Managing nitrogen for climate change mitigation and adaptation in agriculture

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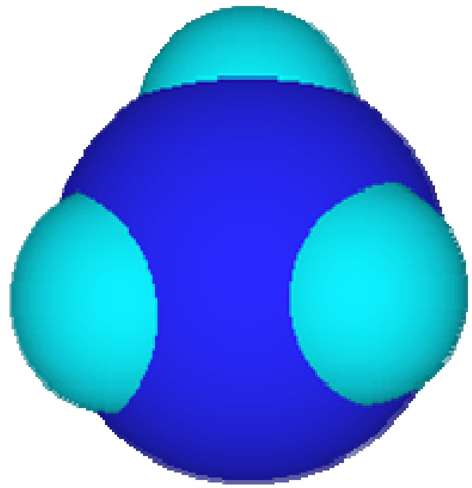
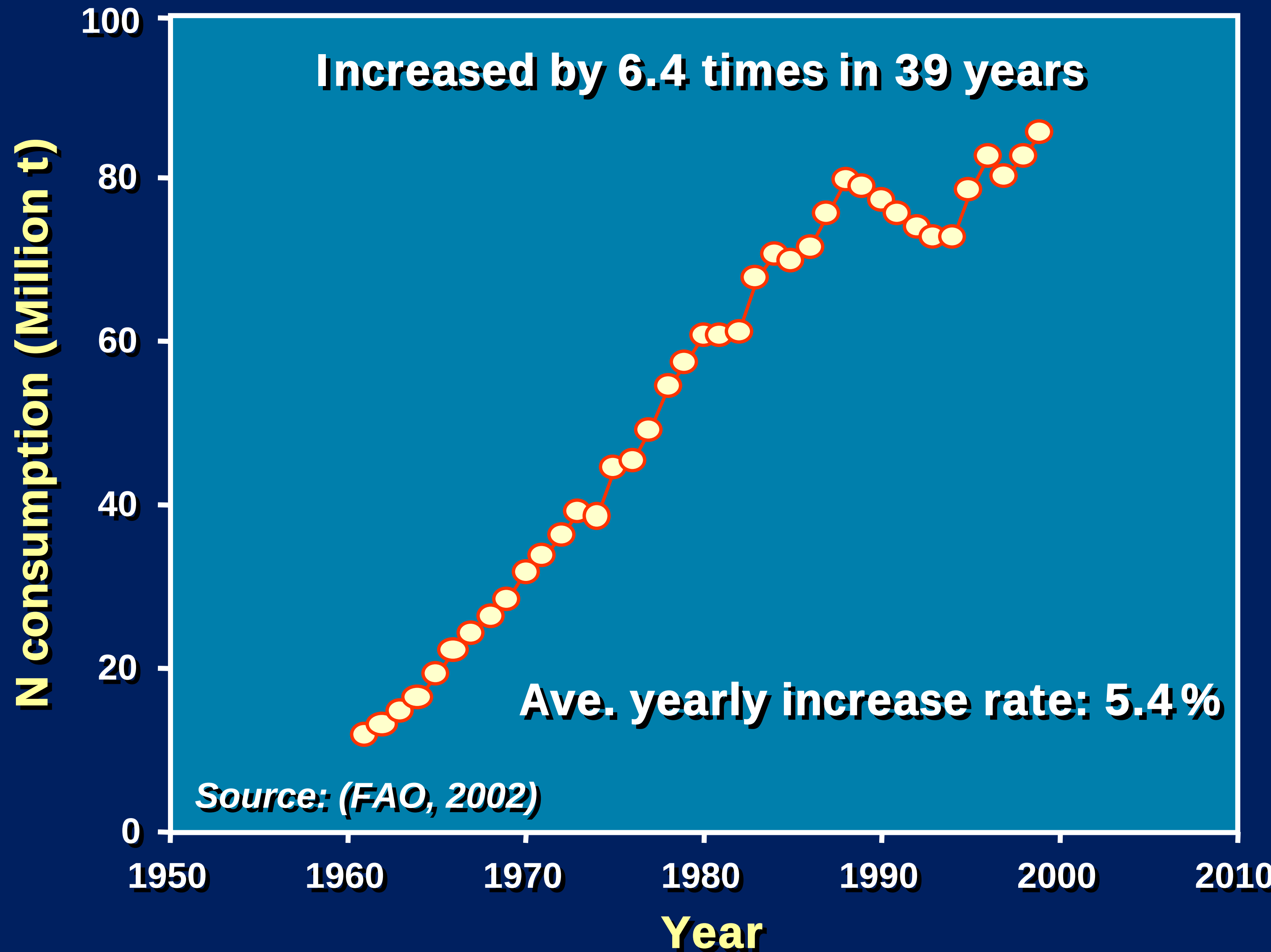
Fertilizer N

- **German chemist Fritz Haber developed a chemical process in which nitrogen and hydrogen gas are combined to form gaseous ammonia.**
- Ammonia can be used directly as fertilizer, but most of it is further processed to urea and ammonium nitrate (NH_4NO_3).
- **Coupled with irrigation, N fertilizer revolutionized agriculture by increasing crop yield.**

