

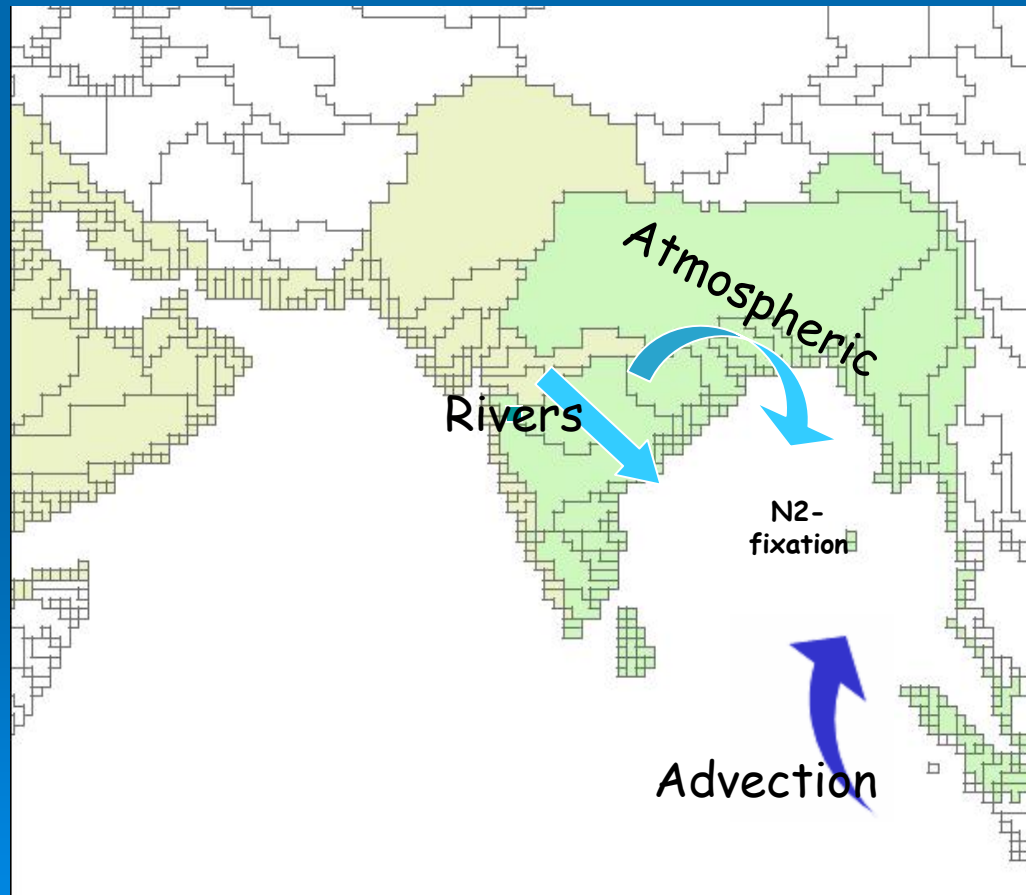
River Nutrient Transport from Watersheds to Indian Ocean Coastal Systems: *Amount, Forms and Sources*

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Wageningen University, Netherlands;

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Netherlands Envir. Assessment Agency

Nutrient Sources to the Indian Ocean Basin



- IN THE BEGINNING -

Biological
N₂-fixation

P Weathering

Water runoff

River export to Coastal Ecosystems



- NOW -

6.5 bill. People
(>1.2 bill. Indian Ocean)

N₂-fixation
P Weathering

- Fertilizer
- N₂-fixation - crops
- Manure
- Sewage
- Combustion FF = NO_y dep.
- Altered water runoff
 - Dams
 - Consumptive water use

