Swedish Environmental Research Institute

Swedish National Nitrogen Budget

Humans and settlements

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Summary

In this report, pool six ‘Humans and settlement’ (HS) of the Swedish National Nitrogen Budget (NNB) is presented. The Humans and settlement pool of NNB is one of the eight major pools defined by the Task Force of Reactive Nitrogen (TFRN) which together represent a total national nitrogen budget capturing all major flows of all forms of reactive nitrogen (Nr) within a country and across the country borders. The methodology to calculate NNB has been provided by the Expert Panel on Nitrogen Budgets (EPNB) in the Annexes to the ECE/EB.AIR/119 – “Guidance document on national nitrogen budgets".

The HS pool includes the sub-pools Organic world, Material world, Human body and Pets and non-agricultural animals. The major flows of Nr to and from these sub-pools were calculated for the year 2015 when data was available. Otherwise, data for adjacent years were used. The largest inflows on Nr consisted of produced food (52.6 kt N) and material products in form of wood and chemicals such as medicine, paints, plastics etc. (71.4 kt N). The largest outflows of Nr consisted of waste from material products (63.3 kt N) and from human excrement (51.5 kt N). Apart from this, flows of Nr have been calculated for net import of food and products, pet and horse food end excrement, fuelwood, fertilizers compost, garden waste, food waste etc.

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Abbreviations

Table 1. The abbreviations used in this report.

Abbreviation	**Explanation**
AG	Agriculture (Pool)
AT	Atmosphere (Pool)
FS	Forest and Semi-natural grasslands (Pool)
HS	Humans and Settlements (Pool)
HS.HB	Humans and Settlements - Human Body (Sub-pool)
HS.MW	Humans and Settlements - Material World (Sub-pool)
HS.OW	Humans and Settlements - Organic World (Sub-pool)
HS.PE	Humans and Settlements - Pets and non-agricultural animals (Sub-pool)
HY	Hydrosphere (Pool)
MP	Materials and Products (Pool)
NNB	National Nitrogen Budget
Nr	Reactive Nitrogen
RW	Rest of the World (Pool)
TFRN	Task Force on Reactive Nitrogen
EPNB	The Expert Panel on Nitrogen Budgets
WS	Waste (Pool)

1 Introduction

The Task Force on Reactive Nitrogen (TFRN) was established under the Working Group on Strategies and Review (WGSR) by the Executive Body at its twenty-fifth session in December 2007.

The purpose of TFRN has been defined as: *"The Task Force will develop in the long-term technical and scientific information and options which can be used for strategy development across the UNECE to encourage coordination of air pollution policies on nitrogen in the context of the nitrogen cycle and which may be used by other bodies outside the Convention in consideration of other control measures."* For the full terms of reference of the Task Force, see Executive Body decision 2007/1[1].

At the first meeting in Wageningen, 2008, TFRN agreed to define reactive nitrogen (Nr) as all biologically active, photochemically reactive and radiatively active N compounds in the biosphere and atmosphere. This meant, in practice, all N except N_2 gas; for example, nitric oxide, nitrogen dioxide, nitrate (NO_3^-), organic N compounds, nitrous oxide (N_2O), ammonia (NH_3) and ammonium (NH_4^+). At the same meeting it was proposed that an expert panel could help in preparing for the reporting of national budgets, first exploring methodologies and providing a reference template for the compilation. The Expert Panel on Nitrogen Budgets (EPNB) was established (first as an ad-hoc group) and commenced work to prepare guidelines for compilations of national N budgets of individual countries. EPNB prepared the "Guidance Document on National Nitrogen Budgets". The document was presented and approved at the 31st meeting of the Executive Body of the Convention on Long-Range Transboundary Air Pollution in December 2012. The document can be downloaded from http://www.clrtap-tfrn.org/sites/clrtap-tfrn.org/files/documents/EPNB_new/ECE_EB.AIR_119_ENG.pdf. After that, the work of EPNB continued to provide detailed guidelines for each of the eight main parts of the National Nitrogen Budget (NNB) summarised in Annexes to the ECE/EB.AIR/119 – "Guidance document on national nitrogen budgets". Currently the version dated 02.03.2021 is available at http://www.clrtap-tfrn.org/sites/clrtap-tfrn.org/files/documents/EPNB_new/EPNB_annex_20210302_public.pdf and it summarises seven out of the eight pools. Annex 5 Waste is still under development.

[1] https://www.unece.org/env/lrtap/executivebody/eb_decision.html

NNB have been constructed for Switzerland (Heldstab et al., 2010 and 2013), Germany (Geupel et al., 2009), Denmark (Hutchings et al., 2014) and for Canada (Clair et al., 2014). These national budget calculations have not followed the EPBN methodology as it was not available at the time but provide information on the most important flows. Bach et al. (UBA, 2020) used the TFRN Guidance document and compiled a NNB for Germany which includes all eight pools described in the document. In Europe, Sutton et al. (2011) estimated that 74% of the total input of reactive nitrogen to the environment stems from the Haber-Bosch process, 16% from combustion, and the remaining 10% from biological fixation, import of feed and products. Leip et al. (2011) calculated nitrogen fluxes for EU27 developing and using the same protocol for all countries. The study by Leip et al. (2011) also recommend development of national nitrogen budgets since the assessment and management of the budgets could become an effective tool to prioritise measures and prevent unwanted effects.

NNB following the TFRN methodology are constructed based on eight pools (Figure 1). In this report, pool 6 "Humans and settlements" for Sweden is presented. Detailed guidelines on constructing the "Humans and settlements" (HS) pool can be found in Annex 6 of the ECE/EB.AIR/119 "Guidance document on national nitrogen budgets" and will hereafter in this report be referred to as Annex 6. As described in Annex 6, HS is divided into: the organic world, the human body, pets and non-agricultural animals and the material world.

