Ref. Ares(2023)5933283 - 31/08/2023

Online inventory of promising NBS relevant for study sites

August 2023

Deliverable D2.1 (version 1)

Funded by the European Union

Project name	**Transformation for sustainable nutrient supply and management**
Project acronym	**trans4num**
Project ID	101081847
Project duration	December 2022 – November 2026
Project Coordinator	University of Hohenheim (UHOH)
Project website	https://trans4num.eu/
Work package	2
Work package leader	University of Hohenheim (UHOH)
Deliverable number and title	D.2.1: Online inventory of promising NBS relevant for study sites
Authors	Morten Graversgaard, Jacques Louis Vos, August Kau Lægsgaard
Version	1
Dissemination level	PU —Public

Table of Contents

List of figures:

List of tables:

1. Introduction

1.1 Work package 2

The overall objective of WP 2 is to characterise, test and assess nutrient-management strategies targeting NBS for a diversity of farming systems, agricultural practices and compare across a selection of sites, characterised by intensive agriculture in Europe and China on local and regional levels. In particular, WP 2 will:

• Quantitatively and qualitatively describe important nutrient management related challenges typical for the selected sites, and characterise possible corresponding NBS with respect to their biophysical, agronomic, and farm management implications at field and farm level;

• Select, implement, test and evaluate selected NBS on the study sites, and

• Provide a multi-perspective appraisal for an out- and upscaling of selected NBS with respect to professional communities, AKIS stakeholders and further actors of concerned value chains.

1.2 Objective of the Task and Deliverable 2.1

Within WP 2, the objective of task 2.1 is to start the development and establish an online facility to collect descriptions/inventories of potentially relevant NBS for the trans4num study sites. NBS innovations potentially relevant for the trans4num study sites will be based on internally available documents (deliverables 1.1 and 1.3) and outputs of EU projects, such as Lex4bio, Nutriman etc. The NBS will be characterised with respect to their biophysical, agronomic, and farm management implications at field and farm levels, and they will be assessed and ranked according to their potential for each of the NBS sites in close consultation with respective farmers and related stakeholder groups. The most promising NBS will be selected for field implementation and testing with farmers' participation.

Consequently, the inventory starts with a selection of already well-captured NBS and then gradually becomes both deepened in contents and extended in cases. These will be connected to the four NBS sites of the trans4num project. The online inventory will be presented at the trans4num website: https://trans4num.eu/en/

2. Target audiences for Dissemination, Exploitation and Communication (DEC) activities

In accordance with the requirements of the original call, the trans4num project is multi-actor project. First and foremost, the project actors involved consist of the diverse consortium of 14 academic and non-academic partners that will implement the various project activities in Europe. These are considered as ‘internal project actors’. See also Deliverable 5.1 for an overview of Dissemination and Communication activities planned in the trans4num project.

The target groups consist of three potential stakeholders, where the main idea is that the inventory serves as a 'show window' of the Trans4num project for:

a) any person that is interested in trans4num type of NBS,

b) for more targeted interest groups that would like to understand the problem, the proposed solution, the practices behind etc. and;

c) it serves internal purposes by making relevant information on the NBS and from the sites visible and thus usable for communication and dissemination.

3. Online NBS inventory

This DEC deliverable will consist of a process description of how the online facility potentially could look like. Also, preliminary content proposals will be presented on the NBS innovations that the four NBS sites are working on.

3.1 Consultation on the NBS inventory elements

Before developing and populating the website with the online inventory, there will be an internal consultation process on three elements before the website is fully developed:

- How should the online inventory be presented and what content is needed?
- What will be the necessary / agreed criteria for collecting and characterising the NBS?
- What will be the workflow for assessment and ranking of the NBS according to their potential for each of the trans4num sites (including process consultation with relevant farmers and related stakeholder groups)?

These questions will be resolved and be an ongoing activity with the inclusion of all trans4num project partners and related stakeholders.

