

Establishing a Scottish Nitrogen Balance Sheet

Analysis of responses to the stakeholder consultation

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1. Executive Summary

This document analyses the responses to the stakeholder consultation on Establishing a Scottish Nitrogen Balance Sheet (SNBS). The consultation opened on 1 December 2020 and closed on 14 January 2020. The consultation document is available [online](#) at the Scottish Government's consultation hub.

A total of 27 responses were received, of which 19 were from groups or organisations and 8 from individuals. The form of responses varied, with some respondents commenting in detail on all questions while others mainly answered the quantitative questions (e.g. to what level they agree with the approaches to the SNBS proposed by the Scottish Government).

Across all of the consultation questions, there was a high level of support for the approaches proposed by the Scottish Government. At least 25 of the 26 responses to each of the quantitative questions (96%) supported (either fully or partially) the approaches proposed.

Some of the key themes emerging within the qualitative elements of the responses were:

- Wide support for the SNBS being as comprehensive as possible in terms of its coverage and level of detail for all sectors of the economy and the environment.
- Wide support for the SNBS being fully integrated with other policy frameworks and strategies.
- Wide support for the SNBS being extended beyond the national scale to a range of more detailed spatial scales, but also some concerns about data availability and potential burdens associated with any new data collections.
- Support from most respondents for the setting of targets for improving nitrogen use efficiency based on the SNBS once the evidence base is sufficiently established to allow for this to be done robustly. Mixed views on the appropriate scale(s) for such targets, with suggestions including national, regional and farm-scale.
- Support from most respondents for the SNBS being updated on an annual basis, but also some concerns that this frequency might only be appropriate for the headline figures.
- Wide support for the outputs associated with the SNBS being made as accessible as possible, subject to this not compromising technical robustness. There were a wide range of specific suggestions for the content and style of the proposed factsheets and other ways of communicating the SNBS.
- Many respondents suggested a range of wider actions for reducing nitrogen losses and improving NUE, such as increased awareness raising on nitrogen and the provision of advisory and other forms of support.
- Several respondent organisations made positive offers of collaborative working around the ongoing design and future implementation of the SNBS.

The remainder of the report sets out more detailed analysis of the responses to each of the questions in turn.

2. Introduction

2.1 Background

This report presents analysis of responses to the consultation on Establishing a Scottish Nitrogen Balance Sheet (SNBS).

A Scottish Nitrogen Balance Sheet will be established by March 2022. As part of a programme of engagement, the Scottish Government is consulting on key aspects of approach to shape this new initiative.

The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 requires the establishment, via a process of regulations by March 2022, of a national Nitrogen Balance Sheet for Scotland. Nitrogen is a basic building block of life and present everywhere across the economy and environment. A Nitrogen Balance Sheet is a way to keep track of how nitrogen is being used, any losses to the environment and whether there is scope for improvement.

In particular, the Scottish Nitrogen Balance Sheet (SNBS) will provide a method for determining a baseline figure for “Nitrogen Use Efficiency” in Scotland. Nitrogen use efficiency means the proportion of nitrogen used for its intended purpose (e.g. growing food) vs. losses to the environment, which can have harmful effects on, for example, climate change, biodiversity, air quality and water quality. Once established, the SNBS will be reviewed and updated at regular intervals, helping us keep track of progress on improving nitrogen use efficiency.

The main purpose, as set out in the 2019 Act, for the SNBS will be to support progress to Scotland’s national climate change targets. This is because one form of nitrogen - nitrous oxide, N₂O - is an important greenhouse gas. Improving nitrogen use efficiency will, therefore, help with tackling climate change. However, the fact that nitrogen in all of its many forms is basically everywhere (in the air we breathe, soils, plants, water, animals, food production, combustion, waste management, etc) means that the SNBS will also have the potential to support a range of wider applications (some key examples around air quality and agriculture are discussed below). The Scottish Government is keen to maximise the potential of the new evidence base from the SNBS to support linkages between as wide a range of policy areas as possible.

A Nitrogen Balance Sheet is, inherently, a technical undertaking – given the complexity of the different flows and types of nitrogen across the economy and environment. The Scottish Government’s current SNBS project is building from a previous study by the UK Centre for Ecology & Hydrology in 2019. This study made a first attempt at a national Nitrogen Balance Sheet for Scotland (those interested in the detailed aspects of the project might wish to review the [report](#) from this work, a summary of which is also included in the technical annex here). In particular, the current project aims is to bring all major sectors of Scotland’s economy and environment into the scope of the balance sheet. Whilst recognising this technical background, we are also keen that the outputs from the SNBS are as accessible and widely usable as possible. Aspects of the consultation questions below relate to both the technical and communication aspects of the work.

2.2 How does this work relate to other Scottish Government initiatives?

As set out in the preceding section, nitrogen is a key nutrient for sustaining life and is a constituent of a wide range of materials and processes. It is especially important in relation to growing and producing food, waste management and activities involving fuel combustion. This means that effective and efficient use of nitrogen is an important consideration across many sectors of the economy, environment and well-being. Establishing the SNBS will be an important step in developing the national evidence base around these matters, by bringing together data from a range of sources and providing baseline figures for nitrogen use efficiency.

This evidence base, once established, can then be used to help support a range of initiatives and policy frameworks. In addition to the central purpose around supporting progress to national greenhouse gas emissions reduction targets, two further key examples of potential future applications for the SNBS will be around:

- a new air quality strategy for Scotland, with related benefits for public health and biodiversity. This link arises because emissions to air of ammonia (NH₃) and oxides of nitrogen (NO_x), which originate mainly from agriculture and transport, are key air quality pollutants. A separate consultation on a draft of the new strategy, including information on how the SNBS can support this, closed on 22 January 2021. The **Cleaner Air for Scotland 2 consultation on a draft new air quality strategy for Scotland** can be found [online](#) via the Scottish Government's consultation hub Citizen Space
- building from existing good practice to further optimise the efficient use of nitrogen in food production. The development of future rural support and consideration by farmer-led groups of delivering environmental and climate outcomes will help identify how best support farmers and crofters to adopt best practice. The SNBS will help provide relevant data to inform this on-going policy development

3. Consultation responses

The consultation opened on 1 December 2020 and closed on 14 January 2020. The consultation document [online](#) via the Scottish Government's consultation hub.

A total of 27 responses were received, of which 19 (70%) were from or on behalf of groups or organisations and 8 (30%) from individuals. The format of responses varied, with some respondents commenting in detail on all questions while others mainly answered the quantitative questions (e.g. .. to what level they agreed with the approaches to the SNBS proposed by the Scottish Government). Most of the responses (24) were submitted through the Scottish Government's Citizen Space consultation web hub, with the remaining three received by e-mail.

All respondents gave consent for their responses to be published (70% with names, and 30% without names).

Responses were allocated to seven categories by the analysis team:

Category	Number of respondents	Proportion of total respondents #
Organisational respondents		
NGO	8	30%
Professional body	7	26%
Business	2	7%
Local authority	1	4%
Public body	1	4%
Total organisational respondents	19	70%
Individual respondents		
Academic expert	6	22%
Other individual	2	7%
Total individual respondents	8	30%
All respondents	27	100%

Values may not add up as expected due to rounding.

