8th GLOBAL NITROGEN CONFERENCE
3rd – 7th MAY 2020 | BERLIN, GERMANY

International Institute for Applied Systems Analysis
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Gridded Soil Surface Nitrogen Surplus on Agricultural Land: Impact of Land Use Maps

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Introduction

Nitrogen (N) compounds as plant nutrients play a key role in food production. Additional N nutrients, including mineral fertilizers, have been applied to agricultural land to an extent that impacts on the global N cycle (1). Negative consequences become visible to the local and global environment through eutrophication, acidification and through the formation of N_2O, a powerful greenhouse gas. Gridded maps of N surplus on cropland have been developed to display major N flows on several levels (global and local) and are key for the development of policies to manage the globally increased N input (2,3). Grasslands, which are responsible for around half of the total agricultural N_2O emissions, have not been analyzed in greater detail yet although required as a background of N management policies (4,5). A major obstacle here is the limited availability of data on grassland N fixation as well as removal at harvest. Here we analyze available input information for sensitivities and uncertainties, with the aim of developing scientific support for N management policies. The concept reflects a similar approach for cropland (6), where we tested the influence of different crop maps. In this work we tested the impact of different land use maps in assessing N surplus on agricultural land (arable land and permanent pastures) for the year 2010. This way we are able to identify critical regions to minimize environmental impacts while also offering a first analysis of the sensitivity of the results, in order to indicate areas where further research is needed.

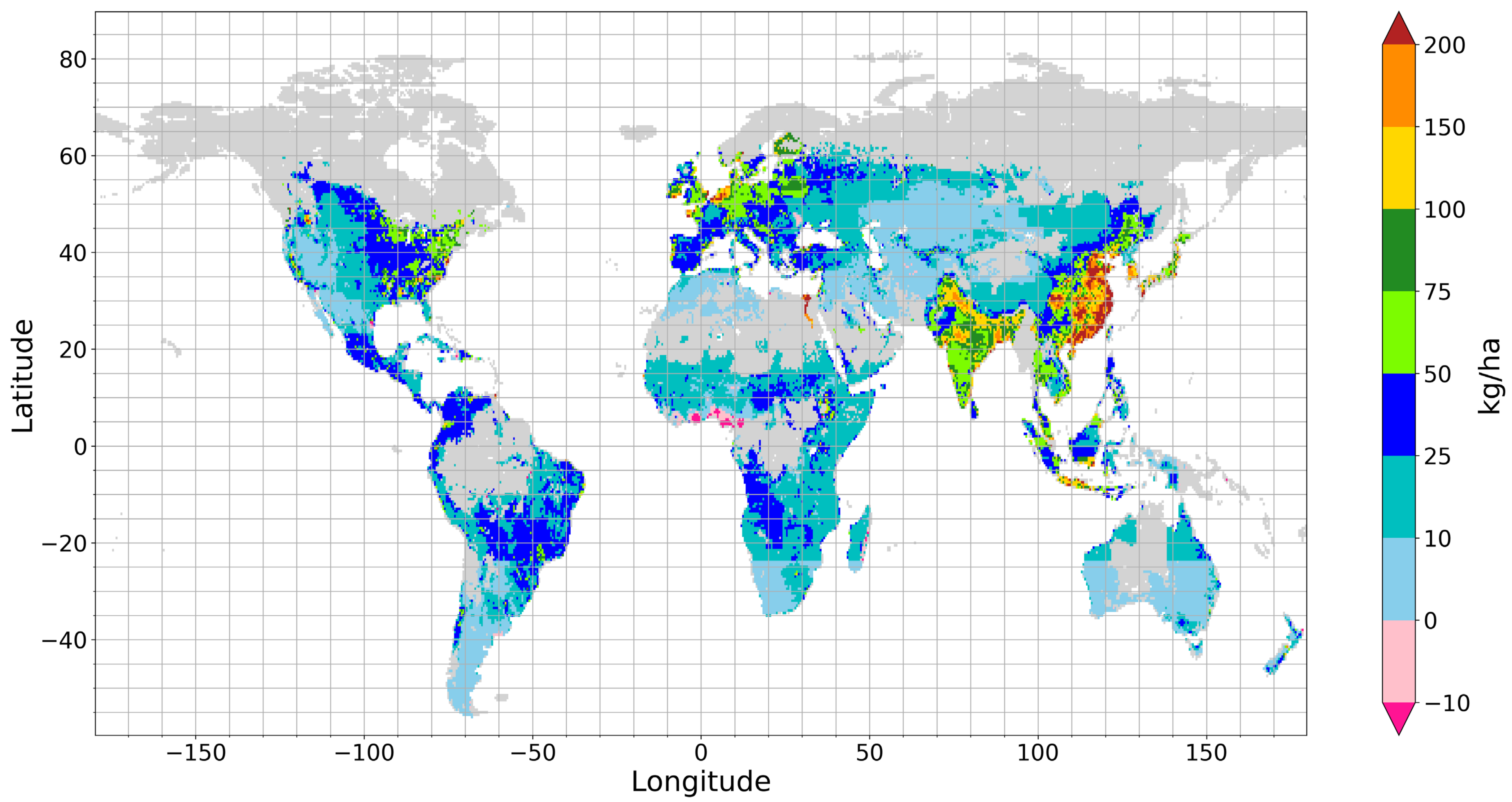

Fig 1. Spatial distribution of N surplus per agricultural land area taken from Ramankutty et al. (2008)