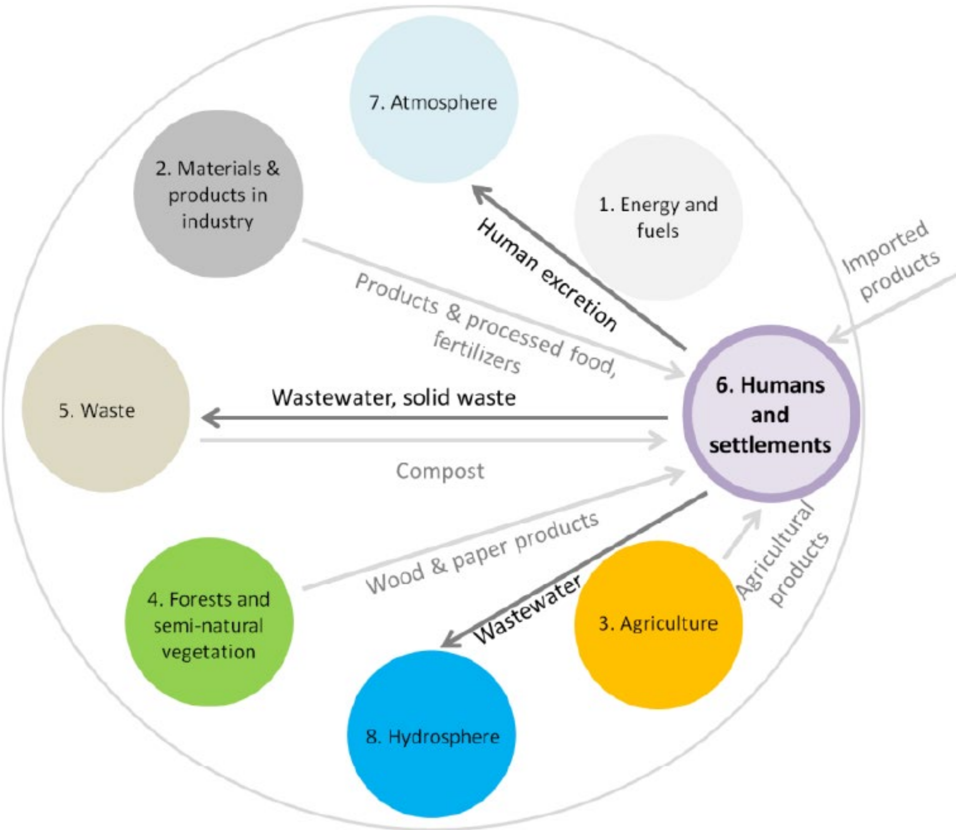

Figure 1. Flows connecting neighboring pools with Human and settlements. The figure is originally from Annex 6 and the flows in the figure represent the flows described by EPNB.

2 Methodology and results

Pool 6, Humans and settlements (HS) is divided into four sub-pools. These are the organic world (HS.OW), the human body (HS.HB), pets and non-agricultural animals (HS.PE), and the material world (HS.MW).

HS.OW represents gardens and public green spaces but also organic material such as food. Inflows of Nr to this sub-pool consists of imported and produced human food and pet feed, and fertilizers and compost for private gardens and public green spaces. Outflows of Nr from HS.OW are food and garden waste to the Waste pool (WS), and consumed human food and pet feed.

The Nr in consumed human food continues to the sub-pool HS.HB, which represents the human population. From there, the majority of Nr continues to WS as human excrement. Similarly, the Nr in consumed pet feed flows to the sub-pool HS.PE and then on to the WS and Agriculture (AG) pools. Because of the population increase there is an increase in the Nr stock in the HS.HB. Stock changes associated with the change in pet population have not been considered.

HS.MW represents products such as clothes, furniture and firewood used in private households. Inflows of Nr to this sub-pool are mainly domestically produced and imported products and outflows are material waste and firewood burning. Stock changes in this sub-pool have been included to account for the buildup of material products in private households. There is a large flow of chemicals, contained in medicine, plastics, glue, paint etc., from Materials and products (MP) to HS. These specific flows are difficult to disentangle so the entire flow is set as a flow to HS.MW although for example medicines should have gone to HS.HB.

2.1 Human body and food

Some of the largest flows of Nr to, from and within HS are associated with food. The inflows come from imported food from the rest of the world (RW) and from domesticated produced food. Since most food produced domestically is assumed to be processed or packaged, the flows of Nr in food have been attributed to pass through the MP, though they originated from agriculture (AG), from Hydrosphere (HY) as caught fish, and from Forest and semi-natural grasslands (FS) as hunted game, picked berries and mushrooms. These inflows go to the sub-pool HS.OW. From HS.OW the food is either consumed by humans, flowing to the sub-pool HS.HB, or discarded as food waste. From HS.HB the Nr is transferred to waste as excrement or emitted as NH_3 to Atmosphere (AT) through sweat and breath.

2.1.1 Consumption and food waste

Data for direct consumption in 2015, divided into 111 food categories, was retrieved from Statistics Sweden[2]. The protein content of each of the 111 category was calculated based on data from the Swedish Food Agency[3]. The Swedish Food Agency also provided the N content of proteins for different foods[4]. From this the

[2] https://www.scb.se/contentassets/a6e7b4399a924fb78130196442efedb5/jo1301_2016a01_sm_jo44sm1701.pdf
[3] https://soknaringsinnehall.livsmedelsverket.se/
[4] https://www.livsmedelsverket.se/livsmedel-och-innehall/naringsamne/protein Table 4.

direct consumption of Nr in food was calculated. The results are presented in Table 2, regrouped into 9 general categories.

Table 2. The table shows food consumption in Sweden 2015. The N content presented here is a weighted average of the foods in each respective category.

Food category	**Consumption (kt)**	**N content**	**Consumption N (kt)**
Meat	802.8	2.9%	23.1
Fish	129.1	3.2%	4.1
Dairy, honey, eggs	1641.7	0.9%	15.6
Vegetables	1651.7	0.2%	3.4
Fruit and nuts	746.6	0.3%	2.0
Coffee, tea and spices	106.3	1.5%	1.6
Flour, bread, pasta	1012.1	1.3%	12.8
Sugar, candy, cacao, chocolate	220.0	0.7%	1.6
Miscellaneous edible preparation	279.4	0.4%	1.0
Total	6589.7		65.3

The data for direct consumption, shown in Table 2, refers to the products reaching the consumer. To determine the actual Nr intake from food, food waste had to be subtracted from the food consumption. This was calculated using data of food waste from 2016 provided by the Swedish Environmental Protection Agency[5]. The distribution of waste for different solid food was assumed to be the same as the distribution of consumed solid food. Liquid food waste was assumed to be the same as 2020, as the 2020 proportion was the only data available. The total Nr in food waste from private residences, public meals, restaurants and hotels was calculated to 10.5 kt N and from grocery stores to 0.3 kt N. Based on this the food intake was calculated to 54.8 kt N.

The Nr flow from HY to HS associated with drinking water abstraction is 0.2 kt N (Stadmark et al., 2020). For simplicity, this flow was not subdivided to HS sub-pools and the whole flow was assumed to go from HY to HS.HB.