3.2 Content proposed for the online NBS inventory

By referring to the EU Horizon project i2connect (see: https://i2connect-h2020.eu/practical-interactive-innovation-cases/), we propose to do something similar but with titles fitting our project instead. From the deliverable 1.3, we extract data from the NBS and propose something like:

- Title of NBS
- Description
- What challenge(s) are addressed with the NBS?
- Which biophysical, agronomic, and farm management implications does the NBS have at the field and farm level?
- Which indicators/criteria are used to assess the success of the NBS in solving the problem?
- Ranking of NBS potential
- Site of implementation

In section 4, in this report, examples of content are described.

3.3 Establishing the online facility

On the project website (https://trans4num.eu/en/) a tap in the main menu called "NBS inventory" will be established (figure 1). To place it here makes it easily accessible and transparent what we are working on within the project.

Possibly in addition, a small section could be added directly to the front page on the website just before the "News" section, where some of the NBS from the inventory could be shown. There could be shown three or maybe four NBS from the inventory at once and they could be circulating/changing within a certain time interval so that all the NBS would at some point be shown at the front page. One NBS should be represented by a picture with the title of the NBS beneath it, and then it should be linked to a page with the specific NBS in the inventory See figure 3. Here could also be added a link to the inventory page similarly to the other links at the front page (figure 2).

At the inventory page every NBS should be presented with a picture and the title of the NBS in the same way as it could be presented at the front page. Here the complete list should be visible at once though. It could be done similar to the setup in the u2connect EU Horizon project (https://i2connect-h2020.eu/practical-interactive-innovation-cases/), or in another illustrative way.

It should be possible to enter each of the NBS in the inventory to read about these. This means each NBS should have their own page. Here the information provided in section 4. for each NBS should be available. Additional pictures of the work with the NBS on the sites could also be provided here. This information is updated regularly as the projects proceed.

