REGIONAL SCALE NITROGEN BUDGETS FROM AGRICULTURE SECTOR IN INDIA AND ENVIRONMENTAL IMPLICATIONS

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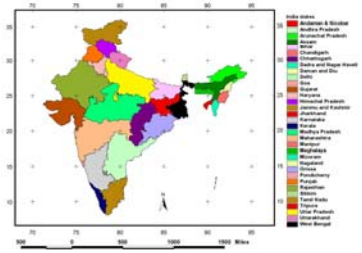
Abstract

In this study, we present nitrogen budgets at a regional scale from agriculture sector in India. Much of the excess nitrogen inputs in the Indian region are related to agriculture. We also quantified soil surface nitrogen loads for agroecological zones (AEZ's) in India using mass balance approach. We estimate nearly 35.0 Tg of nitrogen inputs from different sources, with output nitrogen from harvested crops of about 21.0 Tg. The soil surface nitrogen balance, estimated as inputs minus outputs, is found to be about 14.4Tg surplus from the agricultural land of India. Livestock manure constituted a major percentage of total inputs (44.0%), followed by inorganic fertilizer (32.4%), atmospheric deposition (11.86%) and nitrogen fixation (11.58%). Nitrogen balance varied from deficit to surplus for different states and agroecological zones. Soil surface N balance for agricultural lands showed a surplus of about 14.4Tg. The lowest N loads were found for AEZs in the Eastern Himalaya, with 19kg/ha surplus, and highest surplus in AEZ's with 111kg/ha in Deccan plateau and the south India. Environmental implications of these excess nitrogen loads in India were addressed in addition to some best management practices to reduce these loads from the agriculture sector.

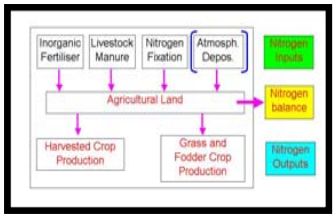
Study region

India is the seventh largest country in the world, with an area of about 328.7 Mha and a population of nearly 1.2 billion. With only 2.4% of the total geographical area, India supports 16.2% of the world's human population. The mainland of India extends between latitudes $8^0 4'$ and $37^0 6'$ north, longitudes 68^0 7' and $97^0 25'$ East. There are 28 states, 1 national capital territory and 6 union territories in India. Three new states, Chattisgarh, Uttaranchal, and Jharkhand, were created during 2000, the areas which were formerly in Madhya Pradesh, Uttar Pradesh and Bihar, respectively. In this study, we aggregated the nitrogen balance for only 25 states, treating the above three new ones as a part of old states.

Methodology



•We used the mass balance calculations from agriculture sector for estimating the soil surface nitrogen losses. Nitrogen (N) balance is calculated as the difference between the total quantity of N inputs entering the soil and the quantity of nitrogen outputs leaving the soil.



•The aggregate inputs of N sources for entire country and agroecological zones, were calculated by summing the area-weighted portion of fertilizer sold for each state and multiplying the nitrogen content of the fertilizer.

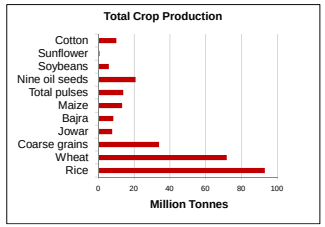
•Livestock manure N production has been calculated as the number of live animals for each species for geographical and AEZ regions multiplied by respective nitrogen excretion coefficients (IPCC, 2006).

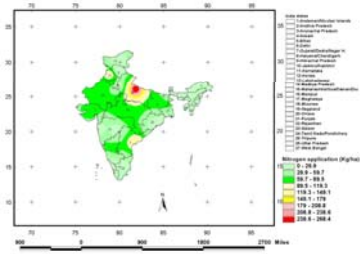
•Nitrogen inputs from biological N fixation (soybeans, clover, alfalfa, etc) was obtained from dry biomass production multiplied the fraction of N in nitrogen fixing crops.

•Nitrogen inputs from atmospheric deposition were calculated from volatilization and subsequent atmospheric deposition of ammonia and nitrogen dioxide resulting from fertilizer inputs and livestock excretion products.

•N uptake per unit of harvested yield from different crops were derived from crop nitrogen concentrations and moisture contents.

Results

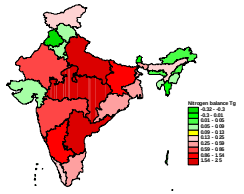




•Fertilizer application rates in the states of Tamilnadu, Punjab, Haryana / Chandigarh, Andhra Pradesh and Uttar Pradesh were found to be 204, 148, 132, 124, and 94 kg ha^{-1} respectively. The indiscriminate and inappropriate use of fertilizer especially in these states has put the land, water and environment under risk.