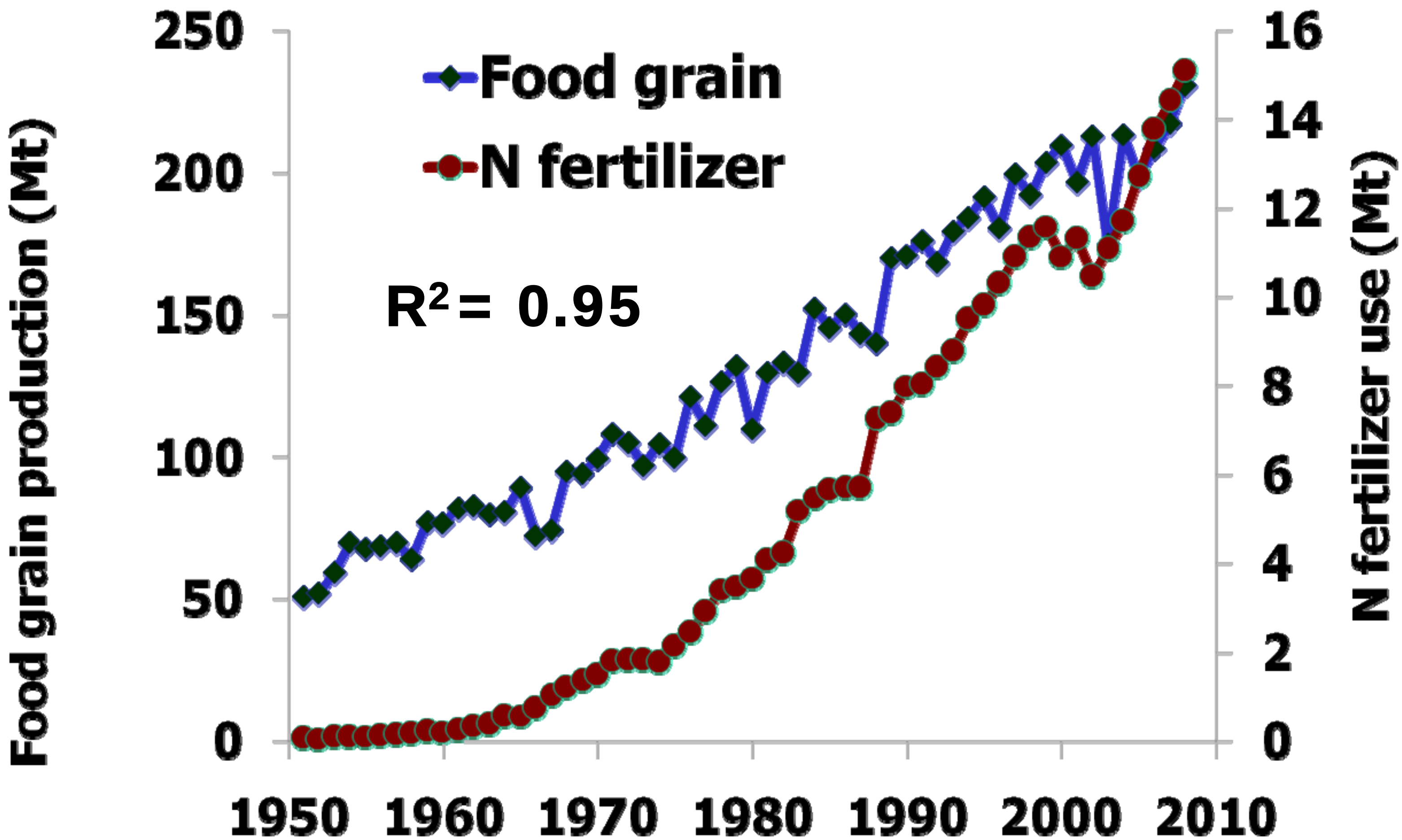


NH_3 molecule

Global Fertilizer Nitrogen Consumption



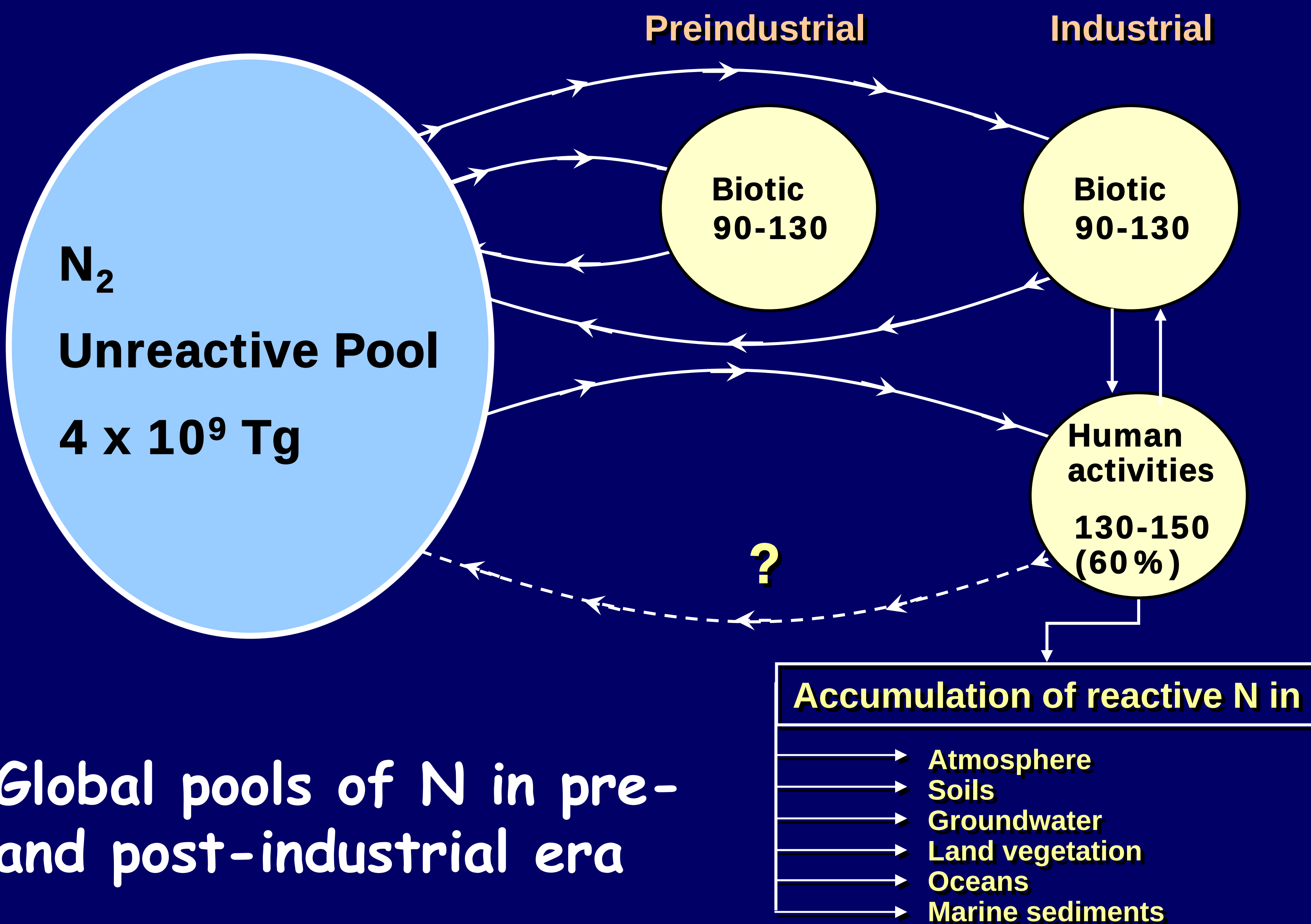
Nitrogen fertilizer is a major driver of food production in India



Pathak (2011)

Environmental Challenge…

Reactive Pool of N (N_2 Fixation Tg/year)



Global pools of N in pre- and post-industrial era

Impact of reactive N (Nr) in global heat balance

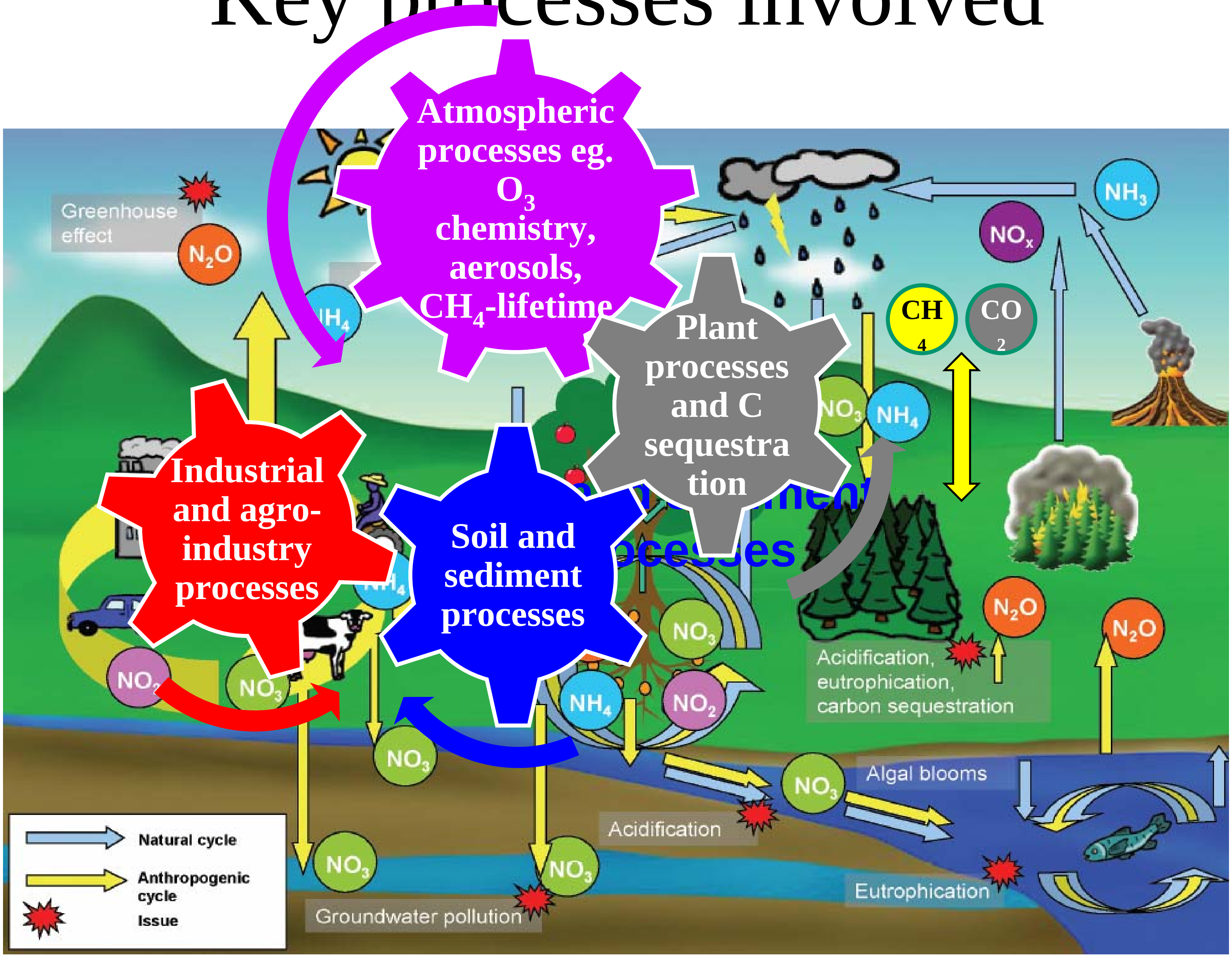
Warming effects of Nr:

- Emission of N_2O
- Production of O_3
- Reduction in the biospheric CO_2 sink by tropospheric O_3.

