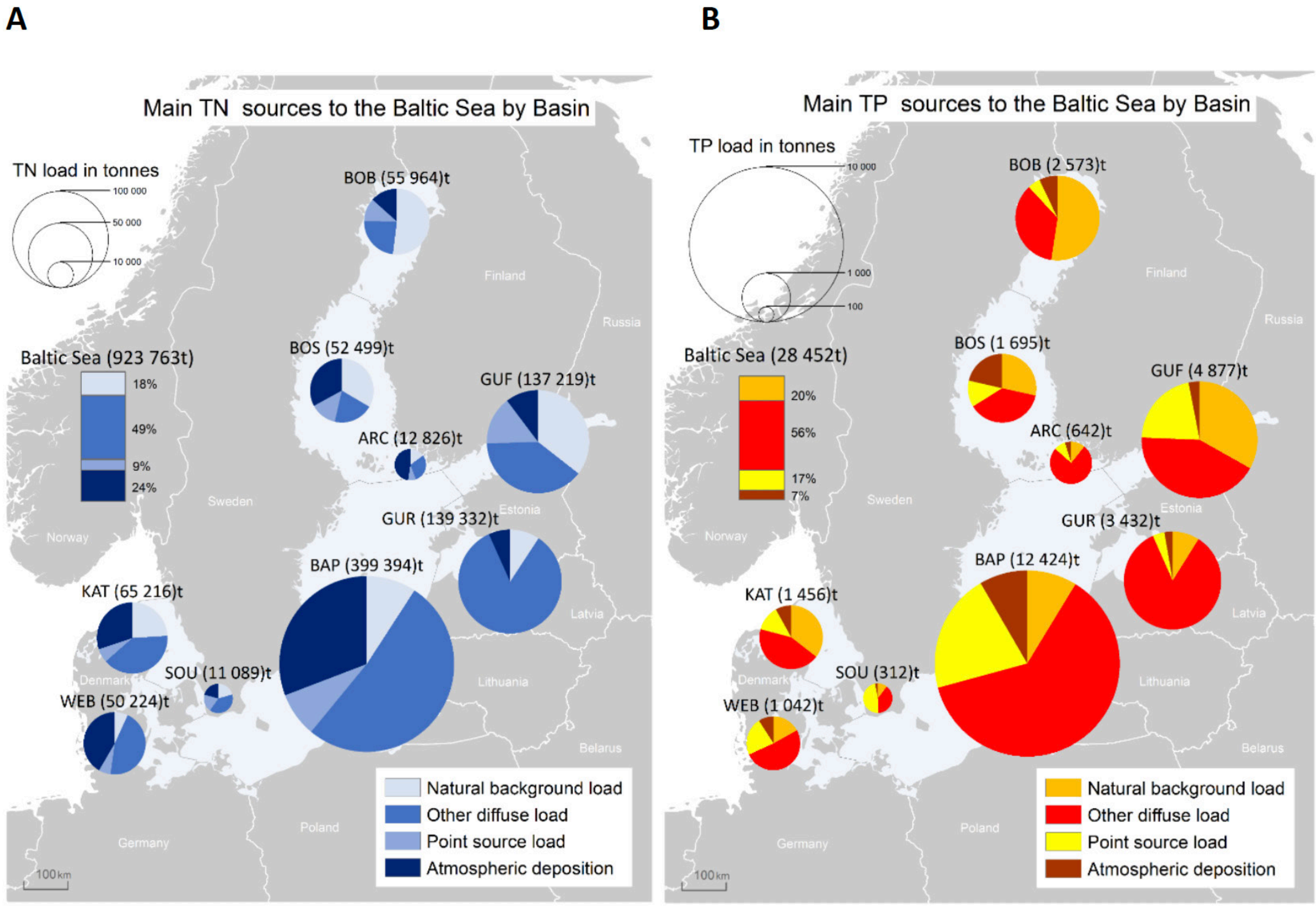
Acknowledgments: The author acknowledges the funding by the Research Council of Finland to the interdisciplinary research profile The Sea at Åbo Akademi Univeristy, as well as the MARBEFES project that has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement no 101060937.

Table of contents

1 Introduction – Defining the wicked problem

Agricultural production in the Baltic Sea Region contribute about one third to the total production in the European Union (Fammler et al. 2018). While being a vital economic activity, it is an established fact that agriculture is a major source of nutrient enrichment and eutrophication of inland surface waters, as well as the coastal and open sea areas of the Baltic Sea (HELCOM 2023a). The latest holistic assessment of the Baltic Sea by the Baltic Marine Environment Protection Commission, HELCOM, showed that despite reductions (12% respectively 28% less), the total input of nitrogen to the Baltic Sea was 858 905 tonne and total input of phosphorus was 26 389 tonne. Thanks to previous effective measures to combat point sources, the contributions now stems from diffuse ones (Figure 1), and in particular from agriculture (HELCOM 2022). Agricultural activities contribute to over 70-90% of nitrogen and 60-80% of phosphorus diffuse loads (HELCOM 2023b). The sector accounts for about half of the total waterborne input to the sea, with inorganic fertilizer consumption and manure input being the major components of nutrient input (52% and 34 %, respectively) (HELCOM 2023b).

Figure 1. Majors sources of A) total nitrogen and B) total phosphorous loads to the Baltic Sea subbasins in 2017.



Source: HELCOM 2022 (Pollution load on the Baltic Sea. Summary of the HELCOM Seventh Pollution Load Compilation (PLC-7))

Regarding the case of Finnish coastal eutrophication, there is one particular area that stands out nationally and internationally, and that is the Archipelago Sea. Located in the south-western part of Finland, the region is the only one left in Finland that is still on the so called "HELCOM Hot Spot" list of significant pollution sites around the Baltic Sea. By December 2020, 40 (25%) of the total of 162 sites, still remain active, the Archipelago Sea being one of them. The sea area receives 480 tonnes of phosphorous per year of which 87 % stems from agriculture (Laamanen et al. 2021). According to the Baltic Sea Action Plan, Finland should reduce the loading ending up in the Archipelago Sea with about 100 tonnes per year (Kuosa et al. 2023). Many projects and efforts (see section 2.1) have therefore, understandably, been focused on this geographical area, particularly in recent years.