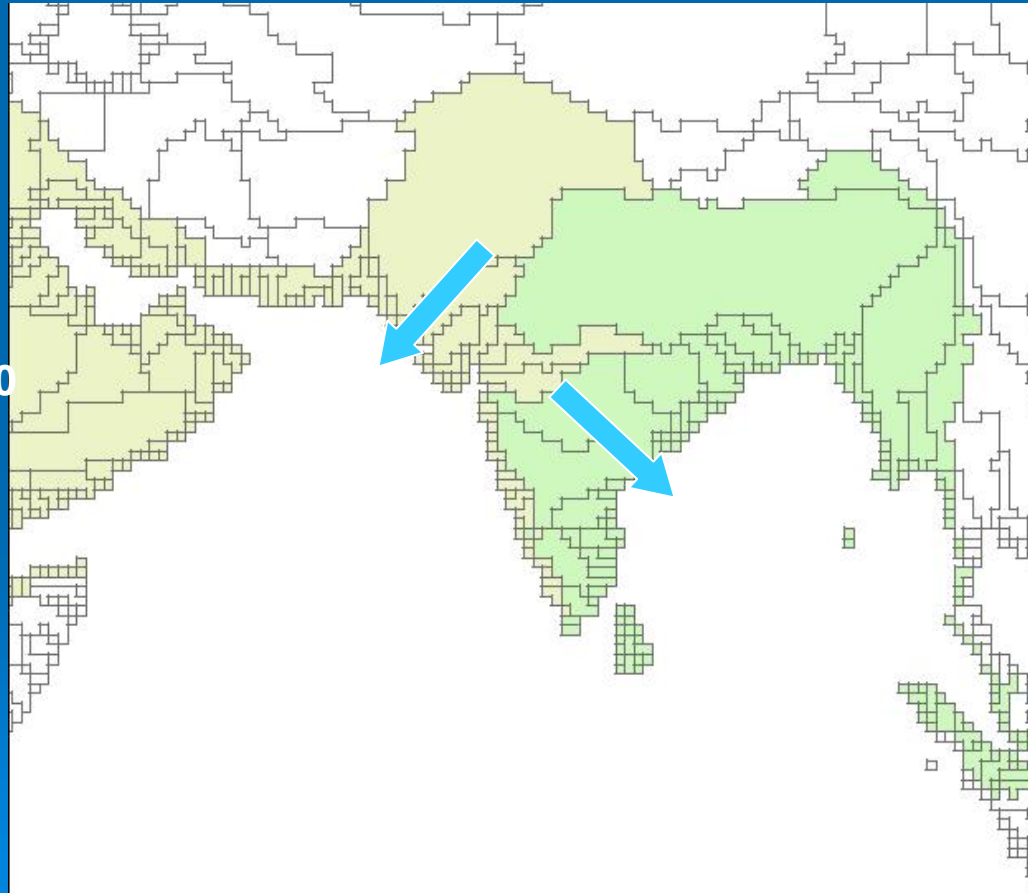


Increased River Inputs of N & P
to Coastal Ecosystems

Watersheds that Drain into the Indian Ocean Basin

~170 watersheds

Vorosmarty et al. 2000





INTERGOVERNMENTAL
OCEANOGRAPHIC
COMMISSION

UNEP



NSF
NOAA



Global *NEWS*

Global *(N)utrient (E)xport from (W)ater(S)heds*

Chair: S. Seitzinger

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J. Harrison, Rutgers Univ, USA
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W. Yan Chinese Academy Sciences, China

Global NEWS Models

Dissolved Particulate
Inorganic Organic

N

DIN

DON

PN

P

DIP

DOP

PP

C

DOC

PC

Si

(DiSi)

(PSi)

Overview

- Spatial variation in river export of N, P & C
- Total river export of N, P & C
- Watershed sources contributing to river export (natural and anthropogenic)
- Scenario for year 2030

Approach

Measured Export by Range of Rivers



Model Predict Export

f (Inputs, Sinks, Hydrology in Watersheds)

+

Spatially Explicit Global Data Bases



Spatial Pattern Nutrient Export Globally

NEWS Model Inputs

0.5° x 0.5° databases

Natural

N₂-Fixation
P Weathering

Anthropogenic

Fertilizer (by crop type)
Manure (by animal type)
N₂-fixation - crops
Sewage (treatment level)
Atmos. Dep. NO₃

Water Runoff
Consumptive Water Use
N & P Removal in
rivers and reservoirs

River export of
DIN, DIP
DON, DOP

Contributions of agricultural sources

Based on e.g.:

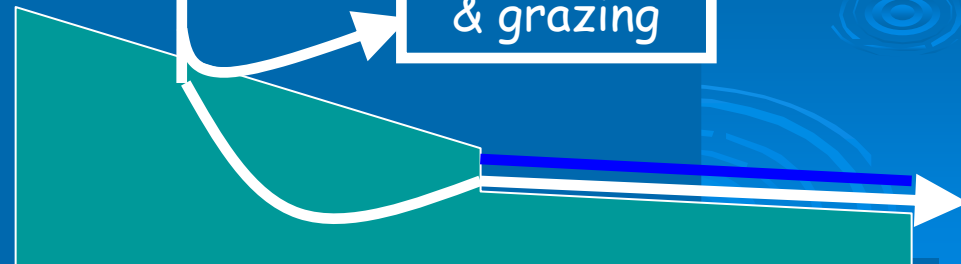
- Spatial land use distribution
- Crop types (FAO)
- Fertilizer consumption (FAO)

Inorganic fertilizer

Manure

N₂ fixation

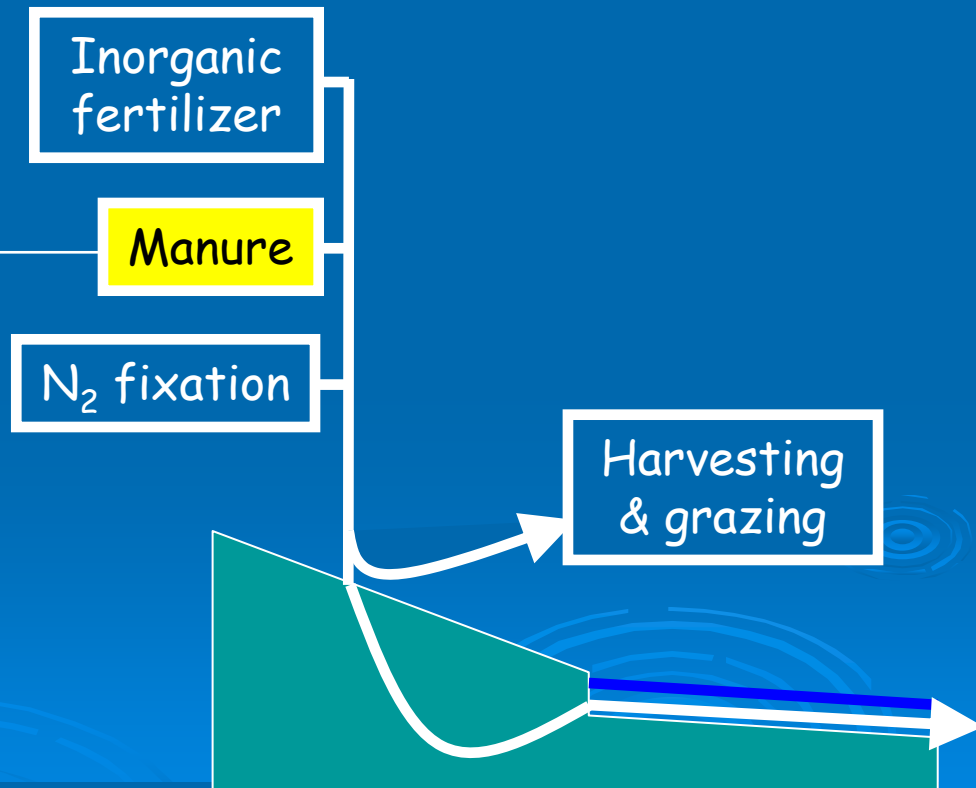
Harvesting & grazing



Contributions of agricultural sources

Based on e.g.:

- Spatial distribution of livestock
- Livestock numbers (FAO)
- Animal species (FAO)
- Type of livestock: "intensive or extensive"



