Indian Nitrogen Assessment and nutrient management for Sustainable Development

N. Raghuram

President, Society for Conservation of Nature

Co-Founder, Indian N Group, SC Member, UNEP-GPNM

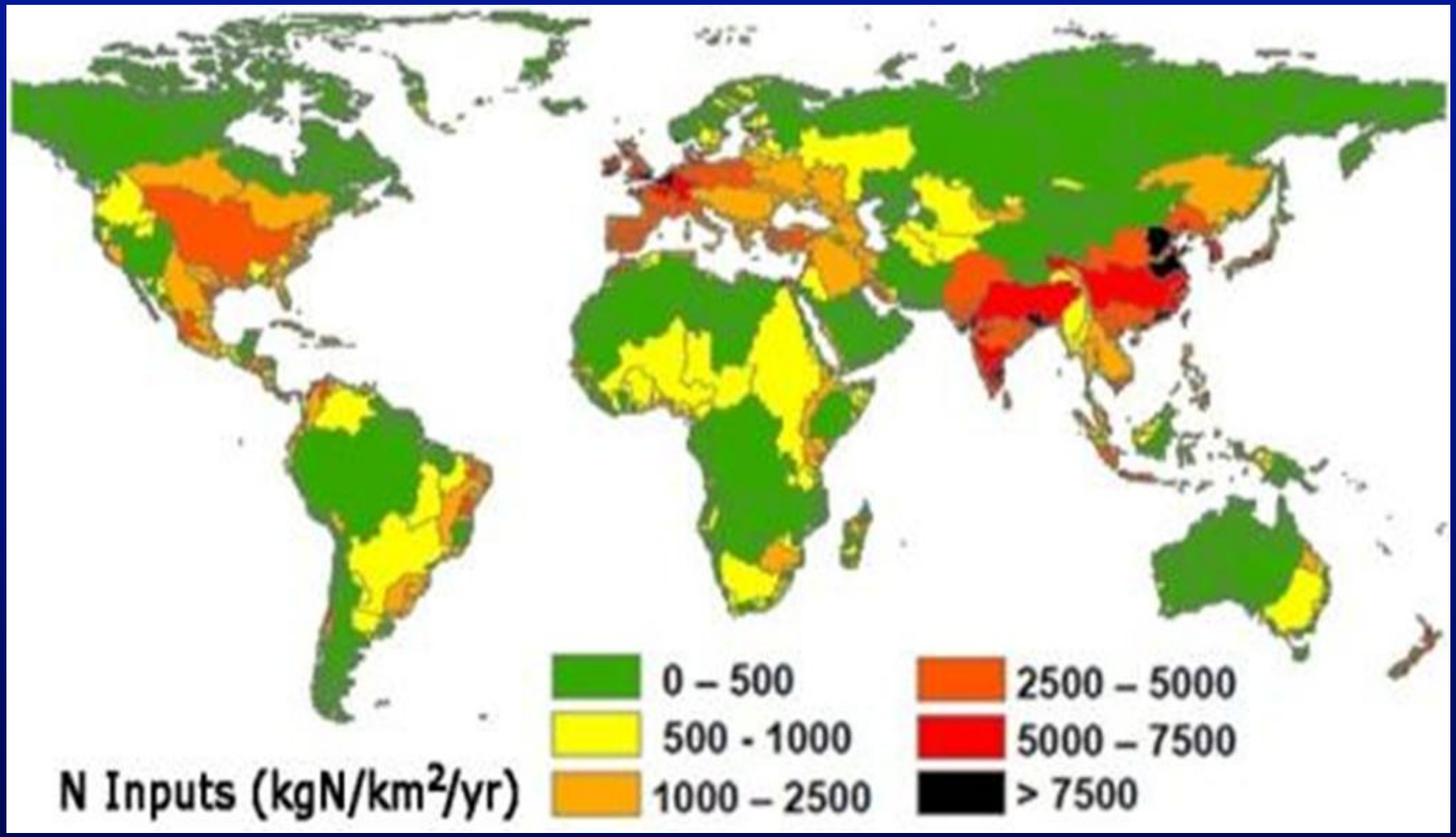
Professor and Dean, School of Biotechnology, GGS Indraprastha University, New Delhi

Editor-in-Chief, Springer journal, *Physiology and Molecular Biology of Plants*

Nutrients at the heart of global environmental concerns

Nitrogen: UNFCC, CBD, LRTAP, GPNM, GSP, ITPS etc.

Some regions use excess N while others don't have enough



Sutton et al., Our Nutrient World (2013)

Reactive N flows and impacts:

air, soil and water quality, health, climate and biodiversity

Biodiversity impacts

N outputs: harvested crops

Climate change impacts

Atmosphere

NH_3 N_2O NO_X N_2

Atmosphere

NH_3 N_2O NO_X N_2

N inputs:
N fertilizer
N fixation
N deposition

Crop production:
- *Crop type*
- *Crop area*
- *Management*

feed

manure

Animal production: -
Animal species
- *Animal number*
- *Management*

N outputs: milk, meat, eggs

NH_4^+ NO_3^- DON N_{part}

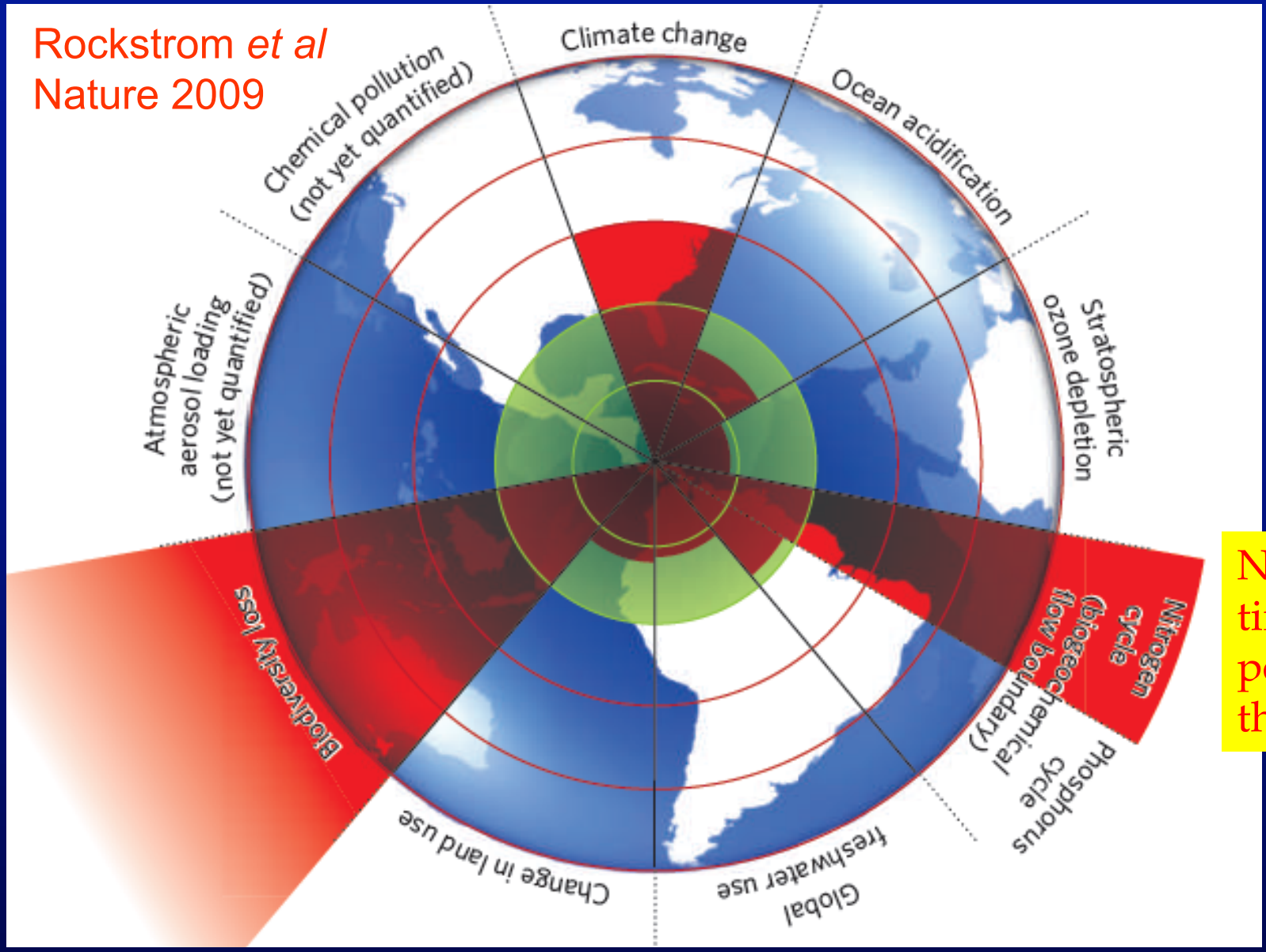
NH_4^+ NO_3^- DON N_{part}

Ground water & surface water impacts

INMS

Reactive nitrogen, biodiversity loss cross planetary limits

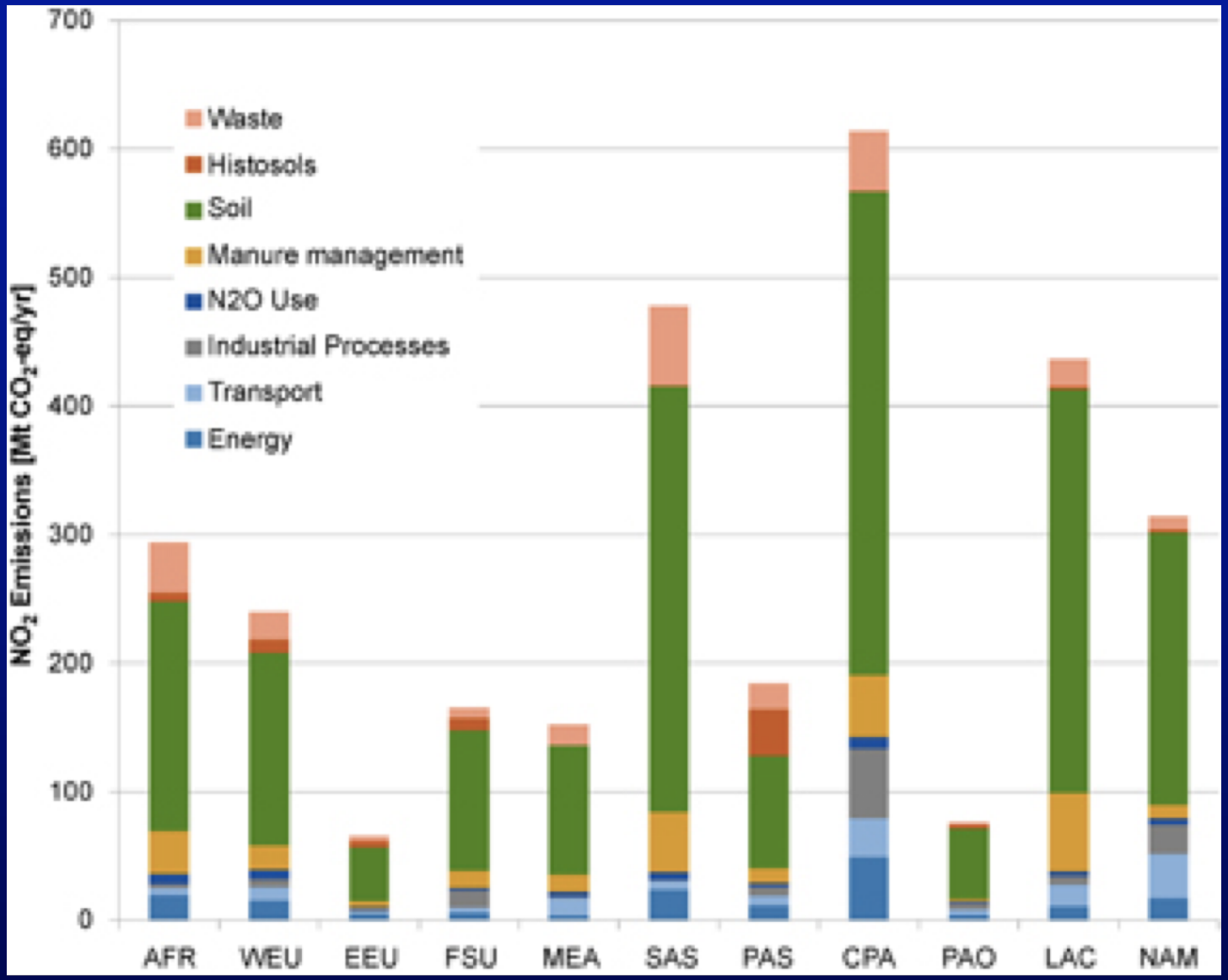
Rockstrom *et al*
Nature 2009



N_2O is 300 times more potent GHG than CO_2

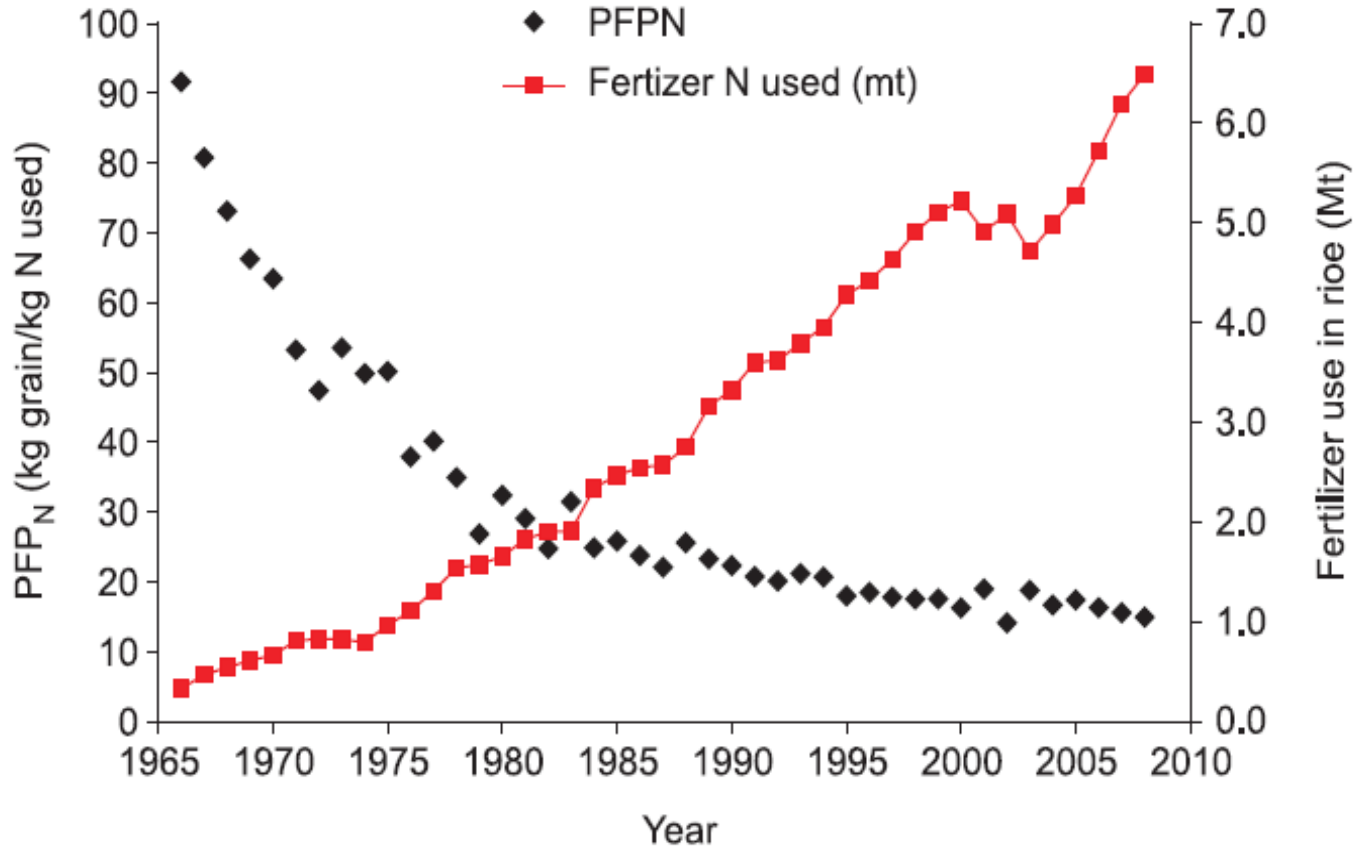
Reactive N species include NO_3^-, NO_2^-, NH_3, NH_4^+, NOx, N_2O, urea, amides...