Cooling effects of Nr:

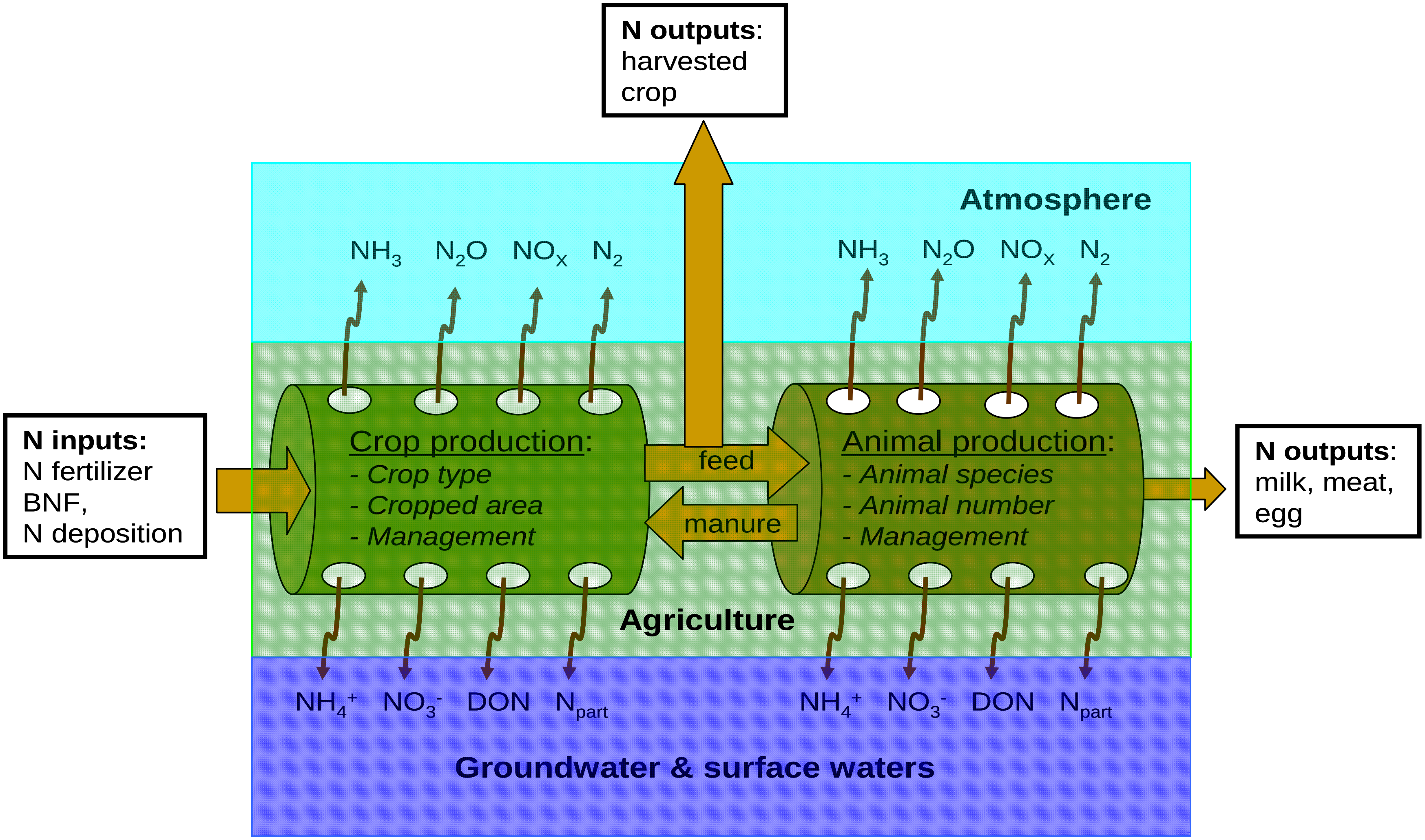
- Increasing biospheric CO_2 sink by atmospheric Nr deposition
- C sequestration due to N fertilization
- Light scattering effects of Nr containing aerosol
- Effect of O_3 in reducing the atmospheric lifetime of CH_4.

Key processes involved



Butterbuck et al. (2011)

Nitrogen in soil-crop-animal-atmosphere continuum



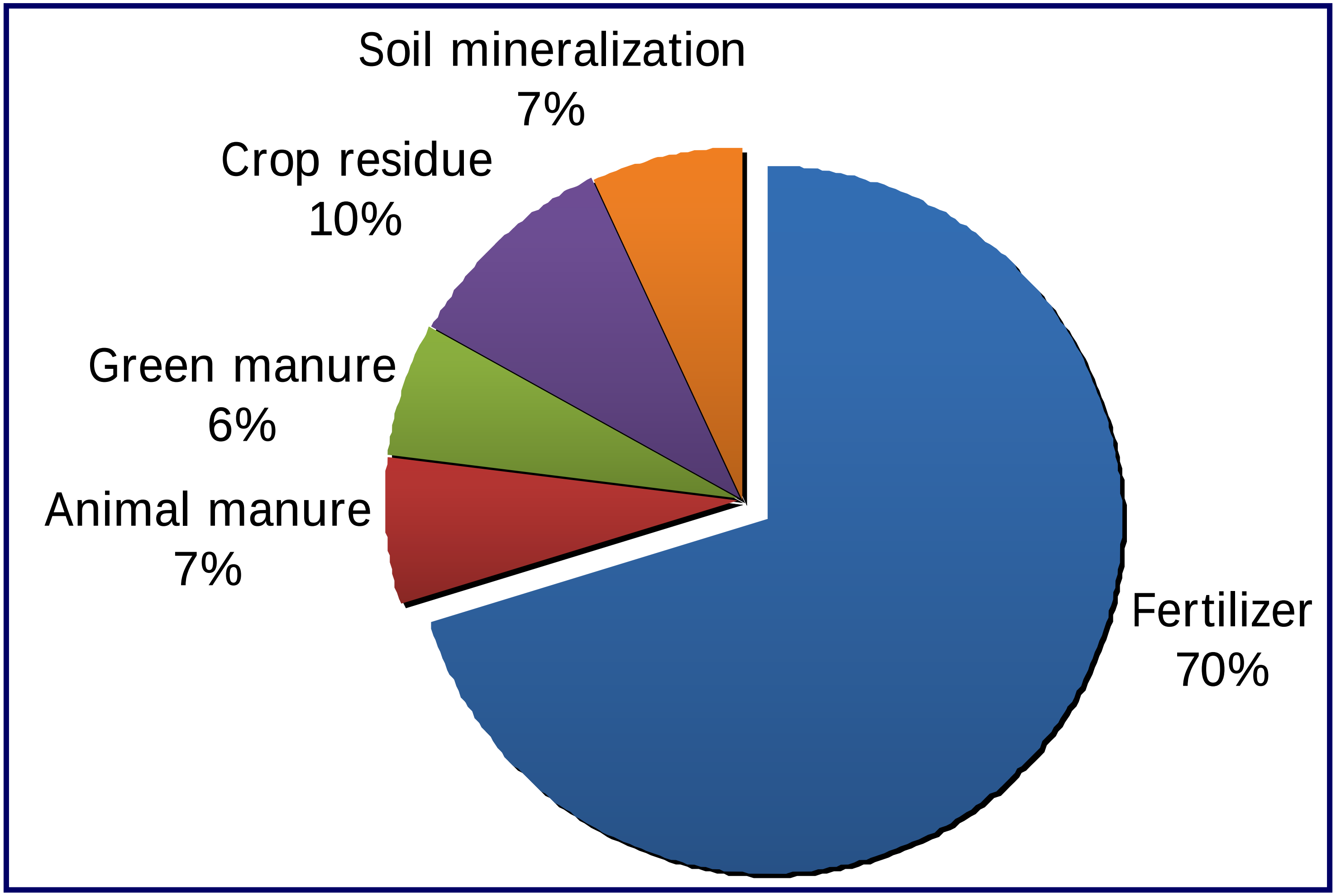
Oenema et al. (2009)

Greenhouse gas emission from Indian agriculture

Source	CH_4 (Mt)	N_2O (Mt)	CO_2 eq. (Mt)
Rice cultivation	3.33	-	83.25
Agricultural soil	-	0.14	41.72
Crop residue burning	0.23	0.006	7.54
Total	3.56	0.146	132.51