•However, fertilizer consumption per hectare in India is considerably low in the range of 20-204 N kg ha^{-1} with a mean of 57.76 kg ha^{-1}, compared to 365 kg ha^{-1} in Japan, 200 kg ha^{-1} in Europe, 150 kg ha^{-1} in China, 89 kg ha^{-1} in Pakistan and 90 kg ha^{-1} in Bangladesh.

Results..



		kg/ha
1	Western Himalayas, Cold Arid Ecoregion with Shallow Skeletal Soils	23.67
2	Western Plain, Hot Arid Ecoregion with Desert and Saline Soils	32.0482
3	Deccan Plateau, Hot Arid Ecoregion with Mixed Red and Black Soils	48.3562
4	Northern Plain and Central Highlands, Hot Semi-arid Ecoregion with Alluvium derived soils	53.599
5	Central (Malwa) Highlands and Kathiawar Peninsula, Hot Semi-arid Ecoregion with Shallow and Medium (inclusion of Deep Black Soils	46.716
6	Deccan Plateau, Hot Semi-arid Ecoregion with Shallow and Medium (inclusion of Deep) Black Soils	82.5375
7	Deccan Plateau and Eastern Ghats, Hot Semi-arid Ecoregion with Red and Black Soils	110.708
8	Eastern Ghats (TN Uplands) and Deccan Plateau, Hot Semi-arid Ecoregion with Red Loamy Soils	220.54
9	Northern Plain , Hot Sub-humid Ecoregion with Alluvium-derived Soils	100.513
10	Central Highlands (Malwa and Bundelkhand), Hot Sub-humid Ecoregion with Medium and Deep Black Soils	67.0161
11	Deccan Plateau and Central Highlands (Bundelkhand), Hot Sub-humid Ecoregion with Red and Black Soils	99.6
12	Eastern Plateau and Chattisgarh region), Hot sub-humid ecoregion with Red and Yellow soils	89.2187
13	Eastern (Chotta Nagpur) Plateau and Eastern Ghats, Hot Sub-humid Ecoregion with Red Loamy Soils	116.15
14	Eastern Plain, Hot Sub-humid with Alluvium derived Soils	53.556
15	Western Himalayas, Warm Sub-humid (Inclusion Humid) Ecoregion with Brown Forest and Podzolic Soils	204.359
16	Assam and Bengal Plains, Hot Humid (inclusion sub-humid) ecoregion with Alluvium-derived Soils	19.2
17	Eastern Himalayas, Warm Perhumid Ecoregion with Brown Hill Soils	15
18	North-eastern Hills (Purvachal) Warm Perhumid Ecoregion with Red and Lateritic Soils	131.21
19	Eastern Coastal Plain, Hot Sub-humid Ecoregion with Alluvium derived Soils	111.68
20	Western Ghats and Coastal Plains, Hot Humid-Perhumid Ecoregion with Red Lateritic and Alluvium derived Soils	-40
21	Islands of Anderman-Nicobar and Lakshadweep, Hot Perhumid Ecoregion with Red Loamy and Sandy Soils	-87

Inputs	Tg	% contribution
Inorganic fertilizer	11.5	32.48
Livestock manure	15.6	44.06
Nitrogen fixation	4.1	11.58
Atmospheric deposition	4.2	11.86
Total inputs	35.4	100
Total outputs	21.2	
Grass + Fodder + Harvested crop production	21.2	
Nitrogen Balance (Tg)	14.4	

•Nearly 35.4Tg of N has been estimated as inputs from different sources, with output N from harvested crops of about 21.2Tg. Soil surface N balance is estimated as 14.2 TgN excess. Further, an average N surplus of 54.11 kg/ha is estimated for agricultural lands of India. It is comparatively higher than the average surplus of 31kg/ha, reported for European countries, using the same soil surface nitrogen mass balance approach.

•Applying more N than needed for crops greatly increases N losses by leaching. The inefficiency of fertilizer use is essentially due to a lack of synchronization between the release of N from mineralization and uptake by the growing plant. Thus, N mobility factor in the soil must be considered when developing N programs and evaluating environmental effects while considering the soil type variations and climate differences.

•The key for the future is to develop sustainable farming systems, that are economically viable, technically feasible, socially acceptable, while maintaining constant production and causing minimal losses to the environment.

Acknowledgements

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