A full list of organisational respondents who gave consent for their name to be published can be found in Annex 1. The content of the individual responses (redacted as appropriate) can be viewed [online](#) via the Scottish Government's consultation hub

4. Analysis and reporting

In total there were 5 closed questions and 6 open questions. The closed questions were asking to what extent the respondents agreed with the approach proposed by the Scottish Government. Each of the closed questions was associated with an open question asking for further comments and explanations for the response to the closed question, with one final question seeking any other comments.

This report presents a question-by-question analysis of the responses and any further comments made. Some respondents included comments or materials that did not directly address the specific questions. This content was analysed qualitatively and included here with the most appropriate section of the report. Direct quotes are shown in quotation marks and italics, and where not quoted directly, the responses were summarised using as much of the original wording as possible.

The number of responses received to each question from the 27 respondents can be summarised as shown in the table below.

#	Question/topic	Closed question	Open question
1	Scope of the SNBS	26	16
2	Spatial resolution of the SNBS	26	15
3	Target setting based on the SNBS	26	14
4	Accessibility of the SNBS	26	16
5	Review period of the SNBS	26	18
6	Any other comments	n/a	16

The analysis set out in this report focuses on evidence supplied by respondents. In addition, the report also contains feedback gathered through a series of stakeholder workshop events held (online) as part of the stakeholder engagement process for the SNBS during early October 2020. A summary of feedback from those events is set out in Annex 3.

It should be noted that many respondents focussed on specific aspects of the SNBS that reflected their sector remit and expertise, rather than the full range of sectors of the economy and environment. Therefore, views expressed cannot necessarily be read as representative of the full range of opinion and need to be read in this context.

A list of acronyms used in the report is provided in Annex 2.

4.1 The scope of the Scottish Nitrogen Balance Sheet

Respondents were asked to indicate to what extent they agreed with the proposed approach by the Scottish Government (Question 1a), and to provide any explanations for their response and further comments (Question 1b). The Scottish Government's proposed approach was set out as follows:

The Scottish Government proposes that the SNBS should, wherever possible, cover all major flows of nitrogen within all parts of the Scottish economy and environment. Flows across relevant national boundaries should also be quantified wherever possible.

Such an approach would mean that the SNBS will cover flows of nitrogen within and between the following sectors of the economy: aquaculture, energy production, fisheries, food and drink production, forestry, human nutrition, industry, transport, waste management. It will also cover the following aspects of the environment: atmosphere, terrestrial, freshwater and coastal systems.

Do you have any changes you would like to suggest and/or any other comments? In particular, are there any important sectors that may be missing from the lists above?

There were 26 responses to the first part of the question (1a). All respondents who answered this question either fully or partly supported the proposed scope of the SNBS, in terms of sectors of the economy and environment included. Of those who answered the question, 20 (77%) fully agreed and 6 (23%) agreed to some extent. As such, all respondents who answered the question agreed to at least some extent.

Option	Total	% of all respondents	% of those who answered the question
fully support the proposal	20	74%	77%
support the proposal to some extent	6	22%	23%
not support the proposal	0	-	-
don't know/don't have an opinion	0	-	-
not answered	1	4%	n/a

There were 16 responses to the second part of the question (1b), four from individual respondents and 12 from organisational respondents. These covered a range of matters, as grouped below.

Sectors and forms of nitrogen to be included in the SNBS:

In response to the question whether any specific sectors were missing from the proposed scope of the SNBS,

- Six respondents (23%) from across the spectrum of individual and organisational backgrounds (academic, NGOs, professional organisations) commented that "agriculture" or "farming" was not explicitly mentioned as a sector of the economy and a key part of the SNBS. In particular, respondents pointed out that "food and drink production" – which was explicitly listed in the

consultation paper - excluded non-food products such as fibres (e.g. wool), fuels (e.g. methane from biomass), oils, starches, dyes, non-edible horticulture, etc. These respondents urged the Scottish Government to fully include all aspects of agricultural nitrogen use and losses of nitrogen within the SNBS.

- Two respondents (NGO) suggested that public health and wellbeing should be included in the scope, with one mentioning human health impacts from NO₂ [oxides of nitrogen] specifically.
- One respondent (academic) asked for clarification whether aquaculture (listed in the intended scope) also included marine aquaculture rather than only the freshwater component, and for this coastal component to be considered as an important part of the SNBS.
- One respondent (NGO) commented that other forms of land use and management should also be included in the scope to cover the management of private estates, nature conservation sites, peat extraction and other forms of extraction.

Looking across responses to this question more generally, NGO, public body and academic respondents in particular explicitly expressed their approval for a broad scope covering all sectors of the economy and the environment, and more effort being invested in the larger flows. Professional bodies from the agricultural sector focused their comments mainly on the agricultural aspects of the SNBS and nitrogen flows related to it.

Other aspects specifically mentioned in terms of the scope and sectoral resolution of the SNBS included the following suggestions:

- To include flows within and between sectors of the economy and environment
- To identify and quantify import and export flows with the rest of the UK and the world, citing considerations of climate justice (two NGO respondents)
- To break down the nitrogen flows to a finer level within the agriculture sector (i.e. between agricultural sub-sectors) and with other sectors to identify links and maximise efficiency
- To be able to look at the SNBS from the perspective of the human food chain, animal feed, alcohol and energy crops and follow these flows across sectors
- To design the SNBS to facilitate cross-government and cross-sector collaboration for a consistent and integrate approach to reducing nitrogen losses and mitigating their impact on people, the environment and the climate
- To develop finer granularity for the sectors with the largest nitrogen losses. The example used by this respondent was agriculture, and suggested that farming systems should be considered at the level of sector sub-types, and providing insights of nitrogen flows for fully pasture-fed grazing vs. more mixed livestock systems, and linear vs. more closed loop types of farming,

The respondents mostly referred to nitrogen in a generic sense. However, there were indications of respondents being keen to see the SNBS include various nitrogen forms, with specific nitrogen forms mentioned under Question 1 as follows: ammonia/NH₃ (two responses), nitrous oxide/GHG (two), nitrogen oxides/NO_x (two), di-nitrogen/N₂ (one response), and several implicit mentions of forms with impacts on water quality, air quality etc.