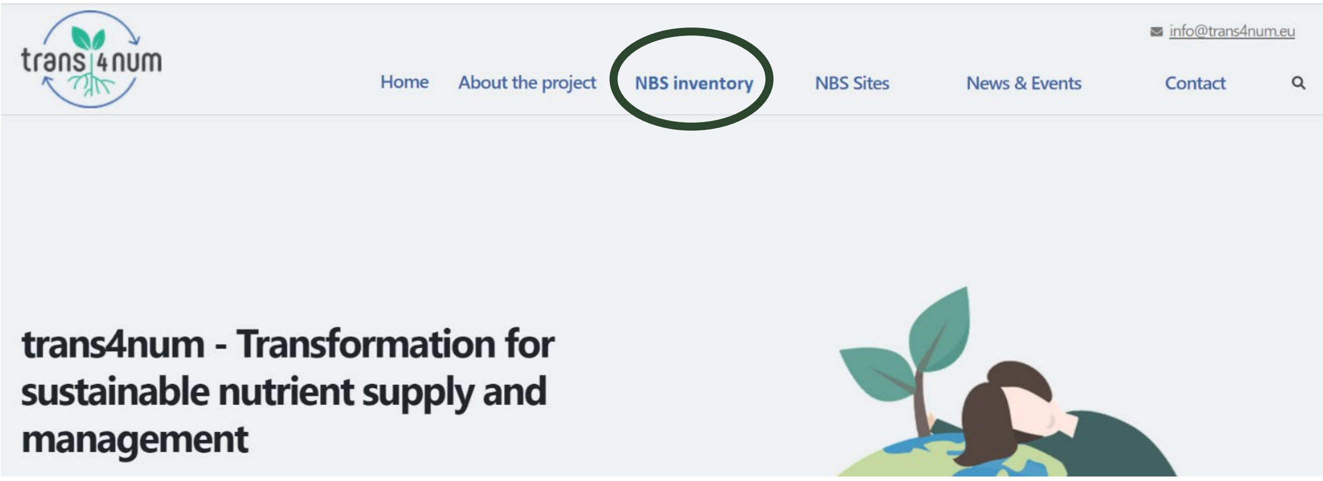

Figure 1: Prototype of the NBS online inventory

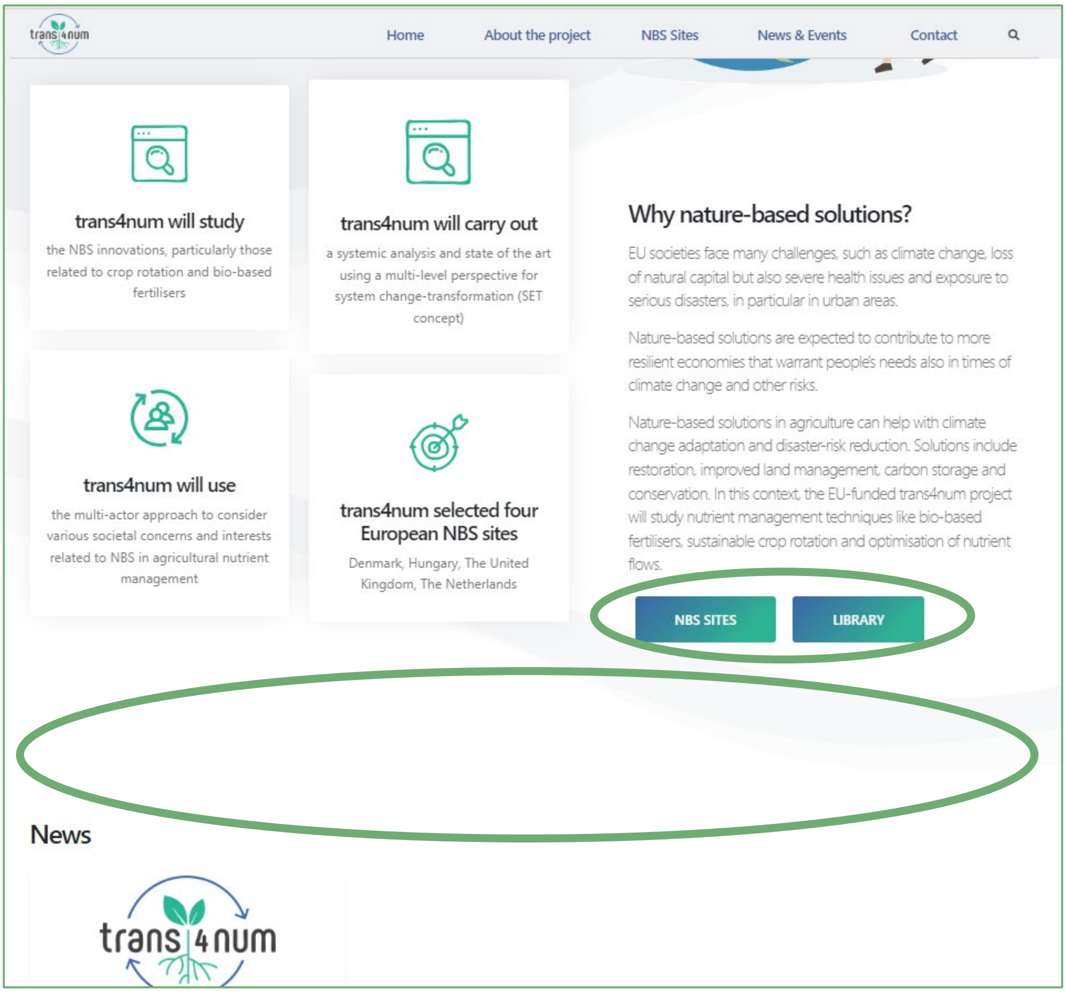

Figure 2: Screenshot of the trans4num front page. Black circle indicates where a "teaser" of the NBS inventory section with a few NBS from the inventory could be added. Red circle indicates examples of links to other taps on the webpage.