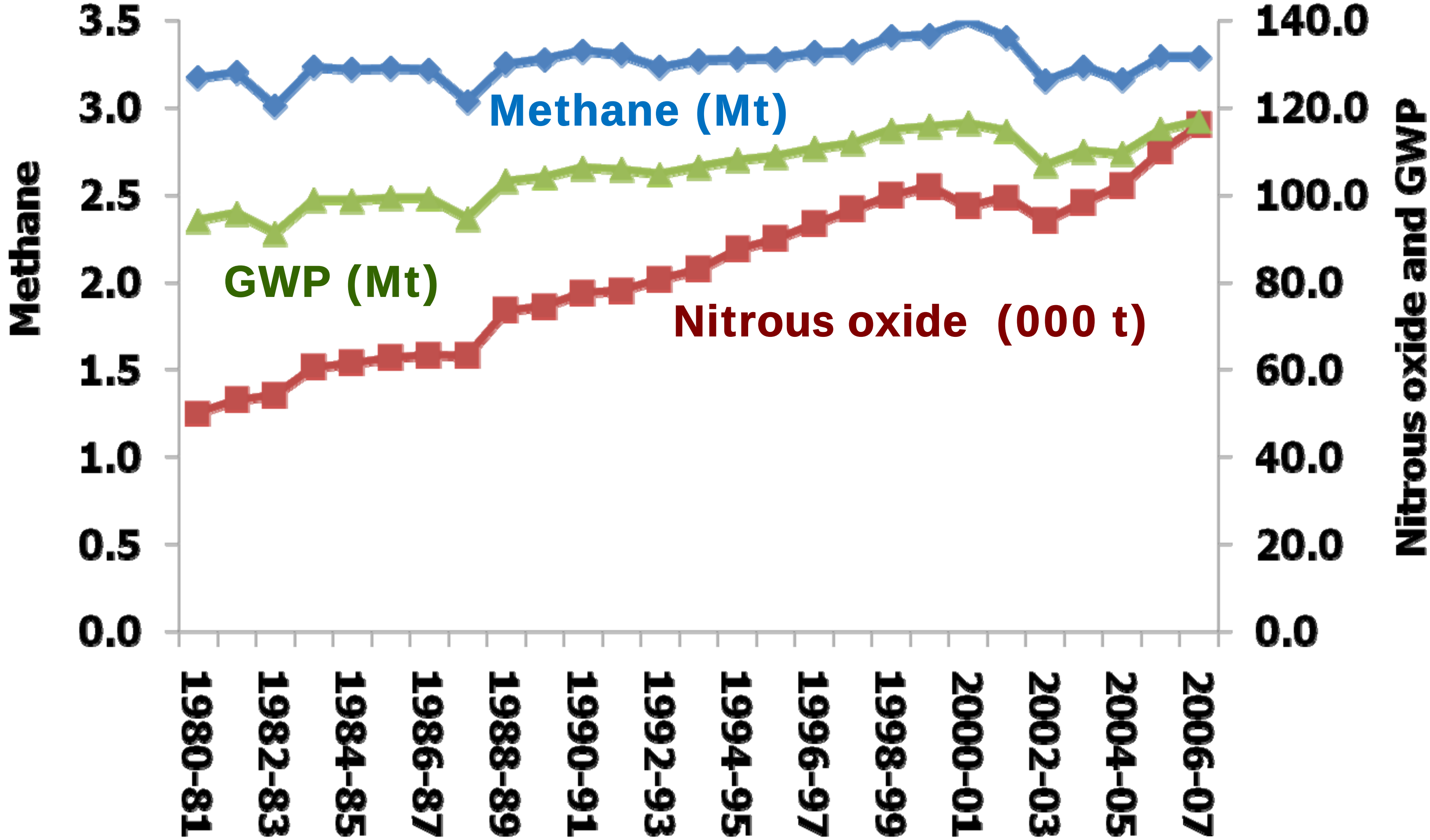
Pathak et al. (2010)

Emission of N_2O-N from different sources in agricultural soils (Total emission 0.14 Mt)



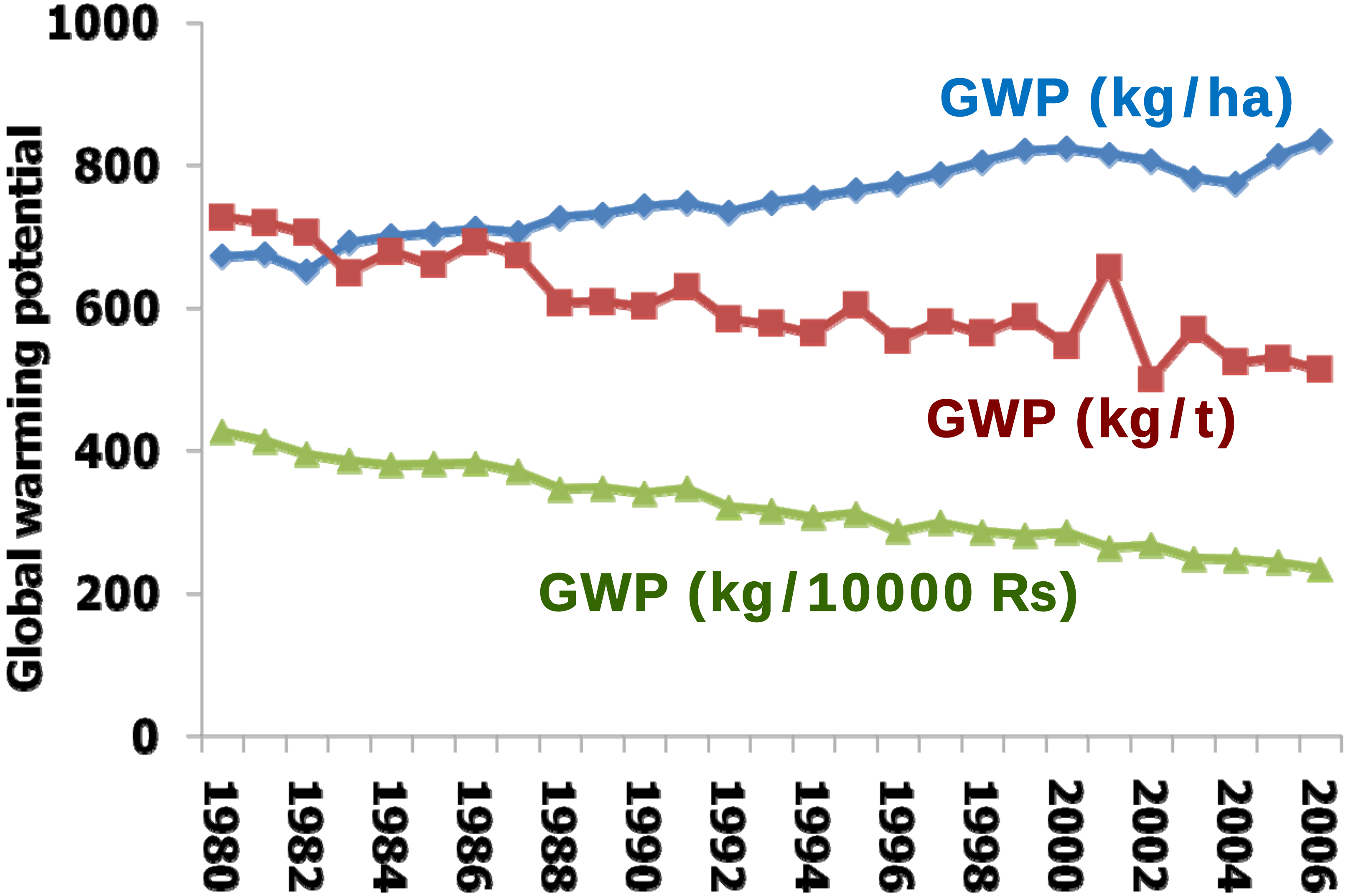
Pathak et al. (2010)

Trends in GHG emission from Indian agricultural soil



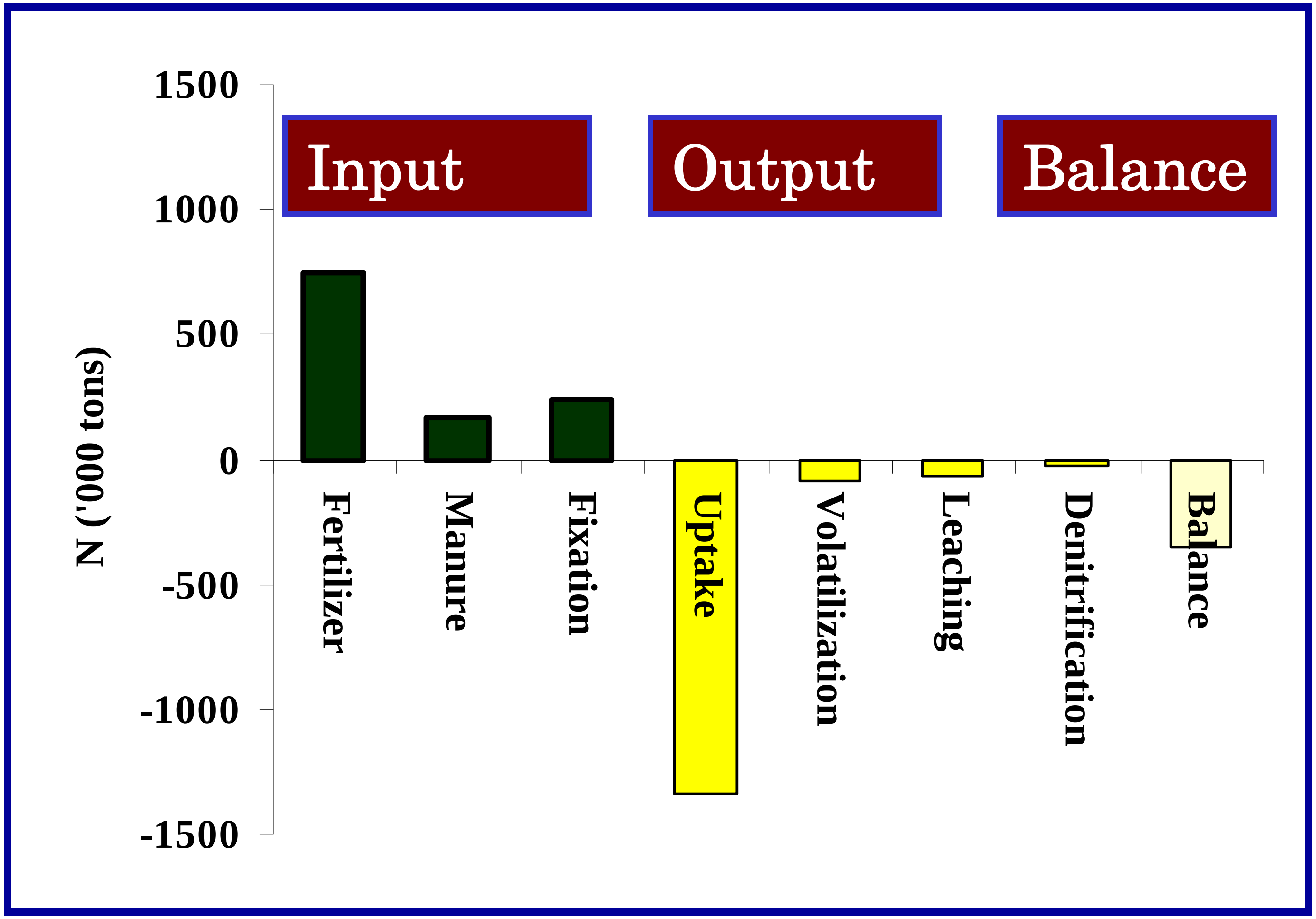
GWP = Methane x 25 + Nitrous oxide x 298