Suggestions for policy applications of the SNBS

Ten respondents (across the spectrum of organisation types and individuals) made suggestions of policy applications that could be associated with the SNBS. These included:

- Establishing a full SNBS will help with managing and controlling nitrogen losses across the Scottish environment. It is recognised that nitrogen losses from human activities can have considerable negative impacts on biodiversity, human health, the wider environment and climate change (several NGO, business, professional bodies, academic respondents).
- The SNBS should be designed to facilitate cross-government and cross-sector collaboration to ensure a consistent and integrated approach to reducing nitrogen losses and mitigating their impacts on people, nature and the climate (NGO respondent).
- The benefit of a single common unit (i.e. amounts of nitrogen) to measure environmental pressure that is relevant across all policy areas, which one respondent referred to as “*a benefit not to be underestimated*”. This should enable the development of coherent policies based on net improvement across the full range of impacts. In this sense, the SNBS should represent a generic tool relevant to air quality, water quality, nutrient management and climate change (business and academic respondents).
- Integration of the SNBS with other legislation and strategies, including Cleaner Air for Scotland Strategy, agriculture sectoral climate groups and any voluntary or regulatory climate-related actions is key (two NGO respondents).
- It is useful to have a high level indicator to monitor trends over time and enable comparisons between countries (business respondent).
- A key indicator to success from the agricultural perspective will be to ensure that policy is designed with engagement and buy-in from farmers and the wider industry, in a partnership approach. (professional body)
- The SNBS needs to be sensitive to changes in farm practice, such as overall improvements in NUE, feed conversion ratio and farm nutrient balance, to chart progress and inform agricultural policy. Reducing the agricultural industry’s environmental footprint through professional training schemes is part of the AICS Roadmap to 2050¹ already, and should improve farm nitrogen balances (professional body).
- The Scottish Government is asked to recognise the investment made by road hauliers to reduce NOx emissions from the HGV fleet, both already implemented and planned towards 2025 (a reduction in NOx pollution from HGVs by 85% from 2013 levels by 2025) (professional body).

Concerns about the application targets based on the SNBS

¹ [Agricultural Industries Confederation \(AIC\) Roadmap - Agri-supply roadmap for a sustainable food chain](#)

- There is concern about the way the SNBS may be used or interpreted, with the potential for national targets to create unintended consequences at the farm level (professional body).
- Another respondent (business) expressed concern that the SNBS will “*turn into a stick to beat certain industries with*”, and that “*it would be much better long term to provide carrot type encouragement to elicit improvement*” – but agrees with the evidence gathering aspect of the SNBS.

The evidence base for the SNBS

In terms of the evidence needs for the SNBS, seven respondents (two business, two academic, two professional bodies and one public body) commented specifically, with key points summarised here:

- The establishment of the SNBS is recognised as an important step in developing the evidence base around nitrogen use and losses by all respondents who referred to evidence in their response to this question.
- The evidence base will be useful for the transitioning of the agricultural sector over the coming years (business respondent).
- It is recognised that the SNBS is a complex undertaking with a number of data sources (business respondent).
- One business respondent stated that most of the national level data are from reliable and well-established data sources. They commented that a “*SNBS would have the advantage of being produced with impartiality and integrity, key qualities for official statistics. They are not susceptible to interference from, for example, political expediency. Assuming a consistent approach can be assured, there is also limited scope for subjectivity in their interpretation. Data sources for the balances are well established so historic data is generally readily available on a consistent basis for the Scotland. This allows a consistent time series to be produced to allow analysis of trends over time*”
- There is a need for careful checking of data sources, and the system and results should be subject to a thorough review every few years (business respondent).
- Similarly, a professional body encouraged the Scottish Government to use as many known datasets as possible, to outline where there are data gaps and to establish a plan for how these challenges will be tackled.
- A professional body recommended that “*atmospheric nitrogen*” inputs [analyst comment: assume this refers to biological nitrogen fixation rather than atmospheric deposition] be distinguished from synthetic nitrogen fertilisers
- One academic respondent stated that it is important to quantify large uncertainties in the nitrogen cycle such as the input of biologically fixed nitrogen, and losses from soils such as di-nitrogen gas (N₂) resulting from denitrification.
- Another academic respondent supported the proposal but suggested that due to uncertainties in the quantification of many key flows, the SNBS approach as proposed by the Scottish Government may not initially meet expectations, but provide a useful stepping stone. In particular, they suggested that “*determining the net import/export of fixed nitrogen via the atmosphere will not be easy*” and propose a quick fix approach.

- One public body commented that it would be useful to develop the evidence base “*towards finer granularity for high emitting sectors*”. Examples mentioned include a “*break down the various inputs in arable and livestock farming practices, to also consider nitrogen flows with different approaches to farming (e.g. fully pasture-fed grazing and more mixed livestock systems) and to explore differences between more linear or more closed loop types of farming systems*”. This was suggested as helpful for explaining the rationale for changes to agricultural practices.
- A professional body recommended that the Scottish Government consider evidence collection by Defra (UK soil nutrient balances for nitrogen and phosphorus)² and ongoing work at Lancaster University on phosphorus flow analysis.

² Department for Environment, Food and Rural Affairs (Defra): [UK and England soil nutrient balances 2018](#)

4.2 The spatial scale of the Scottish Nitrogen Balance Sheet

Respondents were asked to indicate to what extent they agreed with the proposed approach by the Scottish Government (Question 2a), and to provide any explanations for their response and further comments (Question 2b). The Scottish Government's proposed approach was set out as follows:

The Scottish Government proposes that the SNBS, at the point of its establishment, will be national in scale. Further outputs will also be prepared at regional and sector by sector scales, where data availability allows for this. We further propose that the SNBS should also be designed as flexibly as possible, to allow it to fit together with any higher spatial resolution data sources that may become available in the future (e.g. data at the river catchment, farm or community levels). It is recognised that nitrogen accounting at more detailed levels could be of value in terms of understanding improvements in national nitrogen use efficiency and giving appropriate credit for these. Under the proposed approach, the possibility of further development in these directions will be kept under regular review and updates provided to Parliament (see Q5 for the frequency of these reviews).

Do you have any changes you would like to suggest and/or any other comments?

There were 26 responses to the first part of the question (2a). 25 of the 26 respondents who answered this question (96%) either fully or partly supported the Scottish Government's proposals for the SNBS, in terms of the proposed spatial resolution for the SNBS. Of those who answered the question, 18 (69%) % fully agreed and 7 (27%) agreed to some extent, with one respondent (4%) not supporting the proposal.

Option	Total	% of all respondents	% of those who answered the question
fully support the proposal	18	67%	69%
support the proposal to some extent	7	26%	27%
not support the proposal	1	4%	4%
don't know/don't have an opinion	0	0.0%	-
not answered	1	4%	n/a

There were 15 responses to the second part of the question (2b), three from individual respondents and 12 from organisational respondents.

Respondents' comments on the proposals for the spatial scale of the SNBS referred to coverage at national, regional and local/farm scales.

National and regional scale

In terms of national scale, seven respondents (one business, one public body, one NGO, two professional bodies and two academics) commented explicitly. Responses ranged from the national scale being important/appropriate in its own right to it being

a starting point to progressively working towards regional, sector and higher resolution outputs, down to the farming sector and farm scale.

The regional scale was directly referred to by seven respondents and indirectly (e.g. “*at all levels*”) by a further four, across all respondent categories. These respondents all referred to regional outputs favourably.

