**BONUS RETURN**
**Reducing Emissions by Turning Nutrients and Carbon into Benefits**
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**Deliverable No: D.2.8**
**Scientific publication on the results from the evidence-based review**
**Ref: WP (2) Tasks (2.1, 2.1, 2.3)**
**Lead participant: SEI**
**Date: Feb 28, 2020**

BONUS RETURN has received funding from BONUS (Art 185), funded jointly by the EU and Formas, A Swedish Research Council for Sustainable Development; Sweden's innovation agency, Vinnova; Academy of Finland; and the National Centre for Research and Development in Poland.

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|---|---|
| Deliverable Title | **D.2.8 – Scientific publication on the results from the evidence-based review** |
| Filename | BONUSRETURN_D.2.8_ Circular nutrient solutions for agriculture and wastewater - a review of technologies and practices |
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| Date | 28/02/2020 |

Start of the project: 01/05/2017
End of the project: 01/05/2020
Project coordinator: Stockholm Environment Institute (SEI)

Dissemination level

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| X | PU | Public. |
| | PP | Restricted to other project partners. |
| | RE | Restricted to a group specified by the consortium. |
| | CO | Confidential, only for members of the consortium. |

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**EXECUTIVE SUMMARY**

This deliverable provides an overview of the publication “Circular nutrient solutions for agriculture and wastewater - a review of technologies and practices” (Rosemarin et al., 2020).

This paper summarizes key findings from comprehensive efforts to collate current scientific evidence and expert opinions on circular solutions for recovery and reuse of nutrients and carbon from different waste streams in the agriculture and wastewater sectors, including assessment of policy, market and governance aspects, and related economics. Specifically, we identify established and emerging approaches for transformation towards a more circular nutrient economy with relevance to SDGs 6 and 14. The paper cites the example of the Baltic Sea Region which has experienced decades of fertilizer overuse (1950s-1990s) and concomitant urban sources of excessive nutrients. Regulations and incentive policies combining the nitrogen, phosphorus and carbon cycles are necessary if circular nutrient technologies and practices are to be scaled up. Pricing chemical fertilizer at levels to reflect society’s call for circularity is a central challenge.

# 1 INTRODUCTION

The degradation of the Baltic Sea is an ongoing problem, despite investments in measures to reduce external inputs of pollutants and nutrients from both diffuse and point sources. Available technological and management measures to curb eutrophication and pollution flows to the sea have not been adapted adequately to the contexts in which they are being applied. Furthermore, measures are often designed based on single objectives, thereby limiting opportunities for multiple benefits.

In addition, there is a general sense that measures to address the deterioration of the Baltic ecosystem are primarily technologically-driven and lacking broader stakeholder acceptance – the "experts" who define these measures have little engagement with industry, investors, civil society and authorities. This problem is magnified by governance and management, taking place in sectoral silos with poor coordination across sectors.

As a result, research shows that regional institutional diversity is presently a barrier to transboundary cooperation in the Baltic Sea Region (BSR) and that actions to achieve national environmental targets can compromise environmental goals in the BSR (Powell et al. 2013). The regional dimension of environmental degradation in the BSR has historically received weaker recognition in policy development and implementation locally. However, developments in recent years suggest a new trend with growing investments in environmental protection supporting social, economic, and territorial cohesion.

The BSR is an environmentally, politically and economically significant region and like other regions globally, its rapid growth needs to be reconciled with the challenges of sustainable development in a global setting that demands unprecedented reductions in GHG emissions. This poses a truly wicked problem exacerbated by the fact that many of the challenges in the BSR will also magnify in a changing climate. In order to navigate the uncertainties and controversies associated with a transformation towards a good marine environment, BONUS RETURN will enact an innovative trans disciplinary approach for identifying and piloting systemic eco-technologies.

The focus is on eco-technologies that generate co-benefits within other interlinked sectors, and which can be adapted according to geophysical and institutional contexts. More specifically, emphasis is placed on eco-technologies that reconcile the reduction of present and future eutrophication in marine environments with the regional challenges of policy coherence, food security, energy security, and the provision of ecosystem services.