Soils are globally the biggest sources of nitrous oxide



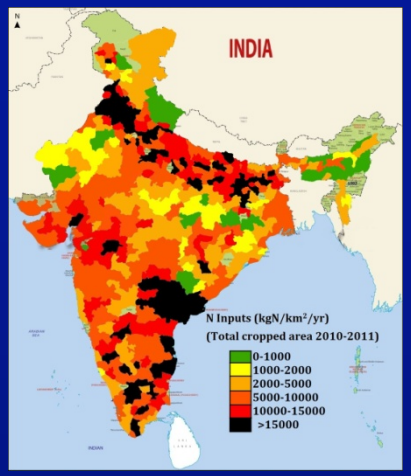
Winiwarter et al., Environ. Res. Lett. (2018)

Nitrogen fertilizer use & NUE in India

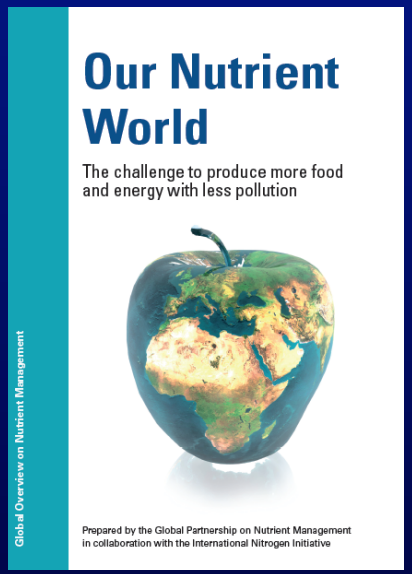


Fertilizer N use pattern and partial factor productivity (kg grain/ kg N apllied) in rice 1965 to 2008 at country level

Source: FAI, 2008–9. Adhya et al., (2010)



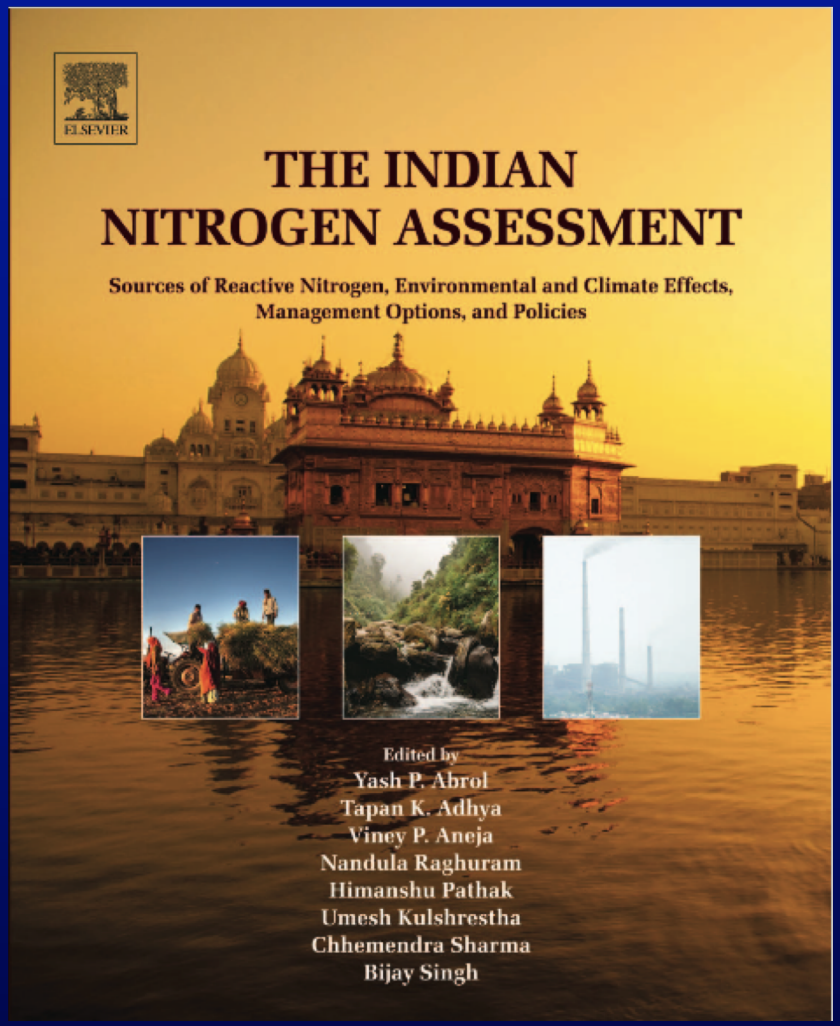
Sutton, Abrol, Raghuram, Pathak etal (2013)



A 20% increase in National NUE for India:
Saving 2.8 Mt N = £1.7 billion / year (over 400 crores for rice)

The Indian Nitrogen Assessment

Sources of Reactive Nitrogen, Environmental and Climate Effects, Management Options, and Policies



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Editors:

YP Abrol
TK Adhya
Viney P. Aneja
Nandula Raghuram
Himanshu Pathak
Umesh Kulshrestha
Chhemendra Sharma
Bijay Singh

Authors:

Over 60 from India and abroad

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The Indian Nitrogen Assessment

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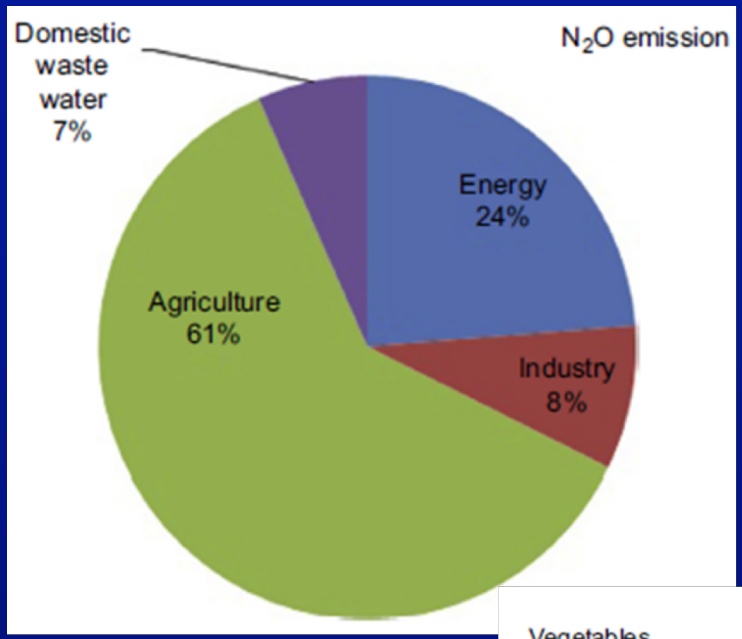
Key source analysis of N_2O emissions (NATCOM, 2012 and INDBUR1, 2015)