N Atmos. Deposition

- Modeled (Dentener et al.) function of e.g.,
 - Fossil fuel combustion
 - Climate
 - Atmospheric circulation

NEWS Model Inputs

0.5° x 0.5° databases

Natural
N₂-Fixation
P Weathering

Anthropogenic
Fertilizer (by crop type)
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N₂-fixation - crops
Sewage (treatment level)
Atmos. Dep. NO₃

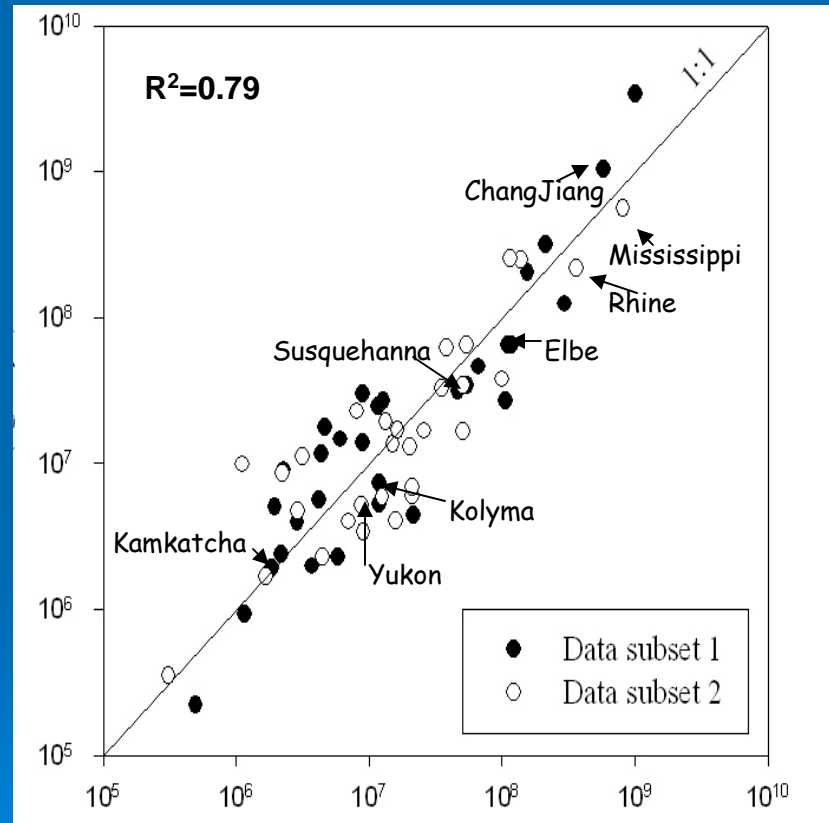
Water Runoff
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River export of
DIN, DIP
DON, DOP

*Export to
mouth of river*

Comparison of NEWS-DIN Model-Predicted & Measured Export for Range of World Rivers (1990's)

Modeled DIN export
(kg N basin⁻¹ y⁻¹)

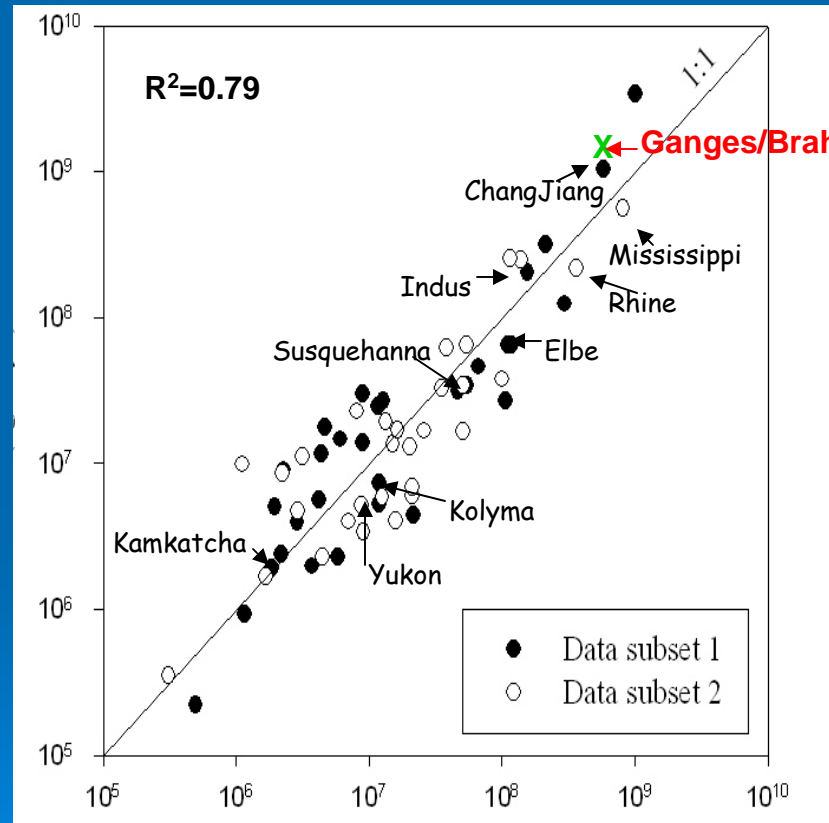


Measured DIN export
(kg N basin⁻¹ y⁻¹)

(Dumont et al. 2005)

Comparison of NEWS-DIN Model-Predicted & Measured Export for Range of World Rivers

Modeled DIN export
(kg N basin⁻¹ y⁻¹)