- In this context, some respondents recommended that the SNBS be designed in a flexible way, to be as scale-able as possible for data at a higher spatial and/or sector/sub-sector resolution where available (two NGOs, one public body, one industry body).
- Two NGO and one public body respondents recommended moving towards the scale and areas at which specific actions need to be taken to tackle nitrogen losses to the environment.
- Specifically, catchment level resolution was mentioned by two respondents as potential regions of interest (one public body, one academic), and regions linked to the Regional Land Use Partnerships (RLUP) are mentioned five times (three NGOs, one public body, one academic).
- Further specific comments on the regional scale referred to:
 - higher granularity enabling better capture of changes in practice, and that sufficient granularity was needed to inform policy development and enable change (one NGO).
 - More detail potentially adding value, but that this needed to be done proportionally across sectors (one professional body)
 - A progressive approach where scaling to higher resolution is valuable for building up the relevant and necessary data (one professional body)
 - Regional differences in practice (such as nitrogen application rates, or offtake from pasture), where regional fertiliser data by crop type would be useful (one business respondent). Another response referred to the geographical differences between regions, specifically mentioning Highland hill farms vs Angus barley grower (one NGO).

Local or farm scale

The local or farm scale was explicitly mentioned by seven respondents (two academic, four NGO, one professional body), with others referring to “any level”, “other levels” (i.e. beyond national level) and “high resolution” (one business, one professional body, one NGO). These respondents’ comments can be summarised as follows:

- Two NGO respondents and one academic respondent suggested that evidence for what does or does not work [in terms of nitrogen use efficiency] can only be shown at a high resolution, and that this is also the resolution at which decisions related to nitrogen use etc. are being made. The academic respondent suggested that some effort should be made regarding examples of farm scale assessment. Along the same lines, one NGO respondent suggested that farm scale data would enable farmers to “*better understand how activities flow into the wider sector and ecosystems*”, and empower them by making the issues visible.
- A further NGO respondent suggested that a farm level nitrogen budget would be “*an important tool for identifying actions on the ground, support and advice needs.*” They requested that it “*be supported by new rules governing N use*”

across all of Scotland by 2024, rollout of compulsory soil testing and NBS on all farms, and implementation of a suite of measures to promote efficient nitrogen use and safe storage of farm manures and slurry.”

- Another professional organisation suggested that downscaling will be a *“valuable way of building up relevant and necessary data. It is important that this data is used effectively.”*
- One professional body suggested that a range of farm adviser training modules exist which demonstrate *“the practical options and benefits of using professional advice. Schemes such as the Feed Adviser Register (FAR), FACTS and BASIS all provide training in this area³”*.
- Another professional organisation suggested they (the organisation) could *“play a crucial role in providing advice to farmers and land managers which will help both improve Nitrogen use Efficiency but in so doing also help to build up the crucial baseline data which will be of value in understanding and giving credit for improvements in NUE”*.

In relation to other potential high-resolution applications of the SNBS (i.e. at scales other than the farm):

- A NGO respondent suggested that the spatial resolution of the SNBS should be extended to reflect the need for action at the habitat level, i.e. at the scale of and in the areas worst affected by nitrogen deposition.
- Another NGO would highly value local level pollutant information (from a human health perspective) but acknowledge difficulties with data availability.

Evidence and data needs associated with the spatial resolution of the SNBS

Another theme among the responses to the question on spatial resolution was about associated evidence and data needs, with six respondents explicitly commenting (one public body, one academic, one professional body, one business and two NGOs):

- Decision makers will require data at multiple spatial scales – the key is collection of relevant data and then effective use (professional body, NGO). The NGO respondent specifically mentioned the examples of Local Authority and RLUP levels.
- One NGO respondent asked for “close monitoring of NO_x concentrations in communities”, mentioning that there are currently only 13 AQMAs [Air Quality Management Areas] in Scotland, and that more monitoring is required, from a human health perspective. Similarly, a public body respondent asked for better monitoring of ammonia concentrations across Scotland, from the perspective of effects on habitats.
- One respondent (public body) requested that account is taken of embedded nitrogen in imported products, such as livestock feed.

³ The online documents listed below provide further information on the key competences on which advisers are assessed including on improving nitrogen use efficiency:

- [FAR modules \(3 and 4\)](#)
- [FACTS course](#)
- [2020 on-line assessment](#)

- An academic respondent suggested that a robust system could also “*allow integration with rural support systems*”, for example support for farm/field scale NUE improvement and ammonia emission mitigation.
- A business respondent suggested that locally significant issues may be obscured by more dominant data in the national context, and that care needs to be taken, with the SNBS designed from the outset to reflect and accommodate best available data to avoid systematic errors, and that care needs to be taken in interpreting the data and decision making based on them.

4.3 Setting targets based on the Scottish Nitrogen Balance Sheet

Respondents were asked to indicate to what extent they agreed with the proposed approach by the Scottish Government (Question 3a), and to provide any explanations for their response and further comments (Question 3b). The Scottish Government’s proposed approach was set out as follows:

The Scottish Government’s view is that targets for improving national nitrogen use efficiency cannot be meaningfully set until the baseline evidence base has first been established. However, we also recognise that such targets may be appropriate in the future. As such, we propose that the setting of targets based on the SNBS should be kept under regular review and updates should be provided to Parliament (see Q5 for the frequency of these reviews) following its initial establishment.

Do you have any changes you would like to suggest and/or any other comments?

There were 26 responses to the first part of the question (3a). 25 of the 26 respondents who answered this question (96%) either fully or partly supported the proposed scope of the SNBS, in terms of the proposal for setting targets related to the SNBS. Of those who answered the question, 17 (65.5%) % fully agreed and 8 (31%) agreed to some extent, with one respondent (4%) not supporting the proposal.

Option	Total	% of all respondents #	% of those who answered the question#
fully support the proposal	17	63%	66%
support the proposal to some extent	8	30%	31%
not support the proposal	1	4%	4%
don’t know/don’t have an opinion	0	-	-
not answered	1	4%	n/a

N.B. Percentage figures may not add up to 100% due to rounding.

There were 14 responses to the second part of the question (3b), three from individual respondents and eleven from organisational respondents.

Comments on types and levels of targets

The single respondent (professional body) who did not agree with the Scottish Government’s proposal under Question 3a stated that they “do not support national targets”, but that they would “support and drive an industry led approach to measuring Farm Nitrogen Balance, Nitrogen Use Efficiency, benchmarking farm performance against national benchmarks by farming sector and to target percent improvements at a farm level.”