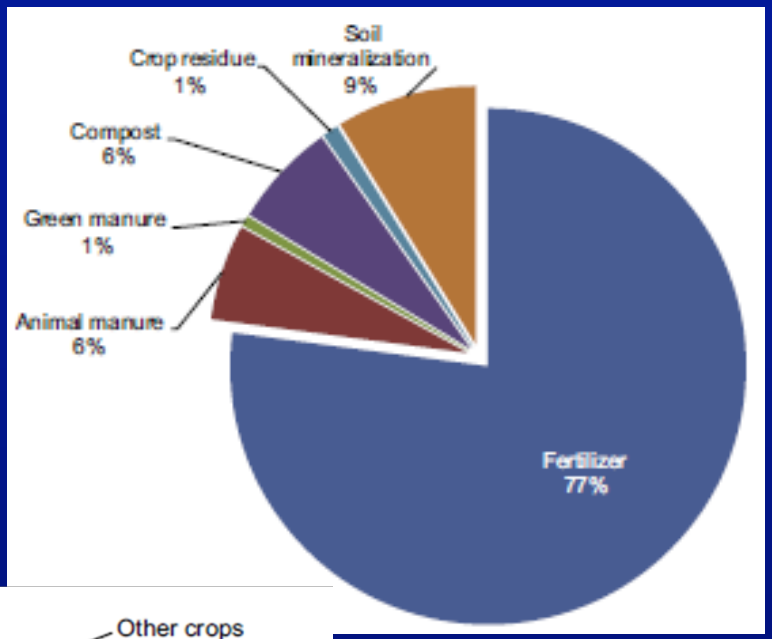
Source (2010 data)	N_2O (Gg)	Cumulative	% of total
Agriculture Soils	261.55	261.55	70.6
Waste water-domestic	43.67	305.22	82.4
Residential/commercial	21.5	326.72	88.2
Electricity Generation	11.48	338.2	91.3
Chemicals	8.19	346.39	93.5
Road Transport	7.4	353.79	95.5
Crop residue burning	7.07	360.86	97.4
Railways	2.58	363.44	98.1
Forest fires	1.87	365.31	98.6
Non specific Industries	1.82	367.13	99.1
Iron and steel	1.5	368.63	99.5
Cement	0.57	369.2	99.7
Aviation	0.35	369.55	99.8
Solid fuels	0.3	369.85	99.9
Navigation	0.13	369.98	99.9
Pulp and paper	0.1	370.08	99.9
Manure Management	0.08	370.16	99.9
Refinery	0.07	370.23	100.0

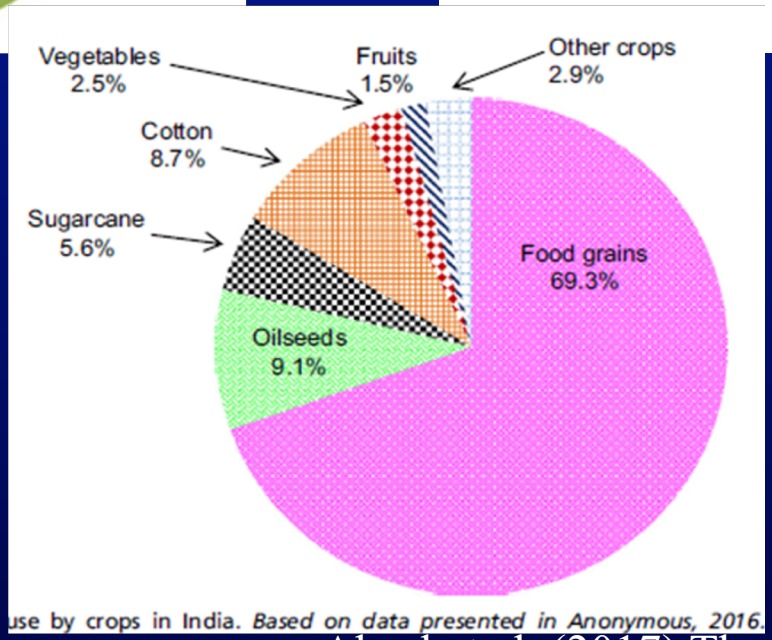
N_2O emissions by source in India as of 2010 (NATCOM, 2012 & INDBUR1, 2015)

	2000 - N2O (Gg)	2010- N2O (Gg)	CAGR (%)
Energy Industries	**7.78**	**11.85**	**4.30**
Electricity	7.75	11.68	4.19
Refinery	0.03	0.07	8.84
Solid fuels	NE	0.3	-
Manufacturing Industry	**15.2**	**12.28**	**-2.11**
Cement	NE	0.57	-
Iron and steel	0.85	1.5	5.84
Non-ferrous metals	0.03	0.03	0.00
Chemicals	13.14	8.19	-4.62
Pulp and paper	0.08	0.1	2.26
Food and beverage	0.2	NE	-
Non-metallic minerals	0.01	NE	-
Mining and quarrying	0.02	0.04	7.18
Textlie and Leather	0.08	0.03	-9.34
Non specific Industries	0.79	1.82	8.70
Transport	**6.22**	**10.46**	**5.34**
Road	4	7.4	6.35
Aviation	0.12	0.35	11.30
Railways	2.06	2.58	2.28
Navigation	0.04	0.13	12.51
Other Comm/Instt	0.03	1.08	43.10
Agriculture	**192.73**	**268.7**	**3.38**
Manure Management	0.07	0.08	1.34
Agriculture Soils	186.49	261.55	3.44
Crop residue burning	6.17	7.07	1.37
Forest fires	**6.74**	**1.87**	**-12.03**
Waste water-domestic	**13.23**	**43.67**	**12.68**
Grand Total	**264.16**	**370.38**	**3.44**