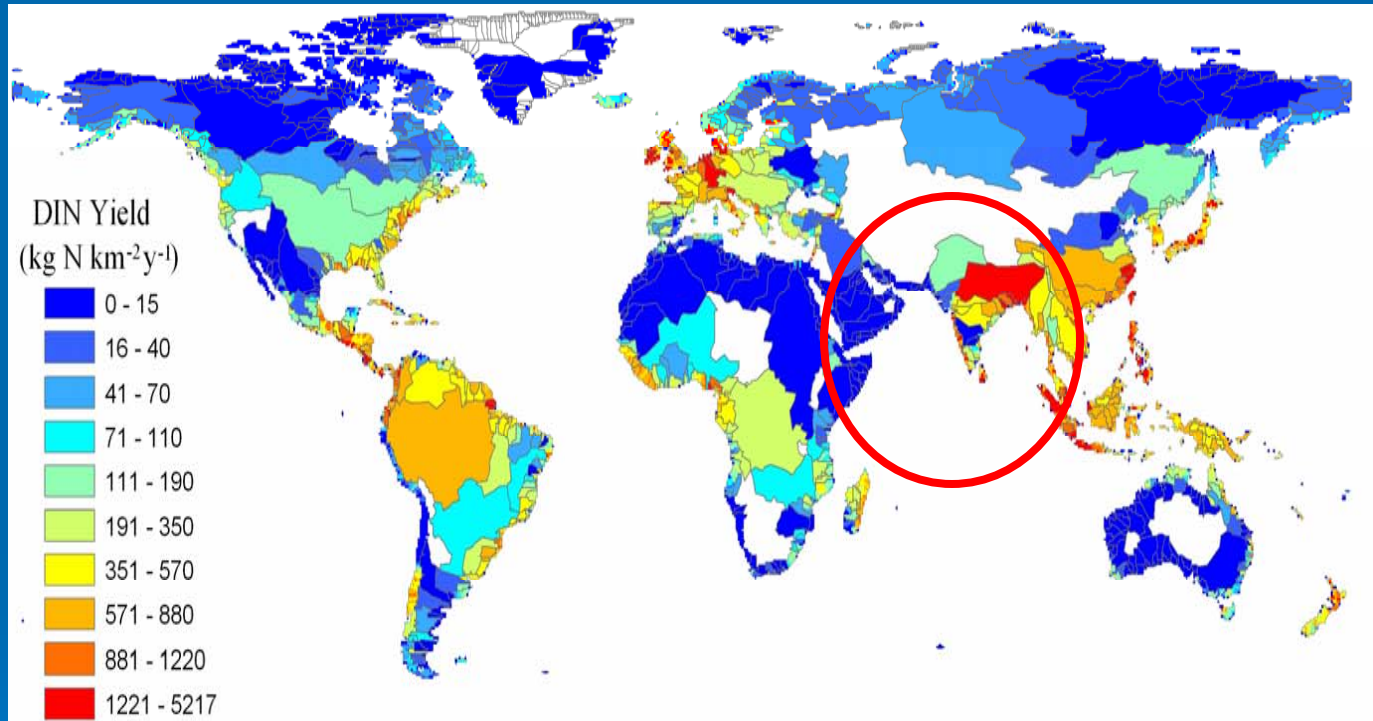


Measured DIN export
(kg N basin⁻¹ y⁻¹)

S.K. Mukhopadhyay &
T.K. Jana
DIN for tributary Ganges
In India (current)

Prediction of DIN yield

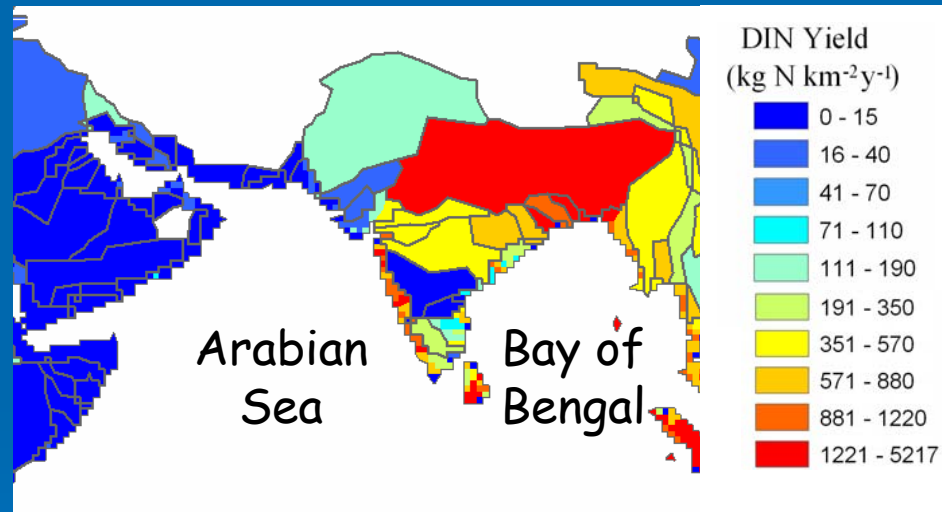
(kg N km⁻² y⁻¹)



Dumont, E., J.A. Harrison, C. Kroeze, E.J. Bakker, and S.P. Seitzinger. 2005. Global distribution and sources of dissolved inorganic nitrogen export to the coastal zone: results from a spatially explicit, global model. *Global Biogeochemical Cycles* 19:19(4): GB4S02.

Spatial Patterns DIN Export by Rivers

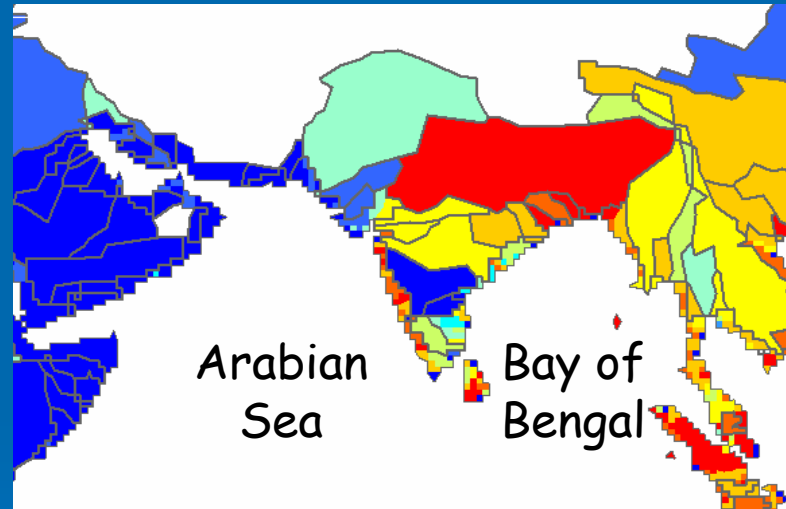
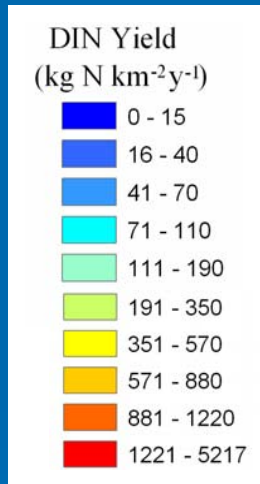
(kg N/km² watershed/yr)