When it comes to the diffuse loss of nutrients from agriculture, water is the key player. Water is central to the transportation of nutrients on the fields for crops to grow, but also to the transport of surplus nutrients from the agricultural crop or livestock farms to the surrounding water courses. Streams, lakes and watersheds downstream from the agricultural fields also plays an important role as filters of the water on the way towards the sea (HELCOM 2023a). However, both lakes, streams, the coastal areas and even the open sea waters can, when in a severe eutrophic state work in the opposite to a filter and release nutrients from the sediment through what is called internal loading. Which is also a part of the diffuse loading complexity, but not comparable in scale to the runoff from the agriculture land areas.

The loss of nutrients from fields is linked to the health of the soil, its capacity to transform and store nutrients, nutrient uptake by crops, what is added to fertilize crops, what farming methods that are applied throughout the year (e.g. spring and/or autumn sowing, rotation of crops, environment-preserving cover-crops) and what management procedures are applied to combat nutrient runoff to the local watershed and catchment area (e.g. buffer zones, drainage efforts, wetland construction) (Valve et al. 2022). The latter can be conducted by the farmers themselves, by local water associations, municipalities or regional level institutions, which in Finland is the regional councils of Centre for Economic Development, Transport and the Environment (ELY-centrals), are also included in the work and have a responsibility and often the oversight to coordinate the efforts. Often the runoff management involves a combination of all three actors. The most effective solution to mitigate the diffuse source pollution is a combination of taking action on the fields and farms (soil, crop, manure and nutrient management), as well as downstream such as water and nutrient retention measures and management (Valve et al. 2022; Valve & Salminen 2022).

By disentangling the case of the agricultural practices and the sector's role in the eutrophication problem, the true nature of what constitutes a *wicked problem* becomes apparent, namely the problem being urgent, complex, multifaceted, and interdependent (Churchman 1967; Rittel & Webber 1973; Paasche & Bonsdorff, 2018). Although the problem with eutrophication is general to the Baltic Sea region, the wickedness of it also means it has unique aspects. For Finland this stems from specific biological, chemical and hydrological processes in nature e.g. the abundance of agriculture fields on acid sulphate soils in Finland and what this means for the diffuse loads. Another example of the uniqueness is the structure of how to report, measure, model, assess and manage the nutrient losses from agriculture to the water bodies and the sea. All countries around the Baltic Sea report on e.g. nutrient levels in their national waters, but how they organise the data collection, assessment of nutrient inputs to the sea, the involvement of actors etc. differ to some degree, and therefore also the knowledge gaps and next steps. This involvement of many stakeholders makes a wicked problem like this, inherently difficult to solve. Moreover, and particularly for the case of the eutrophication, each wicked problem has its cultural, and social dimensions that are entangled with history and politics in a particular way (Pihlajamäki & Tynkkynen 2011).

Identifying solutions to wicked problems in general, and for the Baltic Sea eutrophication problem in particular is never easy, finding sustainable ones where all three pillars of *sustainability;* environmental, economic and social perspectives, are considered and preferably balanced, is a real challenge (Scalia et al. 2018; Ringbom et al. 2023). The ecological solutions, such as various water management measures, are perhaps the most obvious ones and have been applied for a long time, despite differing views on effectiveness (Fammler et al. 2018). Agri-environment regulation is another, traditional, means to mitigate nutrient run-off. Fertilization limits have been set as a condition for voluntary agri-environment commitment and payments (Valve et al. 2022). However, this was removed and an emphasis on a more holistic take on agriculture activities as a condition for financial support was implemented from 1.1.2023. On the other hand, the economical and societal interests and considerations for solutions are less explored, but with an increase in activities supporting the green transition, an interests for these are also on the rise.

In order to identify the next steps towards not only "win-win", but rather "win-win-win" solutions encompassing all three dimensions of sustainability, an assessment of current knowledge basis and gaps is needed. One could argue that a marine biologist in academia, such as this writer, with predominantly insight into the causes and consequences of eutrophication in the coastal sea areas cannot and should not attempt such an assessment. However, working with the receiving end of the nutrient runoff, the marine environment, and the public and private actors related to this, stepping up and onto land to collaborate on this common wicked problem is about time, but from own experience, still challenging in many ways. In addition to the lack of an overview of efforts, the sectorial "language" barriers (i.e. different cultures, terminologies, data needs etc.), and an increased pace of project turnover and development within the field (not a negative development *per se*, rather the contrary) creates an uphill. Specifically when it comes to the Finnish case and for recommendations that require cross-sectorial, -disciplinary and diverse expert collaboration. Targeting such suggested measures, or next steps, should be the motivation for planning future eutrophication-related inter- or preferably transdisciplinary collaborations and projects that contribute to a more sustainable agriculture, nationally and internationally.

2. Recent efforts and key knowledge gaps (current knowledge base)

In order to identify key knowledge gaps or particular needs that would indicate next steps and trends for the agriculture related eutrophication challenges in Finland, a scoping of the current knowledge base was needed. Information on nutrient inputs and cycling, monitoring and protection measures and the role of agriculture in eutrophication and its mitigation in various ways, is naturally scattered across a large spectrum of articles, reports and deliverables from both national and international individual studies, projects and other types of assessments and efforts. This proved to be the case in Finland, and would arguably also be so in other countries (Table 1). In order to focus the investigation, and make sure to include knowledge and suggestions for next steps that have reached some policy level, a search in ministerial or government institutional reporting series was conducted more systematically, covering a 10 year time period. In particular, a review of the publications by the Finnish Environment Institute (SYKE) and the Research and assessment publication series by the Finnish Ministry of Environment was conducted from the year available online to date (2016-2023). In addition, a search of agriculture-sector related projects and reports in different governmental programs, particularly; the Research program for agricultural environmental effects (MATO), the Program for promoting nutrient recycling and improving the state of the Archipelago Sea (RAKI) and the Water Protection program (Fin: Vesiensuojelun tehostamisohjelma) was conducted. In addition, to link with the information and trends on an international level, a search for agriculture and eutrophication related projects and efforts in Finnish waters within the EU Interreg and BONUS programs was conducted. Through snowballing the material, other projects and their outputs were considered. This resulted in a collection of projects and their reports that were used in the assessment (Table 1).

Table 1. Collection of a) national and b) international projects related to agriculture and eutrophication. Project name, lead partner or coordinator, funding program or funding agency to which the project is related, time frame and topic of the project in brief is presented. Projects highlighted in bold are specifically mentioned in scoping exercise and the assessment of gaps and next steps.