Sources of Nr from Indian agricultural soils 2010



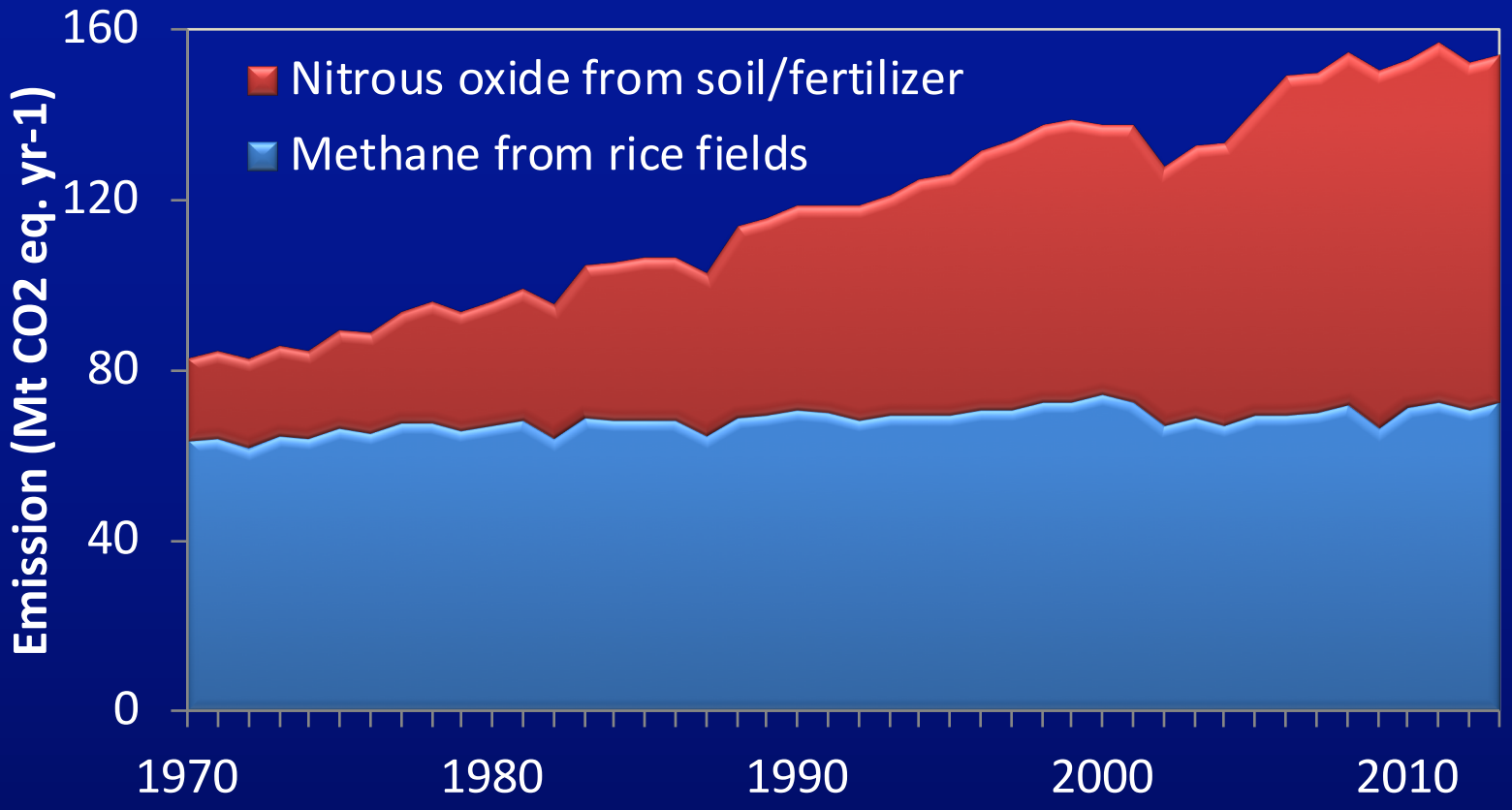




use by crops in India. *Based on data presented in Anonymous, 2016.*

Abrol et al. (2017) The Indian nitrogen assessment

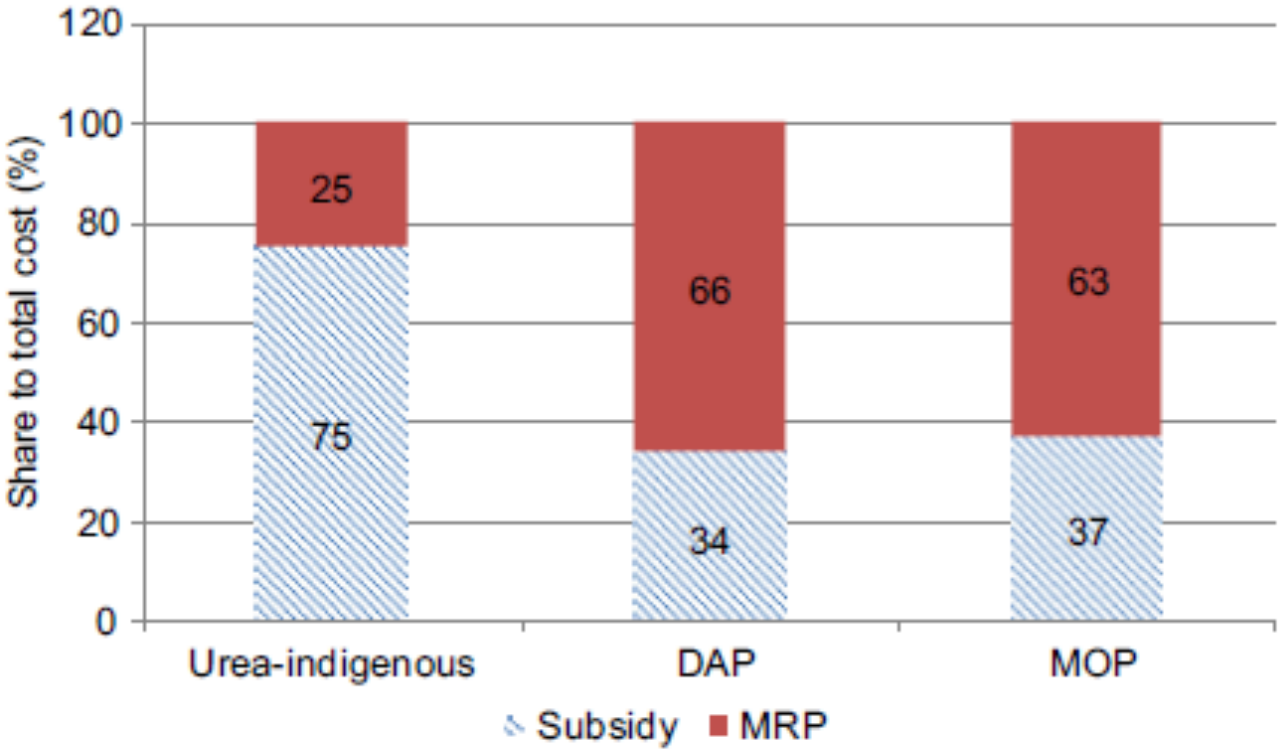
Greenhouse Gas Emissions from Indian Agriculture



- From 1970 to 2010 GHGs grew 75%, but nitrous oxide doubled
- Upto 2002, methane from rice was the 2nd largest source.
- Currently, N_2O from soil/fertilizer is the 2nd largest source.

Pathak et al. (2015)

Indian govt. subsidy for fertilizers as % of total cost (2016)



4.3 Share of subsidy to total cost of urea, diammonium phosphate (DAP) and muriate of potash 2015–16.

Govt's major policy changes in 2017:

a) sell only neem-coated urea and b) reduce bag size by 10%

Tewatia and Chandra (2017) The Indian nitrogen assessment

Indian N_2O emission due to urea and outlook scenarios

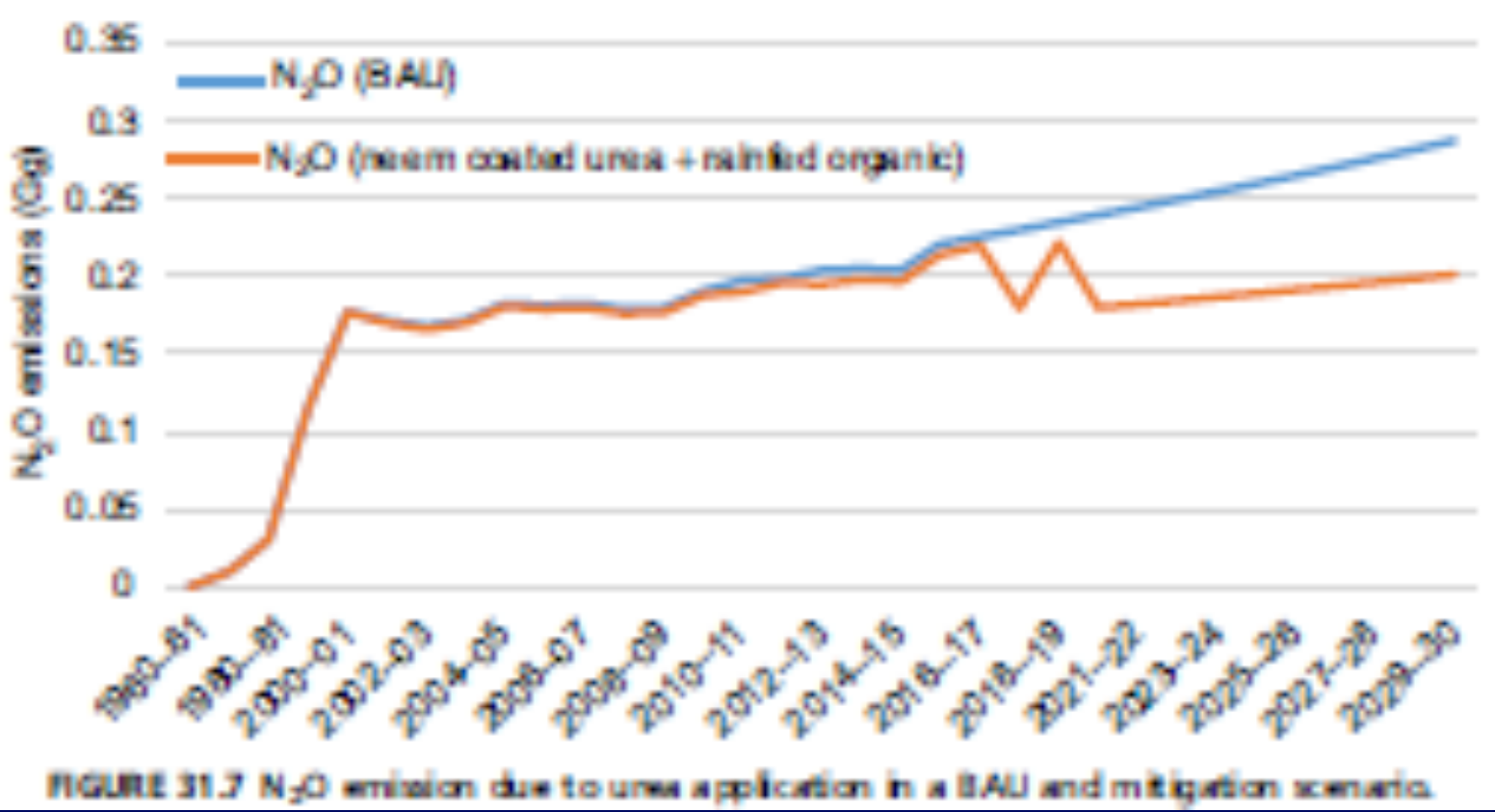
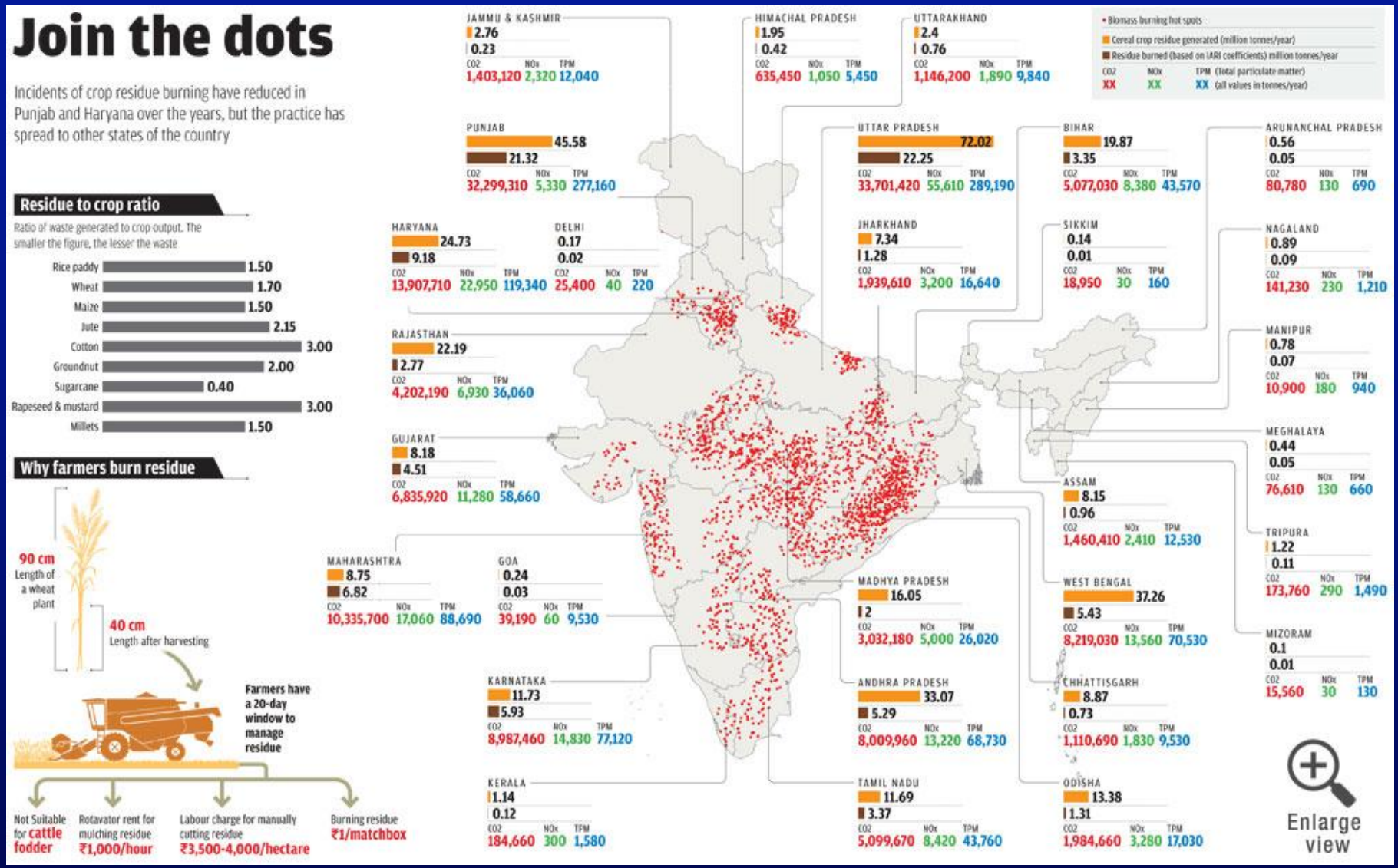


FIGURE 31.7 N_2O emission due to urea application in a BAU and mitigation scenario.

Bhattacharya et al (2017) The Indian nitrogen assessment

Crop residue burning across India (2014)



http://www.downtoearth.org.in/coverage/river-of-fire-57924

Losses from straw burning

Loss of Nutrients

- 100% of C
- 80% of N
- 25% of P
- 50% of S
- 20% of K

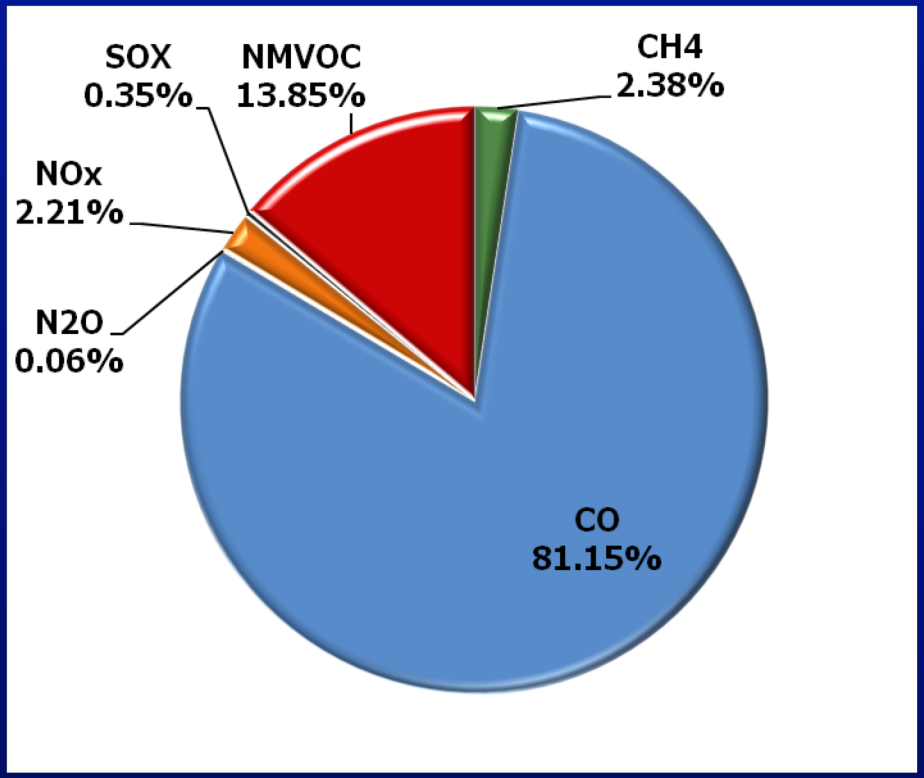
Emissions & aerosols

- 3 kg particulate matter
- 60 kg CO
- 1460 kg CO_2
- 199 kg ash
- 2 kg SO_2
- N_2O, CH4
- Hydrocarbons
- volatile organic compounds (VOCs)
- semi-volatile organic compounds (SVOCs)
- polycyclic aromatic hydrocarbons (PAHs)
- polychlorinated biphenyls (PCBs)
- Dioxins

Acid deposition, increase in tropospheric ozone and depletion of the stratospheric ozone layer.