Excerpt from Dumont et al. 2005

Spatial Patterns DIN Export by Rivers

(kg N/km² watershed/yr)



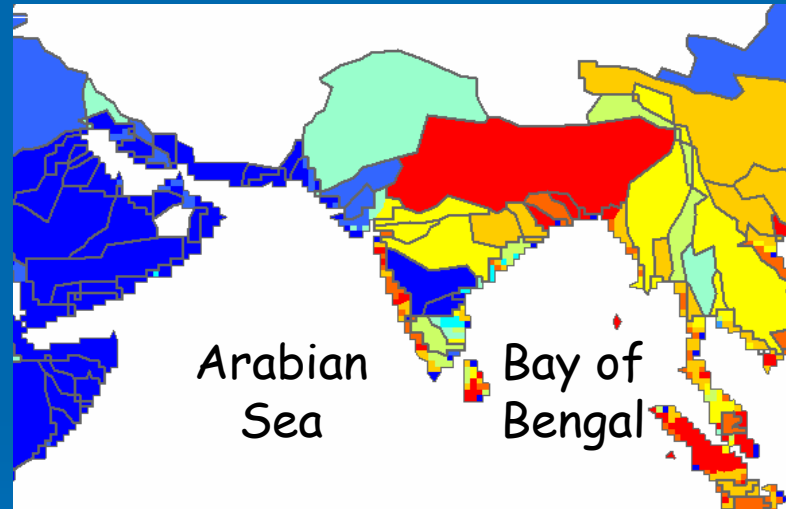
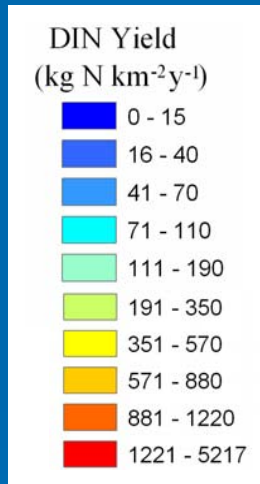
494

3,600

Total Export - 10^9 g DIN/yr

Spatial Patterns DIN Export by Rivers

(kg N/km² watershed/yr)



494

3,600

Total Export - 10^9 g DIN/yr

- Ganges/Brahmaputra accounts for 60% of river DIN load to BB

- DIN load to BB+AS accounts for 20% of total global DIN export

Global NEWS Models

Dissolved Particulate
Inorganic Organic

N

DIN

DON

PN

P

DIP

DOP

PP

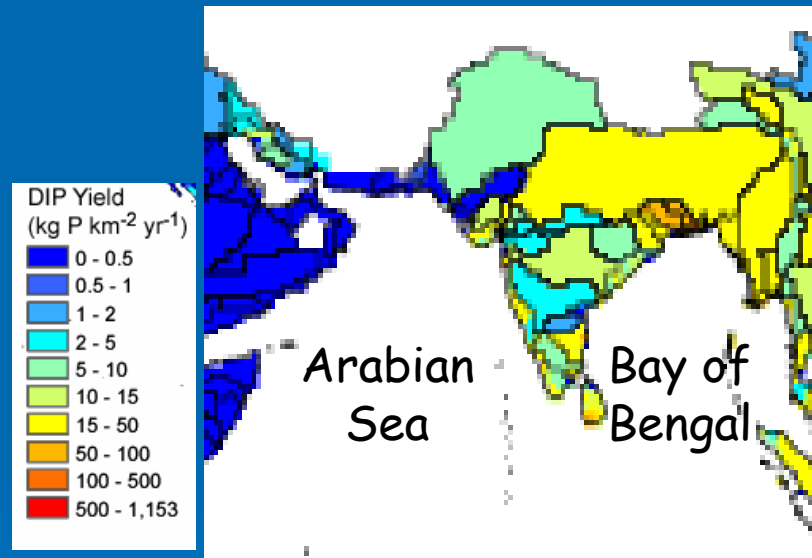
C

DOC

PC

Spatial Patterns DIP Export by Rivers

(kg P/km² watershed/yr)



25

99

Total Export - 10^9 g P/yr

Modified from Harrison et al. 2005

Global NEWS Models

Dissolved Particulate
Inorganic Organic

N

DIN

DON

PN

P

DIP

DOP


PP

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DOC

PC

Overview

- Spatial variation in river export of N, P & C
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 - Scenario for year 2030
- 

