Nitrogen on the Table:

The influence of food choices on nitrogen emissions and the European environment

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Executive summary

Key findings

1. The European Nitrogen Assessment (ENA) [1] identified agriculture as a major source of nitrogen losses. Despite the relatively high nitrogen efficiency of agriculture in the European Union, **the current total loss of reactive nitrogen from European Union (EU) agriculture amounts to an estimated 6.5 - 8 million tonnes per year, representing around 80 % of reactive nitrogen emissions from all sources to the EU environment.** These nitrogen losses mainly are in the form of ammonia to the air, of nitrate to ground and surface waters and of nitrous oxide (a powerful greenhouse gas).

2. **This report examines these losses from the EU agri-food system** further by (i) allocating nitrogen losses to food commodity groups (to determine nitrogen 'footprints') and (ii) by exploring the effect of alternative diets on nitrogen emissions, greenhouse gas emissions and land use.

3.The results show that livestock production chains have a high share in nitrogen losses. Around 79-88% of the total emissions related to EU agriculture of ammonia, nitrate and of nitrous oxide are related to livestock production. In these values for livestock production the emissions related to feed production (as cereals and fodder crops) are included.

4. There are large differences between food commodities in terms of nitrogen losses per unit of protein produced. Plant-based foods, such as cereals, have relatively low losses while livestock products have much higher losses. Nitrogen losses per unit of food protein from beef are more than 25 times those from cereals. For pig and poultry meat, eggs and dairy, the losses are 3.5 to 8 times those from cereals. Corresponding values for nitrogen use efficiency (NUE)[2] are low for meat and dairy products (5-30%) as compared with plant-based commodities (45-75%).

5. The current average nitrogen 'footprint'[3] per person differs by a factor 2-4 between European countries, mainly as a result of differences in average food consumption patterns. Countries with high intake of animal products (such as Denmark) have considerably larger nitrogen footprints than countries with a low intake of animal products (such as Bulgaria and Slovakia).

[1] Sutton, M.A., Howard, C.M., Erisman, J.W., Billen, G., Bleeker, A., Grennfelt, P., van Grinsven, H., Grizzetti, B., (eds.) (2011) The European Nitrogen Assessment: Sources, Effects and Policy Perspectives. Cambridge University Press, Cambridge, p. 612.

[2] The nitrogen use efficiency is defined as the input/output ratio, all the way from the fertilizer input to nitrogen in the final product

[3] This footprint is calculated as the total nitrogen loss to the environment per unit of product

6. The current average per capita protein intake in the EU is about 70% higher than would be required according to the World Health Organization (WHO) recommendations. This provides opportunities for a shift towards European diets with lower nitrogen footprints, reducing adverse environmental impacts on water, air and soil quality, climate and biodiversity. The current intake of saturated fats is 42% higher than the recommended maximum dietary intake, leading to increased risk of cardiovascular diseases. As 80% of saturated fats originate from animal products, a reduction in animal products would be favourable to human health as well.

Scenarios and key outcomes

7. In this study the effect of a number of alternative diets were assessed considering their impact on nitrogen losses from EU agriculture, as well as on greenhouse gas emissions, land use and human health. A reduction in pig meat, poultry meat and eggs was explored in one set of alternative diets. In another, a reduction in beef and dairy was explored. The reduction in all types of livestock products was also explored, in each case considering the consequences of 25% and 50% reductions. The effects on feed requirement, crop production, land requirements and nitrogen losses were examined.

8. Reducing meat and dairy consumption frees up large areas of agricultural land in the EU providing new opportunities of how to manage this land. We considered two alternative scenarios: Greening Scenario and a High Prices Scenario. In the Greening Scenario, land no longer needed for feed production is used for the production of perennial biomass crops. Furthermore, the lower demand for grass is assumed to lead to an extensification of grassland use by lowering mineral N fertilizer input. In the High Prices Scenario, tight global commodity markets and therefore high cereal prices are assumed. Land no longer required for fodder production (including temporary grassland and a fraction of the permanent grasslands) is used for cereal production.

9. In the Greening Scenario, a 50% reduction in livestock product consumption and production would reduce current European agricultural reactive nitrogen emission by around 40% (Table 1, Figure 1). In this alternative diet, the ammonia emissions are 43% lower, nitrous oxide emissions are 30% lower and nitrate emissions are reduced by 36%. The emissions are reduced most in alternative diets involving decreased beef and dairy production. In general, ammonia emission reductions are higher than the reduction in nitrous oxide and nitrate leaching. This is because ammonia emissions are mainly from livestock production, whereas both livestock and arable field-based activities contribute large shares of the nitrous oxide and nitrate emissions. Bioenergy crops expands by 14.5 million, being equal to 40% of the projected use of bio-energy material in the EU in 2020.

