

A NITROGEN BALANCE SHEET FOR SCOTLAND

Quantifying nitrogen flows
across the economy and
environment

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EPNB

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Vienna & online



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Establishing a Scottish
Nitrogen Balance Sheet

December 2021



 Scottish Government
Riaghataas na h-Alba
gov.scot

Scottish Government – statutory requirement

Climate Change (Emissions Reduction Targets) (Scotland) Act 2019

8A Nitrogen balance sheet

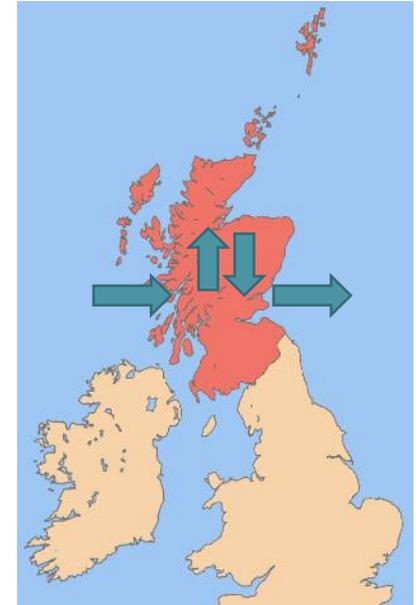
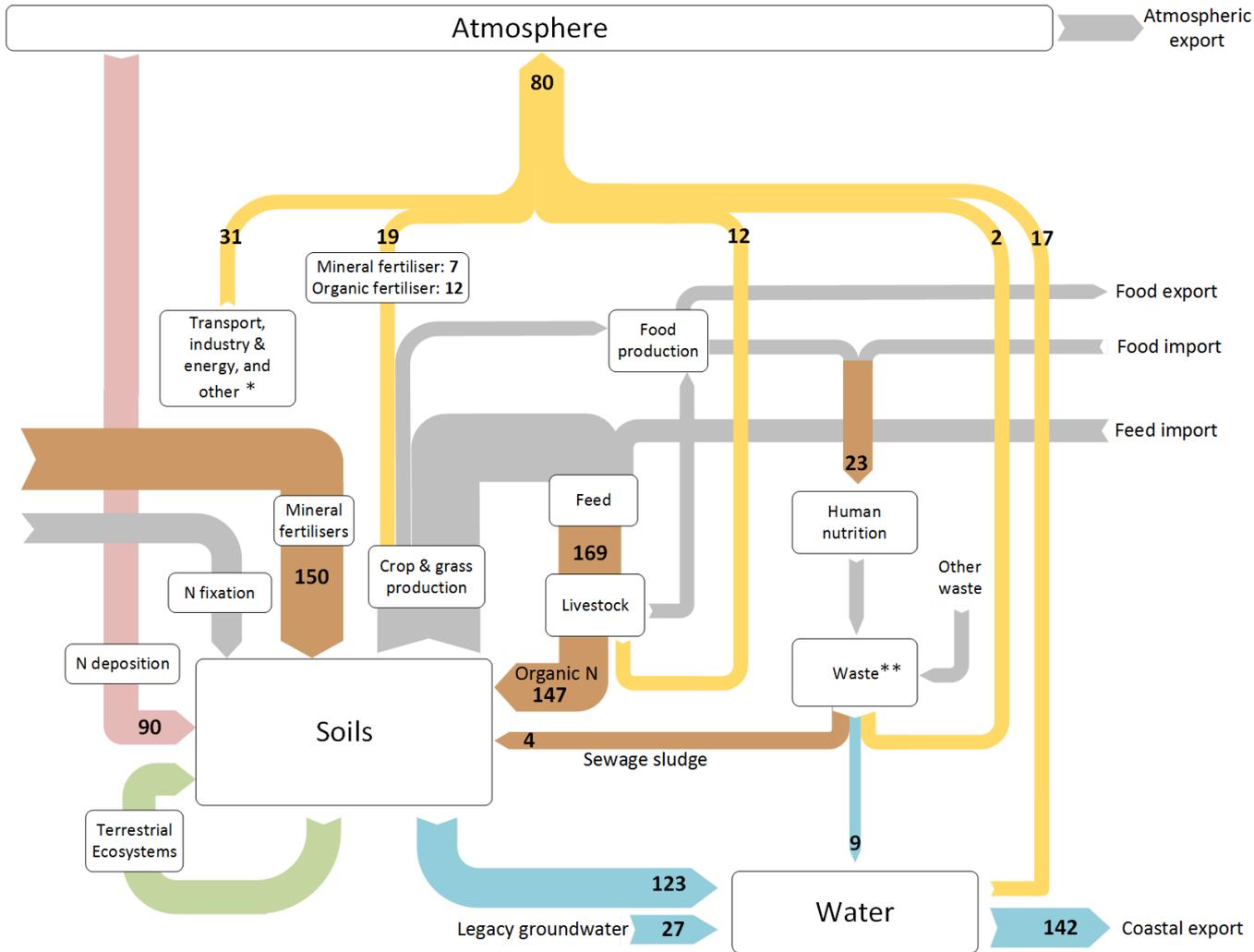