[5] https://www.naturvardsverket.se/publikationer/8800/978-91-620-8891-0/

HS.OW – HS.HB: 54.8 kt N

HS.OW – WS: 10.8 kt N

HY – HS.HB: 0.2 kt N

2.1.2 Food import

Data for food import and export was retrieved from UN Comtrade Database[6]. The N content of each import/export group was estimated based on the previous calculation on N content from the consumption data. This resulted in an import of 52.2 kt N, an export of 39.2 kt N and a net import of 13.1 kt N. Tobacco net import was calculated to 0.4 kt N based on N content of 4% as suggested by Annex 6. The imported and exported N in different food categories are shown in Table 3. The largest net import flow comes from meat.

RW – HS.OW: 13.4 kt N

Table 3. The table shows total N content in imported and exported food, to and from Sweden in 2015.

Food category	Imported N (kt)	Exported N (kt)	Net imported N (kt)
Meat	10.3	4.9	5.4
Fish	24.0	24.7	- 0.7
Dairy, honey, eggs	3.6	1.9	1.7
Vegetables	2.4	0.4	2.0
Fruit and nuts	2.1	0.2	1.9
Coffee, tea and spices	1.9	0.4	1.5
Flour, bread, pasta	5.3	5.0	0.3
Sugar, candy, cacao, chocolate	1.9	1.3	0.6
Miscellaneous edible preparation	0.8	0.5	0.3
Tobacco	0.5	0.1	0.4
Total	52.7	39.3	13.4

[6] https://comtradeplus.un.org/TradeFlow

2.1.3 Food Production

Food production was assumed to be equivalent to consumption + food waste + export – import, which meant a food production of 52.6 kt N. The distribution of the total N content in the produced foods is presented in Table 4. Since most food can be assumed to pass though some kind of industry before it is consumed by humans it is here reported as a flow from MP to HS, although the origin could be from AG, FS or HY.

Table 4. The total N content of produced food in Sweden 2015, calculated from food import, export, consumption and waste.

Food category	**Domestically produced N (kt)**
Meat	17.8
Fish	4.9
Dairy, honey, eggs	13.9
Vegetables	1.4
Fruit and nuts	0.1
Coffee, tea and spices	0.1
Flour, bread, pasta	12.6
Sugar, candy, cacao, chocolate	1.0
Miscellaneous edible preparation	0.7
Total	52.6

The yearly production of edible berries (primarily blueberries (*Vaccinium myrtillus*) and lingonberries (*Vaccinium vitis-idaea*)) in Swedish forests is estimated and presented in the Forest statistics and is part of the official statistics of Sweden[7]. For 2015, 638 000 ton of blueberries and 471 000 ton of lingonberries were produced (Skogsdata, 2020). However, only a small fraction, about 5%[8], is picked-up and removed from the forest. Using an estimate of the protein content in blueberries and lingonberries (1.7g/100g) and a conversion factor between N-content and protein content (6.25) from the Swedish Food Agency[9] the total removal from blueberry and lingonberry picking was 0.06 kt N. Some of the picked berries will be sold and even exported, while some will go directly to household use. For edible mushrooms even less data is available. There are estimates that the amount in

[7] https://www.slu.se/centrumbildningar-och-projekt/riksskogstaxeringen/statistik-om-skog/skogsdata/
[8] https://www.skogssverige.se/hur-mycket-mangdekonomiska-varden-atliga-bar-och-svamp-finns-det-i-svenska-skogar-och-hur-mycket-tas
[9] https://www.livsmedelsverket.se/

tonnes of mushrooms is similar to the amount of blueberry and lingonberry and even less (about 1%) is thought to be removed as compared to berries. Using the same amount as the sum of blueberries and lingonberries and the protein content of chantarelles (1.7g/100g) and the same conversion factor between N-content and protein content (6.25) the total removal from mushroom picking was 0.03 kt N.

The most common larger game that is hunted in Sweden is moose (*Alces alces*), deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*). The Swedish Hunters Association has for a long time collected data to estimate the annual shooting of several game species and have published time series for, among many others, deer and wild boar[10]. There is a lot of information regarding moose, including annual shooting, made available by the County Administrative Boards[11]. For the year 2015 (hunting season 2015/2016) nearly 83 000 moose, about 100 000 deer and close to 100 000 wild boars were hunted. Together with estimates on slaughter weight, and the protein content of meat from the Swedish Food Agency (between 22.1g to 24.3g /100g) and the conversion factor between N-content and protein content of 6.25, the outflow of Nr due to hunting was estimated to 0.6 kt N for 2015.

MP – HS.OW: 52.6 kt N

2.1.4 Human sweat, excretion and population buildup

Humans emit NH_3 through sweat, breath and infant excretion. EPNB Annex 6 provides a formula for calculating this emission, along with the emissions of NO_X from cigarette smoke. These emissions were calculated to 0.2 kt based on population statistics from Statistics Sweden[12] and cigarette consumption statistics from The Swedish Council for Information on Alcohol and Other Drugs[13].

To calculate the build-up of Nr as a result of population growth, population statistics per age group and gender were retrieved from Statistics Sweden[14]. Average weight for age 0-9 was retrieved from WHO[15] [16] and for adults (16-84 years) from Swedish statistics[17]. Average weight for 10- to 15-year-olds was set to

[10] https://www.viltdata.se/wp-content/uploads/2017/04/Bilaga-Avskjutning.pdf
[11] https://algdata-apps.lansstyrelsen.se/algdata-apps-stat
[12] https://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__BE__BE0101__BE0101A/BefolkningR1860N/
[13] https://www.can.se/app/uploads/2020/01/can-rapport-166-tobaksvanor-i-sverige.pdf
[14] https://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__BE__BE0101__BE0101A/BefolkningR1860N/
[15] https://www.who.int/tools/child-growth-standards/standards/weight-for-age
[16] https://www.who.int/tools/growth-reference-data-for-5to19-years/indicators/weight-for-age-5to10-years
[17] https://www.scb.se/hitta-statistik/artiklar/2018/varannan-svensk-har-overvikt-eller-fetma/

an average between adults and 9-year-olds in lack of better data, and weight for 85 and older was set as the same as adults. The population statistics, the weight statistics and a N content in the human body of 2.6% (Campos & Kotanko, 2019) was used to calculate the stock change in the Swedish population 2015. The stock change was calculated to 0.2 kt N.

The outflow from HS.HB in form of excretion was assumed to be the same as the food intake plus Nr intake from drinking water minus the atmospheric emissions from the human body and the stock change in the population, which means an outflow of 54.6 kt N. Most of this outflow ends up in sewage treatment plant (WS), but there is also a flow (3.1 kt N) to HY from small dwellings (Stadmark et al. 2020).