All other respondents to Question 3b fully or partly agreed with the Scottish Government’s proposal that targets “cannot be meaningfully set until the baseline evidence base has first been established”. Several themes on different types and levels of targets can be summarised from the responses received:

- Five respondents (two academic, two NGOs, one professional body) asked the Scottish Government to consider targets for improving NUE. Five respondents (three NGOs, two academic) specifically mentioned that they would like the Scottish Government to adopt a national target of halving nitrogen waste by 2030 in line with the Colombo Declaration on Sustainable Nitrogen, to which the UK is a signatory. Three of these respondents hoped/recommended that the Scottish Government's target for reducing nitrogen waste will be more ambitious than the Colombo target.
- Others (three NGOs, one academic) mentioned targets for reducing one of more of the following effects: environmental losses of nitrogen, impacts of such losses on people, nature and the climate, or air quality, water quality and waste of resources.
- Two respondents (one NGO, one public body) mentioned a time scale for setting targets and asked for the Scottish Government to commit to targets "*at the earliest opportunity*" "*as soon as possible*".
- Three respondents mentioned sector-specific targets. Of these, one public body respondent particularly recommended an ammonia target, as emissions are decreasing very slowly. An NGO respondent asked for no-one sector to get special dispensation from any targets.
- Three respondents mentioned spatial scales. A professional body respondent supported an "*industry-led approach*" to "*target percent improvements at a farm level*", "*against national benchmarks by farming sector*". A NGO would prefer targets at national and regional scales, using RLUPs "*as forums for identification and delivery of regional opportunities, priorities and synergies*" to drive regional actions with farmers, landowners and communities working together, in support of overall achievement of nitrogen, air quality and climate targets. Another NGO recommended targets at a range of scales (and sectors).

Evidence needs for and concerns about setting of targets

Another theme in the responses to this question was on appropriate evidence to support the setting of targets, i.e. the need for accurate information and a meaningful baseline as essential for informing targets (one business, one public body, two professional bodies, one NGO).

There were also some wider concerns around the setting of targets, regarding the lack of detailed/high-resolution agricultural practice data (one professional organisation, one business), extreme/uncontrollable weather patterns thwarting targets (one academic respondent), and inappropriate targets (one professional body). The latter emphasised the importance of taking account of specific farm types (e.g. dairy vs arable) for appropriate targets, with negative nitrogen balances having production implications.

Linking of targets related to the SNBS with other policy areas and targets

Five respondents (three NGOs, one public body, one business) related future targets linked to the SNBS to other policies and targets, either specifically or generically. More generically, a business respondent pointed out that the SNBS needs to be

sensitive to the impacts it is measuring, i.e. monitoring of policy impacts must be possible to gauge effectiveness.

Four respondents (three NGOs, one public body) referred to the SNBS as either enabling an integrated approach to multiple policy areas (which are currently seen as largely separate) or as helpful for demonstrating the wider public benefit of linking up nitrogen issues across sectors of the economy and environment.

These respondents related the SNBS to targets for greenhouse gas emissions (which cause climate change). Two respondents referred to biodiversity targets, four to air quality, three to water quality/diffuse pollution, and one to human health. One respondent (NGO) specifically mentioned that targets would focus efforts towards the 2021 COP climate talks and demonstrate that the Scottish Government is serious about this.

One respondent (professional body) offered alternative/additional initiatives to target setting, suggesting that “*the primary role of the balance sheet should be as a mechanism to chart progress*”. They mentioned a range of existing initiatives to improve key nitrogen performance indicators, where progress could be achieved through combining support, professional advice alongside continuous professional development. They are currently working with partners across the agriculture sector to achieve better nutrient [i.e. not only nitrogen] balance through a more holistic approach that takes into account productivity, soil health, biodiversity and emission reduction. The following key performance indicators were suggested: farm nutrient balance, NUE and feed conversion rate. The same respondent was keen to avoid national level agricultural targets that may create unintended consequences at the farm level (response to Question 1b included here).

Another respondent (business) expressed concern that the SNBS would “*turn out to be a stick to beat certain industries with. It would be much better long term to provide carrot type encouragement to elicit improvement*” (response to Question 1b included here)

4.4 Making the Scottish Nitrogen Balance Sheet as accessible as possible

Respondents were asked to indicate to what extent they agreed with the proposed approach by the Scottish Government (Question 4a), and to provide any explanations for their response and further comments (Question 4b). The Scottish Government's proposed approach was set out as follows:

The Scottish Government proposes that, in order to make the SNBS as user friendly as possible, the outputs should also include a suite of non-technical factsheets. These should set out the key findings on nitrogen use efficiency at national and sector by sector scales.

Our intention is that these factsheets will help with broader understanding of the crosscutting nature of nitrogen across the economy and the environment, and help to support the wider development of joined-up strategies and policy measures. Where possible, the factsheets could include relevant contextual information alongside the nitrogen flow data themselves - for example on the impacts associated with nitrogen losses.

Do you have any changes you would like to suggest and/or any other comments? In particular, are there any other outputs you would like to see?

There were 26 responses to the first part of the question (4a). All 26 respondents who answered this question either fully or partly supported the proposed scope of the SNBS, in terms of the proposed spatial resolution for the SNBS. Of those who answered the question, 19 (73%) % fully agreed and 7 (27%) agreed to some extent.

Option	Total	% of all respondents	% of those who answered the question
fully support the proposal	19	70%	73%
support the proposal to some extent	7	26%	27%
not support the proposal	0	-	-
don't know/don't have an opinion	0	-	-
not answered	1	4%	n/a

There were 16 responses to the second part of the question (4b), four from individual respondents and 12 from organisational respondents.

All respondents that mentioned the proposed fact sheets (14 out of 16) explicitly supported these as a means to make the SNBS more accessible. The further comments provided either referred to the content and style of the factsheets (11 respondents), suggestions for additional communications or dissemination (eight respondents), or policy aspects (three respondents).

Content of the proposed factsheets

In terms of content of the proposed factsheets, twelve respondents offered a wide range of suggestions for inclusion of information, which are summarised as follows:

- Opportunities/measures to reduce nitrogen losses (specifically mentioned were NUE improvement for different farming systems; case study examples for farmers; practical issues where compromises might be needed to avoid unintentional consequences; nuances between farming practices and identifying sources of waste and unintended emissions/losses)
- Impacts of nitrogen losses on human health and ecosystems
- Cost to society and the economy of inefficient nitrogen use and wider benefits of improvements (e.g. cost savings for farms; benefits to water and air quality)
- Time series (current state as well as long/short term trends)
- All sectors, and interactions between sectors
- National level indicators and figures as well as subnational details for specific policy areas as well as local scale case studies to show relevance
- An explanation how the timing mismatch of incoming data (time lag of reporting) will be resolved (this suggestion was made under Question 5).

Style of the proposed factsheets

Regarding the style of the factsheets, the following suggestions were made (four respondents, one professional body, three NGOs):

- A crucial purpose is to improve nitrogen literacy and therefore climate and health literacy
- Fact sheets should be accessible and benefit a wide range of non-specialists. Fact sheets should be sufficiently technical/detailed to inspire action.
- Transparency is important to increase understanding.
- To increase accessibility, rows of numbers and tables are not helpful. For those already aware, diagrams such as those in the report to SEPA⁴ [e.g. Figure 3 as referenced in the consultation paper] are a “*great visualisation*”, however for anybody new to the subject or a single sector interest this may be to intimidating, and the realities of what is shown may not be obvious.