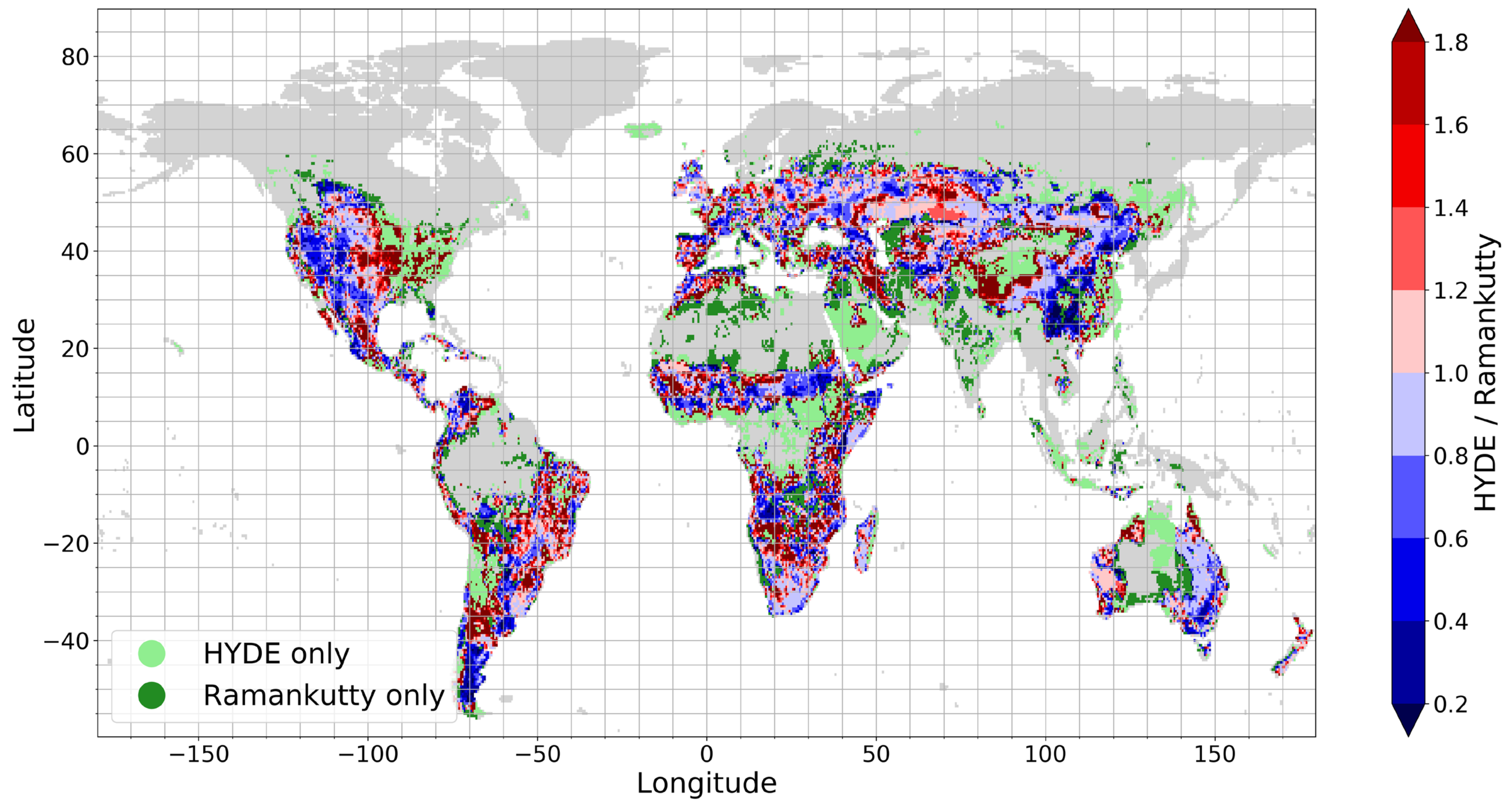

Fig 2. Ratios of grassland area according to different land use maps (HYDE divided by Ramankutty)

Results and Discussion

The resulting global map indicates N surplus for most parts of the world (**Fig 1**). Regions with high surplus are East and South Asia, but also large parts of Western Europe and the North-Eastern parts of the U.S.. Using the land use map by (14), some African countries show N deficits. However, these deficits almost fully disappear when (13) grassland is used as a basis. Further discrepancies are observed when assessing the Nitrogen Use Efficiency, for example for Saudi Arabia, Sudan, or Papua New Guinea. The reason for these discrepancies can be found in **Fig 2,** which displays the ratio of permanent pastures identified by the respective land use maps. Especially in Central Africa, Australia and in Arabia, the two land use maps allocate grassland very differently (green cells indicate that only one of the land use maps assigns grassland) indicating considerable research needs.

The global map of N surplus on total agricultural land in 2010 updates previous work (3) while also providing an analysis of the sensitivity of the results to the underlying land use map, contributing to acquiring a better understanding of N indicator calculations to support excess N reduction globally.

Method

Data typically available on a country scale were assigned to a global latitude-longitude grid of 0.5°. Harvested area, crop yields, N fertilizer use and N content of harvest per crop or crop type were spatially allocated to the M3 crop map following the distribution of 175 different crops (7,8,9). Manure N excretion during grazing as well as manure N application on fields were distributed according to the spatial distribution of animals and livestock systems (10). Plant specific Biological Nitrogen Fixation (BNF) and N deposition used a land use map as surrogate for distribution (11,12). N grazed on pastures was calculated using IPCC 2019 guidelines. To calculate the N surplus per hectare of agricultural land, N content found in harvested crops and grazed pastures was subtracted from the sum of manure N, BNF, N deposition and N fertilizer and then divided by agricultural land area. Grassland maps provided by (13) and (14) were used to investigate the sensitivity of the calculations to the land use map they are based on.

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Funding has been provided by the Austrian Science Fund (FWF): project number P 29130-G27.

FWF Der Wissenschaftsfonds.