NEWS Model Inputs

0.5° x 0.5° databases

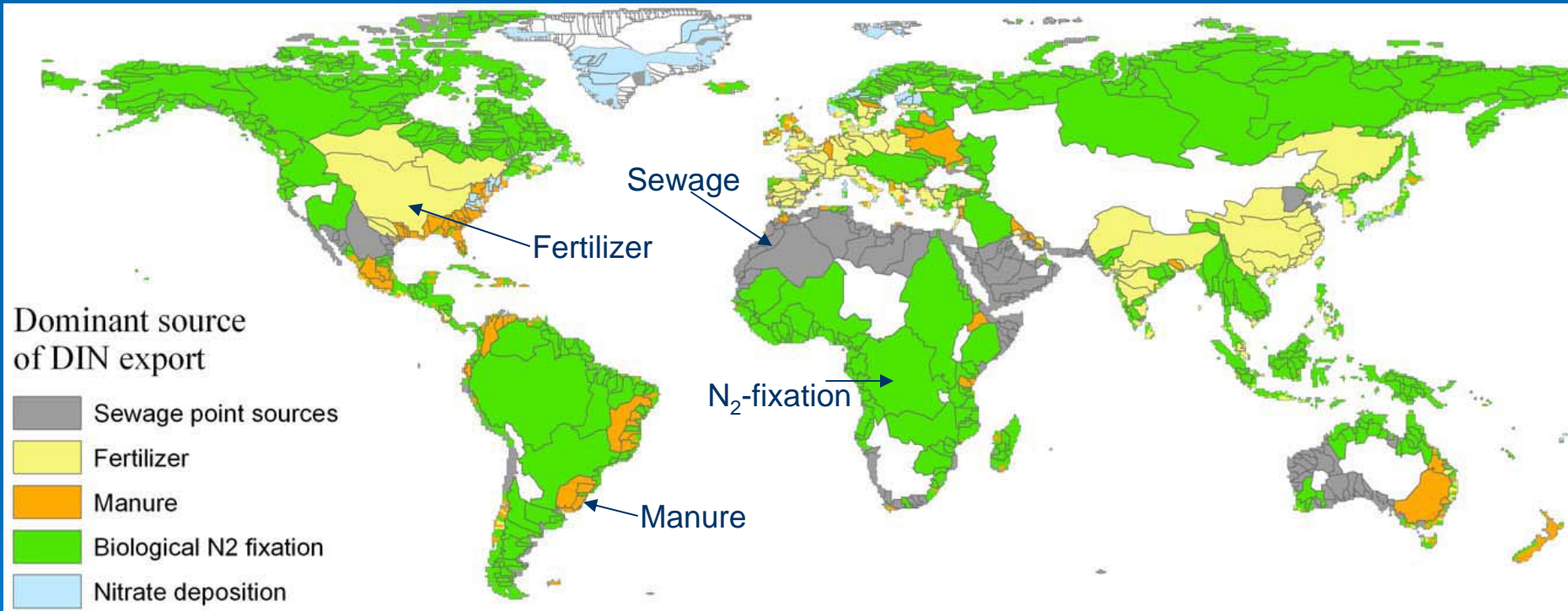
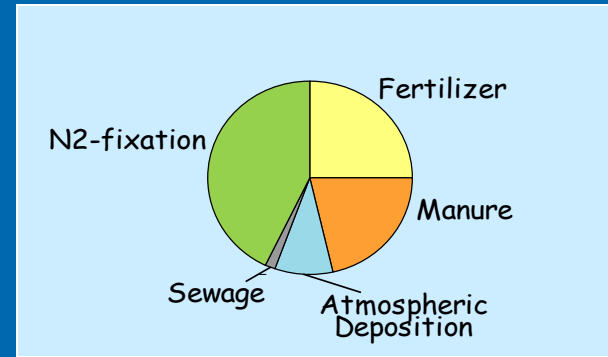
Natural
N₂-Fixation
P Weathering

Anthropogenic
Fertilizer (by crop type)
Manure (by animal type)
N₂-fixation - crops
Sewage (treatment level)
Atmos. Dep. NO₃

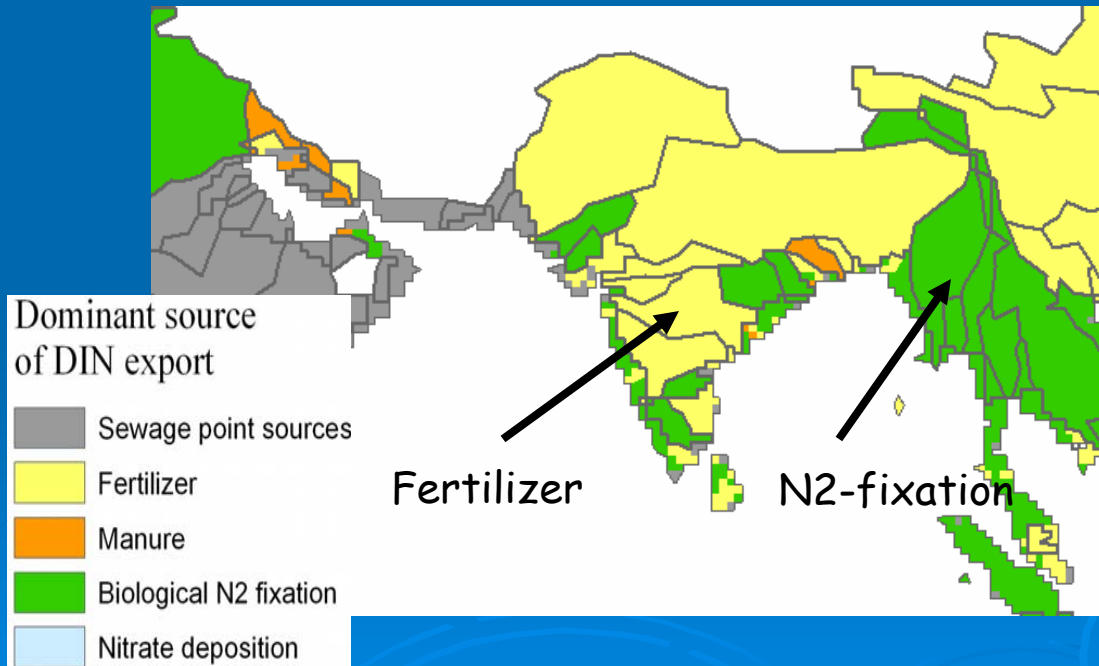
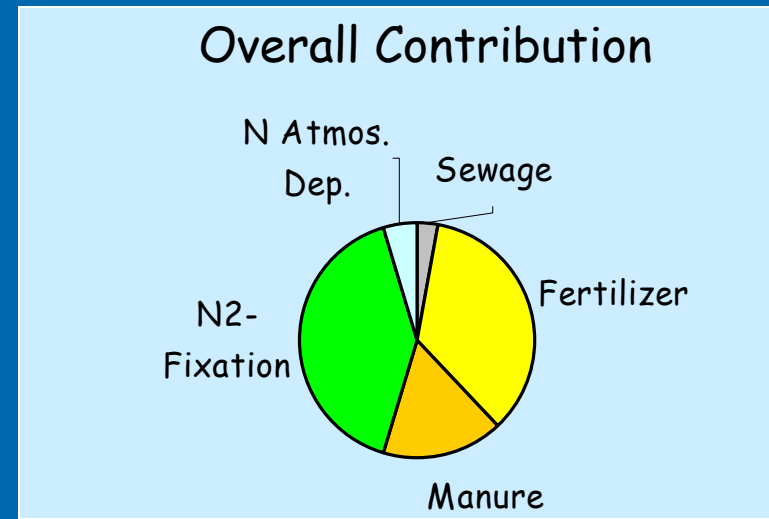
Water Runoff
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rivers and reservoirs