Additional ideas for communicating the SNBS

The following suggestions for additional ways to communicate the SNBS were made, beyond the proposed fact sheets, by eight respondents (one public body, two academics, three NGOs, one business, one professional body):

- Public information/dissemination:
 - Information regarding consumer behaviour (diet, waste, transport, etc)
 - Improve climate literacy across all parts and sectors of Scottish society
 - Wider educational activities to increase nitrogen literacy
 - Make information as widely available as possible to help wider public understanding of the underlying importance of managing the nitrogen problem
- Other materials/pathways:
 - Incorporation of different forms of nitrogen (ammonia, NO_x) and impacts on human health and the environment, e.g. via the Scottish Government’s Air Quality website

⁴ [A nitrogen budget for Scotland. UKCEH report to SEPA: Carnell et al. \(2019\)](#)

- Attractively designed case studies of successful mitigation (including videos, podcasts, etc.)
- Investment in a programme of dissemination and stakeholder engagement tailored to key sectors and the general public (as recommended by the independent CAfS review)
- Farm advisory service and peer-to-peer knowledge exchange (example Scottish Beef Climate Group and similar groups under development) including ammonia emission reduction, and promotion of best practice for those not subject to permits
- Opportunities to engage with the farming sector in a more integrated way to improve nutrient management and reduce losses to air, water and ecosystems, based around a coherent package of advice, support and regulations covering all nutrient cycling including nitrogen, carbon, phosphorus and sulphur and impacts on air quality, water quality and greenhouse gases
- A role for farmer-led groups, as proposed by the Scottish Government under CAfS-2, bringing farmers together for increasing understanding
- Repurpose farm advisory services and upskill to provide relevant information on funding and practices for sustainable farming, and as part of this provide training in the SNBS and use it to identify opportunities (Scottish Link manifesto)
- Tools and modelling:
 - Something more integrated with farmer advisory systems and decision support (e.g. online tools)
 - Scenario modelling to answer “what if” questions
 - An interactive version of the SNBS (e.g. using SpotFire on SEWEB) to allow students and policy makers to explore the impacts of different interventions

Policy-related comments

More policy-related suggestions for additional actions were made by three respondents (one NGO, one professional body, one academic)

- Setting boundaries for local actions via RLUPs and related regional capacity building to take such actions (academic respondent)
- Support for development of joined-up strategies and policies, such as advice and incentives, including capital grant schemes, after identification of nitrogen flows and impacts, thereby reducing waste and nitrogen losses (NGO respondent)
- Proposal for working with the Scottish Government on communication and understanding of wider nitrogen policy and ability to maintain agricultural productivity (professional body)

4.5 How often should the Scottish Nitrogen Balance Sheet be updated?

Respondents were asked to indicate to what extent they agreed with the proposed approach by the Scottish Government (Question 5a), and to provide any explanations for their response and further comments (Question 5b). The Scottish Government's proposed approach was set out as follows:

The Scottish Government proposes that the frequency of review and updating of the SNBS should be annual, following its initial establishment by March 2022. Annual updates would match reporting cycles for other key datasets, such as agricultural census/survey data, the UK National Atmospheric Emission Inventory and the Scottish Pollutant Release Inventory. However, not all of the data will be available on an annual basis. This means that the largest nitrogen flows and those expected to change most over time will need to be prioritised in the updates, with very small flows potentially being updated on a less frequent cycle.

Do you have any changes you would like to suggest and/or any other comments? In particular, if you do not support the proposed annual update frequency, please say which frequency you would prefer.

There were 26 responses to the first part of the question (5a). 25 of the 26 respondents who answered this question (96%) either fully or partly supported the proposed scope of the SNBS, in terms of the proposed spatial resolution for the SNBS. Of those who answered the question, 19 (73%) fully agreed and 6 (23%) agreed to some extent, with one respondent (4%) not supporting the proposal.

Option	Total	% of all respondents	% of those who answered the question
fully support the proposal	19	70%	73%
support the proposal to some extent	6	22%	23%
not support the proposal	1	4%	4%
don't know/don't have an opinion	0	-	-
not answered	1	4%	n/a

There were 18 responses to the second part of the question (5b), four from individual respondents and 14 from organisational respondents.

Eleven respondents provided additional comments on the time frame for review and updates of the SNBS, with further themes emerging on reporting time lags, resources/data collection, the reporting process, links between the reporting cycle and policy/policy cycles.

Time frames for reviewing the SNBS

Comments on the time frame for review (11 respondents) can be grouped into the following categories:

- Annual reporting is welcome/essential/useful for understanding trends and/or provides a sense of continuity (eight respondents; four NGOs, one academic, two professional organisations, one public body)
- Annual reporting is only appropriate after a baseline of 3-5 years has first been collected – specifically referring to some nutrient/farming practice cycles that take longer than one year, such as rotations (one professional body)
- Annual reporting is over-ambitious with NUE improvements a slow process (one business respondent)
- Only headline data should be reported annually, using a proportionate effort; resources are only justifiable for longer reporting cycles on complex granular processes; less critical flows could be reported less often (one business respondent)

Reporting time lags, timeliness and uncertainties

Five respondents commented on a reporting time lag (two academic, two professional bodies, one business) and other issues with uncertainty, continuity and timeliness:

- Acknowledgement of lags between actions and reporting – this is similar to other reporting cycles, such as emission inventory reporting, where data processing introduces further time lags (one academic respondent, one business respondent).
- Concerns about a mismatch in timing for NUE calculations (due to reporting schedules (one professional body). This should be addressed in the fact sheets (see Question 4), i.e. how the timing mismatch of incoming data will be resolved.
- Concerns about inherent variability between years, due to the impact of climate, with no two seasons being the same (one professional body, one academic respondent). The professional body respondent suggests that a multi-year database would be needed to allow for variability. The academic respondent refers to annual measurement data from SEPA (SPRI) and OSPAR (run-off) annually, which show high year-on-year variability of loadings.

Data collection and resources for regular updates

Five respondents (two business, one professional body, one NGO, one academic) mentioned different aspects of associated data collection and related resources:

- The requirement for robust and reliable systems for data collection (professional body)
- Data collection should be investigated in partnership with industry (the same professional body)
- Concern about reporting burden for sectors (business)
- A suggestion to prioritise the largest flows if necessary (NGO)
- One academic respondent suggests that once annual data collection is in place, reporting should become routine, and relatively fast and inexpensive.
- The balance equation [assuming this refers to the soil nutrient balance which is mentioned specifically by this respondent] does not reflect important farm practices due to lack of data (business respondent)

Reporting process

Six respondents commented further on the reporting process:

- The frequency of updates for smaller flows needs to be defined from the outset (one NGO)
- Frequency of reporting should not be at the expense of increased granularity (one public body)
- It is important that the direction of travel is also indicated, not only the largest flows (reflecting the nitrogen cycle) (one professional body)
- Reporting should be done without requiring calculations by the reporter to improve accuracy [interpreted here to mean that any primary data collection should focus on original information rather than asking for derived data, and any follow-on calculations should be carried out within the SNBS system] (one business)
- The process should be reviewed, with any data limitations identified and then addressed urgently (one NGO)
- Data collection should be tested before committing to annual reporting (one professional body)

Links between the reporting cycle and wider policy cycles

Five respondents commented on links between the reporting cycle and wider policy cycles:

- Recommending an alignment of the review of climate change targets and Plans (with SNBS updates, to inform required policy changes (two NGO respondents)
- Dovetailing with the GHG emissions reporting time frames (one academic respondent)
- Recommending an annual update to Parliament and a related document that is publicly accessible in format, language and dissemination (one NGO respondent)
- The SNBS needs to be sensitive to policies whose impacts are being measured (one business respondent).