- (1) The Scottish Ministers must, no later than 18 months after this section comes into force, create a balance sheet to quantify all major nitrogen flows across all sectors and media in Scotland, including its coastal waters, the atmosphere and soil and flows across these boundaries, to be known as a “nitrogen balance sheet” for the purpose mentioned in subsection (2).
- (2) The purpose of the nitrogen balance sheet is to record how nitrogen use efficiency contributes to achieving the targets in this Act.
- (3) The Scottish Ministers must by regulations make provision for—
 - (a) a baseline figure for nitrogen use efficiency,
 - (b) how nitrogen use efficiency is to be calculated,
 - (c) the timescale in which the nitrogen balance sheet is to be reviewed,
 - (d) monitoring and reporting upon the nitrogen balance sheet,
 - (e) such other matters as they consider appropriate.
- (4) The Scottish Ministers must, before laying draft regulations under subsection (3) before the Scottish Parliament, consult such persons as they consider appropriate.
- (5) In this Act “nitrogen use efficiency” means the ratio of nitrogen removed from the environment compared to total nitrogen inputs.
- (6) For the purposes of assessing the ratio mentioned in subsection (5), account should be taken of sources of nitrogen pollution, including—
 - (a) food production and waste,
 - (b) energy, and
 - (c) transport.”.

SNBS supports progress towards Scotland’s national GHG emission reduction targets

Potential to support a wide range of policy applications

Following on from an earlier first attempt...



UKCEH report to SEPA (2019): A Nitrogen Budget for Scotland
 Carnell E.J., Thomas I.N., Tomlinson S.J., Bell V.A., May L., Skiba U., Dore A.J., Eory V., Dragosits U.

Methodology – international guidance

Key source of guidance

UNECE CLRTAP TFRN Expert Panel on Nitrogen Budgets (EPNB)

- UNECE (2013) guidance document on national nitrogen budgets
- UNECE (2021) draft detailed annexes to the guidance document