HS.HB – AT: 0.2 kt N

HS.HB – WS: 51.5 kt N

HS.HB – HY: 3.1 kt N

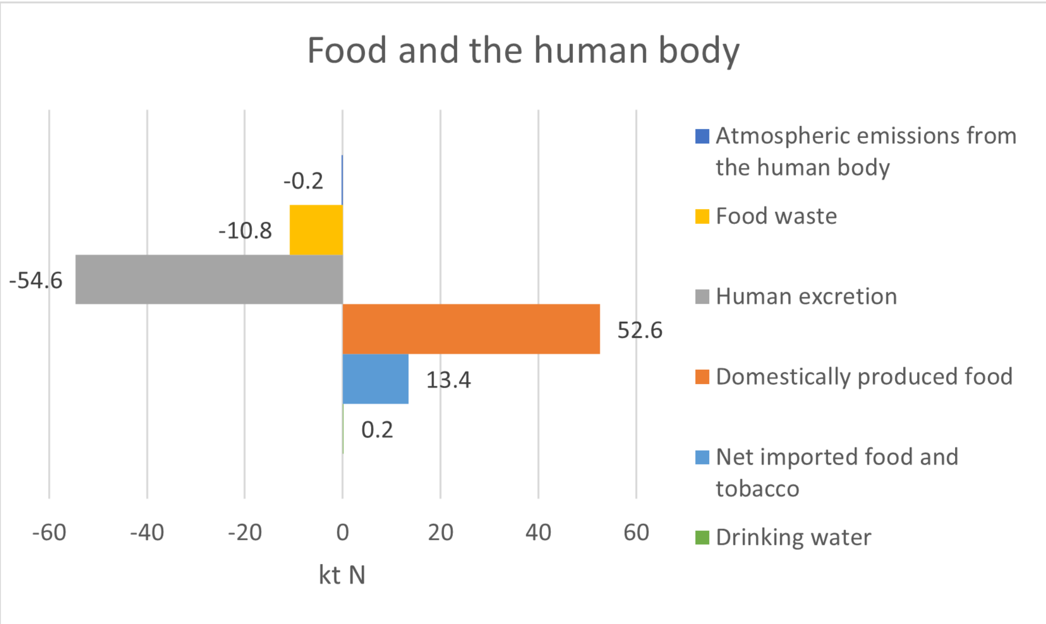

Figure 2. Inflows and outflows of nitrogen for HS related to food and the human body.

2.2 Pets and horses

Nitrogen flows associated with pet feed derive from AG and RW via HS.OW to HS.PE. EPNB Annex 6 provided feed intake and N intake per animal per year for various species. Data for the number of pet cats, small mammals, birds and fish in 2016 and dogs in 2017 was taken from FEDIAFs annual reports (FEDIAF 2018) as data from 2015 was not found. The N content in pet feed is presented in Table 5.

Table 5. Nitrogen content in consumed pet feed.

Animal	**Number of animals**	**N intake / animal / year (kg)**	**N consumption (kt)**
Average small mammals	500 000	0.58	0.3
Cat	1 272 000	3.04	3.9
Dog	880 000	4.73	4.2
Ornamental birds	317 000	0.009	0.003
Ornamental fish	210 000	0.09	0.02
Total			8.3

Horses were also included in the HS.PE. N content in horse excrement was 17.4 kt in 2015 (UNFCCC, CRF_Table3.B(b)) [18]. The Nr consumed by horses in feed was assumed to be equal to the N content in horse excrement. The total Nr consumed in pet and horse feed was calculated to 25.8 kt of which 68% was in the form of horse feed, 16% dog feed, 15% cat feed and 1% small mammals feed. Ornamental birds and fish had less than 0.1% and no other pets were included. The outflow from HS.PE as excretion and waste was assumed to be the same as the feed intake.

HS.OW – HS.PE: 25.8 kt N

Pet excrements from animals other than horses flow from HS.PE to WS, and partly to HY (stormwater), while we assume that horse excrements end up in the AG pool. In PLC 6 Ejhed et al. (2016) estimated that there is a flow of 1.7 kt N in runoff from paved areas to the hydrosphere. This Nr was in Stadmark et al. (2020)

[18] https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/national-inventory-submissions-2018

described as a flow between HS and HY. In this report we have allocated all runoff from paved areas to pet excrements, which is most probably not entirely correct, but an attempt to cover the flow between HS and HY in the best possible way.

HS.PE – WS: 6.6 kt N

HS.PE – HY: 1.7 kt N

HS.PE – AG: 17.4 kt N

Import and export data from Statistics Sweden[19] was compared with the pet feed intake, which showed that 37% of the consumed pet feed was imported. We assumed that the Nr concentration in pet feed was the same irrespective of if the feed was imported or domestically produced. The imported and domestically produced Nr in horse feed was assumed to be proportional to imported and produced forage and roughage, of which 19% was imported based on data retrieved from the Swedish board of agriculture[20]. This assumption has a large uncertainty as horses not only eat forage and roughage, and as the data for produced and imported forage and roughage is not solely for horses. It is still used in this report in lack of better ways to estimate the proportion of imported horse feed. This means a total of 6.4 kt N imported and 19.3 kt N domestically produced pet and horse feed. Domestically produced feed can flow from either MP or AG to HS. We estimated the part from AG based on data available on feed for cattle (Stadmark et al. 2019) and assumed that horses have the same proportion of feed from AG. This amounted to 10.6 kt N. The remaining 8.8 kt N were then assumed to come from MP (Jutterström et al., 2024).

RW – HS.OW: 6.4 kt N

AG – HS.OW: 10.6 kt N

MP – HS.OW: 8.8 kt N

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[19] https://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__HA__HA0201__HA0201B/ImpExpKNTotAr/
[20] https://jordbruksverket.se/download/18.5b7c91b9172c01731757eeb1/1592480970301/2017.pdf Table 8.7