Project Name	Coordinator	Program / Funding agency	Timeframe	Topic (in brief)
a) NATIONAL (Finnish) projects				
KiertoVesi-hanke	SYKE/LUKE	MATO[1] (MAKERA[2])	2016-2019	Nutrient recycling & state of water
P-Kerros	LUKE	MATO (MAKERA)	2018-2020	Rate of P deposition in fields
TOIMI	SYKE	MATO (VN-TEAS[3])	2016-2017	Tools for nutrient recycling
VESIMALLIT	SYKE	MATO (VN-TEAS)	2021	Water & marine management, current state of tools and development needs
Rannikon tila-hanke	SYKE/FMI	VN-TEAS	?-2021	Future water quality and eutrophication status Finnish coastal waters, and its evaluation
LOHKO-hanke	MTK	RAKI program[4]	2015-2016	Nutrient load modelling on field block-scale

1 MATO: Research program for agricultural environmental effects (Fin: Maatalouden ympäristövaikutusten tutkimusohjelma), Finnish Government. A new MATO2 program started 2023.

2 MAKERA: The agriculture development fund (Fin: maatilatalouden kehittämisrahaston)

3 VN-TEAS: Government's analysis, assessment and research activities (Fin: Valtioneuvoston kanslian tutkimus-, ennakointi-, arviointi- ja selvitystoiminta), also a funding instrument.

4 RAKI: Program for promoting nutrient recycling and improving the state of the Archipelago Sea, was launched in 2012 and it has been implemented for three government terms (Fin: Ympäristöministeriön Ravinteiden kierrätysohjelma)

RANKU	VAR-ELY	RAKI program	2015-2017	A model for a nutrient-neutral municipality
RAKI-hanke12	SYKE	RAKI program	2015-2017	Total load model for Archipelago Sea
Ram II	SYKE	RAKI program	2015-2018	Total load model: impact of nutrient emission and water condition
KOTOMA	VAR-ELY	RAKI program	2016-2017	Agricultural water protection measures to risk-sensitive field blocks
RANKU-3	VAR-ELY	RAKI program	2018-2020	A nutrient-neutral municipality – development of RANKU- model and communication
Valumavesi-hanke	SYKE	Water Protection Program[5]	-2022	Methods for sustainable water management in agriculture and forestry
MAAMERI	SYKE	Water protection program	2020-2022	Strengthening the information base to improve the state of coastal waters in the Archipelago Sea region
4 Pilot Drainage areas	ELY-centrals	Water protection program	2023-2024	Water and drought risk management at a catchment area level
Kipsi-hanke	ELY-central	Water protection program	2020-2025	Gypsum spreading to reduce phosphorous and sediment load to the sea
Kuitu-hanke	LUKE	Water protection program	2019-2021	Fiber sludge as a means for water protection in agriculture
RAKENNE-Kuitu-hanke	SYKE	Water protection program	2022	Water protection effects of fiber and structural lime
RAKENNE-Kuitu 2.0	SYKE	Water protection program	2022-2024	Water protection effects of fiber and structural lime
Rakennekalkki-hanke	Turku University of Applied Science	Water protection program	2019-2021	Structural lime as a means of water protection in agriculture
SAVE-hanke	SYKE	Ministry of Environment flagship (fin: kärkihanke) program	2016-2018	Gypsum amendment of agricultural fields – Pilot in the Savijoki catchment area
SAVE2-hanke	SYKE	Ministry of Environment	2019-2021	Water quality improvement for Archipelago Sea with gypsum treatment
LOHKO II	The Central Union of Agricultural Producers and Forest Owners (MTK)	Ministry of Environment flagship (fin: kärkihanke) program[6]	2017-2018	Water quality & flow in 5 catchment areas

5 *Water Protection program (Fin: Vesiensuojelun tehostamisohjelma), Finnish Government. Rahoitetut hankkeet.*

6 *Ministry of Environment flagship program (Fin: YMn vesien- ja merenhoidon toimeenpanoa edistävät hallitusohjelman kärkihankkeet)*

FIMON-hanke	SYKE	Ministry of Environment	2022-2030	Action program for monitoring the state of the environment
MaaTieto	SYKE	Ministry of Environment	2023	Information on soil monitoring, surveys, maps and reports in regard to the EU Soil Health Law
Mammutti-hanke	SYKE	Ministry of Agriculture and Forestry of Finland	2021-2022	Development of common data base for land use changes
Tiima-hanke	SYKE	Ministry of Agriculture and Forestry of Finland (70%)	2022-2023	Information base for climate smart land use
VESSU-St	Pirkanmaan ELY	SYKE	2022-	Development and synchronization of existing materials, models and spatial data tools related to water bodies and water management
TOSKA-hanke	Salaojayhdistys ry	Salaojituksen tutkimusyhdistys ry	2014-2016	Drainage methods
TOSKA-jatkohanke	Salaojayhdistys ry	Salaojituksen tutkimusyhdistys ry and Maa ja vesitekniikan tuki ry	2017	Drainage methods – follow up and development project
Shared Waters (Fin: Samassa Vedessä)	SYKE	Finnish Cultural Foundation	2018-2022	Improving knowledge base for agricultural water protection and nutrient load regulation
b) INTERNATIONAL projects (linked to Finnish areas and eutrophication situation)				
CiNURGi	Research Institutes of Sweden (RISE)	EU Interreg Baltic Sea Region (BSR)	2023-2026	Circular nutrients for a sustainable Baltic Sea Region
Waterdrive	Swedish University of Agricultural Science, SLU	EU Interreg (BSR)	2019-2021	Holistic water management for landscape-and field level action
BALTIC SLURRY ACIDI	RISE	EU Interreg (BSR)	2016-2019	Reducing nitrogen loss from livestock production by promoting the use of slurry acidification
MANURE STANDARDS	LUKE	EU Interreg (BSR)	2017-2019	Advanced manure standards for sustainable nutrient management and reduced emission
BALTIC COMPASS	?	EU Interreg (BSR)	2009-2013	Comprehensive Policy Actions and Sustainable Solutions for Agriculture in the Baltic Sea Region
BALTIC MANURE	MTT Agrifood Research Finland	EU Interreg (BSR)	2010-2013	To turn manure problems into business opportunities
BALTIC DEAL	Latvian Rural Advisory and Training Centre	EU Interreg (BSR)	2010-2013	Raise competence concerning agri-environmental practices and measures to reduce nutrient inputs into the Baltic Sea
BERAS Implementation project	Södertörn University	EU Interreg (BSR)	2007-2013	Ecological Recycling Agriculture network and learning site