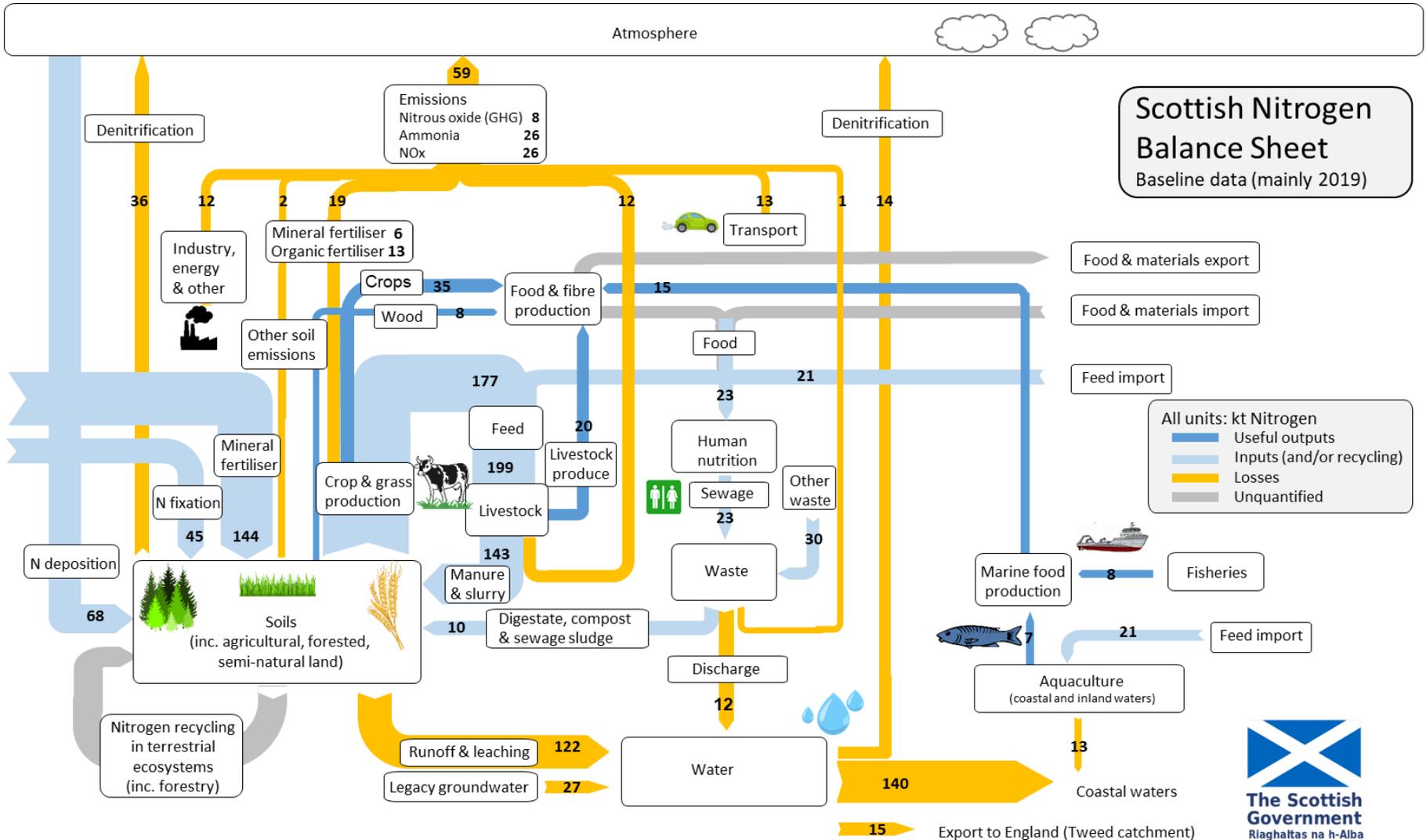
Other methodologies/guidance

- Existing NNBs: Germany, Japan, ENA (country examples inc. UK)
- Other international guidance, e.g.
 - OECD paper Bleeker et al. (2013) – whole-economy NUE
 - EUROSTAT/OECD (2013) Nutrient Budgets Handbook