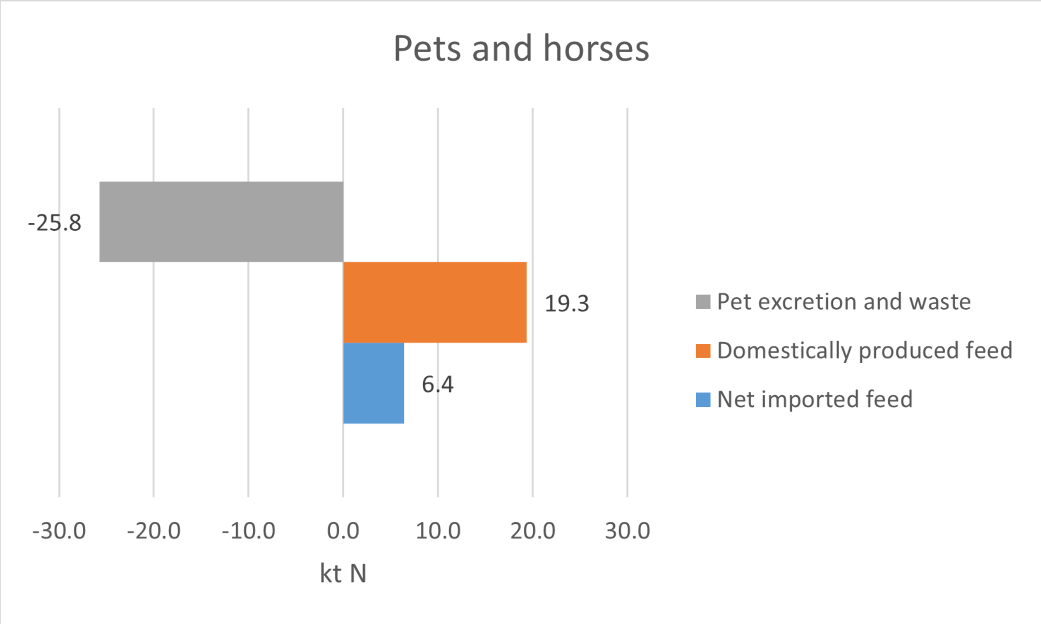

Figure 3. Inflows and outflows of nitrogen for HS related to pets and horses.

2.3 Gardens and public green spaces

The inflow to HS associated with gardens and public green spaces includes fertilizers from MP and compost from WS. Compost waste in Sweden was in total 450 kt 2014 and 522 kt 2016 according to the Swedish Environmental Protection Agency[21] [22]. Due to lack of data for 2015, an average of 2014 and 2016 was used for the calculations in this section. There is no available data on how much of this is used for private gardens and public green spaces. EPNB suggests using 20%, in lack of better data, to calculate compost used for private gardens and public green spaces, based on Egle et al. 2014. This would mean that 97.2 kt compost was used for private gardens and public green spaces in Sweden 2015. The N content of compost varies from 0.6-2.3% according to Annex 6. With an N content of 1.5%, the flow of Nr from WS to HS.OW in compost would be 1.5kT. There is a large uncertainty in this estimate caused by the uncertainty of N content in compost, the amount of compost produced in 2015 and the part of that compost used for private gardens and public green spaces.

WS – HS.OW: 1.5 kt N

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[21] https://www.scb.se/contentassets/55d5999531bc43ff8c48546b3ef16138/mi0305_2014a01_br_mi0305br1601.pdf
[22] https://www.scb.se/contentassets/842cdb4c880247b28fad6fef853a0526/mi0305_2016a01_br_misambr1801.pdf

The fertilizer consumption in Sweden 2015 consisted of 192 kt N according to the International Fertilizer Association[23]. No data was found on how much fertilizer was used for private gardens and public green spaces. Annex 6 suggests that, in lack of better data, 2% is a reasonable estimate of how much of the total fertilizer consumption is used for private gardens and public green spaces. This number is based on values for Austria from Egle et al. 2014. For Sweden this would mean a Nr flow of 3.8kT from the MP pool to HS.OW in form of fertilizers.

MP – HS.OW: 3.8 kt N

As for Garden waste, Sweden had 310 kt waste from household in 2014[24]. The N content in fresh garden waste is approximately 0.8% according to Annex 6. This would mean a Nr flow of 2.5 kt from HS.OW to WS. There is a high level of uncertainty associated with the N-content in this flow and it doesn't include garden waste from public green spaces.

HS.OW – WS: 2.5 kt N

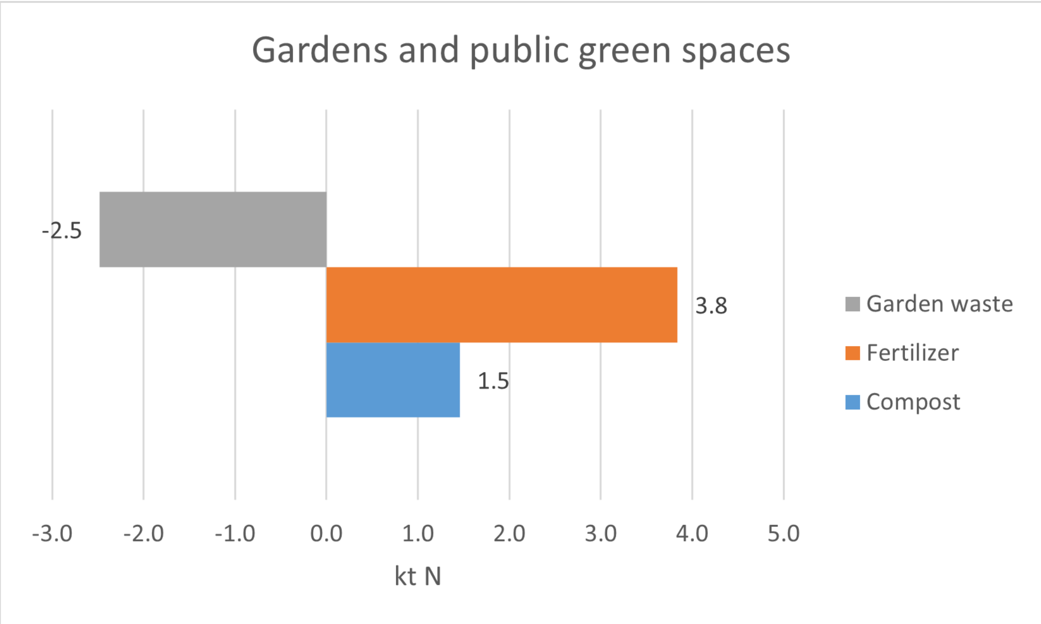

Figure 4. Inflows and outflows of nitrogen for HS related to gardens and public green spaces.

[23] https://www.ifastat.org/databases/graph/1_2
[24] https://www.scb.se/contentassets/55d5999531bc43ff8c48546b3ef16138/mi0305_2014a01_br_mi0305br1601.pdf

2.4 Material world

Inflows of Nr to the subpool HS.MW come from MP, RW and FS as products and fuel wood for household use. Outflows are to WS as discarded material waste, to AT for fuelwood burning and to MP as materials collected for recycling.