10. In the High Prices Scenario, a 50% reduction in livestock product consumption and production would also reduce current European agricultural reactive nitrogen emission by around 40%. In this alternative diet, the ammonia emissions are 29% lower, nitrous oxide emissions are 24% lower and nitrate emissions are reduced by 28%. By contrast, greenhouse gas emissions from agriculture would only reduce by 25%. This is because cereal production is increased, no additional bio-energy crops are produced and grassland use is not extensified. In this scenario, cereal export would increase from the current 3 million tonnes per year to over 170 million tonnes.

11. In both scenarios, the requirement for imported soybeans, as meal currently used as animal feed, is reduced by 75%. The combination of increased export of cereals with reduced import of soy has great implications for global commodity markets, which in turn influence global land use change.

12. A shift to a more plant-based diet will lead to a large decrease in the nitrogen footprint of EU citizens. In the most radical scenario assessed (a 50% reduction in the consumption of all meat and dairy products), the nitrogen footprint of the average diet will be reduced by 40%. The current large differences in per capita nitrogen footprint between EU member states will also become smaller.

13. The reductions in reactive nitrogen emissions will have benefits not only within the EU but at continental and global scales. Both atmospheric ammonia and nitrates in water-bodies cross national frontiers, with the consequence that the dietary scenarios investigated make a significant contribution to reducing international pollution export. The reduced emissions of the greenhouse gases methane, nitrous oxide and carbon dioxide are relevant globally.

14. The scenarios lead to food consumption patterns that are better aligned with international dietary recommendations. All of the reduction scenarios lead to a reduced intake of saturated fats, the main source of which is animal products. Even though the reductions are significant, only the most radical scenario - representing a 50% reduction in all meat and dairy consumption, brings the average intake of saturated fats within a range recommended by the World Health Organization (WHO). This scenario represents a 40% reduction in the intake of fats. The same radical scenario is also the only one assessed where the average intake of red meat is reduced to being only slightly above the maximum recommended by World Cancer Research Fund (WCRF) (See Table 1). Based on the current WHO and WCRF dietary recommendations, the results are clear: the reduced intake of red meat and saturated fats in these reduction scenarios means that public health risks would be reduced.

15. The alternative diets would lead to major changes in EU agriculture, with the expectation of large socio-economic consequences. Livestock production is currently responsible for 60% of the value-added on EU farms, and this revenue would be greatly reduced under the alternative diets. By contrast, the scenario with increased cereal exports assumes a large increase in cereal production and associated revenue. The net farm-level economic effect would depend on world market conditions and especially whether the additional cereal can be sold at a price that is profitable for European farmers. In the scenario where additional cereals are exported, this might have beneficial effects on global commodity markets in terms of food security. However this also has the risk of suppressing production and thus market opportunities for local farmers in developing countries, which is avoided in the increased bioenergy scenario.

16. Considering the major benefits of reduced European meat and dairy consumption for environment, climate and human health, there is now a need to explore further the market, education, policy and other options which would enable the barriers-to-change to be addressed.

Supporting material

Westhoek, H., Lesschen, J.P., Rood, T., Wagner, S., De Marco, A., Murphy-Bokern, D., Leip, A., van Grinsven, H., Sutton, M.A., Oenema, O. (2014) Food choices, health and environment: effects of cutting Europe's meat and dairy intake. Global Environmental Change In Press

Leip, A., Weiss, F., Lesschen, J.P., Westhoek, H. (2013) The nitrogen footprint of food products in the European Union. The Journal of Agricultural Science FirstView, 1-14.

Table 1. Summary of data on average food intake in Europe and environmental indicators under current conditions (based on 2004) and under a 50% reduction in the consumption of animal products.

Aspect	Unit	Reference	-50% meat, dairy and eggs[1]	
Protein				
Average daily intake	g per person per day	83	75	
Proportion of animal origin[2]	%	60%	36%	
Saturated fats				
Average daily intake	g per person per day	36	22	
Compared with the RMDI [3]	%	142%	86%	
Red meat				
Average daily intake	g per person per day	88	47	
Compared with the RMDI [3]	%	207%	107%	
		Reference	High prices scenario	Greening scenario
Environment				
Total losses of N_r (EU)	Million tonnes per year	6.5	4.1	3.8
Losses of NH_3 N to air		2.8	1.6	1.6
Losses of N_r to water		3.3	2.1	2.0
Losses of N_2O N to air		0.4	0.3	0.2
GHG emissions (EU)[4]	Million tonnes per year	464	347	268
NUE[5] food system (EU)	%	22	47	41
Agriculture				
Soy imports (as beans)	Million tonnes per year	34	8	8
Cereal exports	Million tonnes per year	3	174	54
Additional production of bioenergy	EJ per year	-	-	2.3