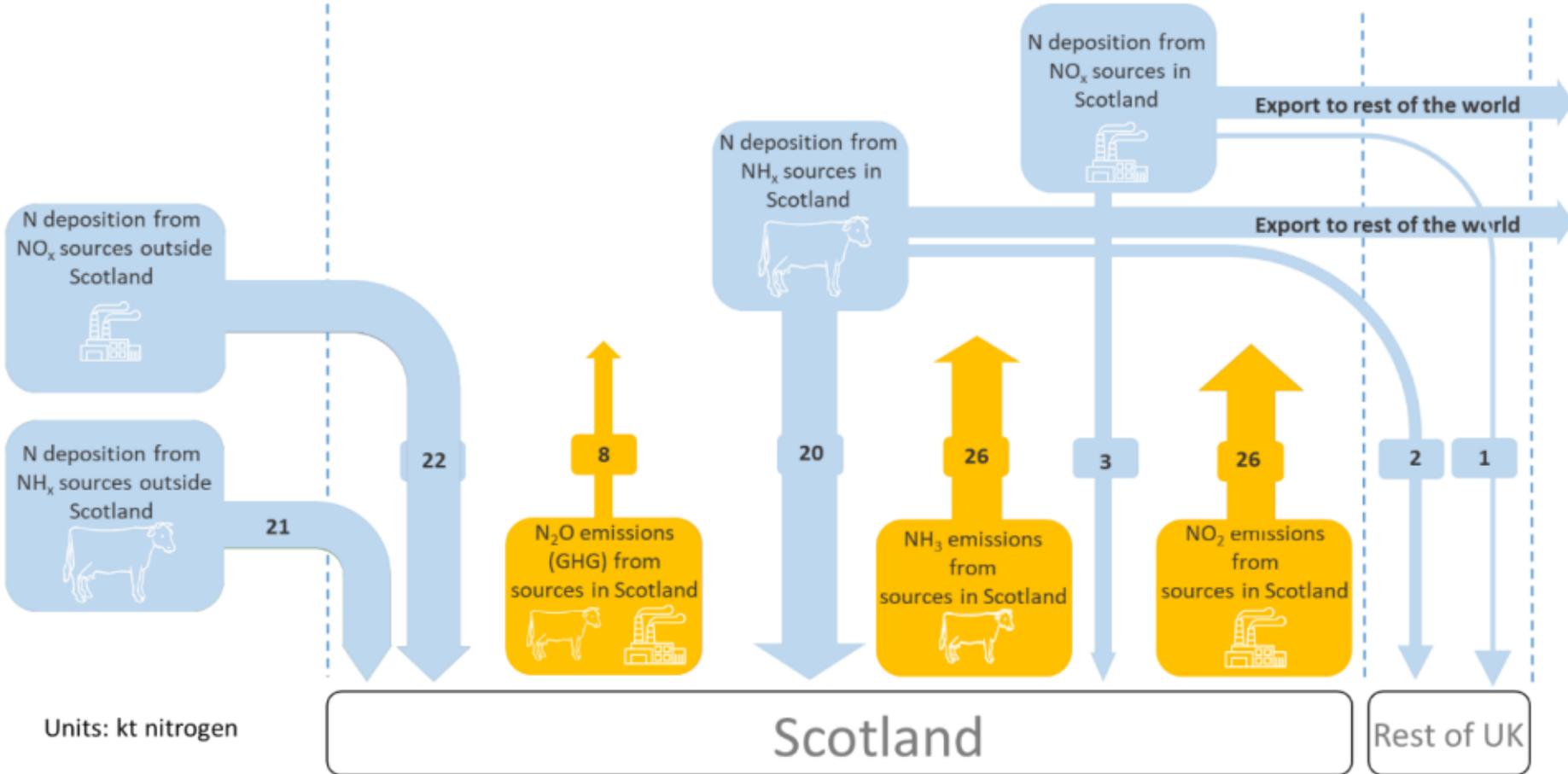
Methodology – data sources for N flows

- Use publicly available statistics where possible (e.g., agriculture, transport, energy)
- Build on existing regularly produced national datasets where available
 - UK National Atmospheric Emission Inventory including GHG inventory (NAEI, naei.beis.gov.uk) following international reporting conventions
 - Gross Nutrient Budgets (OECD countries)
 - SEPA Scottish Pollution Release Inventory (SPRI)
 - Material Flow Accounts
- Use other published data (e.g., periodic publications, peer review literature)
- Use best estimates (expert knowledge) where detailed data are not available
- Use default “Tier 1” tables as last resort