River export of
DIN, DIP
DON, DOP

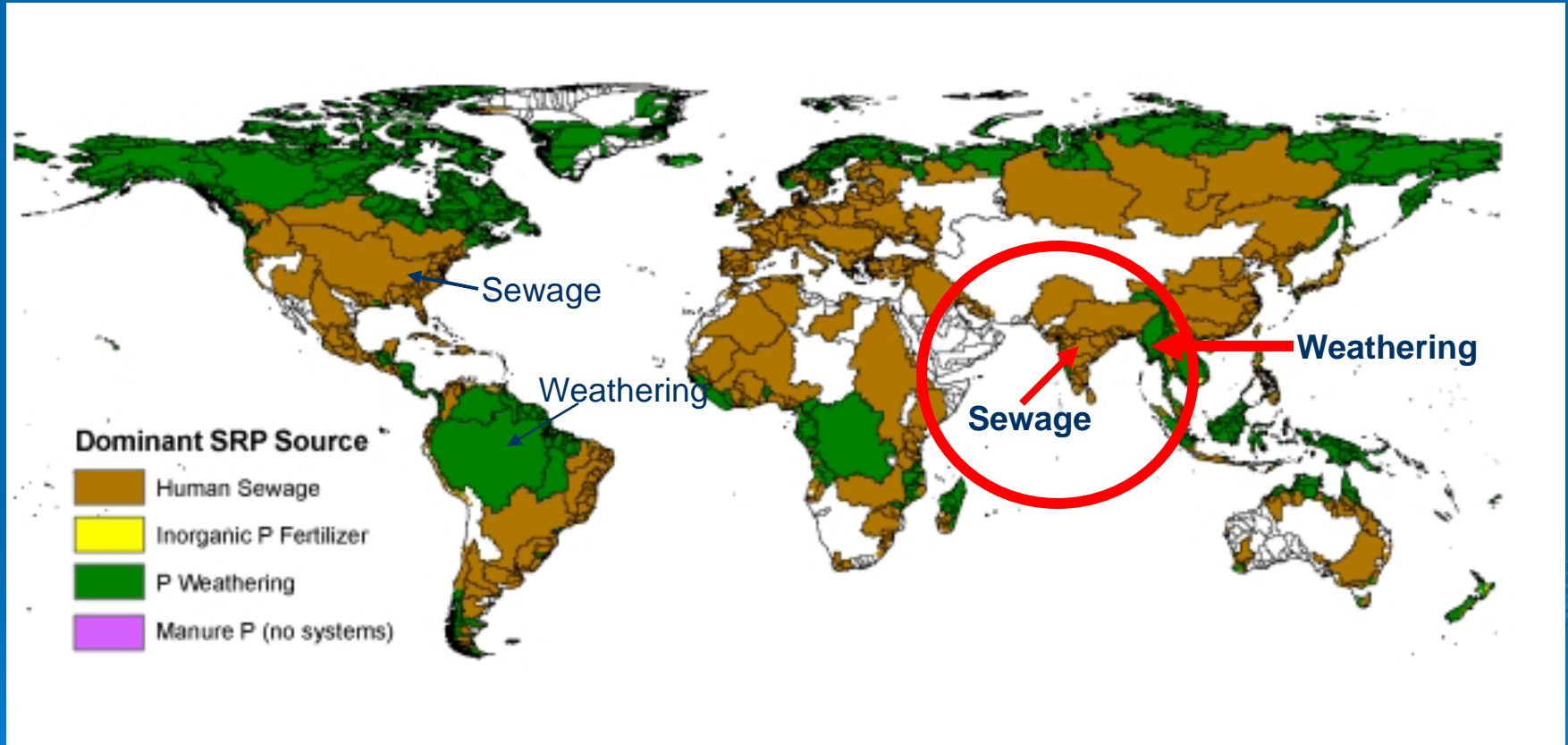
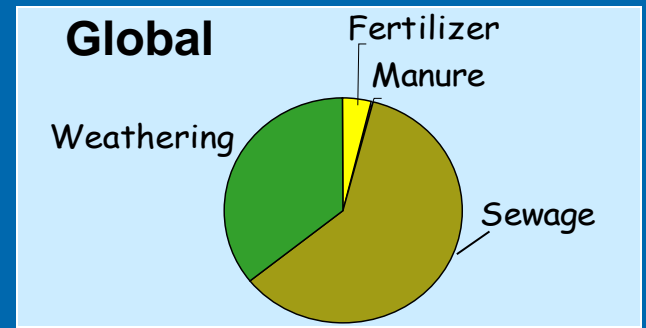
DIN Export Variation in Dominant Source



DIN River Export Variation in Dominant Source



Variation in Dominant Source of DIP Export



From: Harrison, Seitzinger, Bouwman, Caraco, Beusen & Vörösmarty 2005.
Global Biogeochem. Cycles 19:19(4): GB4S03