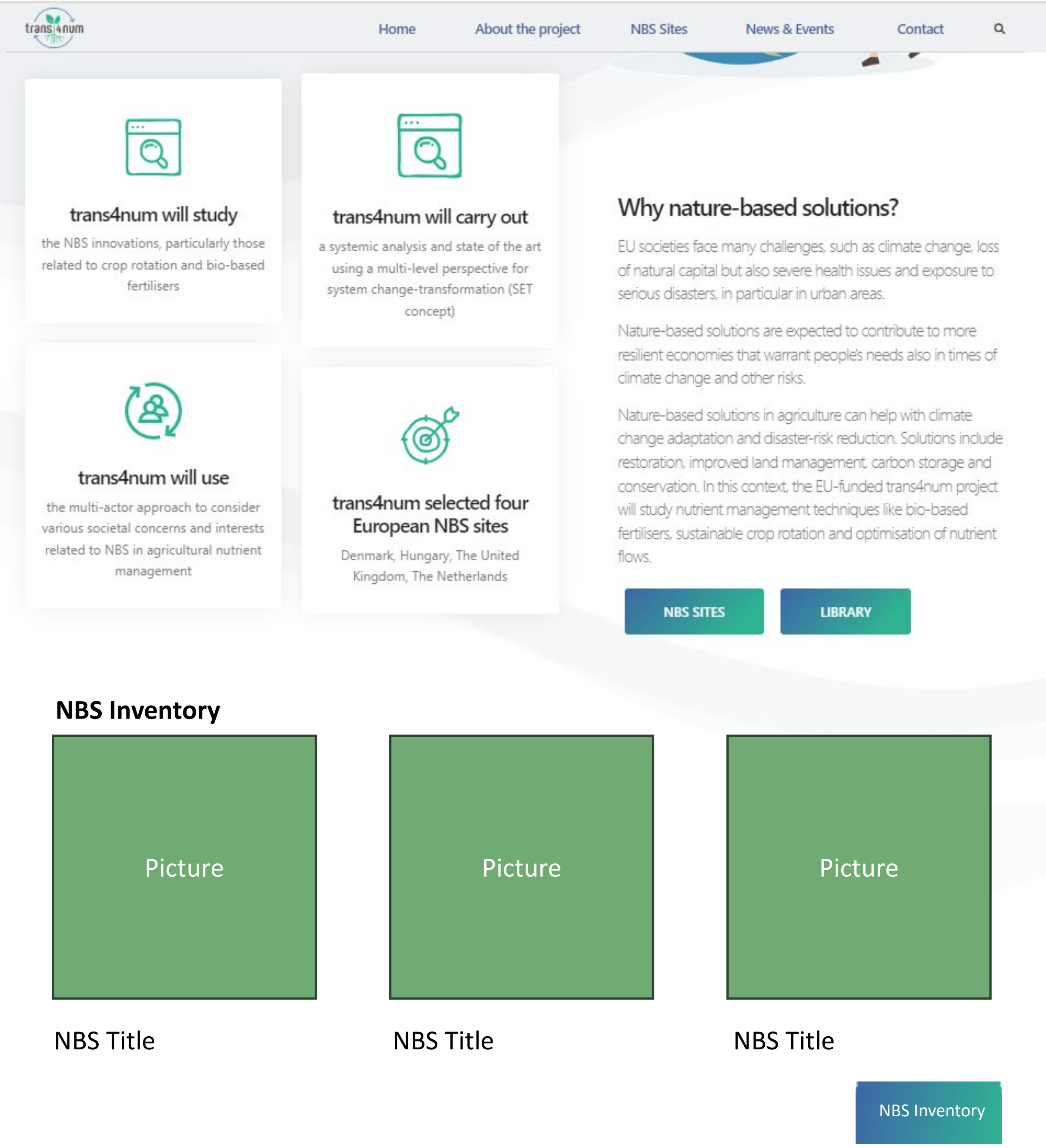

Figure 3: Example of how the NBS inventory could be presented at the front page of the trans4num web page (https://trans4num.eu/en/).

