Human nitrogen fixation and greenhouse gas emissions: a global assessment

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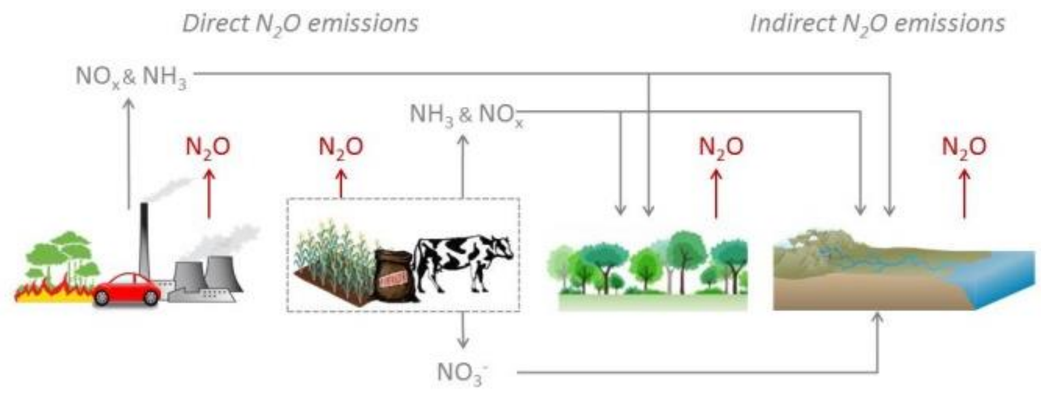
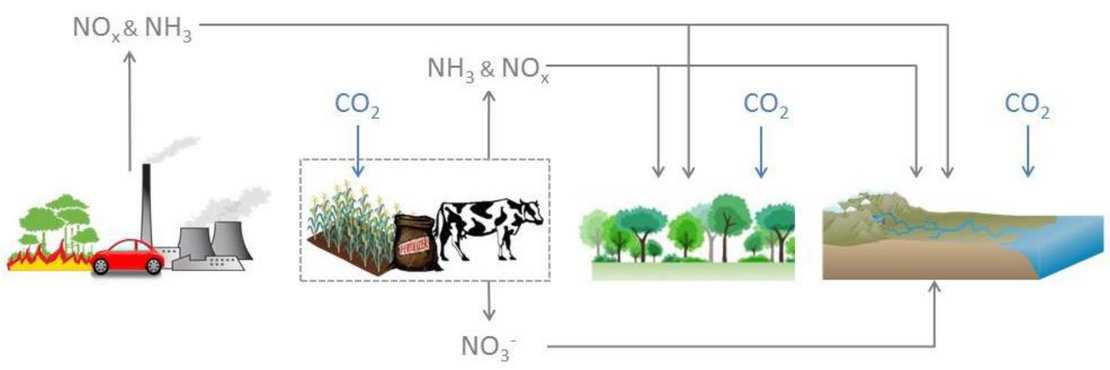
Introduction

Use of reactive nitrogen (Nr) affects the atmosphere-biosphere exchange of the green house gases nitrous oxide (N_2O), carbon dioxide (CO_2), and methane (CH_4). It causes (i) increased direct and indirect N_2O emissions due to energy production and agricultural production, (ii) increased sequestration of CO_2 in N limited ecosystems due to an increase in productivity and (iii) (iii) decreased sequestration of CO_2 due to NO_x emission induce tropospheric ozone (O_3) formation reducing productivity (Figure 1). Nr production also affects net atmospheric uptake of CH_4 by soils but this effect is negligible compared to N_2O and CO_2.

1. Direct and Indirect N_2O emissions



2. N-induced C sequestration



3 NO_x-induced O_3 formation reducing C sequestration

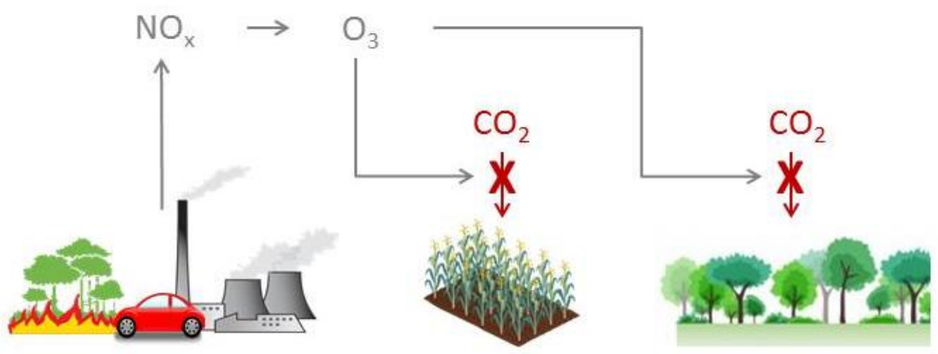


Figure 1. Linkages between human N fixation and greenhouse gas emissions

Approach

An estimate is made of current (year 2000) impacts of global N_r use on N_2O and CO_2 fluxes induced by human Nr fixation.