## 1.1 Project Objectives

The **overall** aim of BONUS RETURN is to improve the adaptation and adoption of eco-technologies in the Baltic Sea Region for maximum efficiency and increased co-benefits.

The **specific objectives** of the project can be divided into six categories presented below. These categories are interlinked but for the purpose of providing a step-wise description, the following overview of each category proves useful. BONUS RETURN is:

1) **Supporting innovation and market uptake of eco-technologies by:**
- Contributing to the application and adaptation of eco-technologies in the BSR through an evidence-based review (systematic map) of the developments within this field.
- Contributing to the development of emerging eco-technologies that have the capacity to turn nutrients and carbon into benefits (e.g. bio-energy, fertilizers), by providing an encompassing framework and platform for rigorous testing and analysis.
- Developing decision support systems for sustainable eco-technologies in the BSR.
- Contributing to better assessment of eco-technology efficiency via integrated and participatory modelling in three catchment areas in Finland, Sweden and Poland.
- Contributing to methodological innovation on application and adaptation of eco-technologies.

2) **Reducing knowledge gaps on policy performance, enabling/constraining factors, and costs and benefits of eco-technologies by:**
- Assessing the broader socio-cultural drivers linked to eco-technologies from a historical perspective.
- Identifying the main gaps in the policy environment constraining the implementation of emerging eco-technologies in the catchments around the Baltic Sea.
- Informing policy through science on what works where and under which conditions through an evidence-based review (systematic map and systematic reviews) of eco-technologies and the regional economic and institutional structures in which these technologies evolve.

3) **Providing a framework for improved systematic stakeholder involvement by:**
- Developing methods for improved stakeholder engagement in water management through participatory approaches in the case study areas in Sweden, Finland and Poland.
- Enacting a co-enquiry process with stakeholders into opportunities for innovations in eco-technologies capable of transforming nutrients and pollutants into benefits for multiple sectors at different scales.
- Bringing stakeholder values into eco-technology choices to demonstrate needs for adaptation to local contexts and ways for eco-technologies to efficiently contribute to local and regional developments.
- Disseminating results and facilitating the exchange of learning experiences, first within the three catchment areas, and secondly across a larger network of municipalities in the BSR.
- Establishing new cooperative networks at case study sites and empowering existing regional networks by providing information, co-organizing events and engaging in dialogues.

4) **Supporting commercialization of eco-technologies by:**

- Identifying market and institutional opportunities for eco-technologies that (may) contribute to resource recovery and reuse of nutrients, micro-pollutants and micro-plastics (e.g. renewable energy).
- Identifying potential constraints and opportunities for integration and implementation of eco-technologies using economical models.
- Facilitating the transfer of eco-technologies contributing to win-win solutions to multiple and interlinked challenges in the BSR.
- Linking producers of eco-technologies (small and medium enterprises – SMEs), to users (municipalities) by providing interactive platforms of knowledge exchange where both producers and users have access to BONUS RETURN's envisaged outputs, existing networks, and established methodologies and services.

**5) Establishing a user-driven knowledge platform and improved technology-user interface by:**

- Developing an open-access database that maps out existing research and implementation of eco-technologies in the BSR. This database will be intuitive, mapped out in an interactive geographical information system (GIS) platform, and easily managed so that practitioners, scientists and policymakers can incorporate it in their practices.
- Developing methodologies that enact the scaling of a systemic mix of eco-technological interventions within the highly diverse contexts that make up the BSR and allows for a deeply interactive medium of knowledge.

### 1.2 Project Structure

BONUS RETURN is structured around six Work Packages that will be implemented in three river basins: The Vantaanjoki river basin in Finland, the Słupia river basin in Poland, and Fyrisån river basin in Sweden.

Work Package 1: Coordination, management, communication and dissemination.
Work Package 2: Integrated Evidence-based review of eco-technologies.
Work Package 3: Sustainability Analyses.
Work Package 4: Environmental Modelling.
Work Package 5: Implementation Support for Eco-technologies.
Work Package 6: Innovative Methods in Stakeholder Engagement.