NutriTrade	John Nurminen Foundation	EU Interreg Central Baltic Programme (CBP)	2015-2018	Nutrient offsetting for the Baltic Sea
NUTRINFLOW	ProAgria	EU Interreg CBP	2015-2019	Practical actions for holistic drainage management for reduced nutrient inflow to Baltic Sea
WATERCHAIN	Satakunta University of Applied Sciences	EU Interreg CBP	2015-2018	Pilot watersheds as a practical tool to reduce the harmful inflows into the Baltic Sea
SEABED	Åbo Akademi University	EU Interreg CBP	2009-2012	Phosphorus from the seabed and water quality in archipelagos - modeling attempt
Go4Baltic	Aarhus University	EU BONUS programme	2015-2018	Coherent policies and governance of the Baltic Sea ecosystems
SOILS2SEA	Geological Survey of Denmark and Greenland	EU BONUS programme	2014-2018	Reducing nutrient loadings from agricultural soils to the Baltic Sea via groundwater and streams
RETURN	Stockholm Environment Institute	EU BONUS programme	2017-2020	Reducing emissions by turning nutrients and carbon into benefits
PROMISE	LUKE	EU BONUS programme	2014-2017	Phosphorus recycling of mixed substances
OPTITREAT	Swedish Environmental Research Institute	EU BONUS programme	2014-2017	Optimization of small wastewater treatment facilities
COCOA	Aarhus University	EU BONUS programme	2014-2017	Improving understanding of the transformation and retention of nutrients and organic matter in the coastal zone
BLUEWEBS	SYKE	EU BONUS programme	2017-2020	Blue growth boundaries in novel Baltic food webs
BIO-C3	GEOMAR	EU BONUS programme	2014-2017	Biodiversity changes - causes, consequences and management implications
ResponSEAble	ACTeon	EU Horizon 2020		Human-ocean relationship.
Living Coast & Living Cost II	Stockholm University, Baltic Sea Centre	Baltic Sea 2020 Foundation	2010-	Full-scale demonstration project to restore a eutrophic bay
IPP Program	Baltic Sea 2020 Foundation	Baltic Sea 2020 Foundation	2010-2020	Measures to reduce nutrient-leaching from industrial livestock production
CONSUME	WWF	WWF Baltic Ecoregion Programme	2016-2018	Developing consumer meat guides in all Baltic Sea countries
Eat4Change	WWF Finland	Development Education and Awareness Raising Programme (DEAR).	2020-2024	Toward more sustainable diets and food production practices

2.1 Recent projects and efforts – diverse but still too siloed

A total of 30 national and 25 international projects was included in the compilation and further assessment (Table 1). This is by no means an exhaustive list. Notable is, for example, on a national level the large number (>700) of additional, smaller and locally directed projects (e.g. to regional ELY-centrals, municipalities, cities, specific pilot catchment areas or groups such as farmers) that have been funded within the Water Protection Program (2019-2023), which is not listed here. Moreover, in the RAKI-program (2012-2025) a total of 147 projects had been funded by October 2022. This makes of course an overview of insights and the knowledge base challenging. Regarding the programs, there are as well as interim reports, also yearly reports (e.g. the Water Protection Program) as well as assessments of effectiveness (e.g. the RAKI-program: Ramboll 2018). No cross-program assessment exist to date.

All listed projects had at least one other partner involved in the project apart from the lead, and more often than not, a number of other government linked institutions, research institutions, private sector stakeholders such as farmers, or NGOs. The topics of the national projects are diverse, focusing on both improvements of the knowledge base, e.g. in terms of baseline data, understanding of processes or development of models and modelling frameworks, and evaluations of practical solutions to mitigate runoff, such as gypsum, fiber and structural lime (Table 1). In terms of the international projects, the trend in diversity of topics is similar, but applied on a Baltic Sea region level. In addition, there is also a focus on the effects of eutrophication on the marine ecosystem as a whole (Table 1). However, the projects and thereby the efforts and often policy suggestions still do not cross the disciplinary or sectorial boarders, although a large number of partners are included. For example, efforts to improve nutrient cycling might still be focused primarily on the farmland to immediate catchment area compared to the catchment to sea and coastal area. Many are focused on technical solutions, but from a larger water modelling perspective compared to smaller local scale practical applications and its effects, meaning data and information might not effectively be exchanged between groups. There are, however, some recent examples of cross-disciplinary projects making it across stakeholder groups and sectors. A good example on the national level is the Shared Waters project (Valve et al. 2022) and on the international level the Waterdrive project (Lund & Granholm 2021).

Here, a more systematic mapping of the scientific literature was not conducted, partly because many of the national outcomes from programs are presented in the institutional and ministerial publication series (in Finnish), although reports and project outcomes also on a national level have been turned into scientific articles. Partly also because such a scoping exercise on the international level was conducted recently regarding how research on Baltic Sea eutrophication has handled the land-coast-sea interactions (Vigoroux & Destouni 2022).

2.2 Identified gaps and bottlenecks

In the literature spanning the listed national projects (Table 1), a number of gaps and bottlenecks for improved water quality is outlined from a number of perspectives. A good overview and realisation of what has reached the policy level for new funding, is the bottlenecks listed in the new government funding research program on Environmental effects of agriculture (Fin: Maatalouden ympäristövaikutusten tutkimusohjelma, MATO 2, 2023-, accessed Nov. 10.2023: https://mmm.fi/mato2/tutkimusohjelma); i) low profitability of agriculture and the week utilisation of market-based measures as well as difficulty in assessing the economic benefits of environmental measures, ii) fragmentation, inaccessibility and slow operationalisation into practice of research information, iii) differing natural conditions within the country and between years, iv) the cross cutting (and sectorial) effects and interdependencies of agri-environmental measures, v) slow change in attitudes, iv) regional differences in plant and animal production, vii) strong political dependence of agriculture, and viii) deficiencies related to the measurement, reporting and verification of agricultural environmental measures.

Linking to several of the identified bottlenecks, one key aspect in particular is increasingly reported and in recent years also assessed on a national level, that is the lack of agricultural and land use information for water and marine management including modelling (Tattari et al. 2017 and the TOIMI project, Lund and Granholm 2021, Valve et al. 2022 and the Shared Waters project, Haavisto 2023 and the MaaTieto project). Some of this type of information is used, but much is not reported or measured, let alone accessible (Table 2). For example, regarding the most basic agriculture-related data: the arable field block type, the Finnish Food Authority produces the data it is not openly accessible and only updated by SYKE, e.g. for modelling purposes (Table 2). To date, fertilization and manure application are monitored through field parcel-specific notes collected on farms. The notes are made available to the authorities in the context of the annual inspections, however, these are focused on only a fraction of all farms (Tattari et al. 2017). Since the data is not systematically collected or transferred to the authorities, it is scarcely used by the authorities or not even available to other interested parties such as researchers. The different types of data is also stored or produced by many different institutions (Table 2), making transparent analysis and usage difficult.