Greenhouse gas emissions from burning of crop residues in India (Gg)

- CH_4 - 257
- CO – 8822
- N_2O - 6.7
- NOx - 239
- SOx – 38



Jain and Pathak (2010)

Nr losses (Mt) from poultry

Table 17.1 Estimated Poultry Population, Feed Requirement, and Nitrogen Excretion

Attributes	Units	Year			
		2016	2020	2025	2030
Poultry population	Million, number	762.3	839.0	945.8	1066.2
Feed requirement (total)	Million tons	21.20	28.20	40.35	57.84
Feed requirement, broiler	Million tons	10.31	14.20	21.17	31.57
Layer	Million tons	10.10	12.99	17.80	24.39
Ducks and others	Million tons	0.783	1.01	1.37	1.88
Excreta (DM)	Million tons	7.70	10.18	13.48	17.87
Excreta (25% DM basis)	Million tons	30.79	40.72	53.92	71.48
N excretion	Million tons	0.415	0.546	0.770	1.089

Mandal et al (2017) The Indian nitrogen assessment

Estimated N_2O emissions (Gg) from Indian livestock 2014

Table 26.3 Estimated and Projected Nitrous Oxide Emissions (Gg) From Livestock in India

Livestock Category	1961	2010	2025	2050
Cattle	4.2	4.1	4.1	3.9
Buffalo	2.2	4.8	5.4	6.8
Sheep	0.6	1.2	1.3	1.5
Goat	1	2.4	2.7	3.4
Swine	0.29	0.54	0.94	1.2
Poultry	0.3	2.3	3	4.6
Camel	0.014	0.007	0.006	0.005
Ass	0.017	0.005	0.004	0.003
Mule	0.001	0.002	0.002	0.002
Horse	0.004	0.002	0.002	0.001
Total	8.67	15.3	17.5	21.4

Patra, A.K., 2014. Trends and projected estimates of GHG emissions from Indian livestock in comparisons with GHG emissions from world and developing countries. Asian-Australasian Journal of Animal Sciences 27(4), 592–599, http://dx.doi.org/10.5713/ajas.2013.13342.

Kulshreshtha et al (2017) The Indian nitrogen assessment

Groundwater nitrate content in metropolitan areas 2014

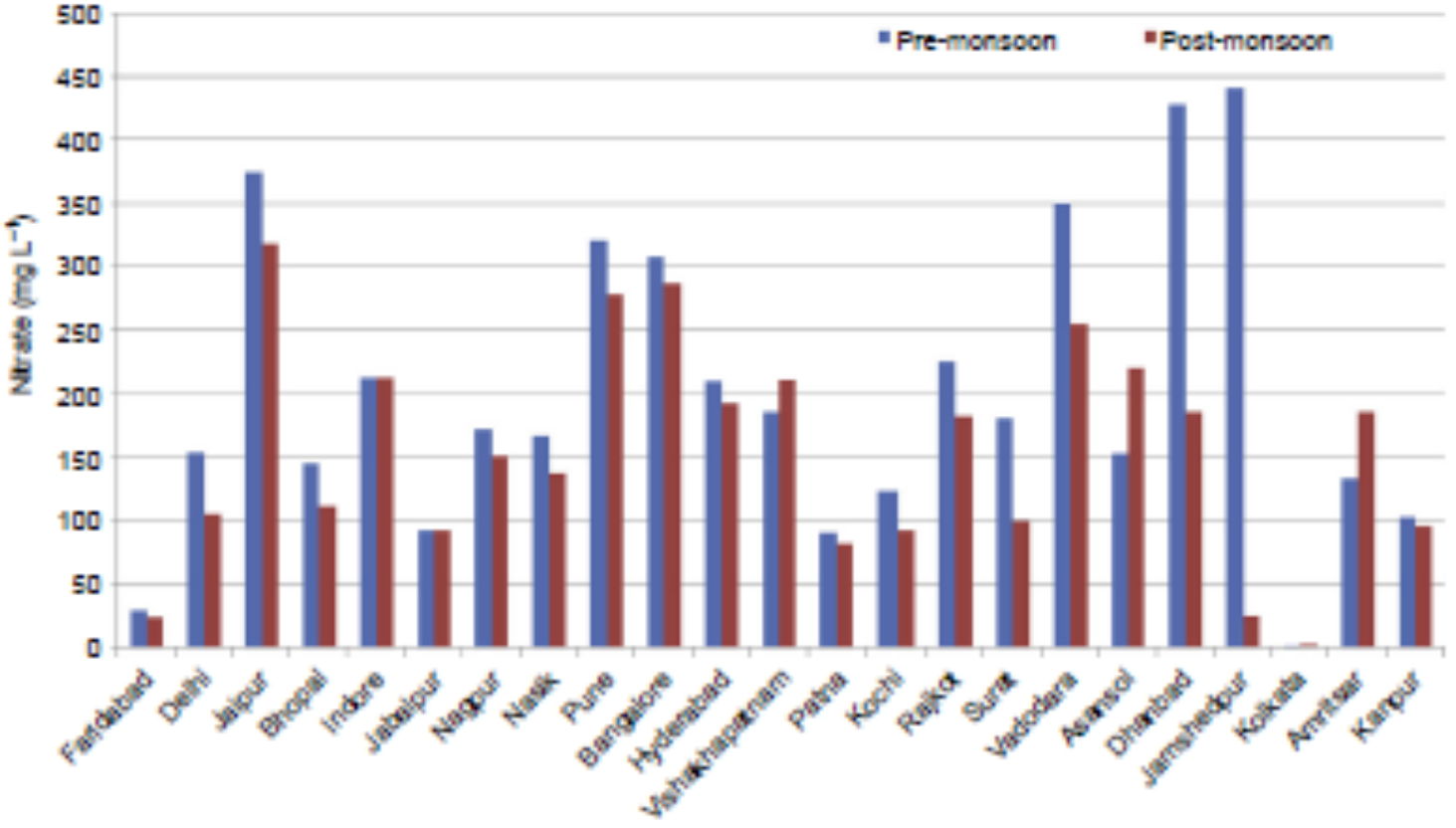


FIGURE 21.1 Nitrate content in groundwater of metropolitan areas. *CGWB, 2014a. Concept Note on Geogenic Contamination of Ground Water in India with a Special Note on Nitrate; CGWB, 2014b. Ground Water Year Book, 2013–14.*

Nationally, 381 out of 640 districts spanning 21 out of 29 states, 7 UTs are affected