[1] sheep and goat meat are not reduced
[2] including fish and other seafood
[3] RMDI = Recommended Maximum Dietary Intake
[4] RMDI as advised by the World Cancer Research Fund (WCRF)
[4] Nitrogen use efficiency of the total food system (total output of N in the form of food crops and livestock products /total input of N into agricultural system)
[5] including direct emissions from agricultural production of N_2O, CH_4 and CO_2

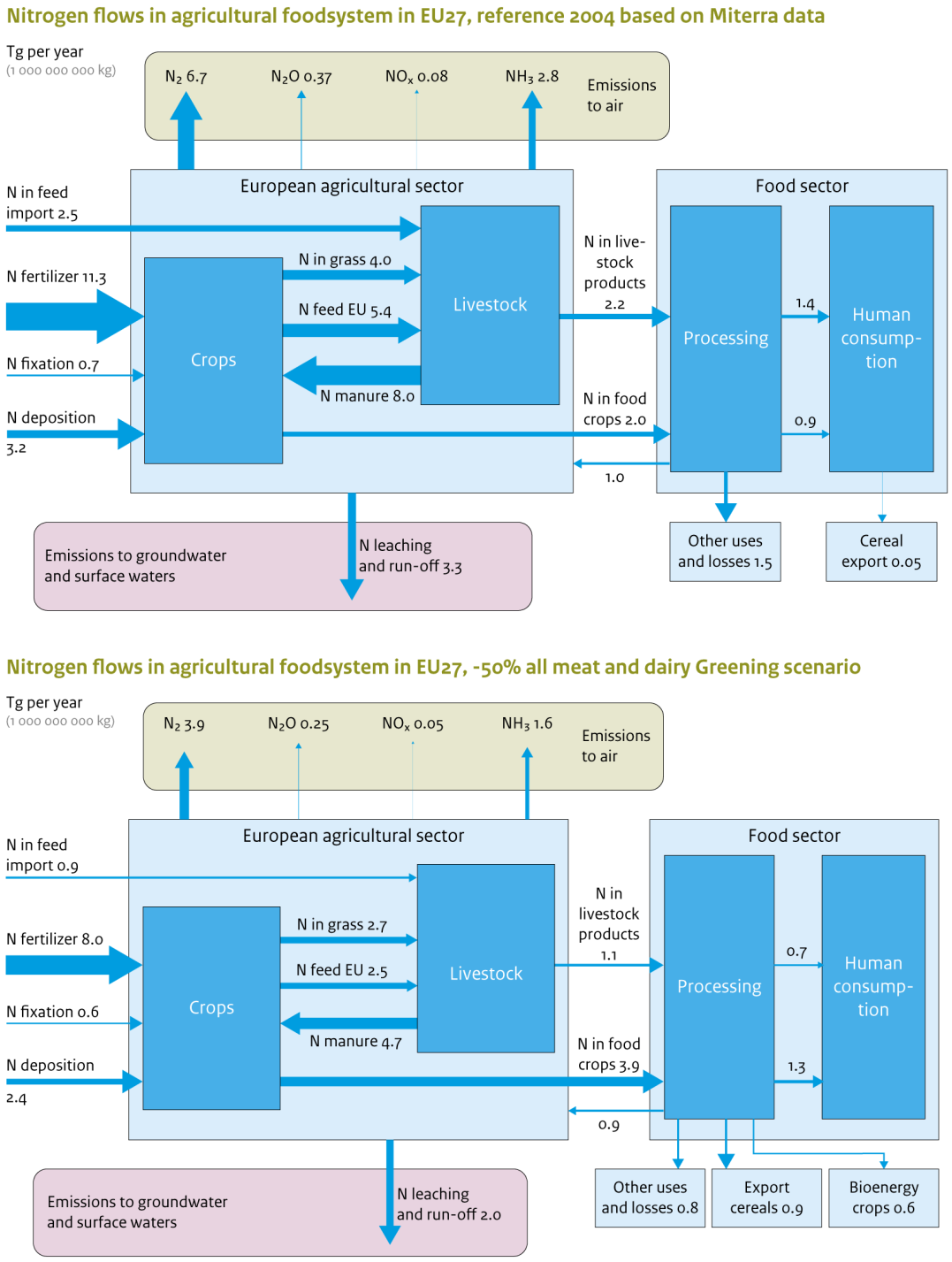

Figure 1. Nitrogen flows in the EU agricultural and food system in the reference situation for 2004 (top) and in case of the alternative diet with 50% reduction in consumption of meat, dairy and eggs in the Greening Scenario (bottom).