Table 2. The need for agricultural knowledge in water and marine management planning.

Type of data needed	Data producer	Data availability & adequacy	How it is used currently in planning
Arable field block -basic block -growth block	Finnish Food Authority[7]	No open access	SYKE uses location information of the arable field blocks, updated on a regular basis
Soil types and P-values of the fields	Viljavuuspalvelu (Eurofins Agro) (free eng. translation: soil fertility service)	Municipality-specific average summary statistics at the service webpage. Not adequate.	Ordered separately from the service. Payable.
Agricultural methods applied to fields	In farmers own notes, potentially in the VIPU-platform[8]	No open access	?
Manure application rates	Finnish Food Authority	No open access	SYKE has got access to info on animal numbers from some time periods
Animal farms	LUKE[9]	Municipality-specific annual statistics accessible at LUKE webpages. Not adequate.	SYKE has got access to info on animal numbers from some time periods
Agricultural environmental compensation measures	Finnish Food Authority	No open data	SYKE has tabular info on special support and additional procedures from some time periods
Use of veterinary drugs	Fimea[10]	National summary statistics of the sale of veterinary medicines at Fimea webpages. Not adequate.	Data is not open, can be ordered.
Use of plant protection products	LUKE	Open data includes amount of plant protection products used in cultivation of the most important crops in Finland per five years.	For assessment of harmful substances, a more detailed summary statistics for each active substance must be requested separately, to be kept secret and destroyed by the deadline.
	TUKES[11]	No open data	Nationwide annual information on imported and produced substances to be separately ordered, is confidential and payable.

Modified from Tattari et al. 2017.

7 Finnish Food Authority, former Agency for Rural Affairs (Fin: Maaseutuvirasto or "MAVI").
8 VIPU: "Farmers online service platform" (freely translated to English), provied by the Finnish Food Authority
9 LUKE: Natural Resource Institute Finland
10 Fimea: Finnish Medicines Agency (Fin: Lääkealan turvallisuus- ja kehittämiskeskus)
11 TUKES: Finnish Safety and Chemicals Agency (Fin: Turvallisuus ja kemikaalivirasto)

This type of agricultural information would be needed for example in water status assessments, evaluating pressures on inland and coastal waters, economic analysis of water and sea resources, determining and dimensioning measures as well as evaluating implementation (Tattari et al. 2017). The level of information varies as the level of assessment level vary, for example in nutrient load modelling of waterbodies, the level can be a single field block or water management and catchment area level (Tattari et al. 2017, Fleming et al. 2021, Puntila-Dodd et al. 2022).

In addition to the lack of agricultural information and its coordination, the Shared Waters project (Ekholm et al. 2023; Valve et al. 2022) highlighted a number of other gaps. Particularly the role of appropriate cultivation of the fields e.g. regular modification of vegetated fields, for reduced nutrient loadings to the waters (Ekholm et al. 2023). On an international level, the Waterdrive project (Lund & Granholm 2021) outlined bottlenecks that are much in line with those identified in the new MATO 2 program, namely: 1) lack of local cross-sector joint actions among landowners, farmers and other actors, 2) lack of holistic water management that would target not only nutrient management, but also secure food production, access to clean water, soil fertility, biodiversity and climate change mitigation as a whole, 3) lack of leadership in terms of bridging the still existing divide within organisations between agricultural and environmental interests, especially on a national and central level, 4) lack of support of the strong motivation, amongst a majority of farmers, for water management and nature, and 5) lack of services to facilitate local water management (Lund & Granholm 2021).

3. Next steps on the quest to find sustainable solutions to the eutrophication problem

There is of course a need to close all of the highlighted gaps in order to effectively reach a sustainable approach to food production. However, in this section I will highlight two aspects in particular, as the next steps suggested to close those gaps are rather novel and stands out, both in the reporting of the assessed projects as well as has come forward in discussions during e.g. workshops and closing seminars.

3.1 Need for improved data and coordination of agriculture-related information – not the usual "more is needed"

Traditionally, scientists and experts are always keen on collecting and analysing more data to improve our understanding of ecosystems or our human pressures on them. When it comes to the agriculture driven eutrophication, it is as pointed out in previous sections, not more data overall that is needed, but particularly characteristics of the field blocks/parcels (soil types, nutrient and other elemental levels, crop types and yields), fertilisation levels and cultivation methods. This is specifically needed and called for to improve models, whether process-based (such as the Finnish VEMALA or FICOS models), or data driven (Fleming et al. 2021, Puntila-Dodd et al. 2022). For example, the MAAMERI project, focused on the Archipelago Sea area, advocated based on its findings a need to update, enlarge and improve the data base for modelling, as well as sustain long-term support for upkeep of the information (Kuosa et al. 2023). The models are not only serving an improved understanding of run-off but should specifically also serve as a means to plan mitigation of nutrient runoff to the catchment and sea area, as well as enable tests of local or more regional solutions (e.g., gypsum or structural lime applications) (Lund & Granholm 2021). These possibilities can only be enhanced if good, adequate, open and digital data from the entire transect from farm to the sea is included. Accessibility to well-coordinated agriculture data should also improve services to farmers (Valve et al. 2022). For example services for acquiring such data, as well as end-user products based on such data, which can serve the farmer's production, nature- and water management planning in a more holistic way. An example of what could be achieved with such data was highlighted in the TOIMI-project (Tattari et al. 2017): the Austrian modelling framework for which significant investments have been made to integrate agricultural, economical and hydrological models that can produce different climate and policy scenarios for crop production on a catchment level (Zessner et al. 2017).

Recently, the ways to achieve an improved and implemented agriculture-related data resource in Finland have been assessed (Tattari et al. 2017; Valve et al. 2022; Haavisto 2023). It is suggested that the establishment of such a "nutrient data resource" should be digital, and based on the past agri-environment scheme, but of course also needs to align with the new scheme from 2023. All farmers should be required to maintain and report parcel-specific records to the authorities. The information that these records contain is mainly for authorities, and are public environmental information. Therefore, restrictions on the availability of the data upon request are unjustified (Valve et al. 2022). However, the disclosure of the information requires new legislation (Valve et al. 2022). There are several legislative options, but because nutrient load prevention is scattered in different laws and, thus, different authorities are tasked to enforce and compile with them, it is important that all parties have access to a comprehensive and up-to-date “nutrient data resource”. At the same time, the farmer should not be imposed with an administrative burden, such as overlapping reporting.