Prakasa Rao et al (2017) The Indian nitrogen assessment

Indian N_2O emission due to wastewater and scenarios

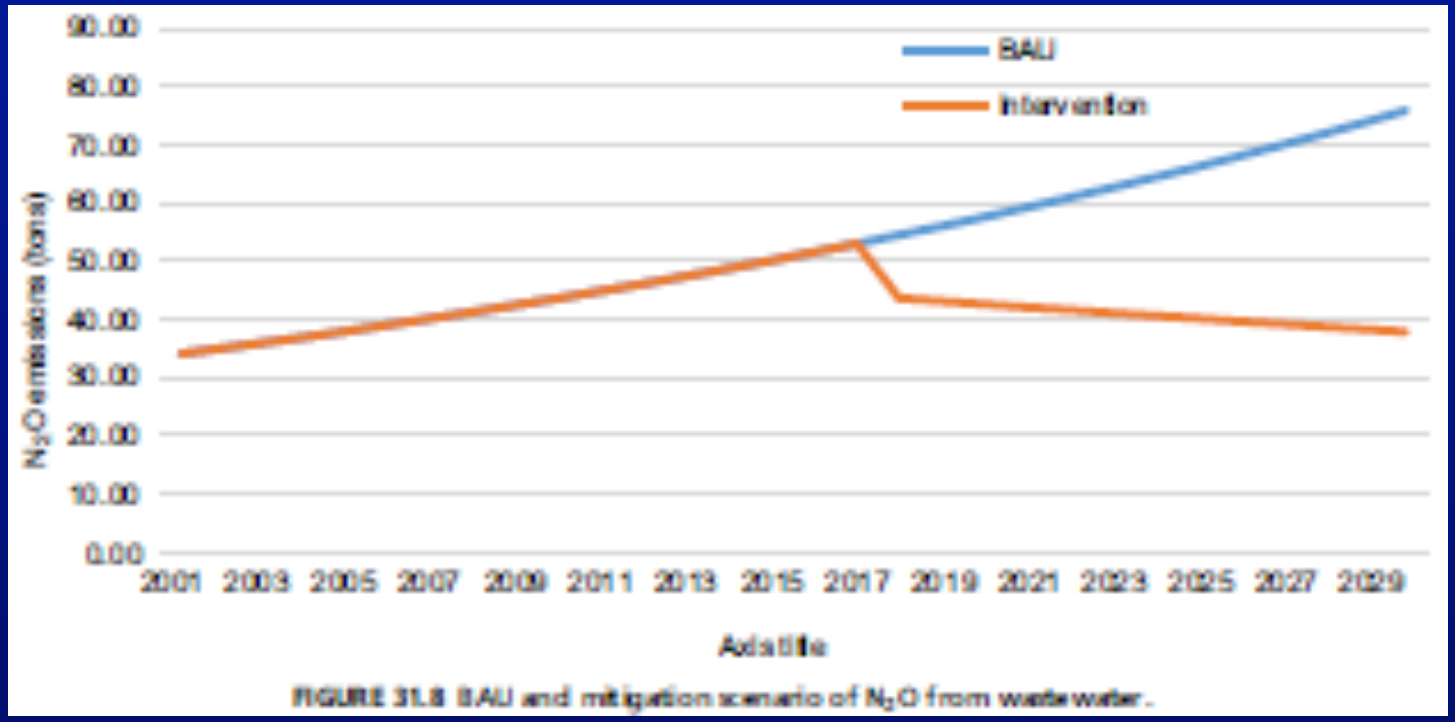


FIGURE 31.8 BAU and mitigation scenario of N_2O from wastewater.

Bhattacharya et al (2017) The Indian nitrogen assessment

Vehicular N_2O and NOx emission and mitigation scenarios

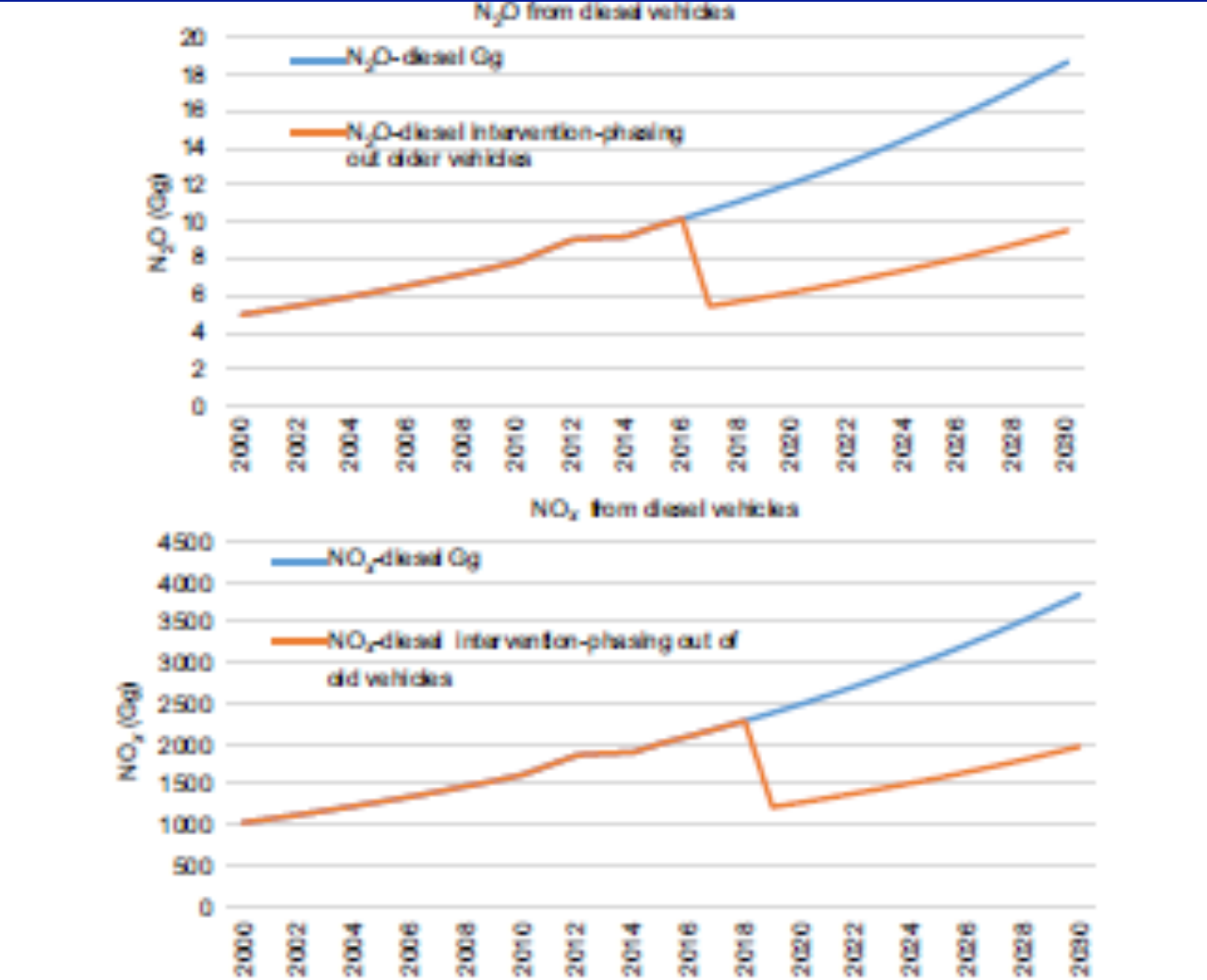


FIGURE 3.19 Impact of phasing out of diesel vehicles (buses, heavy commercial vehicles, light commercial vehicles, and commercial cars and UVs) on N_2O and NO_x emissions from diesel-run vehicles.

Bhattacharya et al (2017) The Indian nitrogen assessment

Where are we with nitrogen policy?

- General fragmentation of issues, ministries, agencies
  - Water, air, GHG, biodiversity, food, fertilizer, etc
- Major barriers to change
  - Cars struggle to go further in reducing NO_x
  - Agricultural lobbies prevent adoption of N policies
  - Insufficient of investment in waste water treatment
- Recent Govt Initiatives (2017)
  - Neem coated urea is the only urea available in retail market
  - Size of urea bag reduced by 10% keeping the price constant
  - PM and agri minister advocate reduction of urea by half in 5 yrs

Thanks!

raghuram98@hotmail.com