This is done by multiplying N inputs with N_2O emission factors/functions, ecosystem C–N responses and ecosystem C–O_3 responses, making use of results from experimental studies, field measurements and modelling approaches.

- N inputs and outputs to and from agricultural and other terrestrial systems are based on IMAGE model calculations at a 0.5° × 0.5° resolution (Bouwman et al., 2011; 2013).
- N depositions on different land use classes are based on an overlay of TM5 model results (Dentener et al., 2006) with the global land cover (GLC) 2000 map. For inputs to oceans, data by Duce et al (2008) are used.
- N inputs and outputs to and from agricultural and other terrestrial systems are based on various sources as described in De Vries et al (2016).

Results

Results (Table 1) show comparable N inputs in agricultural and marine, but the human contribution is much larger in agriculture

Table 1. estimated global-scale average natural (bold) and anthropogenic N input and N output estimates (Tg N yr^{-1})

N fluxes	Agriculture	Forests	Marine
N inputs			
N fertilizer	83	-	-
N manure	102	-	-
N fixation	39	53	157
N deposition	35	33	46
Total	258	86	213
N outputs			
N harvest	110	n.a.	-
N retention	-	n.a.	22
NH_3-N emissions	34	n.a.	9
NO_x-N emissions	2[1]	0.5	n.a.
N_2O-N emissions	7	3	7
N_2-N emissions	66	n.a.	207
N loss water	39	n.a.	- 44
Total	258	n.a.	213

[1] The estimate for total anthropogenic NO_x-N emissions is 40 Tg N yr^{-1}.

The effect of human N fixation on the net greenhouse gas emissions is calculated at 0.41 Pg CO_2-C eq. yr^{-1}. (Figure 2)

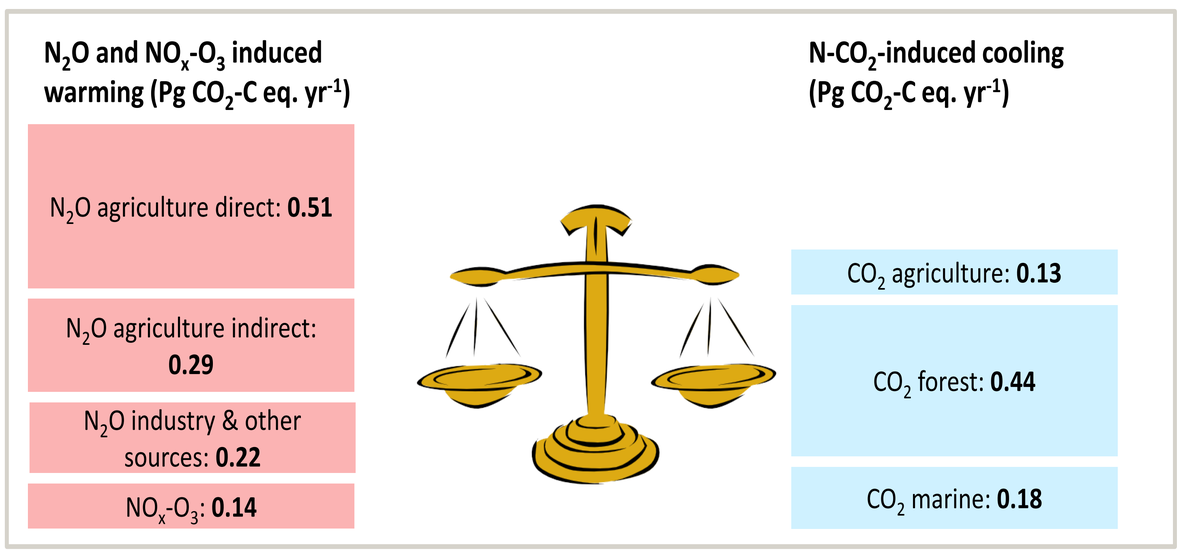


Figure 2. Estimated impact of N use on the net greenhouse gas emissions at global scale

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