Trend in GHG emission intensity in Indian agriculture

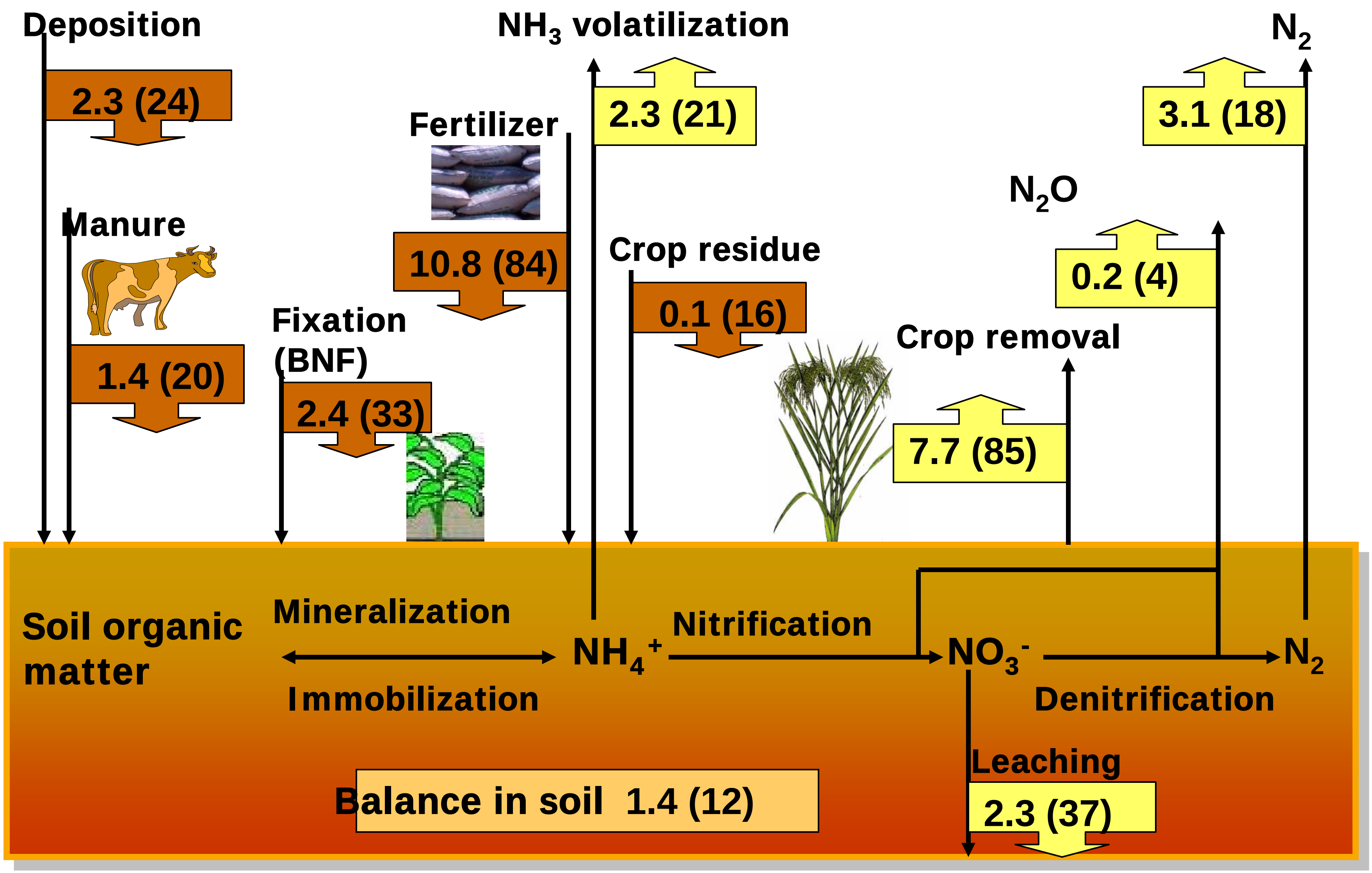


GHG intensity = GWP / Ag-GDP

Estimate of annual inputs and outputs of N in the rice-wheat systems in the Indo-Gangetic Plain



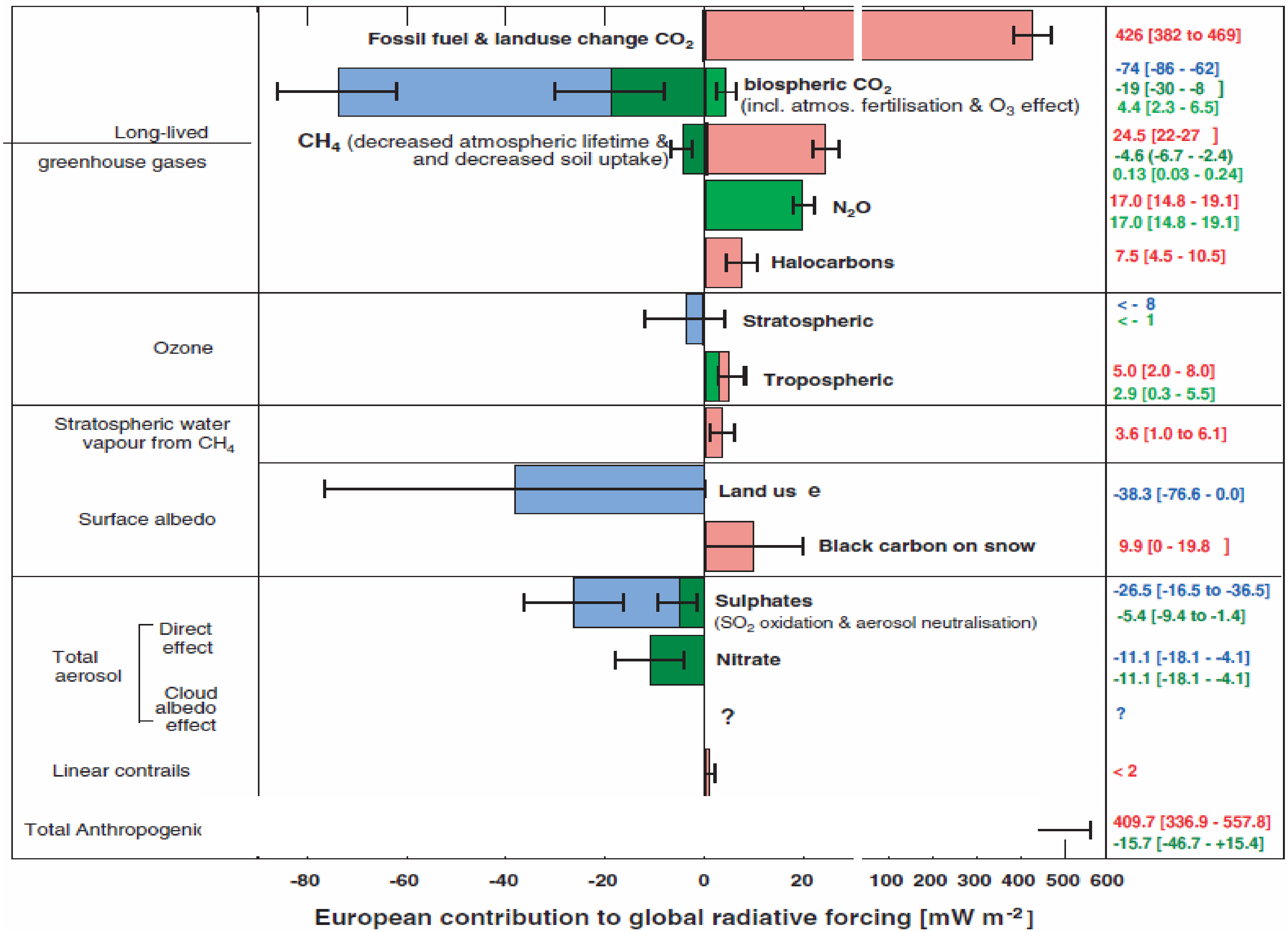
Pathak, H. et al. (2006) Soil Sci. Soc. Am. J. 70:1612-1622.



