NBS CASE

Innovative crop rotation for grass production: A biorefinery approach in Denmark

This Nature-Based Solution (NBS) presents a multi-faceted approach to reducing nitrogen leaching, improving the economy, mitigating climate change, reducing rainforest impact, and enhancing Danish nature, all through the transformation of the landscape. While this may seem utopian at first glance, it is achievable through the implementation of novel crop rotations on a regional scale.

The introduction of more perennial grass crops into the rotation can lessen the environmental impact of crop production while simultaneously creating a new value chain for the use of grass biomass in biorefinery applications. This shift paves the way for a circular nutrient scheme, prioritizing Nitrogen-efficient crop rotation systems. These systems incorporate more perennial grass crops, which have a longer growth season, are adaptable to weather extremes and climate change, reduce nitrate leaching, enhance biodiversity, and can be combined with local protein supply chains.

Green biorefining emerges as a key technology in this context, reducing nitrate leaching while producing protein for monogastric animals and fibre for ruminants. The protein produced could potentially replace imported soybean, which is predominantly cultivated in the rainforest regions of Brazil and Argentina. Additionally, this approach generates bio-based fertilisers from residual products, contributing to local circular systems that utilize green biomass, manure, and more, suitable for both conventional and organic farming systems.

In essence, the goal is to reduce nitrate leaching and reap the ensuing benefits in an economically viable manner for farmers and related industries. This is achieved while considering how to maximize biomass resource efficiency through business symbiosis, bringing us closer to our utopian vision.

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Challenges addressed by the NBS

The primary challenge is the reduction of nutrients, particularly nitrogen, in the recipient fjord. This is a requirement to comply with EU regulations, specifically the Water Framework Directive, and to meet the needs of the water environment.

Secondary goals are to reduce the reliance on the import of protein feedstuff for livestock production. This currently has significant environmental and climate impacts. The NBS proposes the local production of "green" protein for monogastric animals and fibre for ruminants as an alternative.

Additional harvested biomass can be used for green biorefinery (protein production) or biogas facilities. Increasing biomass availability could incentivise more investment into these facilities. The NBS also promotes a biomass chain perspective with farmer engagement to facilitate better nutrient export between farmers.

trans4num's main research questions and ambitions

- Exploring if perennial grasses for biorefineries can provide a viable solution to address multiple zero pollution challenges.
- Identifying feasible transformation pathways and effective engagement of relevant stakeholders across the entire value chain.
- Determining the essential regulatory and governance frameworks to facilitate and sustain the transformation toward zero-pollution biorefineries.
- Assessing the environmental benefits and trade-offs associated with using perennial grasses in biorefineries compared to other feedstocks.
- Optimizing the cultivation and management practices of perennial grasses to enhance their biomass yield and quality for biorefinery applications.
- Developing economic models and cost-benefit analyses to guide decision-making for transitioning to perennial grass-based biorefineries.
- Integrating circular economy principles into the biorefinery value chain using perennial grasses, thereby minimizing waste and maximizing resource utilization.

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Which biophysical, agronomic, and farm management implications does the NBS have at field and farm level?

The NBS has several biophysical, agronomic, and farm management implications at the field and farm level:

- **Nutrient loops:** The primary implication is the closing of nutrient loops through the implementation of NBS at local and regional scales. This is achieved through the exchange of nutrients/biomass in the biomass chain, reducing nutrient loss and thus reducing the need for input from exogenous sources of mineral fertilisers.
- **Carbon sequestration:** There is increased carbon sequestration in agricultural soil through the use of more perennial crops. This has positive effects on the climate as grasses store more carbon than cereals in their root systems.
- **Biodiversity:** The implementation of NBS can increase insect and pollinator communities, leading to positive biodiversity effects. Grasses support stronger biodiversity compared to cereals and maize. Additionally, there is stronger biodiversity in nearby waters due to lower nutrient leaching to streams and lakes.
- **Nutrient utilisation:** The NBS leads to higher nutrient utilisation, which is beneficial for farm management.

These implications highlight the potential of the NBS to address environmental challenges while also benefiting farm management practices.

Which indicators/criteria are used to assess the success of the NBS in addressing the challenge?

The success of the NBS in addressing its challenges is assessed using the following indicators/criteria:

- **Nitrogen reduction**: The reduction of nitrogen in the recipient area after the implementation of the NBS is measured. This is achieved by a higher nitrogen uptake which reduces the risk for nitrogen leaching and nitrogen emission.
- **Biomass chain understanding**: The understanding of the biomass chain, including its structural, social, and economic aspects, is evaluated. This is measured through interviews, surveys and studies assessing the knowledge and attitudes of relevant stakeholders.
- **Farmers' perception**: The understanding of the farmers' perception of the NBS is assessed. This could be measured through interviews or surveys with farmers, gauging their views and experiences with the NBS.
- **Nutrient exchange system**: The effectiveness of the exchange system amongst stakeholders exporting nutrients/bio-based fertilizer from fields with no additional nutrient needs to fields in need is evaluated. This could be measured by tracking the volume and frequency of nutrient exchanges.
- **Biomass production**: The amount of biomass grown in the form of grass, clover, alfalfa, etc., to be used in biorefineries is measured. The use of the digestate (the by-product of anaerobic digestion) as an alternative source of fertilizer instead of mineral fertilizer is also assessed.
- **Economic performance**: Economic indicators such as investments or future investment plans with respect to green biorefinery production are considered. This could be measured by tracking investment trends and conducting cost-benefit analyses.

These indicators provide a comprehensive assessment of the NBS's success in addressing its challenges.

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What methods/tools are used for the NBS assessment?

Remote sensing: Remote sensing technology will be used to monitor and measure various aspects of the NBS. This could include tracking the growth and health of biomass crops, assessing the effectiveness of nutrient reduction efforts, and monitoring changes in biodiversity.

Machine learning techniques: Novel machine learning techniques will be employed to analyze and interpret the data collected through remote sensing and other means. These techniques can help identify patterns, make predictions, and provide insights that can guide the implementation and improvement of the NBS.

NBS site and scale

DENMARK

Northern Jutland, Limfjord catchment

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trans4num is a four-year project funded under the Zero Pollution call as an EU-China international cooperation action on nature-based solutions (NBS) for nutrient management in agriculture.
trans4num ambition is to broadly enhance the NBS implementation in Europe with an integrative and tested multi-level approach, in dialogue with academic partners, practice partners and societal stakeholders.

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