### 1.1 Deliverable context and objective

The current deliverable (2.8) is part of WP 2. The objective of WP 2 is to systematically collate scientific research of existing and emerging eco-technologies as well as of the economic models and policy instruments that support the implementation and development of these technologies in the BSR countries. The systematic map collates and describes existing research for eco-technologies across the BSR and leading to the following outputs that feed into the other work packages:

- A comprehensive list of studied eco-technologies from the literature relevant to the BSR.
- A description of all studies that have investigated these eco technologies
- An assessment of 'knowledge gaps' where known eco-technologies are unrepresented or underrepresented in the published (grey and traditional academic) literature
- An assessment of 'knowledge clusters' where sufficient reliable evidence exists to allow full systematic review and meta-analysis
- A list of existing reviews that focus on the effectiveness of single or multiple eco-technologies

Following the systematic mapping including input from stakeholder platforms, selected eco-technologies are taken forward to full systematic review and meta-analysis, allowing quantitative summaries to be produced that can be used to validate analyses in WP3 and models in WP4. Prioritisation and selection of eco-technologies to fully synthesise with the meta-analysis are undertaken in consultation with stakeholders via WP6.

This deliverable is a review publication covering the systematic mapping, the comprehensive list of eco-technologies, the assessment of economic models and tools and the review of governance and policy instruments all relevant to the BSR.

### 1.2 Outline of the report

This report provides the main conclusions from the publication submitted to Elsevier's journal "Current Opinion in Environmental Sustainability" ISSN: 1877-3435.

## 2 CIRCULAR NUTRIENT SOLUTIONS FOR AGRICULTURE AND WASTEWATER - A REVIEW OF TECHNOLOGIES AND PRACTICES

This paper shows there is a wide array of technological solutions and practices for recovery and reuse of N, P and C in the agriculture and municipal wastewater sectors. Given that implementation of these solutions at scale can be hindered by limitations in market mechanisms, governance and current infrastructure, we explored the established and emerging technologies, EU legislation and economic assessments that could transform these sectors towards a more circular economy also adding the Baltic Sea Region as an example.

Expansion of the markets for reuse fertilizer products is hindered by the availability of relatively inexpensive chemical fertilizers. Implementation and scaling of the reviewed agriculture and wastewater technologies is steered to a great extent by global markets for the raw materials used in producing fertilizers. This ultimately affects the revenue and profitability of recapture/reuse processes and products since the recovered nutrients must compete to be economically feasible. However, there exist key societal drivers that can go beyond the market. For example, the need to increase sovereign sources of P has promoted P recovery and reuse. Also, the need to reduce greenhouse gases through renewable energy promotes the reuse of organic material in both agriculture and wastewater. The banning of ocean

dumping and landfills to dispose of sludge and manure has already nurtured alternative solutions including reuse in other parts of the world as well.

Policy and governance are central to transforming the agriculture and wastewater sectors towards increased circularity. The EU Circular Economy Package was adopted in 2018, but most EU policies and regulations are rooted in the age-old linear, resource to waste paradigm. P has yet to enter the EU Nitrates Directive to allow for harmonized reuse with N. P recycling within the EU and the Baltic Region remains characterised by fragmented decision-making in regional or national administrations. Regulatory interventions, such as recycling obligations and subsidies are still lacking in most countries. In the case of the Baltic region, HELCOM is a regional coordination body producing recommendations to control nutrient emissions from member countries, but a compliance protocol is still lacking. Harmonisation of legislation, meshing recycled P with existing N fertiliser regulations with support for new operators would enhance markets for technologies, reduce nutrient losses and safeguard European quality standards.

Regulations and incentive policies combining the N, P and carbon cycles are necessary if circular nutrient technologies and practices are to be scaled up. Pricing chemical fertilizer at levels to reflect society's call for circularity is a central challenge.

The publication is currently under review. It will be available on line once published https://www.sciencedirect.com/journal/current-opinion-in-environmental-sustainability

## 3 REFERENCES

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