N annual budget (2000-01) in Indian and World (in parentheses) agriculture (in million tons)

Pathak et al.

Net effect of N_r on European GHG balance



Butterback et al. (2011)

Nitrogen management for climate change adaptation

- N fertilizer enhances crop yield and acts as an insurance of climatic risks.
- Compensating quality of crop with additional N application under elevated CO_2.

Approaches for enhancing the N use efficiency

Strategic options
- Improving supply and demand synchrony
- Improvement in soil health
- Improvements in varieties

Management options
- Site-specific nutrient management
- Integrated nutrient management
- Improving application methods
- Improving the fertilizer formulations
- Integrated crop management

Nutrient use efficiency

Tools and technologies
- Leaf colour chart
- Decision support system
- Remote-sensing
- Geographic information system
- Precision farming

Policy options
- Communication and dissemination of the technologies
- Improving management skills of farmers
- Private/public partnerships
- Infra-structure, subsidy, crop insurance

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How to Improve N Use Efficiency and Minimize Leakage of N into Environment?

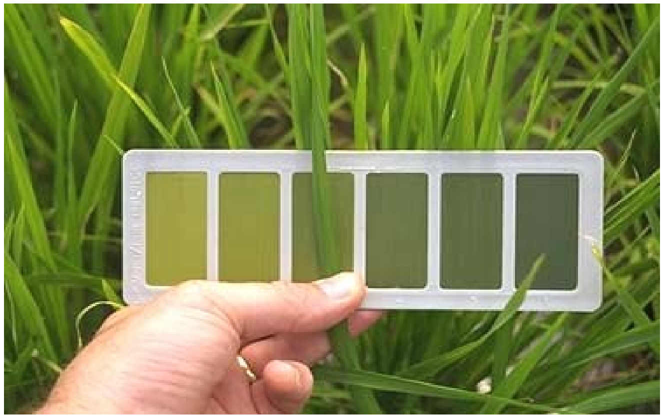
Synchronize

Plant N Demand

Soil N Supply

Mineral Fertilizer

Organic Residue GM



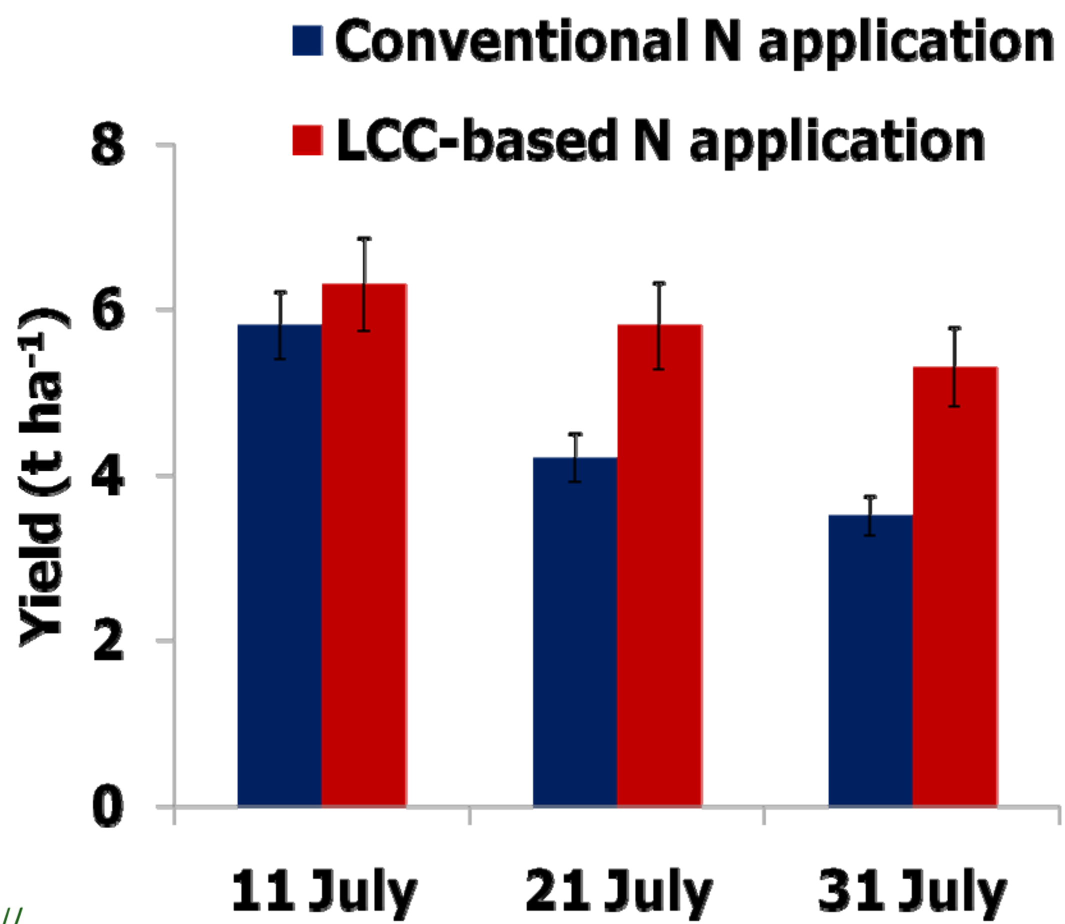
Leaf colour chart

Urea tablet /
Nitrification inhibitor

Smart Nitrogen Management for N_2O Mitigat

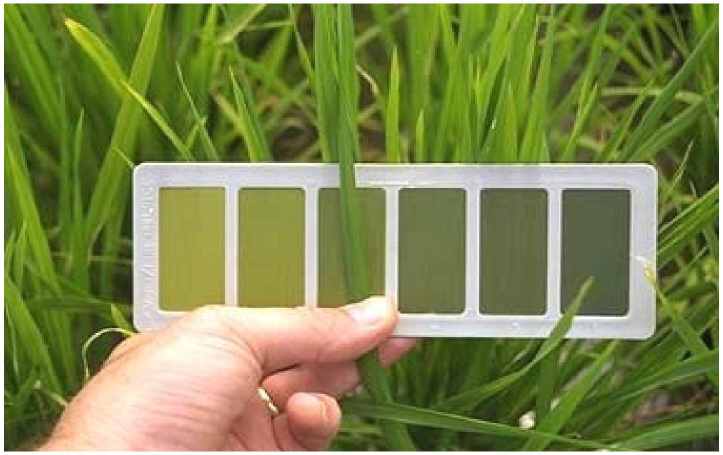
Ladha and Pathak (2005) Adv. Agron.

Adaptation of late planted rice with demand-driven N management



- Demand-driven N use can help in adaptation

- But it requires 30 kg ha^{-1} extra N fertilizer



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Nitrous oxide mitigation with nitrification inhibitor

Nitrification inhibitor	Mitigation (%)
Dicyandiamide (DCD)	13-42
Neem cake	10-21
Neem oil	15-21
Nimin	25-30
Coated Ca-carbide	12-29
Thiosulphate	15-20

Source: Pathak et al. (2011)

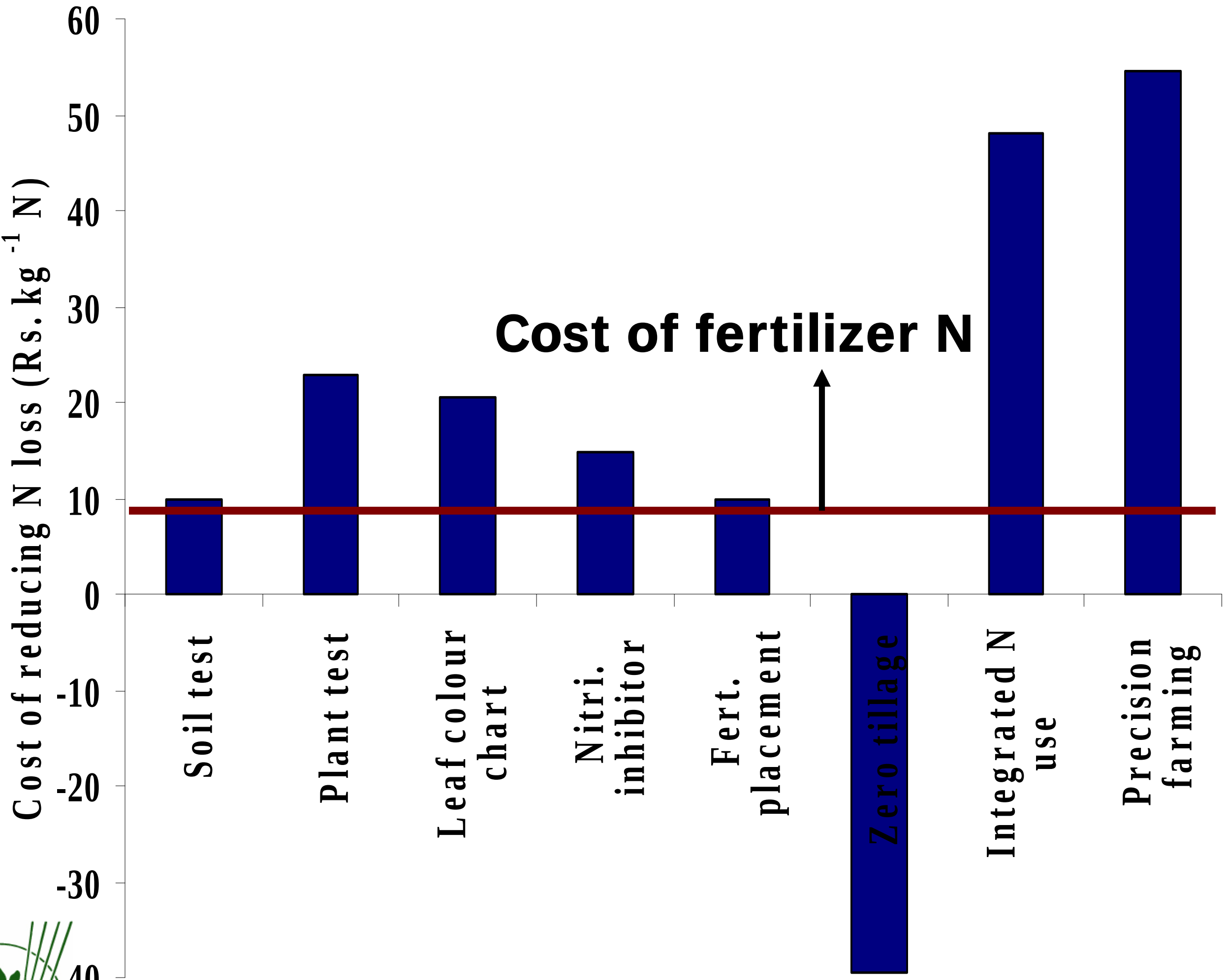
Fertilizer N Management tools/tactics – a comparison