2.4.1 Products (medicine, paints, plastics etc.) from MP to HS

Flows of Nr contained in products are rather difficult to estimate as there is a vast range of products that are made of a combination of many different materials. In Swedish National Nitrogen Budget - Material and Products in Industry report (Jutterström et al., 2024) there is a large amount of N-containing chemicals used in industry to produce medicines, glues, paints, plastics etc. (excluding the products used in the agricultural sector, explosives, and reduction agents) which most likely will be used for human consumption or human use. Instead of estimating the N-content and flow of each product group, we have chosen to set the remainder of the chemicals used for production in industry as a flow to HS:

MP – HS.MW 53.9 kt N

2.4.2 Textiles, Wearing apparel and Leather products

ENPB provided N-content for crop fibre, animal fibre, synthetic fibre and leather. Import and export data for textile products was gathered from Statistics Sweden[25] and categorized into the four above mentioned groups. 16% of the imported and 38% of the exported textiles in the data from Statistics Sweden did not specify material. An assumption was made that the proportion of different materials in this group was the same as for the clothes with specified material, not including leather. N content for each group was calculated and is presented in Table 6. The total net inflow to HS.MW in the form of textiles was 6.8 kt N. There is an uncertainty in the calculations associated with the group of clothing with unspecified material. Domestic production of textiles was not included as it was assumed to be insignificantly small[26].

[25] https://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__HA__HA0201__HA0201B/ImpExpKNTotAr/
[26] https://www.naturvardsverket.se/data-och-statistik/textil/textilkonsumtion/

RW – HS.MW: 6.8 kt N

Table 6. The table shows N content in imported and exported textiles and leather.

Fibre group	**Imported N (kt)**	**Exported N (kt)**	**Net imported N (kt)**
Crop fibre	0.2	0.0	0.1
Animal fibre	0.5	0.1	0.3
Synthetic fibre	10.8	3.8	7.1
Leather	3.0	3.8	-0.8
Unknown fibre	2.0	1.9	0.0
Total	16.4	9.7	6.8

2.4.3 Wood & Paper and Products thereof

Sweden is a large producer of wood for manufacturing and building industry and the production of pulp and paper products is one of Sweden's biggest industry sectors. The N-budget for the Forest and-seminatural vegetation which includes biomass harvest and flow from the forest to other parts of the Swedish NNB is described in detail in the report "Swedish National Nitrogen Budget - Forest and semi-natural vegetation" (Jutterström et al., 2020). The flow to HS from FS that is accounted for in the FS-report is the flow of fuel wood (shown in this report in section 4.4).

The import, export and production of wood and wood products is not described in the FS-report but in the report "Swedish National Nitrogen Budget - Material and Products in Industry" (Jutterström et al., 2024). Production, export and import numbers (by weight or volume) for wood and wood products were collected from the EUROSTAT database[27] and the UN Comtrade Database[28]. The wood and wood products in EUROSTAT were divided into basic, primary, and secondary categories. For paper and paper products the N content is estimated by a factor of 0.2%. For more solid wood products, the factor for stem wood was used (1.2 kg/t).

As described in the MP-report: after subtracting the export (basic, primary and secondary wood products) from the production of basic and primary wood

[27] https://ec.europa.eu/eurostat
[28] https://comtradeplus.un.org

products leaves 9.6 kt N in MP. Adding the import of basic and primary wood and wood products yields **18.3 kt N** still in MP. A small part of this, 0.8 kt N, is estimated to end up as waste. The remainder we have set as a flow from MP to HS:

MP – HS.MW: 17.5 kt N

The import of secondary wood products was estimated in the MP-report, but not attributed to a flow to MP, the flow is instead set from RW directly to HS:

RW – HS.MW: 6.2 kt N

The flow of Nr for production of recovered paper is set from HS to MP.OP:

HS.MW – MP: 1.5 kt N

2.4.4 Bark and fuel wood

In the EPNB Annex 4, fuel wood for domestic use (cooking, heating of power production) is set as a flow from FS to HS. In the Swedish FS-report, also bark removed from stems was assumed to be used for heating. During logging stems are harvested with the bark on and after being removed the bark is assumed to be used for heating as is the common practice e.g. in the pulp industry. This flow might instead have been set as FS to MP, but the decision was to follow Annex 4.

The same density (0.45 t/m^3) and N-content as for the stem wood are used (1.2 g/kg).

FS – HS.MW: 7.3 kt N

For calculating the flow of Nr due to the production of Fuel wood (including wood for charcoal) excluding wood for export, the same density as for the roundwood is used but with the N-content for the whole tree from Table 16 in Annex 4 (3.4 g/kg). Here we assume that the bark is also used as fuel and so the calculation uses the reported volumes over bark.

FS – HS.MW: 14.4 kt N

Imported fuel wood has not passed through MP and is a flow directly between RW and HS:

RW – HS.MW: 0.6 kt N

The amount of NOx produced when burning fuel wood in HS is calculated based on how much NOx that is emitted from wood stoves (8 kg NOx/year in stoves producing 20000 kWh[29]), the energy content in wood (4.1 kWh/kg), and the total weight of fuel wood including bark (8960 kt).

HS.MW – AT: 4.0 kt N

The rest of the reactive nitrogen in fuel wood and bark is assumed to be emitted as non-reactive N_2 to the rest of the world. Some of the NOx produced during burning originates from the wood and some from atmospheric thermal oxidation.

HS.MW – RW (N_2): 18.3 kt N

2.4.5 Material waste

Material products disposed as waste contribute to a flow of Nr. Annex 6 suggests using Gu et al.'s (2013) estimate, that around 25% of industrial products accumulate in settlements, for the calculations of material waste. This would mean that the outflow from HS.MW to WS is 75% of the inflow in form of textiles and wood products (that is not bark and fuel woods), and chemicals, plastics and medicine.

HS.MW – WS: 0.75*(17.5+6.2+6.8+53.9) = 63.3kt N

This figure is associated with a large uncertainty as the estimate of 25% refers to the global level. We can assume that rapidly developing countries accumulate more N in products than developed countries where products to a higher degree replaces old products rather than adding to the pool of accumulated Nr. This would mean that the material waste of 63.3 kt N could be an underestimate. As no statistics were found to confirm this, the recommendation from Annex 6 of using 25% is used in our calculations.