3.2 Need for more effective collaboration and integration across sectors

The other aspect advocated for in the assessed literature, is increased and improved collaboration across sectors and, if you wish, actors and stakeholders along the farm to sea transect. It is specifically for two reasons that more effective cross-sectorial collaboration are interesting, novel and worth highlighting.

3.2.1 …for improving a shared common knowledge base and language – the basis for any next steps.

As pointed out in previous sections, reporting and project collaboration currently is largely within sectors, topics and/or within organisations, although multiple partners are included and interdisciplinarity is called for and clearly on the rise in this Finnish case, as well as generally for marine wicked problems (Bryson et al. 2015; Tynkkynen et al. 2023). Cross-sectorial collaborations are important especially for creating a shared knowledge base, common language and trust (Bryson et al. 2015; Tynkkynen et al. 2023). This also encompass data sharing, discussed in the previous section as a key next step in the agro-environmental eutrophication challenge. The potentially different interest and goals for data sharing amongst actors from different sectors may be a source of both value and conflict (Klievink et al. 2018; Susha et al. 2023). Although it may be foremost a legislatively technical challenge, as argued for the case in Finland regarding creating a digital “nutrient data resource” (Valve et al. 2022), navigating the public sectors agenda for transparency and openness and the private sector’s more “data monetisation” course can be tricky (Susha et al. 2023). At the same time the urgency of societal challenges, in this case the wicked problem of eutrophication, increasingly also linked with climate change and biodiversity loss, creates the impetus for collaboration across sectors to use data for the public good (Susha et al. 2023). An important step in collaborations that are propelled by datafication and shared digital resources is that data is made available to allow for data analytics (Susha et al. 2023). This strengthens a shared interest in being part of the solution to a wicked problem by creating a sense of inclusivity and ownership. Different models exist for overcoming challenges in data sharing and succeeding in the data sharing partnership goals (Susha et al. 2023). Assessing the suitability of such models in the case of the Finnish and Baltic Sea eutrophication would be an essential next step.

The heterogeneity and diversity within cross-sector collaborations, and particularly the diverse stakeholder groups linked to the eutrophication problem is most efficiently used when it is considered an asset to developed better and innovative solutions (Lund & Granholm 2021). Importantly, the collaborative work needs to be nurtured and respect, trust and mutual understanding needs to be developed between partners (Bryson et al. 2015; Lund & Granholm 2021). An aspect that is crucial in regard to this, is the acknowledging of experience-based knowledge, that is experiential, situational, personal and sensory forms of local knowledge, as valuable and complementary to scientific and expert insights into the eutrophication problem and its management (Tynkkynen et al. 2023)

3.2.2 …for rephrasing the narrative of agriculture.

The other reasons for why cross-sectorial collaboration should be supported and increased, is the potential for rephrasing the narrative of agriculture in general in society, but specifically in the context of eutrophication. It is arguable that a sense of “we and them” narrative have existed in the eutrophication and nutrient load debate in society and media. The increased activities and collaborations between farmers, researchers, policymakers and other experts in for example the projects funded through the agri-environment programs have helped change this narrative and will, with further increased cross-sectorial collaborations, continue to do so. It is, however, important to remember to oversee and up-date the incentives’ structure and motivations, both for climate- and water priority areas, to ensure engagement and commitment from farmers and landowners as collaboration work increases and intensifies (Lund & Granholm 2021). Farmers themselves, their umbrella organisations or other advisory services can take a more prominent leading role in this.

In regard to advisory services and the interface between all sectors and stakeholders, an interesting potential solution to mitigating tensions, conflicts and contribute to the narrative change needed is the suggestion of so called "catchment officers", "water management officers" or similar. This type of service was particularly advocated for in the Waterdrive project (Lund & Granholm 2021), but also suggested in governmental reporting (e.g. Häggblom et al. 2020). In order to support a transition towards a more holistic water and landscape management, there is a need to expand existing advisory services with expertise that combines both water management and legislation as well as co-creation and interdisciplinary knowledge that enable effective stakeholder participation (Lund & Granholm 2021).

The question is if these catchment officers could also potentially play a role in the more general shift and rethinking of agriculture, globally but especially in Europe and the Baltic Sea Region (EEA 2021)? For example could catchment officers contribute to the way in which agriculture is seen as more than an economic sector for climate and water management or to which an agroecological system approach is promoted and implemented where farms are diversified and pollution mitigated? Another suggested framing of agriculture, worth reflecting upon and whether such experts could support is farmers as our guardians of rural heritage and cultural landscapes. Cross-collaborations and potentially additional experts could raise the knowledge and notion of farming as a way of living and knowing and farmers and knowledge-holders and guardians of traditional practices (EEA 2021). Points that also needs be address in order to rephrase the narrative of agriculture for a shift towards a more sustainable food production in the future.

4. Conclusions

This report aimed to provide an overview of current efforts and activities related to the agri-environmental eutrophication problem, as well as identify knowledge gaps and next steps. The assessment was specifically focused on the Finnish eutrophication case, but reflections regarding knowledge gaps and future steps extends to the broader and more general challenges and possible solutions of the wicked problem. The report showed that national projects, especially those funded from governmental programs, have targeted a diverse set of topics and have a multitude of partners within the projects, however, have still mostly been confined to disciplines, sectors or organisations. The reported findings of these, as well as international projects, particularly highlights the role of increased sharing of knowledge and data among sectors, actors and stakeholders. Additionally, increased cross-sectorial collaborations including co-creation are raised as key next steps for reaching a more holistic and effective water management and sustainable agriculture production.

The green transition in combination with global goals to mitigate climate change and biodiversity loss, are all working in favour of eutrophication impact neutrality, as well as lowered carbon and biodiversity footprint, by the agricultural industry (EEA 2021). The next steps advocated for in both international and national reports require continued investments as well as innovative structural and legislative changes. These changes should naturally, also support the evaluation and advancement of circular economy and nature-based solutions in a water- and nutrient management perspective. Circular economy has got, not only a great potential in reducing eutrophication of the Baltic Sea, but it could also restore trust between environmentalists and the agricultural lobby, which will undoubtedly facilitate further cooperation and co-produced knowledge leading to "win-win-win" solutions (Lund & Granholm 2021). Thus, it is encouraging to see such aspects being built into agri-environmental programs, of which the new Finnish research program on Environmental effects of agriculture (MATO 2) will be an interesting example to follow. Brave policy decisions are key for enabling explorations of the systemic change that the wicked problem of eutrophication requires.