Wider usability of any higher resolution datasets

One further comment was provided that did not readily fit into the above themes:

- Any detailed data collected will be useful to both the Scottish Government and businesses to help with decision making. The data could be used to provide support, advice and tools to industry to improve NUE (professional body respondent)

4.6 Any other comments

This question was to capture any other comments related to the establishment of the SNBS and was phrased as follows:

Is there anything else you would like to suggest or comment on that has not been covered by the previous questions?

There were 16 responses to this question, four from individual respondents and 12 from organisational respondents. These covered a range of topics, with the primary theme related to wider policy and measures (12 respondents; three professional bodies, one public body, five NGOs, one business, two academic). Other themes included further comments on targets (two responses), the evidence base (one response), data collection burden (one response), data gaps (one response), time series (one response), the nutrient balance approach in general (one response), presentation/accessibility (one response) and offers of collaboration/assistance (two respondents).

Wider policy linkages and implications

Seven respondents pointed out opportunities for more holistic policy making:

- The SNBS provides an opportunity to identify “*cross-benefits or trade-offs of related policy-making in terms of other pollutants (such as phosphates and sulphur) and the carbon and water cycles. Although the SNBS represents a step forward in more holistic policy-making, this in itself cannot be considered in isolation from these other elements of healthy ecosystem functioning, public health and climate change*” (one NGO respondent).
- An academic respondent made a similar point, linking to policy objectives related to biodiversity loss, climate change, water and air quality.
- Another NGO respondent referred to the SNBS as an “*ideal opportunity to create new ways of managing nitrogen across Scotland with the aim of contributing to reduced climate change, positive farmers' livelihoods, healthy ecosystems, great soil health and excellent human health.*”
- A NGO respondent also mentioned that spatial planning and environmental permitting systems should be considered and relevant stakeholders engaged in the SNBS development process.
- The SNBS “*could play an important role in informing future air quality policy and future farming policy (including post-2024 agricultural funding). There may also be opportunity to inform land use policy, and the SNBS should reflect Scottish Government commitment to the RLUP by considering these when establishing the SNBS scope, spatial scale, targets and accessibility.*” (NGO respondent).
- One NGO requested that the Scottish Government should utilise the SNBS for human health benefit as well as for environmental benefit. They commented on the link with the concurrent CAFS-2 consultation and state that “*CAFS 2 is currently not strong enough on reducing the levels of vehicles on our roads and as such this will make it harder to achieve the aims and targets of this balance sheet*”.

- An academic respondent made a link with education policy and suggested that nitrogen pollution should be included in the school curriculum.

Comments on specific policy measures

The comments on the theme of specific policy measures associated with nitrogen management (five respondents) can be summarised as follows:

- The creation of the SNBS is a “*necessary step towards reducing nitrogen losses in both policy and practice*” (one NGO). Similarly, another NGO refers to the SNBS as a first step towards making both positive and negative impacts of nitrogen “*visible to those who have power over its management*”. [...] “*Nitrogen is everywhere but invisible.*”
- It would be helpful if “*the strategy could explore farm management opportunities to increase nitrogen use efficiency and reduce losses. There are many management interventions that could help achieve this (e.g. the wider use of legumes in farming systems) that should be explicitly developed within this proposal*” (one academic respondent).
- Measures have the potential to result in unintended consequences, and it is important that the Scottish Government is “*cognisant when considering actions arising from the SNBS*” (one professional body)
- An NGO respondent referred to current measures related to Nitrate Vulnerable Zones as “*disliked by the farming community, and have not shown to produce the intended results, nor were they designed with the issue of reducing greenhouse gas emissions in mind.*”
- A public body highlighted tree belts as a potential measure for recapturing ammonia emissions near sources while acknowledging that reduction of emissions at source should be prioritised over recapturing pollutants that have already been emitted. The respondent suggested that it “*would be useful to explore whether the role of trees on farms could be accounted for in the SNBS*” and referred to additional benefits tree planting could bring, such as reduced soil erosion and improved biodiversity, depending on the location and the tree species.

Support for industry on nitrogen issues and offers of assistance by respondents

Two respondents (professional bodies) highlighted the need for support to help industry make progress with nitrogen issues, specifically the “*cost associated with reducing and improving nitrogen use on farm*”. Concern was expressed about future policies that may increase regulatory and cost burdens on agricultural businesses and that this would “*create further barriers for Scotland’s farmers, crofters, and growers in adapting to climate change against an already-challenging financial backdrop.*”⁵

In particular, grant schemes were highlighted, such as the Sustainable Agriculture Capital Grants Scheme, and an ask for these to “*broaden their focus to other*

⁵ Agricultural businesses within Scotland were estimated to make a loss of around £9000 in 2018/2019 [[Scottish Government, Farm Business Survey 2018 – 2019](#)]. Operating in such circumstances has been reported to limit optimism, investment, innovation, and employment opportunities and it is therefore essential that no unnecessary financial burden is placed on farm businesses because of rapid changes required [[NFU Scotland, Brexit Survey Shows Ongoing Uncertainty is Eroding Confidence Levels in Scottish Agriculture](#)].

solutions that can improve the nitrogen cycle on farm". In this context, a respondent also wished to ensure a *"level playing field in terms of environmental regulation in comparison to other third countries"*.

Another professional body highlighted their willingness to invest in environmental wellbeing, in tandem with economic and social wellbeing.

In terms of specific policy tool requests linked to the SNBS, a business respondent stated that would be very keen to get a harmonized, practical approach for farmers to calculate their NUE established.

Two respondents offered assistance to the Scottish Government, on waste management (professional body) and in understanding of the effects of air quality on public health (NGO).

Further comments on targets

Two respondents provided further comments on targets (linked to Question 3):

- A NGO respondent reiterated their ask for a NUE target to be set as part of a process in which the SNBS is the first step.
- An academic respondent asked the Scottish Government to clarify on their approach to targets, saying that it is no clear from the proposal set out for Question 3 as to *"what targets are being proposed and what activities might be recommended in order to achieve any proposed targets"*.

Other comments (visualisation, data collection burden)

One respondent (NGO) provided further comments on the eventual visualisation of the SNBS but appreciated that the work to produce the more detailed SNBS is still ongoing. In particular, they emphasised that they would like to see a more detailed representation of nitrogen flows affecting terrestrial and aquatic ecosystems than is provided in the currently available diagram shown in the 2019 report to SEPA⁶ (and referred to in the consultation paper).

One respondent (professional body) noted a potential data collection burden, i.e. *"the consultation does not set out whether there is expected to be any additional reporting or monitoring obligations required so as to produce the Scottish Nitrogen Balance Sheet (SNBS)." Setting out the example of the current obligation for farmers to report for Nitrate Vulnerable Zones on farmland in Scotland, they "would favour simplicity in any additional reporting or monitoring obligations so as not to increase the burden on individuals and businesses to provide data"*.