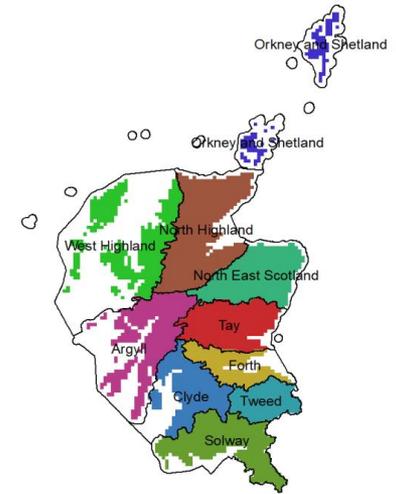
Scottish Nitrogen Balance Sheet – Version 1



SNBS – Atmosphere exchange

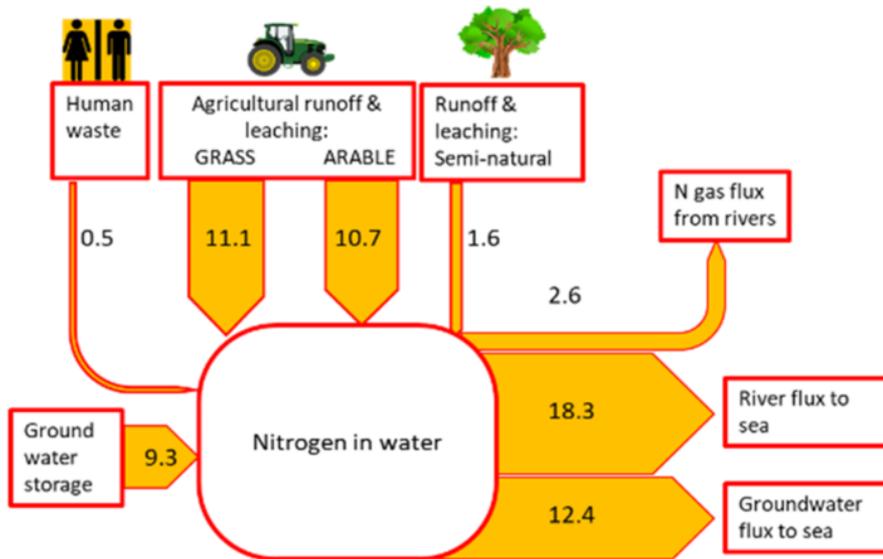


SNBS – Hydrological flows

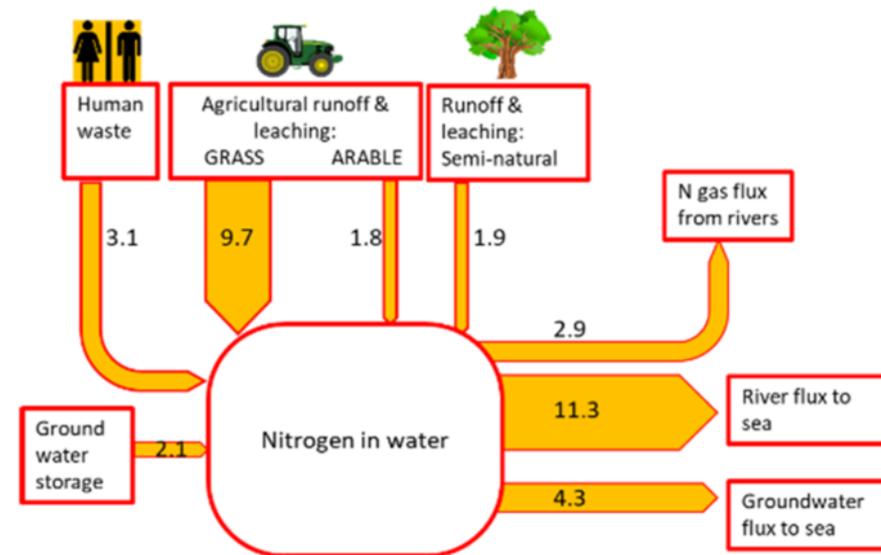


Water Framework Directive: Sub-basin Districts/Area Advisory Group boundaries

NE Scotland



Clyde



Nitrogen Use Efficiency (NUE) metrics

- NUE is the ratio (expressed as a percentage) of useful nitrogen-containing outputs to all nitrogen inputs

$$NUE = \frac{N \text{ outputs}}{N \text{ inputs}} \times 100\%$$

- NUE is often calculated at the level of individual economic sectors (e.g. crop production, food production) or at a whole-economy scale (more novel)
- System boundaries matter (definition of input/output/recycling terms)
- **SNBS**
 - Crop production NUE
 - Livestock production NUE (simple feed conversion)
 - Whole-agriculture NUE
 - Aquaculture NUE
 - All food production NUE
 - Whole-economy NUE