[29] https://www.naturvardsverket.se/globalassets/media/publikationer-pdf/8300/978-91-620-8392-2.pdf

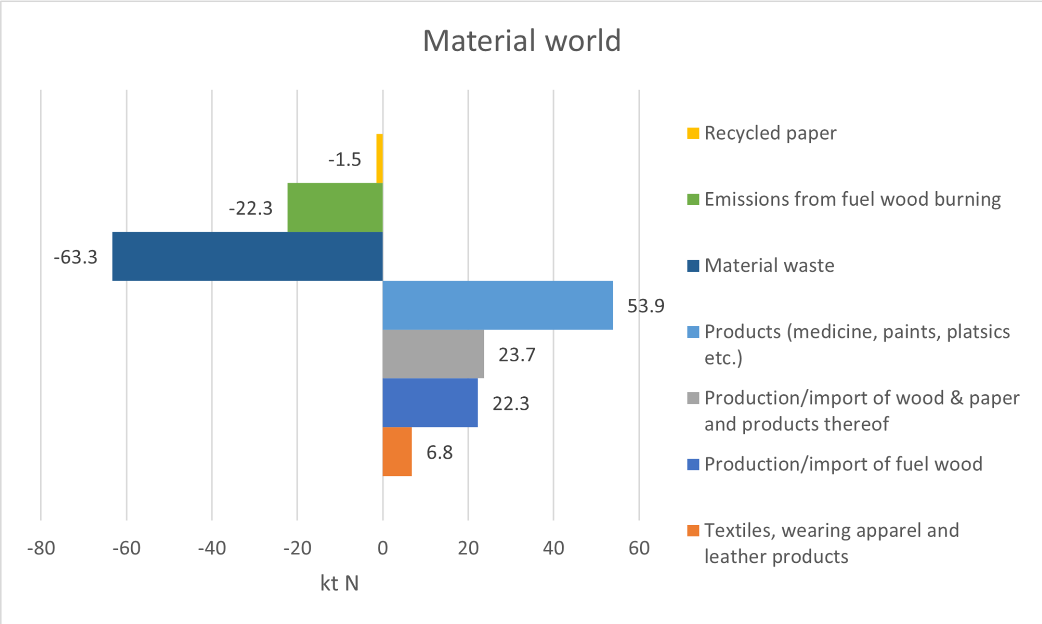

Figure 5. Inflows and outflows of nitrogen for HS related to the material world.

3 Summarising discussion and conclusions

All the calculated flows to, from and within HS are presented in Figure 6 as a bar chart. The largest flows of Nr are associated with imported and produced products, food and discarded waste, mainly material waste. Among the products, chemicals (medicines, paints, plastics) were the largest contributor (53.9 kt). While there are quite a lot of statistics available on the amount of chemicals stored in different industrial sectors (import+production), there is less information available on the final products. After removing the flows to AG (fertilizers) or RW (export or reducing agents) there was still a large quantity of chemicals listed as a raw material for synthesis without any other description. We have assumed that these will end up in medicines, plastic, paints, glue, deicing agents, etc. and more products that will eventually end up in HS.

When it comes to Nr in food, *Meat* is the food group with the largest total Nr flow for both production (17.8 kt), net import (5.4 kt) and consumption (23.1 kt) followed by *Dairy, honey, eggs*. *Flour, bread, pasta* contribute to large Nr flows in produced food and consumed food while *Vegetables*, *Fruit and nuts*, and *Coffee, tea and spices* are among the top contributors on imported Nr in food.

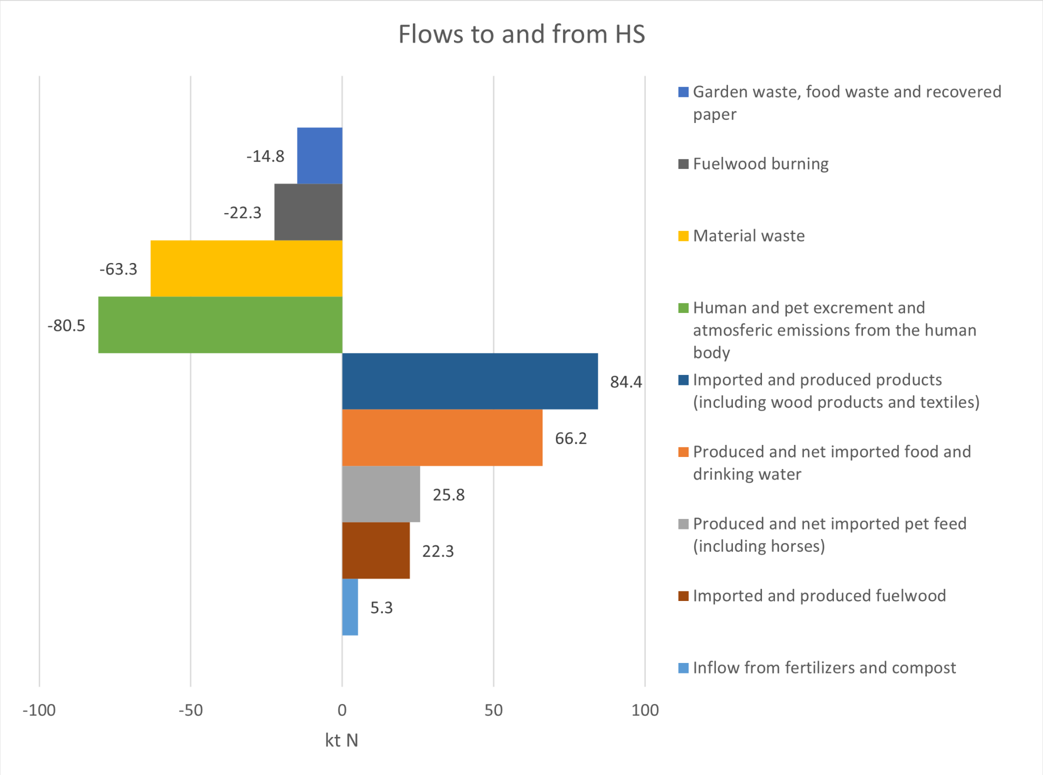

Figure 6. Net in- and outflows of N (kt) from and to HS.

Figure 7 shows the flows of Nr to and from other pools and within the HS sub-pools. The largest net flow is between MP and HS, where chemicals (53.9 kt) and food (52.6 kt) make the largest contributions. In this report most food from Swedish agriculture (meat, cereals etc.) are processed in MP before it reaches HS. Domestically produced feed for pets and horses derives from AG. WS receives the, by far, largest outflow of Nr (134.7 kt). This outflow consists of 75% of all Nr in products that are reaching the HS sub-pool material world (in total 63.3 kt N), Nr in human excrement (51.5 kt N), food waste (10.8 kt), pet excrements (not from horses, 6.6 kt), and garden waste (2.5 kt).