Other comments (data/evidence needs)

Four respondents (one academic, one professional organisation, two businesses) provided further comments on data/evidence needs:

- One respondent (business) commented that there *"are substantial areas of the SNBS that warrant further investigation to complete the understanding of nitrogen flows between sectors, and to fill data gaps"*.

⁶ [A nitrogen budget for Scotland. UKCEH report to SEPA: Carnell et al. \(2019\)](#)

- A professional organisation respondent emphasised the need for firm data and evidence to underpin policy frameworks, and welcomes the establishment of the SNBS to provide this evidence base.
- An academic respondent summarised their experience of work for the River Purification Boards (RPB) and SEPA in terms of catchment scale nitrogen flows and loadings to coastal waters, the different forms of nitrogen (ammonia, nitrate, total nitrogen including dissolved and particulate forms) under high and low flow rates) and available data sources (including the SPRI and NAEI). The respondent also commented on the approach taken in the UKCEH report to SEPA⁶ and advocated using measured flows and concentration data instead of using the LTLS-IM model where available. The respondent agreed that more research on Biological Nitrogen Fixation is needed to quantify this nitrogen flow reliably.
- A business respondent commented that a clear distinction will need to be made in future SNBS time series between revisions of a coefficient to provide a better estimate and any updates that reflect genuine changes. They recommended that any improved coefficients would need to be applied retrospectively to historic data to produce a consistent time series.

One respondent (business) critiqued the balance sheet approach for calculating nitrogen surpluses (that can be lost to air or water) which does not quantify these loss pathways or eventual impacts. The respondent described an approach for the detailed estimation of losses that takes into account a wide range of data on farm practices, soil management and environmental data, and provided examples of uncertainties and spatial variability in these data which influence the nitrogen balance.

Annex 1: Organisational respondents

J K Playfair and sons	Business
Scottish Agronomy Ltd	Business
Shetland Islands Council	Local authority
The National Trust for Scotland	NGO
RSPB Scotland	NGO
Asthma UK and British Lung Foundation Partnership	NGO
WWF Scotland	NGO
Stop Climate Chaos Scotland	NGO
Friends of the Earth Scotland	NGO
Nourish Scotland	NGO
Plantlife Scotland	NGO
Road Haulage Association (RHA)	Professional body
NFU Scotland	Professional body
CWM Scotland Centre (Chartered Institution of Wastes Management)	Professional body
AIC Scotland (Agricultural Industries Confederation Scotland)	Professional body
Scottish Salmon Producers' Organisation	Professional body
Association of Independent Crop Consultants	Professional body
Law Society of Scotland	Professional body
NatureScot	Public body

Annex 2: Acronyms used

AQMA	Air Quality Management Area
NH ₃	Ammonia
NO _x	Oxides of nitrogen
N ₂	Di-nitrogen
RLUP	Regional Land Use Partnerships
SNBS	Scottish Nitrogen Balance Sheet
NGO	Non-governmental Organisation
COP/COP26	Conference of the Parties, attended by countries that signed the United Nations Framework Convention on Climate Change (UNFCCC) - a treaty agreed in 1994. The 2021 meeting in Glasgow will be the 26 th meeting.
CAfS	Cleaner Air for Scotland
SEPA	Scottish Environmental Protection Agency
HGV	Heavy Goods Vehicle
NUE	Nitrogen Use Efficiency
SEWEB	Scotland's environment web
NAEI	National Atmospheric Emission Inventory
SPRI	Scottish Pollutant Release Inventory
RPB	River Purification Boards
UKCEH	UK Centre for Ecology & Hydrology
LTLS-IM	Long-Term Large-Scale Integrated Model

Annex 3: Summary report of stakeholder engagement events (October 2020) preceding the consultation

Stage 1 - initial workshops

- Fri 2 October, 13:30-15:30 focussed on agriculture / land management
- Tue 6 October, 15:00-17:00 focussed on environment / waste
- Fri 9 October, 14:00-16:00 focussed on air quality / transport

Summary of themes raised across the three sessions:

1. Overall there was a very positive response from all participants on the principles of the new evidence base being collated for a national Nitrogen Balance Sheet (SNBS) for Scotland. Most stakeholder representatives explicitly welcomed the establishment of a SNBS and indicated that they are keen to engage with the process. Many stakeholders also noted that they are already raising awareness of nitrogen use efficiency (NUE) and working towards increasing NUE.
2. **Joining up with wider policy structures and strategies** - There was a wide consensus on the importance of joining up between the SNBS and a range of other national policy, regulatory and advice structures (across agriculture, transport and a range of other areas).
3. **Spatial granularity** - Many participants noted that a higher spatial resolution than national / regional (e.g. river catchment / landscape and/or farm scale) would be desirable for the SNBS at some point. Whilst there was recognition that the current statutory requirement and time-constraints mean that a focus on a “top-down” national scale is necessary for the establishment phase of the NBS, this needs to be able to dovetail with any more detailed bottom-up approaches in the future.
4. **Frequency of updates** - Several stakeholders expressed views in favour of annual updates, once the SNBS is established, noting that this would match reporting cycles for other key datasets (e.g. agricultural census/survey data; UK National Atmospheric Emission Inventory; Scottish Pollutant Release Inventory (SPRI)). There were also suggestions to prioritise the largest nitrogen flows and those most expected to change over time, with others perhaps on a less frequent update cycle.
5. **Targets for increasing nitrogen use efficiency** - Some stakeholders suggested that such targets would likely be helpful at some point, but that the baseline evidence needs to be established first.
6. **Presentation and content of SNBS outputs**
 - Accessibility – Some stakeholders expressed a desire for SNBS outputs to be as accessible as possible (including for the wider public), to help with wider understanding of the cross-cutting nature of nitrogen across all sectors of the economy and the environment, and for developing joined-up strategies and measures.
 - Additional functions / content elements for the SNBS:
 - Some stakeholders suggested including information on impacts (financial and otherwise) alongside the actual N flows. Examples mentioned were the savings potential to sectors from reducing nitrogen losses, or

mitigation measures and associated cost curves (MACCs) to determine the most effective strategies.

- Across a range of sectoral stakeholders, there was an interest for “sub-sectoral” level values for NUE to be available from the SNBS (e.g. the NUE associated with different types of businesses within agricultural sectors, such as intensive/extensive systems)
- One stakeholder queried whether the NBS could, at some stage, be extended to include scenario modelling functions to explore policy interventions.

7. Specific/technical points raised

- The definitions of the external system boundaries were mentioned by several stakeholders (e.g. for marine/coastal systems, import/export such as livestock feed/food)
- A range of specific data sources suggested for checking/potential inclusion (e.g. urea use for de-icing, N emissions from rocket launches, fishery discards)
- [One stakeholder suggested consideration of a different acronym (to avoid confusion with Nature Based Solutions)]. *N.B. This has been addressed, with the acronym changed from NBS to SNBS.*



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