Crop production NUE Scotland (~2019)

Inputs to arable land	kt N
mineral fertiliser	62.1
slurry/manure	17.8
atmospheric N deposition	4.0
seeds (sowing/planting)	1.7
digestate (non-crop/crop waste feedstocks only)	1.7
Biological N fixation (BNF) by arable crops	1.6
sewage sludge	1.2
Compost	0.9
total N inputs	90.2

Useful outputs	kt N
Food crops (inc. human-edible crops that end up as livestock feed, seed materials or biomass)	56.3
Fodder crops harvested (turnips, kale etc.)	1.9
total N outputs	58.2

Recycling terms (not included in either inputs or outputs for the purpose of this NUE calculation):

digestate from crops, crop residues

NUE = 65%

Nitrogen Use Efficiency (NUE) metrics

- Crop production NUE – 65%
- Livestock production NUE (simple feed conversion) – ~10%
 - Whole-agriculture NUE – 27%
 - Aquaculture NUE – 34%
 - All food production NUE – 28%
 - Whole-economy NUE – 25%

Inputs (at whole-economy level)	kt N	Useful outputs	kt N
mineral fertiliser (all land)	143.8	harvest (as food, excl human-edible crops used as livestock feed or seed)	34.8
biological N fixation (all land)	45.0	livestock produce (milk, eggs, meat, wool)	19.6
atmospheric N deposition (imported NOx + NHx only)	44.5	import: fishery landings	8.4 ²⁷
NOx emissions from fuel burnt in Scotland (to account for transport & energy)	24.3	Forestry harvest - all uses (inc. export)	7.5
livestock feed (not grown in Scotland)	21.4	aquaculture produce (finfish, shellfish)	7.3
aquaculture feed (assumed to be mostly imported)	21.3	exported materials	n/a ²⁸
import: fishery landings	8.4 ²⁷	total N outputs	77.7
import of wood	0.1		
seeds (net import)	-0.7		
import: consumer goods, food etc.	n/a ²⁸		
total N inputs	308.2		

Recycling terms (not included in either inputs or outputs for the NUE calculation):

Manure, slurry, digestate of agricultural origin, crop residues and fodder crops produced in Scotland, atmospheric N deposition (where the NOx and NH₃ originated from Scottish emissions)

NUE = 25%

Use of guidance chapters – what worked?

1. **Energy & Fuels** – approach simplified
2. **Materials & Processes in Industry** – simplified, no Haber-Bosch in Sc; import/export data very patchy/unavailable
3. **Agriculture** – simplified (not reported at livestock category & crop category resolution of the guidance document, but based on summary output from detailed agric. GHG and NH₃ emission inventory) and expert knowledge; Aquaculture treated in more detail
4. **Forest & Semi-natural Vegetation** – mix of guidance doc/German NNB/Scottish data & expert knowledge
5. **Waste** – no guidance available; used approach very similar to German NNB; additional data available from Scottish “Materials to Land” report to SEPA)
6. **Humans & Settlements** – simplified from guidance
7. **Atmosphere** – Scottish import/export/“home-made” deposition: UK modelling (“blame matrices”)
8. **Hydrosphere** – long-term UK flow modelling (spin-up 200+ years; covers all processes/N forms, but aggregated to “N” rather than split; geological delays)

National Nitrogen Budgets – what next in Scotland?

Scottish Government

Scotland is, to our knowledge, the only country in the world to have enshrined in law a **regularly updated**, cross-economy and cross-environment Nitrogen Balance Sheet (next version due 2023)

SNBS peer review paper (in progress...)