Tool	Benefit / cost	Limitation
Smart N Timing		
Blanket splits	High	Tendency to overuse
LCC-aided real time mgt	High	None
Soil-test	Medium	Facilities
Remote-sensing (NDVI)	Low	Not perfected & high cost
GIS / GPS	Low	Not perfected
Smart N Supply		
Placement	High	Machines
CRF	Low	High cost and not reliable
Inhibitors	Low	High cost and not reliable
Foliar	Low	Equipment, risk

Implementation of Mitigation Options

- Cost effectiveness
- Enhanced production
- Resource availability of the farmers
- National and international policy environment

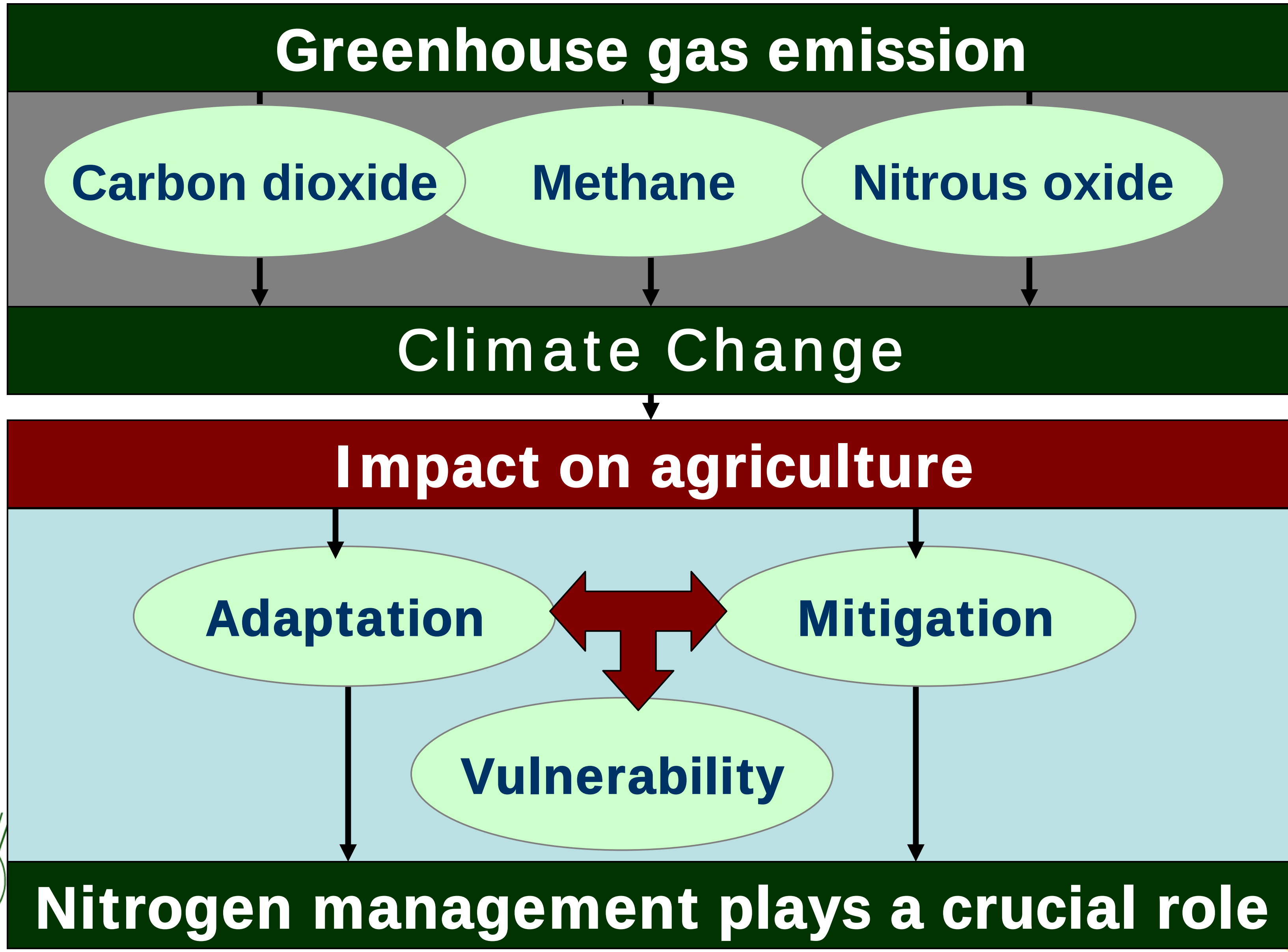
Mitigation of GHG by improved N management



Pathak (2010)

- **Emission of GHG can be mitigated with improved N management.**
- **But, in most cases, cost of mitigation is more than the cost of N.**
- **Incentives and policy support, therefore, are required to popularize these technologies.**

Climate Change and Agriculture

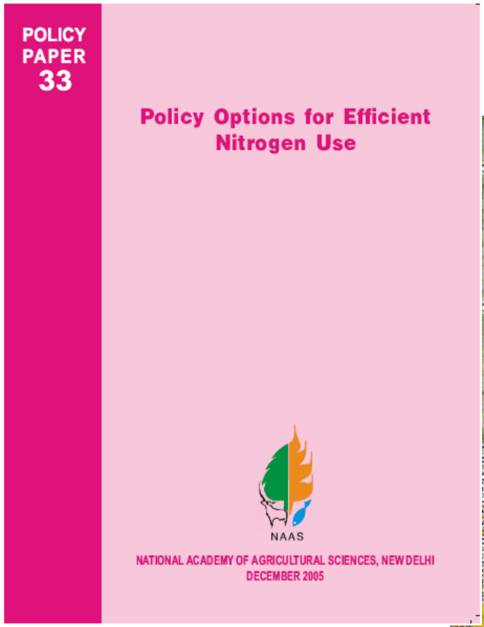


Conclusions

- N influences climate change.
- Efficient N management can help in adaptation and mitigation while reducing other environmental threats such as eutrophication, acidifi cation, air quality and human health.
- Complex and important effects of Nr on climate change processes needs more attention

Publications from ING Workshops

2005



NAAS Policy Paper

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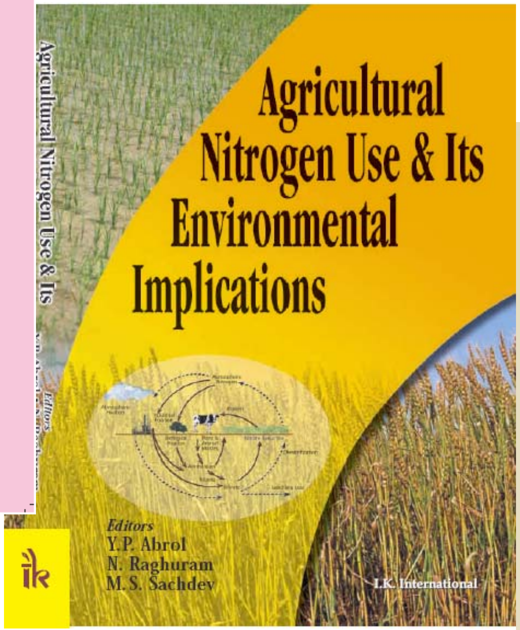