References

Bryson, J.M., Crosby, C.B., Middleton Stone, M., (2015) Designing and implementing cross-sector collaborations: needed and challenging. Public Administration Review 75:647-663.

Churchman, C. W. (1967) “Wicked Problems”. Management Science 14:B-141–B-146

Ekholm, P., Valve, H., Iho, A., Kauppila, J., Koikkalainen, K., Lehtoranta, J., Salminen, J., Uusitalo, R., Vasänen, S., (2023) Maatalouden ravinnetietovaranto tarvitaan tukemaan Itämeren ja vesistöjen kuormituksen vähentämistä. Shared Waters project policy brief.

European Environment Agency (2021) Rethinking agriculture, Briefing no. 25/2021 doi: 10.2800/952554

Fammler, H., Weber, H.,S., Fawzy, T., Kuris, M., Remmelgas, L., Veidemane, K., Bryan, T., Johansen, T., B., Piwowarczyk J., (2018) The story of eutrophication and agriculture of the Baltic Sea.

Fleming, V., Kuosa, H., Hoikkala, L., Räike, A., Huttunen, M., Miettunen, E., Virtanen, E., Tuomi, L., Nygård, H., Kauppila, P. (2021) The future of the water quality and eutrophiction status of Finnish coastal waters, and assessing it. Publications of the Government’s analysis, assessment and research activities 2021:14

Haavisto, T., (2023) Monitoring and State of Finland’s Soil and Policy Instruments for its use Publications of the Ministry of the Environment 2023:33

HELCOM (2022) Pollution load on the Baltic Sea. Summary of the HELCOM Seventh Pollution Load Compilation (PLC-7).

HELCOM (2023a) Thematic assessment of Eutrophication 2016-2021. Baltic Sea Environment Proceedings No.192.

HELCOM (2023b) Agricultural nutrient balance. HELCOM driver indicator report. Online. [12.11.2023]. ISSN 2343-2543.

Häggblom, O., Härkönen, L., Joensuu, S., Keskisarja, V., Äijö, H (2020). Water management guidelines for agriculture and forestry. Publications of the Ministry of Agriculture and Forestry 2020:10.

Klievink, B., Van Der Voort, H., & Veeneman, W. (2018) Creating value through data collaboratives. Information Polity, 23(4), 379–397.

Kuosa, H., Järvinen, E., Kotilainen, A., Tuomi, L., Norkko, J., Jilberg, T., Puttonen, I., Kaartokallio, H., Puntila-Dodd., R (2023) Vaikuttavaa merentutkimuksen yhteistyötä Saaristomeren parhaaksi, MAAMERI-hanke 2020-2022. www.syke.fi/hankkeet/maameri

Laamanen, M., Suomela, J., Ekebom, J., Korpinen, S., Paavilainen, P., Lahtinen, T., Nieminen, S. and Hernberg, A., (2021) Suomen merenhoitosuunnitelman toimenpideohjelma vuosille 2022–2027. Ympäristöministeriön julkaisuja 2021:30.

Lund S., Granholm, K., (2021) Waterdrive findings and strategic recommendations. 42 pages

Paasche, C. & E. Bonsdorff (2018). The wicked ocean. AMBIO 47:265–268.

Pihlajamäki, M., Tynkkynen, N., (2011). Introduction chapter, in Pihlajamäki, M., Tynkkynen, N. (eds) Governing the blue-green Baltic Sea, Societal challenges of marine eutrophication prevention. FIIA Report 31, p.11-20.

Puntila-Dodd, R., Kotamäki, N., Juntunen, J., Tolkkinen, M., Kuosa, H., Varjopuro, R., Lauri, H., Vähänen, K., Suominen, F., Airaksinen, J., Saario, M., Soininen, N., Puharinen, S-T., Belinskij, A. (2022) Cirteria to clarify the modelling process in environmental impact assessments VESIMALLIT-Final Report. Publications of the Government’s analysis, assessment and research activities 2022:13.

Ramboll 2018. Kiertotalouden läpimurto, puhtaat ratkaisut käyttöön, kärki hankkeen toimenpiteen 2 “lisätään ravinteiden kierrätystä ja tehostetaan toimia Itämeren ja vesien suojelemiseksi” arviointi. Ministry of Environment YM/122/481/2018.

Ringbom, H., Hellström, M., Pansch, C., Tynkkynen, N., & Törnroos, A., (2023) 'The Anatomy of Complex Marine Problems: A Case Study of Decision-making on Archipelagic Aquaculture', in Jetoo, S.; Kouri, J.; Laine, S.; Tynkkynen, N. & Törnroos, A.(eds.), Understanding Marine Changes: Environmental knowledge and methods of research, Edward Elgar, Cheltenham.

Rittel, H.W.J., Webber, M.M. (1973) Dilemmas in a general theory of planning. Policy Sci. 4:155–169

Scalia, M., Barile, S., Saviano, M., Farioli, F. (2018). Governance for sustainability: a triple-helix model. Sustainability Science, 13, 1235–1244.

Susha I., Rukanova B., Zuiderwijk A., Gil-Garcia J., R., Hernandez, M.G., (2023) Achieving voluntary data sharing in cross sector partnerships: Three partnership models. Information and Organization 33: 100448.

Tattari et al. (2017) The most effective tools for cost-effective management of waters and nutrient recycling. Publications of the Government´s analysis, assessment and research activities 70/2017.

Tynkkynen, N., Jetoo., S., Kouri, J., Laine, S., Törnroos, A., (2023) Towards holistic knowledge of marine environmental changes? in Jetoo, S.; Kouri, J.; Laine, S.; Tynkkynen, N. & Törnroos, A.(eds.), Understanding Marine Changes: Environmental knowledge and methods of research, Edward Elgar, Cheltenham.

Valve, H., Taipale K.,, Ekholm, P., Kauppila, J., Koikkalainen, K., Miettinen, A. (2022) Maatalouden ravinnetietovaranto – työkalu viranomaisille ja viljelijölle. Suomen Ympäristökeskuksen raportteja 4/2022.

Valve H., Salminen J., (2022) "I don't fertilise quite like that" – Mediating and distancing capacities of nutrient records at Finnish farms. Journal of Rural Studies. 95:58-66.

Vigoroux, G., Destouni, G., (2022) Gap identification in coastal eutrophication research – Scoping review for the Baltic system case. Science of the Total Environment 839:156240.

Zessner, M., Schönhart, M., Parajka, J., Trautvetter, H., Mitter, H., Kirchner, M., Hepp, G., Blaschke, A.P., Strenn, B., Schmid, E., (2017) A novel integrated modelling framework to assess the impacts of climate and socio-economic drivers on land use and water quality. Science of the Total Enviroment 579:1137-1151.