Proposed timeline for establishment of the online NBS inventory

As part of the delivery process a timeline has been developed, see table 1.

Table 1: Timeline for establishment of the online NBS inventory

Plan elements	Time frame
Engage with the technical team at Plan4all for how to set up the design.	End of September 2023
Getting feedback on the proposed content from all partners	End of September 2023
Adding the content to the webpage	October-November 2023 (with regular updates)
Adding additional NBS from other projects	From January 2024 and ongoing when results from other projects are shared.
Ranking the NBS via our stakeholder engagement plans (D1.2)	Ongoing from autumn 2023 following farmer group meetings.

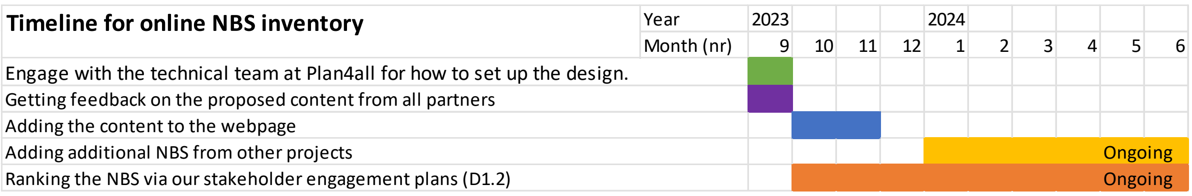

Figure 4: Gantt chart of the NBS inventory establishment.

4. Promising NBS cases

Here, we demonstrate preliminary content for the NBS inventory based on the four NBS sites of trans4num and the literature. The promising NBS cases (Table 1) are first taken from the project report D1.3 but will be elaborated step by step, see section 4.1-4.9. Besides these project NBS innovations, the project will also expand the online inventory with other promising NBS, see for example Keesstra et al. (2018) as an example of literature with NBS. Other promising NBS included will be from projects, as the Lex4bio etc.

Table 2: Overview of the promising NBS cases (to be updated)

No.	Title	Site of implementation
1	Grass production with novel crop rotation for biorefinery purpose	Denmark, regional and catchment scale
2	Crop rotation and plant-based fertilizers	Netherlands, Kollumerwaard, field scale
3	Plant-based fertilizer and natural crop protection	Netherlands, Kollumerwaard, field scale
4	Plant-based fertilizer obtained from crops in the crop rotation	Netherlands, Kollumerwaard, field scale
5	Lucerne and grass-clover pellets for fertilising winter wheat	Netherlands, Ebelsheerd, field scale
6	Grass-clover mixtures in rotation with organic winter wheat	Netherlands, Ebelsheerd, field scale
7	Multiple NBS approach (Hungary)	Hungary, Szigetköz, field and farm scale
8	Novel biobased fertilizers on crop and grass & clover ley production	United Kingdom, Devon, field scale
9	Multiple NBS approach (UK)	United Kingdom, Harpenden, field scale

4.1 Grass production with novel crop rotation for biorefinery purpose

Description

Changes in crop rotations towards more perennial grass crops for reducing environmental impacts of crop production and with the purpose of using the grass biomass for biorefinery purposes. This change ensures a new circular nutrient retention scheme and prioritized N crop-rotation systems including more perennial grass crops with longer growth season and adoption potentials to weather extremes and climate change, and combination with local protein supply chains.

Green biorefining will be a driving technology to reduce nitrate leaching while also producing protein to feed monogastric animals and fibre for ruminants. This will further create a supply of bio-based fertilisers from residual products that can feed into local circular systems building on green biomass, manure etc. for both conventional and organic farming systems.