Future Scenario - Yr 2030

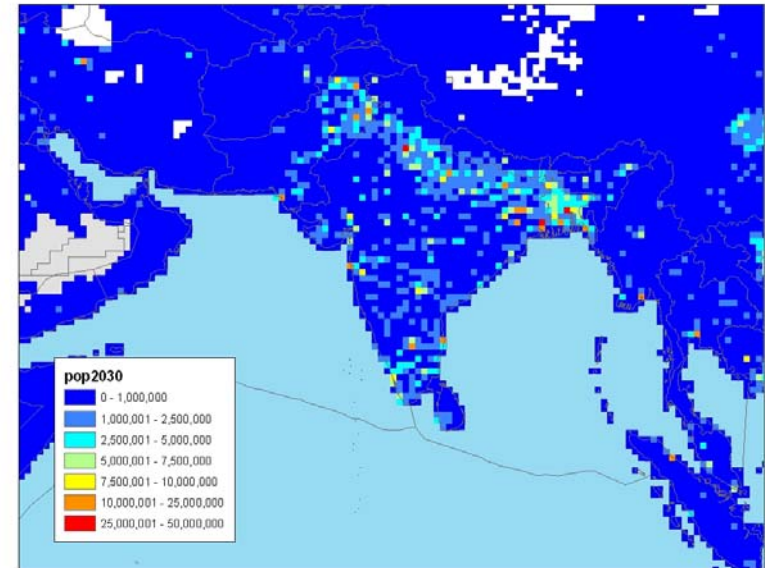
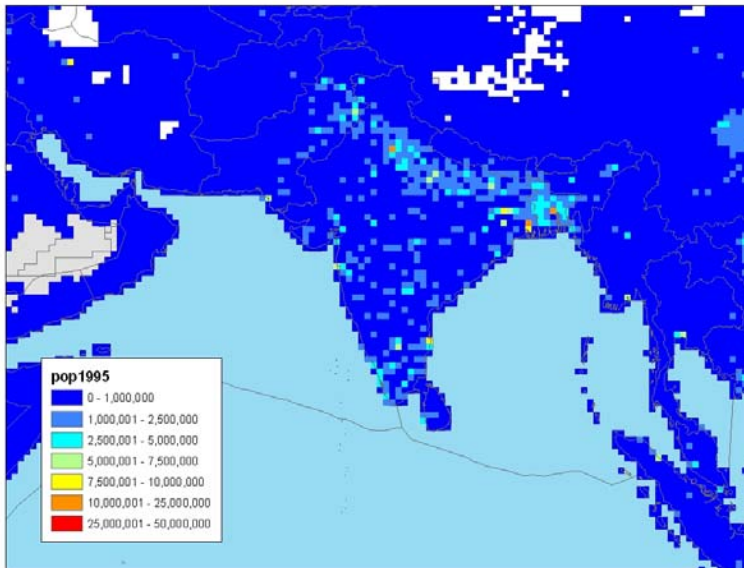
Human Population

1990

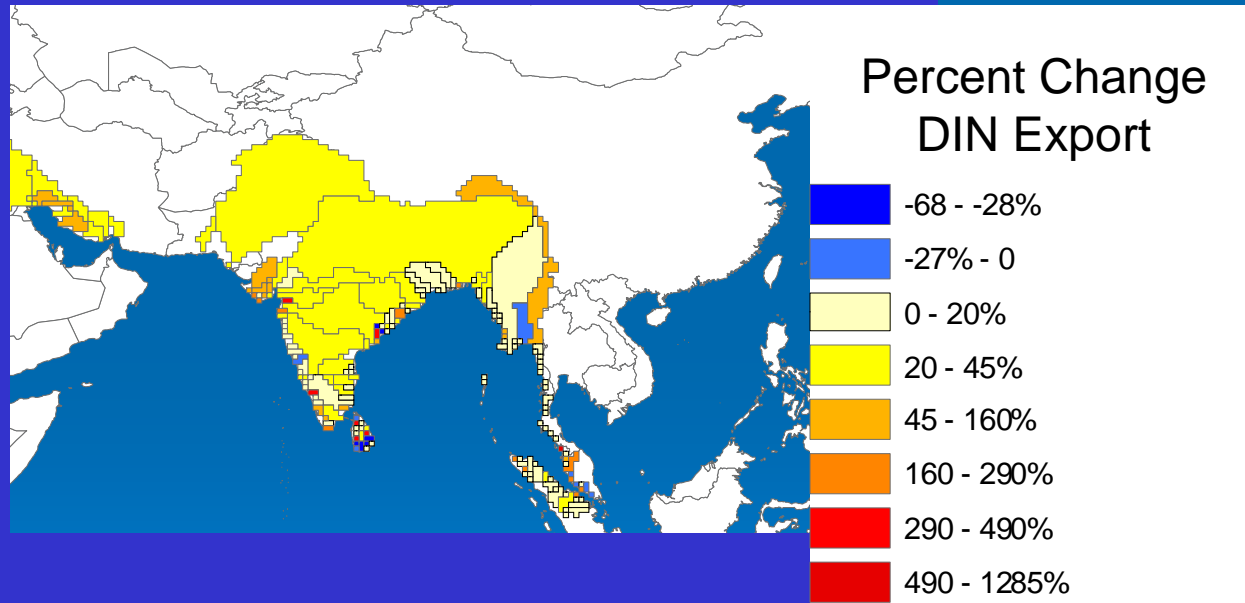
1.2 billion

2030

2.0 billion



Percent change DIN export 2030 relative to 1990



Future Directions

- Model refinement for Indian Ocean region - updating of databases, comparisons with local data, scenarios.....
- Seasonal variation - pre-post-monsoon
- Transport of river inputs to shelf and interior locations
- Effects on C, N and P cycling and production in IO

Acknowledgments

- Global NEWS workgroup
 - UNESCO- IOC
 - UNEP
 - GEF
 - NSF
 - NOAA
- 