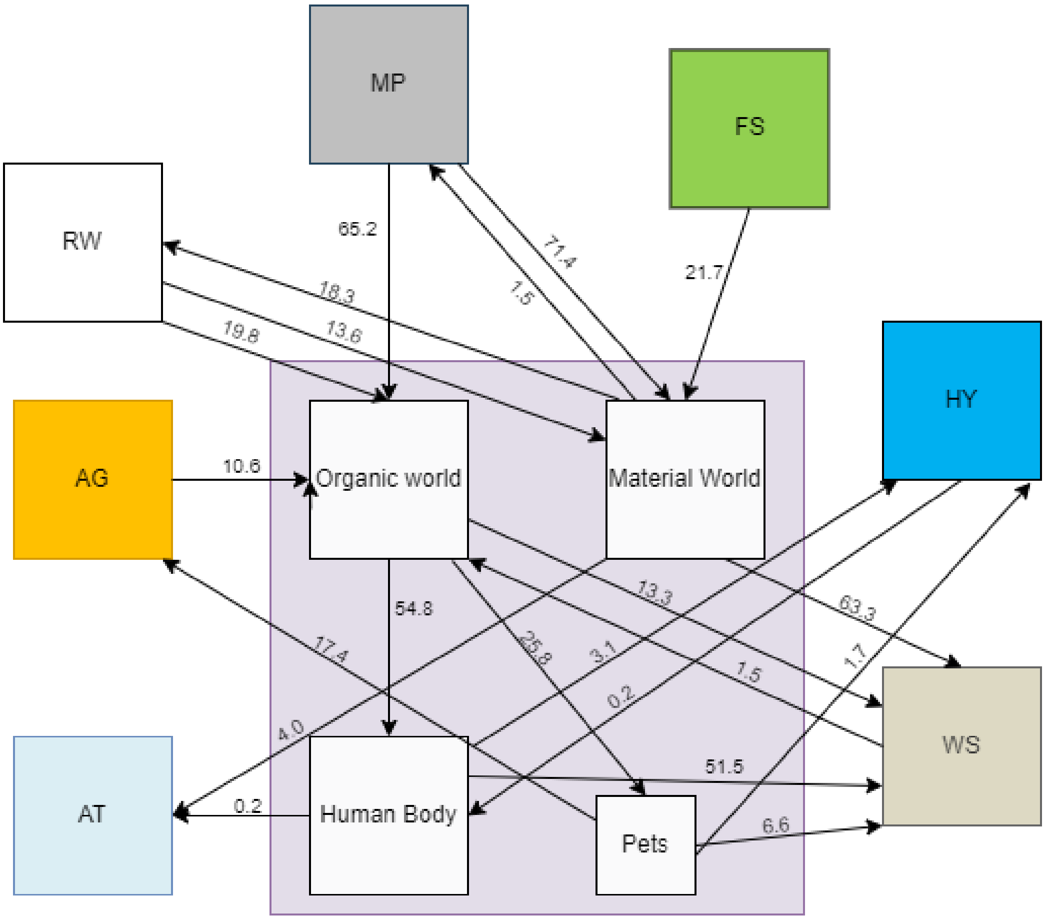

Figure 7. The figure shows all calculated flows of N to, from and within the HS-pool in kt.

Based on the difference between inflows and outflows, the total stock change in HS is 23.1 kt N. A majority of the stock change (19.6 kt N) can be attributed to the HS.MW sub-pool as accumulated products in private households. As discussed in section 2.4.5 this is probably an overestimation caused by an underestimation of material waste. To assume that HS.MW stock is increasing is, however, to some extent reasonable given that the total living area in Sweden increased by 1.2% per year between 2013-2017[30] [31]. The amount of Nr in the households and other living areas is not known and difficult to quantify, which makes the annual 1.2% increase in living area difficult to directly translate into the Nr stock change. However, if we for the sake of argument assume, that more or less all products we use in our living areas have a life span of maximum 30 years, then the size of Nr stock could be roughly estimated as 15 times the annual input, based on another uncertain

[30] https://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__HE__HE0111__HE0111A/HushallT23/
[31] https://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__BE__BE0101__BE0101A/BefolkningNy/

assumption, that products are turned into waste linearly over the life span of 30 years. The annual input of 106.7 kt N would then translate to an estimated HS.MW stock of 1 600.5 kt N and the 1.2% increase in living area would result in an annual increase of Nr stock by 19.2 kt N, with the assumption that the amount of Nr in products per area of living space is not changing. That is essentially the same number as the identified difference between the annual inputs and outputs to HS.MW.

A stock change of 3.2 kt N is caused by the differences in inflow of compost and fertilizers to gardens and public green spaces and the outflow of garden waste. These values, as mentioned above, had to be calculated based on assumptions with large uncertainties and in particular using the value of 2% of total fertilizer use for gardens and public spaces (suggested by Annex 6, based on case study in Austria) might be for Swedish conditions an overestimate. There is no stock change in HS.PE as the Nr in food intake was assumed to be equal to the Nr in waste and excrement from that pool. The same is true for HS.HB except for the small stock change (0.2 kt N) associated with an increased population. Since the production of food was calculated based on the other inflows and outflows to and from the sub-pool, the stock change there is also very low. In summary, the stock change of 23.1 kt N in HS is associated with uncertainties and is likely overestimated.

The sources used to calculate the flows associated with HS has mainly been official statistics from Statistics Sweden. Other important sources have been comtrade.un, the Swedish Food Agency, the Swedish Environmental Protection Agency, the Swedish Board of Agriculture and FEDIAF. The main uncertainties stem from assumptions that had to be made because of lack of information or data. As mentioned previously, there is a large inflow of chemicals from MP to HS. As the processing/products data is to a large extent lacking it is quite possible that there is an overestimation of this flow to HS. There could be more of the chemicals that should be going to Waste (although there is a small flow from industry to Waste in MP). There could also be products that are being used up in the industry sector and therefore should not be going to HS. Regarding products that are known, it is also not always straightforward to set an appropriate N-content. Another example is the calculations associated with Gardens and public green spaces, where the Nr flows in HS was calculated as a percentage of national totals of fertilizers. These percentage estimations were recommended by EPNB based on other countries who might not have the same conditions as Sweden. Assumptions also had to be made for the division of imported and produced nonagricultural animal feed and for textiles without specified material. Another uncertainty is associated with the protein content of different foods. As the import consumption food classes did not exactly align with the protein content data from the Swedish Food Agency, some assumptions had to be made of protein content in different food groups.

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This report has been reviewed and approved in accordance with IVL's audit and approval management system.