The aims are to reduce nitrate leaching in an economically viable way for farmers and related industries while taking into consideration how to maximize biomass resource efficiency through business symbiosis.

What challenge(s) are addressed with the NBS?

Nutrient challenge (focus on N) in the recipient fjord. It is an obligation to reduce the nutrient challenge to comply with EU regulation (Water Framework Directive) and the needs of the water environment.

Import of protein feedstuff for livestock production has a high environmental and climate impact. Producing "green" protein to feed monogastric animals and fibre for ruminants could be a local alternative to this.

Additional biomass harvested can be utilized for green biorefinery (Protein production) or biogas facilities. Increasing the biomass availability would incentivise more investment into green biorefineries and biogas facilities.

Nutrient densities are higher in livestock-intensive areas and this biomass chain perspective with farmer engagement will enable better nutrient export between farmers.

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

Closing nutrient loops with NBS implementation at local and regional scale through exchange of nutrients/biomass in the biomass chain. Reduce loss of nutrients and thus reduce needed input from exogenous sources of mineral fertilisers.

Increased carbon sequestration in agricultural soil. Positive effects on climate (grass store more carbon than cereals).

Improved soil micro-biodiversity in soil due to perennial crops.

Increase insects and pollinators communities. Positive biodiversity effects (grass support stronger biodiversity as compared to cereals).

Higher nutrient densities.

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

N reduction in the recipient area after implementation of the NBS.

Improved understanding of the biomass chain (structural, social and economic).

Improved understanding of the farmers perception of the NBS.

Exchange system amongst stakeholders exporting nutrients/biobased fertilizer from fields with no additional nutrient needs to fields in need.

The extra biomass grown in the form of grass, clover, alfalfa etc., can be used in biorefineries. The digestate (anaerobic digestion) that is the by-product can then be used for an alternative source of fertilizer instead of mineral fertilizer.

Investments or future investment plans with respect to green biorefinery production.

Ranking of NBS potential

To be given when the stakeholder engagement (D1.2) is implemented for a participatory ranking.

Site and scale of implementation

Denmark, NBS site at regional and catchment scale.

4.2 Crop rotation and plant-based fertilizers

Description

Additional crop in the traditional crop rotation aimed for plant-based nutrition supply in organic farming system with potato, wheat, carrot rotation. Possible nutrient sources can include grass, clover, alfalfa etc., both for mulching and silage.

What challenge(s) are addressed with the NBS?

This NBS addresses a nutrient challenge with the aim of reducing nitrate leaching, nitrogen substitution and improving soil P availability on farmland.

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

The GHG emission and nitrate leaching are expected to be reduced. This is expected to increase the soil nutrient use efficiency and reduce the need of import of exogenous sources of nutrients by closing nutrient loops.

The structural stability of the soil will be expected to improve due to the non-tillage in NBS trails. Further, the improved crop rotation practice will reduce the need of chemical pesticides. Finally, the biodiversity of agricultural ecosystem and soil health will be improved in NBS trails.

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

- Data on N inputs and outputs in regard to amount of mineral N that can be replaced via the plant-based fertilizer.
- Reduction in the GHG emission and soil leachate.
- Improvement on available P content in the soil.
- Better N/P use efficiency by target crops.

Ranking of NBS potential

To be given when the stakeholder engagement (D1.2) is implemented for a participatory ranking.

Site and scale of implementation

Netherlands, Kollumerwaard NBS site at field scale.

4.3 Plant-based fertilizer and natural crop protection

Description

Cover crops (grass clover and/or grass) in rotation with seed potato. The nitrogen effect of the cover crops and the effect of the cover crops on aphid abundance in seed potato is investigated. This work will include monitoring aphid populations since there is evidence to suggest that different cover crops and other soil ameliorations can reduce aphid numbers and thereby enhance the efficiency of soil nutrient use.