Edited Book

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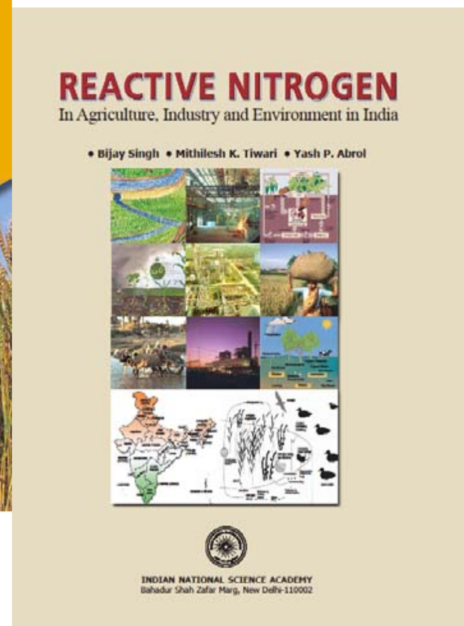
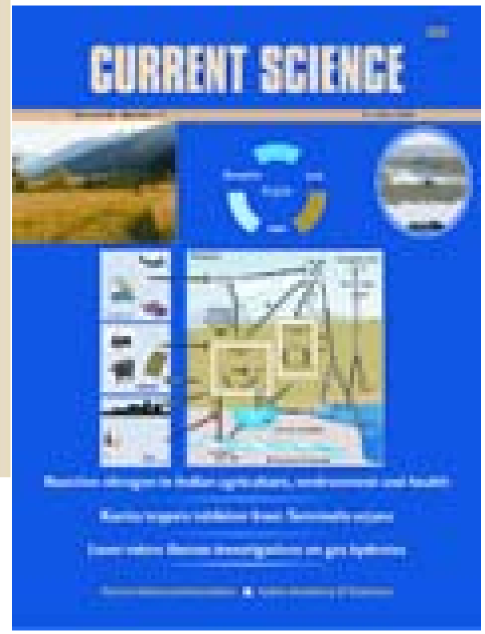


IGBP-WCRP-SCOPE Report 3, INSA

2008



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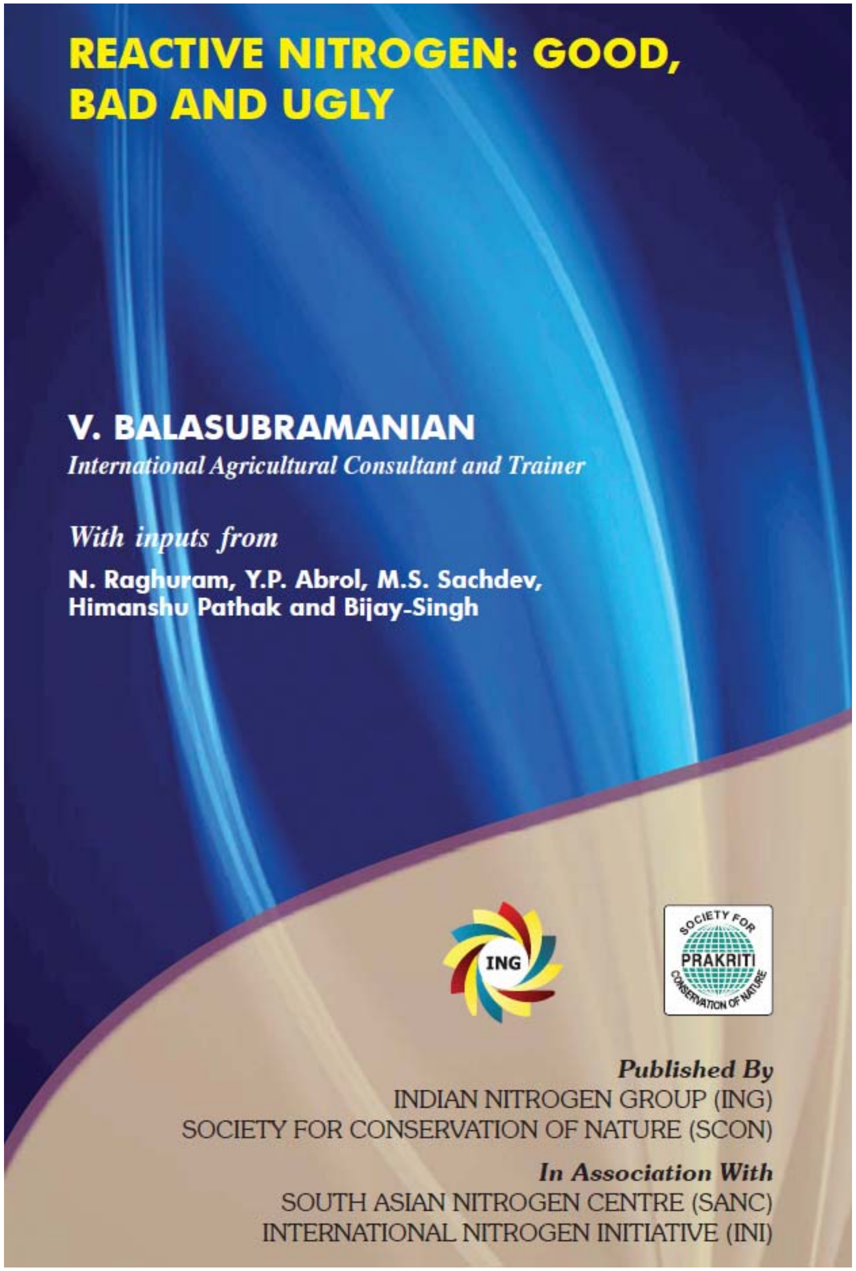

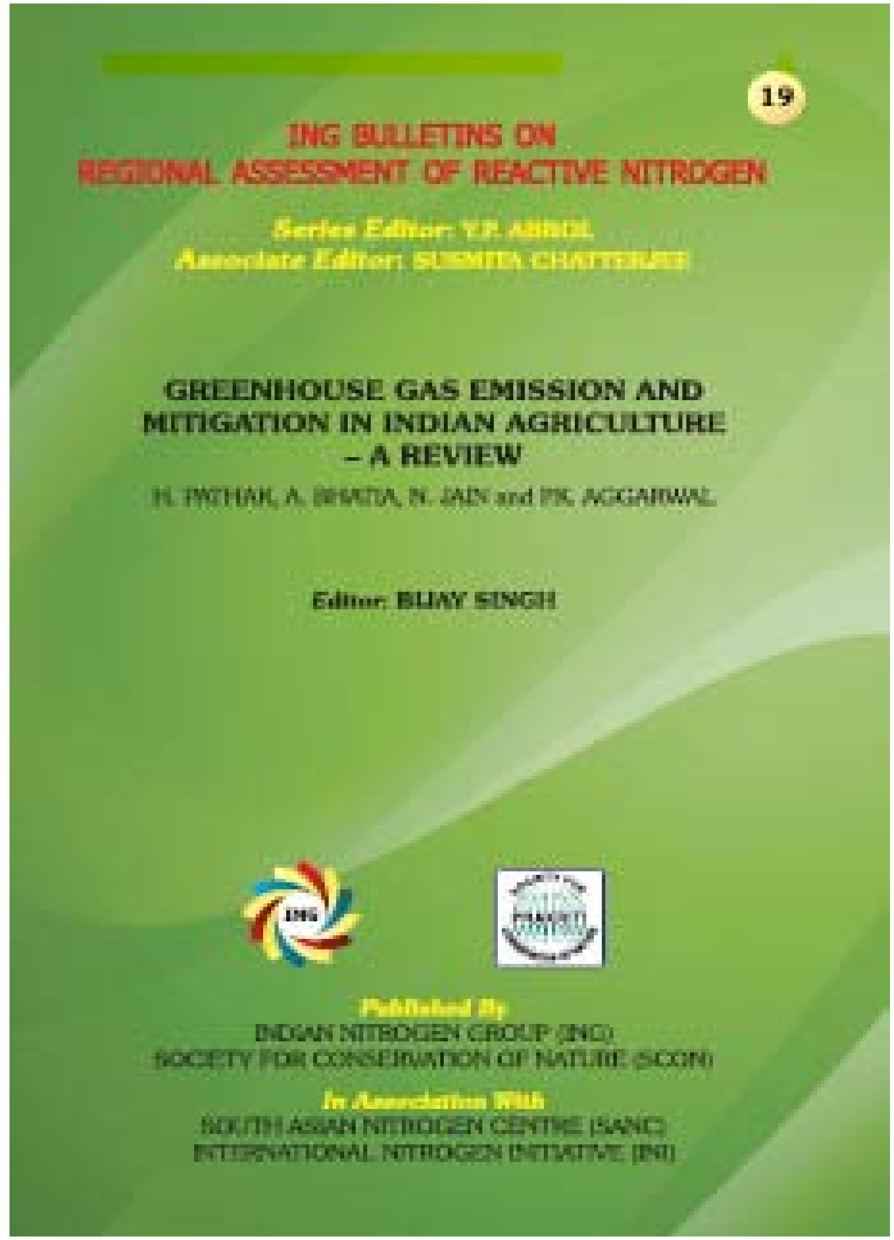

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