Earlier publications in the BSR Policy Briefing series by Centrum Balticum Foundation

BSR Policy Briefing 3/2021: "The German economy and the Corona shock – An acceleration of structural changes?" by Michael Grömling

BSR Policy Briefing 2/2021: "Contemporary trends and future scenarios for the Greater St. Petersburg region" by Nikita Lisitsyn

BSR Policy Briefing 1/2021: "The COVID-19 in Estonia: Governance of the Health Care System, spread of the disease, regulations and impact on economy" by Alari Purju

BSR Policy Briefing 6/2020: "Leadership in Turbulent Times: Germany and the Future of Europe" by Kimmo Elo

BSR Policy Briefing 5/2020: "Denmark and COVID-19" by Marin A. Marinov

BSR Policy Briefing 4/2020: "Lithuania and Belarus: Will Lithuania become Belarus' "Iceland"?" by Ruslanas Iržikevičius

BSR Policy Briefing 3/2020: "The corona pandemic and its impact on the economic development of the Baltic Sea region in 2020" by Kari Liuhto

BSR Policy Briefing 2/2020: "Increasing Eco-efficiency via Digitalisation in Maritime Industry in The Baltic Sea Region: Policy Support through Carrots or Sticks?" by Milla Harju

BSR Policy Briefing 1/2020: "The forest industry around the Baltic Sea region: Future challenges and opportunities" edited by Kari Liuhto

BSR Policy Briefing 9/2019: "The Baltic states and security in the Baltic Sea region: Dark clouds in blue sky" by Kristi Raik

BSR Policy Briefing 8/2019: "Creation of regional gas market in the Baltic States and Finland: Challenges and opportunities" by Tadas Jakstas

BSR Policy Briefing 7/2019: "US FDI in the Baltic Sea region: The state of American investment and selected challenges" by Kalman Kalotay

BSR Policy Briefing 6/2019: "Germany and the Baltic Sea region: political and security interests" by Tobias Etzold

BSR Policy Briefing 5/2019: "Government support for the Russian shipbuilding industry: Policy priorities and budgetary allocations" by Elena Efimova and Sergei Sutyrin

BSR Policy Briefing 4/2019: "Finnish tonnage as the implementer for security of seaborne supply in maritime transport" by Bo Österlund

BSR Policy Briefing 3/2019: "The Estonian-Finnish economic cooperation" by Alari Purju

BSR Policy Briefing 2/2019: "Bioeconomy Policies in the BSR" by Torfi Jóhannesson

BSR Policy Briefing 1/2019: "Cooperation between Saint-Petersburg and Finland" by Stanislav Tkachenko

BSR Policy Briefing 10/2018: "The sanctions against Russia. Are there winners and losers around the Baltic Sea?" by Susanne Oxenstierna

BSR Policy Briefing 9/2018: "Future of Public Sector Governance and Digitalization" by Meelis Kitsing

BSR Policy Briefing 8/2018: "American Policy Towards the Baltic States" by Stephen Blank

BSR Policy Briefing 7/2018: "Russian direct and indirect investment in the Baltic Sea region" by Alexey Kuznetsov

BSR Policy Briefing 6/2018: "Foreign economic relations of the Kaliningrad region" by Vitaliy Zhdanov, Vladimir Kuzin and Mikhail Pliukhin

BSR Policy Briefing 5/2018: "Why is Russia seeking to ignite a civil war in the European Union and how to stop it?" by Ruslanas Iržikevičius

BSR Policy Briefing 4/2018: "On the paradoxes of foreign expansion: the experience of Polish firms" by Piotr Trąpczyński and Krystian Barłożewski

BSR Policy Briefing 3/2018: "The bioeconomy in the Baltic Sea region" by Anna Berlina

BSR Policy Briefing 2/2018: "Russia vis-à-vis Ukraine: On Some Economic Costs" by Sergey Kulik

BSR Policy Briefing 1/2018: "Chinese Direct Investment in the Baltic Sea Region" by Jean-Marc F. Blanchard

BSR Policy Briefing 5/2017: "The economic impact of China on the Baltic Sea region" by Jean-Paul Larçon

BSR Policy Briefing 4/2017: "National innovation and smart specialisation governance in the Baltic Sea region" edited by Zane Šime

BSR Policy Briefing 3/2017: "The economic state of the Baltic Sea region" edited by Kari Liuhto

BSR Policy Briefing 2/2017: ”Russia’s foreign relations and the Baltic Sea region” by Sergey Kulik

BSR Policy Briefing 1/2017: ”Russia and the security in the Baltic Sea region” by Justyna Gotkowska & Piotr Szymański

BSR Policy Briefing 2/2016: ”The EU-Russia relations and their reflections in the Baltic Sea region” Stanislav L. Tkachenko

BSR Policy Briefing 1/2016: ”The maritime cluster in the Baltic Sea region and beyond” edited by Kari Liuhto

BSR Policy Briefing 1/2015: ”Natural gas revolution and the Baltic Sea region” edited by Kari Liuhto

BSR Policy Briefing 4/2014: ”A Russian Sudden Stop or Just a Slippery Oil Slope to Stagnation?” by Torbjörn Becker

BSR Policy Briefing 3/2014: ”Poland and Russia in the Baltic Sea Region: doomed for the confrontation?” by Adam Balcer

BSR Policy Briefing 2/2014: ”Energy security in Kaliningrad and geopolitics” by Artur Usanov and Alexander Kharin

BSR Policy Briefing 1/2014: ”The Baltic Sea region 2014: Ten policy-oriented articles from scholars of the university of Turku” edited by Kari Liuhto

BSR Policy Briefing 4/2013: ”The Kaliningrad nuclear power plant project and its regional ramifications” by Leszek Jesien and Łukasz Tolak

BSR Policy Briefing 3/2013: ”Renewable Energy Sources in Finland and Russia - a review” by Irina Kirpichnikova and Pekka Sulamaa

BSR Policy Briefing 2/2013: ”Russia’s accesion to the WTO: possible impact on competitiveness of domestic companies” by Sergey Sutyrin and Olga Trofimenko

BSR Policy Briefing 1/2013: ”Mare Nostrum from Mare Clausum via Mare Sovieticum to Mare Liberum - The process of security policy in the Baltic” by Bo Österlund

BSR Policy Briefing series 8/2023

CENTRUM
BALTICUM

www.centrumbalticum.org/en