What challenge(s) are addressed with the NBS?

When using straw to reduce the availability of aphids on the field farmers needs more nitrogen to decompose the straw. The research is based on the possibility for grass clover and or fresh grass to supply enough nitrogen to facilitate the decomposition of straw. This will be evaluated against the traditional method of mineral fertilizer addition.

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

A high reduction to almost zero use of aphid killers and oils to prevent viral infection spread due to aphids.

Healthier crops through a reduction of stress in the crops due to the decreased chemical usage.

Reduced use of fertilizers.

Restore lost productivity and enhance resilience and efficiencies of the farm.

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

The nutritional value of the different products is known and it's also known if they give the same effects of straw on reducing aphids available in the field.

This will be a comparison between an industry standard practice and a possible novel substitute for the industry standard practice.

Ranking of NBS potential

To be given when the stakeholder engagement (D1.2) is implemented for a participatory ranking.

Site and scale of implementation

Netherlands, Kollumerwaard NBS site at field scale.

4.4 Plant-based fertilizer obtained from crops in the crop rotation

Description

Cover crops is grown in a seed potato-based crop rotation to provide nutrients to the potato crop.

What challenge(s) are addressed with the NBS?

Nutrient challenge. It is investigated when the best moment is to destroy a cover crop to provide the most nutrients for the crop.

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

- Reduced use of mineral fertilizers and an improvement of biodiversity.
- An improvement of the nitrogen uptake out of cover crops during the growing season.
- Restore lost productivity and enhance resilience and efficiencies of the farm.

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

Knowing when the best moment of destroying a cover crop is.

Ranking of NBS potential

To be given when the stakeholder engagement (D1.2) is implemented for a participatory ranking.

Site and scale of implementation

Netherlands, Kollumerwaard NBS site at field scale.

4.5 Lucerne and grass-clover pellets for fertilising winter wheat

Description

Trials at SPNA Ebelsheerd will test the use of lucerne and grass-clover pellets (a form of bio-fertiliser) as an innovative alternative to the conventional use of mineral fertilisers and manure applications.

What challenge(s) are addressed with the NBS?

Wheat production in the Netherlands is typically very intensive, with large inputs of mineral nitrogen fertilisers which has adverse environmental effects.

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

Reduced use of chemical fertilizer and manure application.

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

The nutritional value of the pellets compared to mineral fertilizer. Comparison of the mineral fertilisers and bio-fertilisers will include investigation of the impact on both short- and longer-term soil nutrient status and crop yield and quality.

Ranking of NBS potential

To be given when the stakeholder engagement (D1.2) is implemented for a participatory ranking.

Site and scale of implementation

Netherlands, Ebelsheerd NBS site at field scale.

4.6 Grass-clover mixtures in rotation with organic winter wheat

Description

It is investigated if growing grass-clover mixtures in rotation with organic winter wheat could work as an alternative nitrogen source and reduce or eliminate the nutrient deficiency in the region.

What challenge(s) are addressed with the NBS?

The heavy clay soils at SPNA Ebelsheerd are ideal for growing winter wheat. Organic winter wheat is mainly fertilised with animal manure; however, there are shortages of manure in the region and farmers are looking for alternatives.

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

Reduced use of manure.

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

The nutritional value of the grass clover.

Ranking of NBS potential

To be given when the stakeholder engagement (D1.2) is implemented for a participatory ranking.

Site and scale of implementation

Netherlands, Ebelsheerd NBS site at field scale.

4.7 Multiple NBS approach (Hungary)

Description

Implementation of multiple innovations at once as one NBS including:

- Crop rotation with diversity of crops (durum wheat, sorghum, soya)
- No tillage
- No herbicides, and minimal usage of pesticides
- Biobased fertiliser (poultry manure pellets)
- Bio-stimulants (microorganisms' inoculation)
- Cover crops after wheat over winter (mulching)

What challenge(s) are addressed with the NBS?

The improved crop rotation will have positive effects on soil Health, nutrient use efficiency, and combat pests and weeds.

No tillage practices will reduce CO2 emissions/increase C-sequestration of the soil.

No use of herbicides and minimal use of pesticides will increase biological soil activity and C-cycling.

Using natural fertilizer (Poultry manure) instead of artificial will reduce the impact of imported mineral fertilisers.

Bio-fertilisers increase crop productivity under environmental stress & Climate change.

Mulching wheat over winter will increase C-sequestration and improve resilience to climate change.

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

Increased carbon sequestration in agricultural soil.

Improved soil biological activity via inoculation.

Better soil structure.

Increased organic matter content.

Increased number of species of insects and pollinators communities and increased species of birds.

We expect lower carbon emission.

It is expected to show the path towards a more sustainable production methodology.

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

Measurement of increased carbon content and biological activity in the soil. Carbon content in soil can be measured with total soil carbon and humus measurements.

Decreased CO_2emission from soil.

Reduce N leachate in the soil and improved nitrogen use efficiency

More resilient crops and increased measurable yield.

Ranking of NBS potential

To be given when the stakeholder engagement (D1.2) is implemented for a participatory ranking.

Site and scale of implementation

NBS site in Szigetköz region, Hungary at field and farm scale

4.8 Novel biobased fertilizers on crop and grass & clover ley production

Description

Processing of abattoir waste to utilise food waste products and to produce a phosphorus and carbon rich bio-fertiliser. This bio-fertiliser is derived from animal bones, resulting in a fully circular recovery process with zero waste. Experimental and demonstration field plot trials will be established comparing the efficiency of this fertiliser to conventional mineral fertilisers and traditional organic amendments (e.g. farmyard manure).

What challenge(s) are addressed with the NBS?

Viability of using these novel alternative fertilisers from abbitiore waste in comparison to standard bagged dry fertilizers in order to produce crops.

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

Increased recycling of nutrients within the food production system, and less reliance on importation of newly produced macro fertilizers.

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

Yield and quality of arable crops and grass & clover.

Comparisons will be made with conventional P fertilisers, and the novel abattoir waste source. Measuring P unit equivalents in the conventional to this novel source.

Ranking of NBS potential

To be given when the stakeholder engagement (D1.2) is implemented for a participatory ranking.

Site and scale of implementation

United Kingdom, Rothamsted North Wyke, Devon at sub-field demonstration scale.

4.9 Multiple NBS approach (UK)

Description

Implementation of multiple NBS in one experiment to investigate trade-offs of NBS implementation.

NBS includes:

- Crop Rotation (Increased proportion of legumes)
- Green compost (organic fertiliser-Green Waste).
- Cover Crops.
- Reduced Tillage
- Integrated Pest Management {IPM} (non-chemical, companion cropping, resistant cultivars, delayed drilling)

What challenge(s) are addressed with the NBS?

Not designed to address a specific challenge but designed to study trade-offs between agronomic, environmental and economic outcomes via a systematic approach.

Outcome envisioned:

- Possible improvement to integrated weed management.
- Improved nutrient use efficiency.
- Provide data for achieving net-zero from this study site with multiple interventions.

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

Less competitive weed communities

Better soil health (combination of structure and biology).

Leading to better water regulation.

Improve biodiversity with applicability to increase more diverse communities of natural enemies of crop pests

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

Quantify the contribution that NBS has to reducing the reliance on synthetic nitrogen fertilisers to maintain productivity.

Utilizing an app (Farm Crap App) to quantify the nutrient replacement possibility between the green manure envisioned and synthetic fertiliser additions.

Ranking of NBS potential

To be given when the stakeholder engagement (D1.2) is implemented for a participatory ranking.

Site and scale of implementation

United Kingdom, Rothamsted Research, Harpenden, Hertfordshire, Large-Scale rotation experiment at field scale.